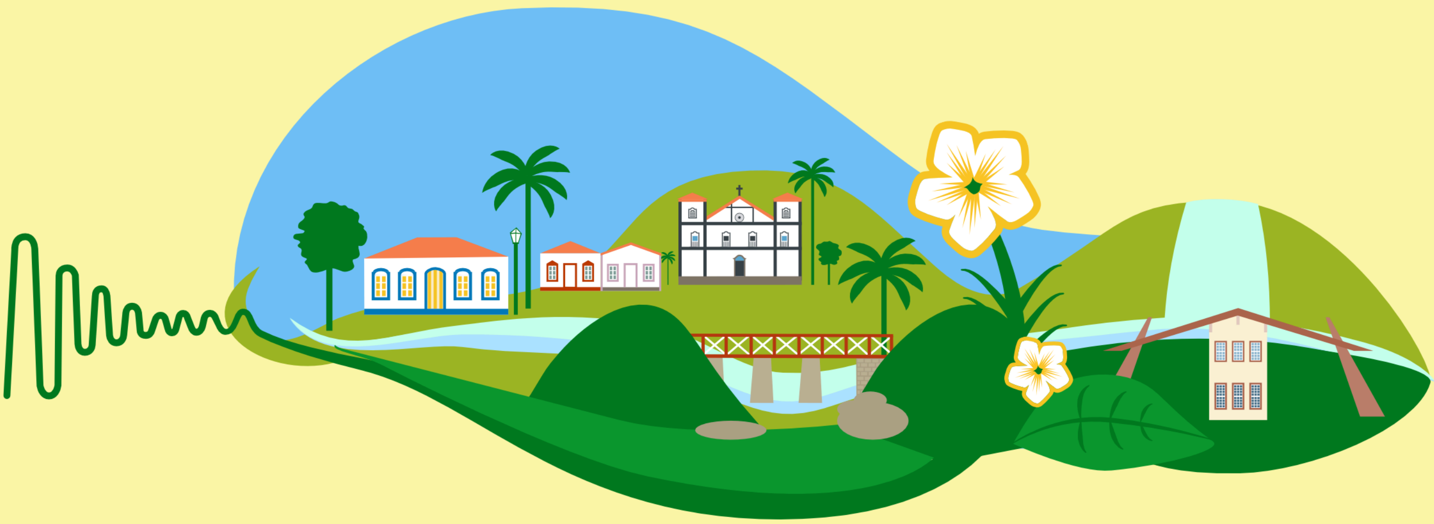
Hands-on Science

Science Education and Sustainability



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Manuel Filipe P. C. Martins Costa
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The Hand-on Science Network

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Foreword

Science Education and Sustainability

Sustainability is a key concept of fundamental importance in all aspects of our lives and to society.

Back in 2006, the 3rd International Conference on Hands-on Science held in Braga, Portugal, had as main theme "Science Education and Sustainable Development". The more than four hundred participants, that were coming from all over Europe and the World, presented at the conference a remarkable number of examples of good practices and discussed passionately this issue in a friendly and most productive way setting important and significant conclusions. The proceedings book of the conference remains a most valuable tool freely available to all at the website of the Hands-on Science Network (www.hsci.info).

Almost two decades later no one (hopefully…) have doubts about the importance of sustainability in all aspects of our society and to our future, and how fundamental is the role of Science Education and a sound widespread scientific literacy in promoting sustainability and sustainable development.

From September 23 to 27 these issues are going to be further explored and discussed at the 21st International Conference on Hands-on Science in the charming city of Pirenópolis in Goiás, Brazil. With an excellent organization by the local organizing committee, conformed by members from all over the Brazilian state of Goiás, and the enthusiasm of all the participants teachers, educators, ecologists, researchers, world renowned scholars and local schools' students, an exciting and fruitful week waits us all.

All presentations at the conference and the works selected, after careful reviewing, to be included as chapters or abstracts in this book, will be a valuable tool available to all concerned and interested on these topics of utmost actuality.

Vila Verde, Portugal, September 6, 2024.

Manuel Filipe Pereira da Cunha Martins Costa
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FOREWORD

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Activities of the Department of Physics Education, Faculty of Mathematics and Physics, Charles University

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Abstract. The Department of Physics Education, Faculty of Mathematics and Physics, Charles University, offers a lot of activities designed to promote physics education to pre-service and in-service teachers, students of different types of schools as well as children and adults of all ages. The contribution gives information about selected activities that cover wide spectra of topics that can be presented to pupils and students from primary school to university level. We will focus especially on the project of Collection of solved problems in physics and Collection of physics experiments as well as the project of Interactive physics laboratory for high school students and their teachers and Demonstrations for high school students.

Keywords. Pre-Service and In-Service Science Teacher Training, Collection of Solved Problems and Experiments in Physics, Interactive Physics Laboratory, Demonstrations for High School Students.

1. Introduction

The main task of the Department of Physics Education at the Faculty of Mathematics and Physics of Charles University in Prague is to prepare future physics teachers. Other equally important tasks include support for teachers in practice, popularization of physics and research in physics education. The Department also runs a number of activities and projects designed to promote physics education, which we offer to different age categories, from young children, through students of different types of schools to adults.

In this paper we will present some projects that we have been developing in the department for a long time. One is the electronic Collection of solved problems in physics and the Collection of physics experiments, and the other is the Interactive physics laboratory and Demonstrations for high school students.

2. Collection of solved problems in physics

Solving physics problems is one of the key abilities which students should reach during their physics education. To reach this goal it is necessary to invest quite a lot of time to train this skill during lessons. Moreover it is very hard to train problem solving without the help of a tutor or without specially designed materials. The lack of suitable materials was the starting impulse for creating a Collection of solved problems specially aimed to develop problem-solving skills.

The development of the Collection of solved problems in physics started in 2006 as a small project [1]. The successful adoption of a new problem-solving methodology among our students encouraged us to broaden our scope by not only adding more problems but also incorporating additional branches, subjects, languages, sorting, and search criteria. We also started to translate problems into English to make the Collection accessible to both foreign students of our faculty and interested individuals from abroad. Since 2015, the problems have been categorized according to the cognitive functions they develop. In 2017, interactive components started to be integrated into appropriate problems [2-3].

The collections team consists of four members of the Physics Education Department. They propose, supervise and evaluate the creation of new problems. Texts and other components of the problems are prepared by students of our department, future physics teachers. These materials form part of the bachelor's theses or are created as part of the student projects.

The electronic collection is designed primary for students in introductory university physics courses to practice and deepen the knowledge gained in high school. High school students interested in physics can use this collection as well, e.g. for their independent study and for preparation for school leaving exams or entrance exam to university. Because we want to enlarge the usability of the collection, simpler high school tasks as well as junior high school tasks are also gradually inserted into the database. Availability of the collection on public web pages enables usage of the collection by both students and teachers not only at our faculty but also at other universities and high schools.

Our intention is not only to make a Collection of solved problems but also to help its users to learn how to solve physics problems independently and lead them to active thinking about presented physics problems. The structure of problems' solutions is specially designed to substitute tutor's help during lesson and encourage students to solve at least some parts of a problem independently. There are various hints, notes with laws and formulas, plots and other tools supporting students' effort before detailed solution. To fulfil our intention, we have developed our own web interface for these problems which does not show the entire solution at first.

The task page is divided into several parts (Fig. 1). A drop-down menu with tasks list can be found on the left side. Tasks in each part of physics are structured into chapters and subchapters. The task itself is located on the right side of the web page. Ribbons with individual sections of the solution are placed under the assignment of the task. The required section is displayed only after clicking on the ribbon. Further clicking on the ribbon hides the section again. Tasks are classified according to difficulty into four categories. Each task can be included into special categories if it is solved using some special way (qualitative task, graphical task, task with unusual solution, complex task or task with theory).

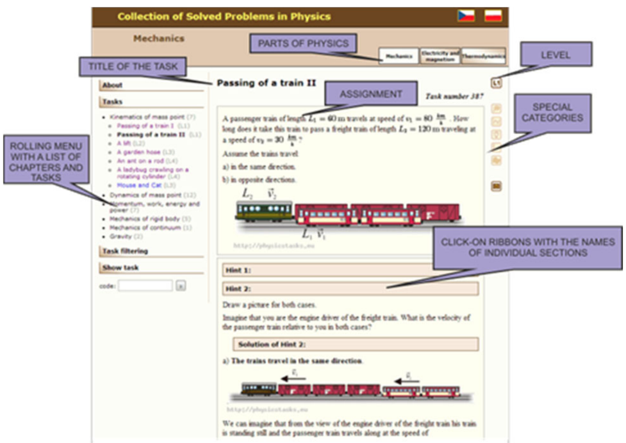

Figure 1. Appearance of the collection

The initial parts of each problem are an attractive title, followed by a clearly formulated assignment that incorporates realistic physics values. The solution to a problem is divided into sections with titles and collapsible content, allowing the sequential display of each part of the solution. There are seven types of sections: hints (which should aid users in the problem-solving process), solutions to the hints, analysis (containing the solution strategy in words without formulae), a detailed account of the solution (listing all mathematical processes employed), a brief answer to the question, comments (e.g. alternative solutions, variation in the problem, practical applications and other points of interest for users), and links to analogous problems or experiments.

Thanks to the fact that our collection is entirely electronic, we enhance certain problems with interactive components created in GeoGebra or Wolfram Mathematica (Fig. 2). These components are intended for the readers to explore and experiment freely.

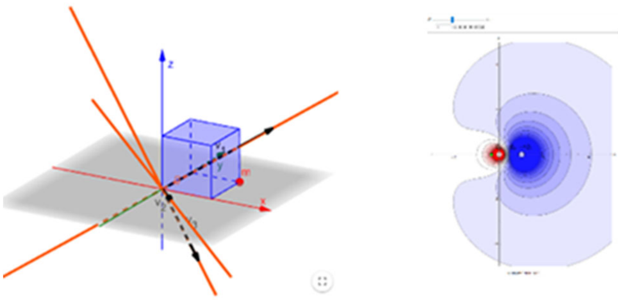

Figure 2. Interactive components

Table 1. Numbers of problems

Topic	Czech	English
Mechanics	235	108
Electromagnetism	282	93
Thermodynamics	158	84
Optics	67	26
Small-scale physics	111	15
Theoretical mechanics	48	
Mathematical methods	25	
PISA tasks	27	

The problems from the international PISA research started to be added to the Collection of solved problems five years ago. The PISA problems are unique; they link physics to other sciences and real-world situations and enhance students' critical thinking. Solving problems of this type is not common in Czech schools and there are no other sources of such problems. Therefore, we aim to improve their availability for pupils and teachers of lower secondary schools.

Nowadays the database contains more than 950 fully solved physics problems in Czech, more than 100 problems in Polish and over 320 problems in English (Table 1). Further problems are still being translated.

The database is available at the website http://www.physicstasks.eu/.

3. Collection of physics experiments

In 2015 the Collection of physics experiments was created using the same interface and database as the Collection of solved problems in physics. The purpose of this collection is to be an inspiration for teachers, especially at the primary and secondary school level. The description of experiments is written in great detail, supplemented by technical and methodological notes, photos and video sequences capturing the exemplary performance (Fig. 3) [3].

Figure 3. Appearance of the experiment

Each experiment description follows a typical structure, consisting of the experiment's objective, a brief overview of the theory, necessary equipment, methodology, example outcomes, technical remarks, and pedagogical notes. The latter two sections are directly based on the proper and reliable testing of all experiments and on well-documented experience with processing the experiment. The results section, which shows the expected outcome of the experiment, is important. For quantitative experiments, this section usually shows a table and/or graph of the data obtained during the measurements. Most of the experiments are supported by short video clips, which are posted on a dedicated YouTube channel [4], these help teachers to quickly understand the progress of the experiment. Experiments are classified based on, among other things, their type, complexity, tools and the time needed for preparation and execution.

The collection contains now about 170 experiments in Czech and 80 experiments have been translated into English (Table 2).

Table 2. Numbers of experiments

Topic	Czech	English
Mechanics	13	1
Electromagnetism	52	13
Thermodynamics	75	55
Optics	30	12

The database is available at the website http://physicsexperiments.eu/en/physics. The use of the same web interface allows easy connection of problems and experiments with the same topic. A problem whose solution can be verified by an experiment should be linked to the corresponding experiment and vice versa. The intention is to make it easier for teachers to use problems and experiments together.

4. Interactive Physics Laboratory

The goal of the Interactive Physics Laboratory (IPL) is to offer high school students (and their teachers) a space for controlled experimentation on a given physics topic, where all experiments and measurements are performed by the students themselves. The IPL was launched in December 2008 [5-6].

Students work in small groups up to three or four, in the laboratory spend a total of 120 minutes working on experimental units that together create an experimental set related to a particular physics topic. The IPL currently offers ten experimental sets:

- Electrostatics

- Oscillations and rigid body mechanics
- Motions under gravity
- Rotating frames of reference
- Magnetic field of solenoids
- Thermodynamics I – quantitative approach
- Thermodynamics II – qualitative approach
- Optics - quantitative approach
- Optics - qualitative approach
- Quantum effects in microworld.

Each set consists of four to six units. The experiments in the units are mostly of a dual nature, either experiments that would be difficult to carry out in the classroom due to the amount of time required or equipment demands, or those that have the potential to strengthen students' conceptual understanding.

Students are given maximal autonomy. They perform all of the activities independently, including preparing measurements, and recording and evaluating data. Furthermore, at the end of IPL visit, each workgroup describes one of the experimental units in a presentation lasting a few minutes, including major findings and results.

Figure 4. Students experimenting in IPL

Every unit has its own worksheet, which is given to the students to record their results. After the session, the students can take this sheet with them, thus giving their teacher an opportunity to build on the experimenting in the IPL in subsequent regular lessons. During the entire time of their visit, students can consult with lecturers regarding the steps of the experiment. The lecturers are Master and Pd.D. students or younger employees of the Department of Physics Education.

5. Demonstrations for High School Students

High school teachers with their students have the opportunity to come to the Faculty of Mathematics and Physics to see sets of demonstration experiments from various physics topics. The project of physics demonstrations (DEMOS) has a tradition of more than three decades. The main goals of the demonstrations for high school students are to present and explain experiments that are usually not shown at school (for lack of time or equipment) and to promote physics to wide range of students, not only to science fans.

During both semesters, one forenoon a week is dedicated to an experimental show for upper secondary students. Each performance takes 75 minutes and is repeated two or three times in a row. Every year almost seven thousand high school students accompanied by approximately fifty teachers come to see the programme. At present, seven different physics topics are offered for teachers to choose from:

- Mechanics
- Acoustics
- Electricity and magnetism
- Electromagnetic radiation
- Thermodynamics
- Optics
- Ionizing radiation

The experiments are performed by teachers from the Department of Physics Education (Fig. 5).

Figure 5. Experiments from Acoustics and Mechanics

6. Summary

Among the wide range of outreach and popularisation activities the Department of Physics Education offers to pre-service and in-service teachers, students and public the above mentioned activities represent important addition to standard education [7]. The Collection of solved problems and Collection of physics experiments are long-standing, successful projects that have proven useful per feedback from our students and anonymous users, as well as web traffic.

IPL enables sophisticated experimental work for high school students, and DEMOS contribute, among other things, to the popularization of physics for a wide range of high school students. Both projects are highly valued by both high school teachers and the students themselves. Both of these projects are also followed by larger research studies. One of them is the quantitative study dealing with students' intrinsic motivation and related attitudes towards practical work in the IPL on one side and towards physics demonstrations on the other side. As a research tool was used a modified Intrinsic Motivation Inventory supplemented by additional questions on attitudes towards physics. The respondents were more than 2000 Czech upper secondary students who had visited the IPL and almost 5 000 students who had visited DEMOS [6, 8-9]. Further research concerns parameters influencing perception of physics demonstrations by different communities of people involved in the upper secondary school education. Its aim is to determine such parameters in various groups of people (teachers, students, pre-service physics teachers, pre-service physics teacher trainers) and to compare these parameters between different groups. The design is mixed methods research comprising of a video-study using high-inference rating scales and open-ended qualitative questions. The video-study mixes holistic and analytical approach to the lecture demonstrations. [10-11].

7. Acknowledgements

In the last more than ten years, the development of both Collections and IPL has been financially supported by the IRP of the Ministry of Education, Youth and Sports.

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Inquiry-Based Hands-on Methodologies as a Strategy for Science Education in a Prison

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Abstract. Learning in prison is highlighted in the Spanish Constitution (Article 25.2) as a key point in reducing recidivism rates. Likewise, educational policies increasingly reflect the need to improve and generalise scientific literacy so that citizens can understand the globalised and highly technological world that surrounds them and as a source of empowerment and enjoyment for all. In this sense, Inquiry-Based Hands-on Methodologies have successfully connected subjects in an interdisciplinary way with this goal in multiple contexts.

However, to our knowledge, there are few experiences in adult education in prisons. In this paper, we detail the protocols we have implemented to carry out a pilot research project during the 2023-24 academic year, focused on hands-on science education in a prison in Spain. We present the methodological design, the chronogram and the most relevant conclusions of this contact pilot programme in this educational reality. First impressions are positive and shows that students are involved with the proposal and acquire knowledge and skills through hands-on work based on inquiry.

Keywords. Inquiry-Based, Hands-on, Prison.

1. Introduction

Adult learners are practical, motivated and highly goal-oriented; they expect the educational experience to be relevant to them, they seek to connect their life experiences and prior knowledge with new learning, and they desire respect [1]. Educational success in this context most often depends on teachers using best practices tailored to the needs of the learners, without the pressure of time or a strict curriculum.

Evidence shows that students generally learn in a critical, active, autonomous and motivated way about a scientific concept when they investigate in groups and question unsubstantiated claims [2]. This approach also fosters social relationships and positive attitudes, which facilitates critical and responsible decision-making in everyday life when faced with a variety of problems [3-5].

This approach of learning scientific knowledge through inquiry-based practical work can be useful in adult education contexts in general [6-7] and particularly in cases where training programmes take place within a correctional facility [8-14].

There is insufficient evidence in the literature on the effect that active science learning methodologies can have on learners in a prison setting. It is assumed that the participation of incarcerated adults in inquiry activities can increase their positive emotions and improve their sociability [12-13]. However, previous experience shows that teaching in a prison environment is a complex activity [11, 14]. In addition to taking place in a restrictive environment, there are resource gaps and challenges compounded by the significant heterogeneity of the students, in terms of age and educational, affective and emotional needs. The educational process must be based on the desire to learn and enjoy learning in a group, while promoting routines of organisation, study, tolerance and responsibility.

This paper presents the methodological design, chronogram and main conclusions of the pilot phase carried out during the academic year 2023-24 of an action-research project for science education for adults based on practical science activities in the EPAPU 'Nelson Mandela' located inside the Penitentiary Centre of A Lama, Pontevedra, Spain.

2. Instruments and methodology

2.1. Instruments

In this pilot phase of observation and contact with pupils, it was decided to use a collaborative diary among the teachers involved as a methodological resource for reflection and peer validation [15]. This diary, in the form of a shared document, was made available via a link to docs.google.com, to record the individual

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perceptions, observations, comments and feelings of those participating in the project.

2.2. Methodology

Thus, the aim of this action research project [16] is to generate strategies for the implementation of scientific practices in adult education classrooms inside a penitentiary centre, by means of practical work based on enquiry that involves carrying out mini experimental research projects that must be documented by the students themselves [17-18]. Once these mini-projects were completed, the students moved to a dedicated unit where they could access security-enabled computers to type their work. The computers were equipped with word processors, spreadsheets and office software designed to create slide presentations.

The experimental research mini-projects developed are directly related to the Official Curriculum of the Scientific-Technological Area of Adult Secondary Education (ESA) required to obtain the Secondary Education Graduate Diploma [19]; they are, therefore, an additional learning tool that complements the methodologies that were being used in the centre.

Briefly, the students, organised in small working groups, must choose a project from a list of proposals prepared by the teachers, search for information, carry out an experimental set-up using low-cost materials, collect and analyse data, document their work in digital format using a template provided by the teachers as a final report, and make an oral presentation of their work, thus finding possible solutions to the open problems posed. The materials needed for the activities were either purchased by the school or provided by the external researcher.

An external researcher, the first author of this work, authorised by the prison administration to assist the science teacher of the group, provides resources, advice, guidance and support to the students in this process, with a weekly face-to-face attendance of two hours in the 4th year of Adult Secondary Education (ESA) and three hours per month in the Science Club. The assumption is that enriching educational programmes in prisons with the participation of adult learners in inquiry-based activities can make them more sociable, creative and self-confident. It enhances their skills and abilities, and increases their positive emotions during school activities based on guided scientific research.

In this pilot phase of observation, an initial presentation was given to create interest and curiosity about the proposal, seeking the students' commitment to science and scientists, as well as their willingness to communicate what they had learnt. The students in small groups chose three possible projects to carry out in order of preference from a list provided by the researcher.

3. Sample characteristics

The pilot proposal was implemented at the school from the beginning of the 2023-2024 academic year with a class of 12 secondary school students enrolled in the Science and Technology Area of 4th year of Secondary Education for Adults (ESA), and with a group of 9 non-formal education students from the ‘Science Club’, made up of volunteer students from 1st and 2nd year of baccalaureate. In the 4th ESA class, 83.3% are male, 41.7% are Spanish and the average age is 45 years old. In the Science Club, 66.7% are male, 77.8% are Spanish and the average age is 31. Students are normally selected by the management according to their academic motivation, good behaviour or physical-psychological state.

4. Inquiry-Based Hands-on activities

Between October 2023 and March 2024, pupils carried out mini-science projects and documented them in digital format. These projects were carried out in the classroom during school hours with five groups of 3rd and 4th year of Secondary Education for Adults (ESA), for example:

1. Water rocket propulsion
2. Free fall
3. Energy generated by climbing stairs
4. Newton's car
5. Period of a simple pendulum
6. Heron´s fountain

and with four Science Club groups with high school students, for example:

7. Potato battery
8. Determination of vitamin C in food

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Although the list of projects was longer, these selected projects are briefly described below as examples.

4.1. Water rocket propulsion

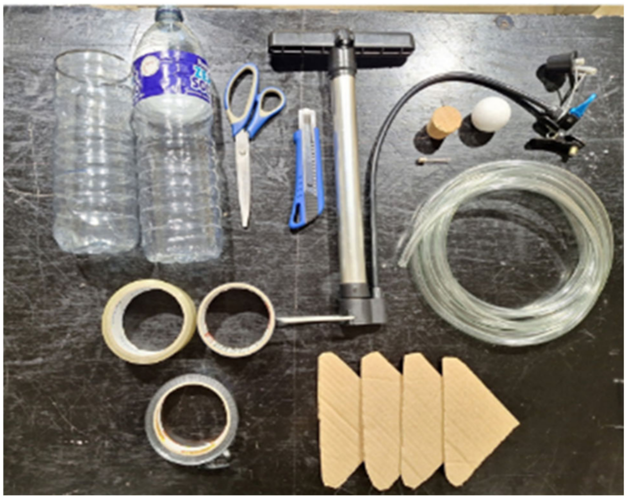

Figure 1. Low-cost materials needed for the construction of a Water Rocket

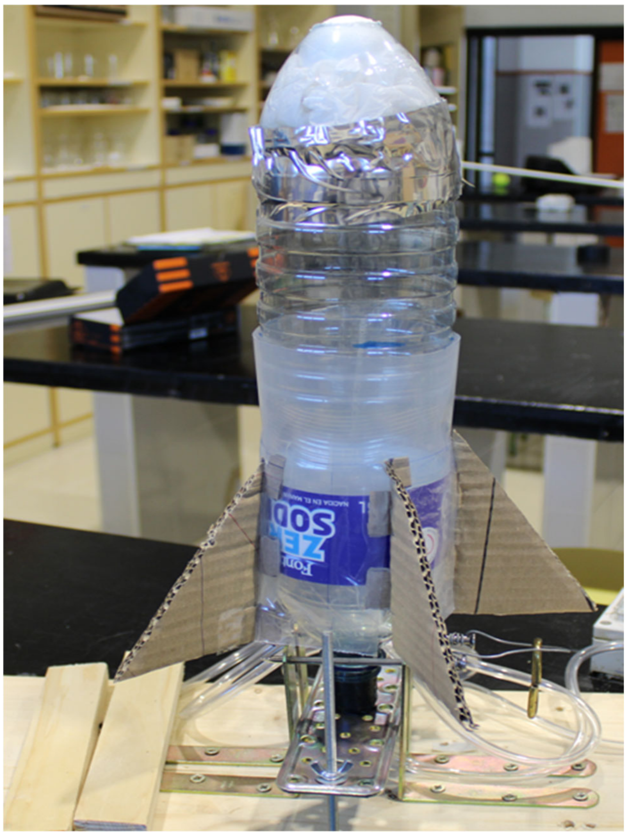

Figure 2. An assembled water rocket

A water rocket is a device that uses a plastic bottle, usually a 1 or 2-litre soft drink bottle, as a fuselage and water tank. The rocket is launched by the pressure generated by compressing air inside the bottle, which expels the water at high velocity through a nozzle [20]. During the design and construction phase (Fig. 1), the students used simple and readily available materials, such as plastic bottles. They added fins and a cardboard or plastic nose cone to improve stability and aerodynamics (Fig. 2). It was not possible to test the prototype inside the prison or on the sports field, so it was reserved for use during an educational outing. However, the incarcerated students easily came to the conclusion that, according to Newton's third law (action and reaction), the rapid expulsion of water generates a thrust force in the opposite direction, propelling the rocket upwards.

4.2. Free fall

The aim of this project is to measure the free fall time t of a small mass using photoelectric gates. The first photoelectric gate is placed at a predetermined height, marking the starting point of the object's descent. Just below, the second gate is carefully aligned, and the vertical distance h between the two is meticulously measured and precisely recorded to ensure accurate data collection. When the object is released, it interrupts the beam of light from the first door, setting off a timer. When it falls through the second gate, the beam is interrupted again, stopping the timer (Fig. 3). By varying the height of the second gate, the acceleration of the object due to gravity g can be analysed using the principles of uniformly accelerated motion. This technique ensures accurate timing, eliminating human error and reducing measurement inaccuracies.

This experiment is repeated several times at different heights (Fig. 4). During the analysis phase, the students compare the height values with the corresponding experimental fall times to determine whether the results match the theoretical predictions, which correspond to the theoretical times obtained by applying $t = \sqrt{2h/g}$ assuming a value for the acceleration due to gravity of 9.8 m/s^2 (Fig. 5).

The highest quality measurement turned out to be the third one for h=1.43 m, with an error of 1.22% in the g determination. Finally, the students discussed the possible sources of error and concluded that it is crucial to measure as accurately as possible the distance between the two photoelectric gates.

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Figure 3. Student checking the photoelectric gate

Altura (m)	t1(s)	t1(s)	t1(s)	Tiempo medio (s)	g (m/s²)
2,42	0,74	0,71	0,71	0,72	9,34
1,81	0,66	0,61	0,64	0,64	8,93
1,43	0,54	0,54	0,53	0,54	9,93
0,88	0,5	0,5	0,5	0,5	7,04
0,97	0,51	0,51	0,5	0,51	7,46

Figure 4. Results showing the variation of the fall time with height

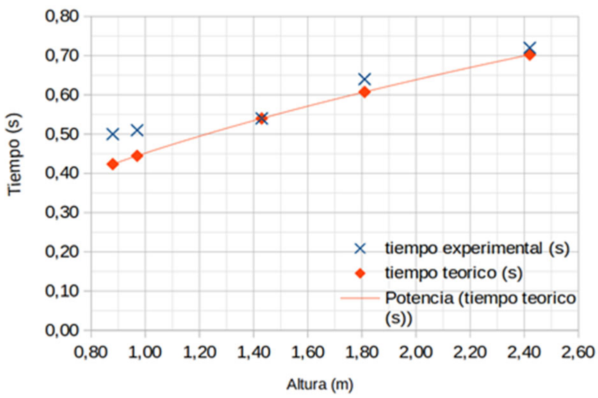


Figure 5. Analysis of the results showing the variation of experimental fall time and theoretical fall time with height

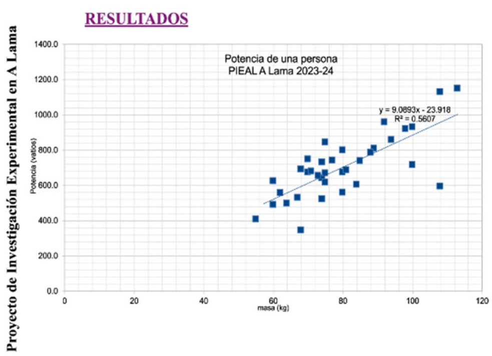
It is explained to the students that the accuracy of the free-fall experiment could be further improved by using a smartphone equipped with the Phyphox app [21], which offers an acoustic stopwatch function to accurately measure time. This app uses sound to trigger the start and stop of the stopwatch as the object falls, eliminating the need for photoelectric gates. However, the use of smartphones is restricted in prisons, so this option is not available in our educational programme.

4.3. Energy generated by climbing stairs

The main objective of the project is to assess whether factors such as physical activity, diet, rest and body weight affect an individual's performance in a specific task: climbing stairs as fast as possible. Assuming that the speed of ascent remains almost constant and that air resistance is negligible, the work required to climb the stairs can be equated to the change in potential energy [22]. Using a spreadsheet together with mathematical formulae and graphs, we can analyse results that indicate, for example, a linear correlation between body mass and power during stair climbing (see Fig. 6). In particular, as body mass increases, so does power.

Subsequently, the students carried out two analyses using the computers in the school's computer laboratory. The first analysis aimed to investigate whether there was a correlation between age and the power exerted when climbing stairs. Based on the resulting graph, they determined that there was no significant correlation between these two variables (see Fig. 7).

Finally, the students analysed the relationship between power output and the presence or absence of smoking. The mean power output of the smoking volunteers was 679.1 watts, while that of the non-smoking volunteers was 743.4 watts. With a mean power output of 701.1 watts for the entire study sample (N = 35), the mean power output of smokers was found to be 3% lower than the mean, while the mean power output of the non-smoking sample was found to be 6% higher than the mean.



Masa (kg)	Potencia (W)
70	674,2
74	641,5
70	747,6
73	654,2
84	603,2
55	405,7
75	668,2
68	343,7
80	796,5
80	557,8
92	956,5
74	521,4
108	594,4
71	677,0
80	673,6
94	857,7
60	488,5
64	497,0
85	737,4
77	740,2
67	528,0
68	689,4
62	556,6
98	918,7
100	928,4
81	685,8
89	808,6
88	784,0
60	623,2
75	616,8
75	841,8
100	714,7
74	730,6
108	1129,5
113	1147,8

Figure 6. Power-to-body mass ratio obtained in the experiment

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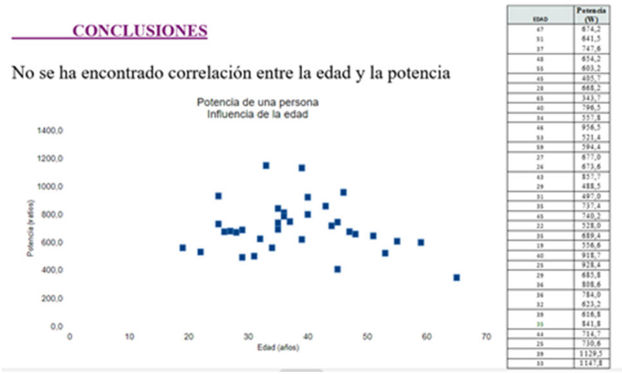

Figure 7. Study of the correlation between age and the power exerted

4.4. Newton Car

The students carried out an experimental study on Newton's Third Law, or the Principle of Action and Reaction. First, they built a prototype Newton Car (Figs. 8 - 10) and confirmed that, when the car was mounted, the expulsion of air generated a reaction force that propelled the car in the opposite direction [23].

Figure 8. Low-cost materials needed for the construction of a Newton Car

Figure 9. Prototype testing of Newton Car

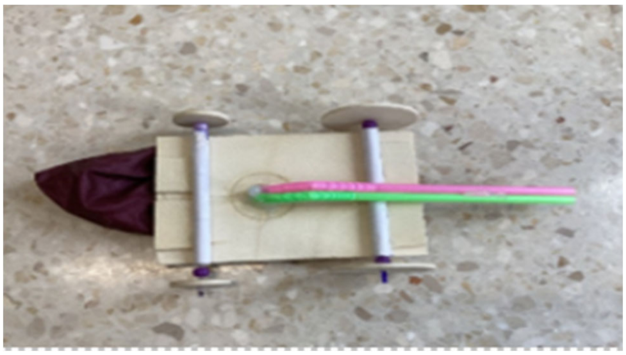

Figure 10. Design details of Newton Car

They then tested their initial hypothesis, which proposed that increasing the mass of the Newton Car would, to some extent, improve stability and distance travelled due to inertia. However, beyond this point, excessive mass would decrease performance due to increased air resistance and friction. All hypotheses were qualitatively confirmed by analysing successive videos of the launches (Fig. 11).

Figure 11. Video recording of the prototype test

4.5. Period of a simple pendulum

The students experimentally studied how the mass, initial amplitude and length of the rope influence the period of a pendulum made from low-cost materials (see Figs. 12 - 17).

The aim of this mini-project was to demonstrate a fundamental aspect of scientific research: the control of variables. Therefore, the acceleration due to gravity was not determined using this method, considering also that the students might not have acquired the necessary mathematical fundamentals. Instead, the students used a spreadsheet to show the variation of period with length (see Fig. 18) and plotted the best-fit line for all data points, which turned out to be a second-degree polynomial trend line [22].

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Figure 12. Students measuring the period of a low-cost pendulum

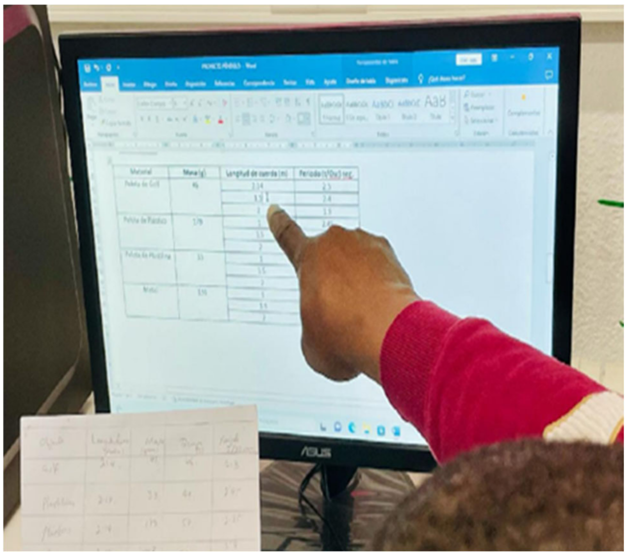

Figure 13. Analysing conclusions using a spreadsheet

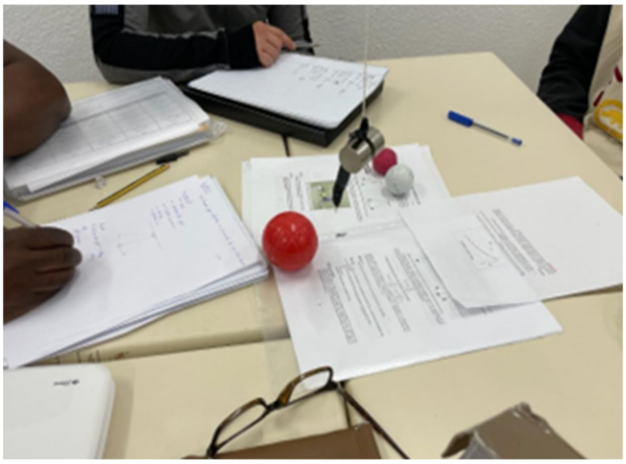

Figure 14. Group discussion drawing conclusions

Possible activities include determining how long a pendulum must be, based on the graph above, to be a 'pendulum of seconds' - that is, a pendulum with a period of 2 seconds. Once the calculation is done, the pendulum is constructed and its period is measured [22].

¿Influye la masa en el periodo?

L= 148 cm
ángulo = 20 grados

m1 (g)	t1	t2	t3	t4	t medio	T = t/10
Cobre	23,90	24,28	23,90	23,90	24,00	2,40
Acero	24,04	23,75	23,75	24,13	23,92	2,39
Aluminio	23,91	23,63	23,75	23,92	23,80	2,38
Madera	24,10	23,84	24,09	23,75	23,95	2,39
Bronce	24,25	23,93	23,88	24,07	24,03	2,40

CONCLUSIÓN: El periodo no depende de la masa

Figure 15. Experimental results obtained by varying only the mass of the pendulum

¿Influye la amplitud inicial en el periodo?

¿Influye la amplitud en el periodo de un péndulo?

L= 148 cm
masa = Bronce

Un

ángulo	t1	t2	t3	t4	t medio	T = t/10
10	23,3	23,04	23,18	23,66	23,295	2,33
15	23,75	23,63	23,68	23,65	23,6775	2,37
20	24,25	23,93	23,88	24,07	24,0325	2,40

CONCLUSIÓN: El periodo no depende de la amplitud

Figure 16. Experimental results obtained by varying only the initial amplitude of the oscillations

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¿Influye la longitud sobre el periodo?.

masa = Bronce
amplitud = 20º

Longitud (m)	t1	t2	t3	t4	t medio	T = t/10
3	31,4	31,53	31,38	31,94	31,56	3,16
2	24,46	25,47	24,94	25,31	25,05	2,50
1,48	24,5	24,38	24,41	24,22	24,38	2,44
0,8	18,28	18,22	18,38	18,25	18,28	1,83
0,4	12,66	12,75	12,35	12,97	12,68	1,27

CONCLUSIÓN: La longitud de la cuerda si influye en el tiempo de duración por oscilación

Figure 17. Experimental results obtained by varying only the length of the pendulum

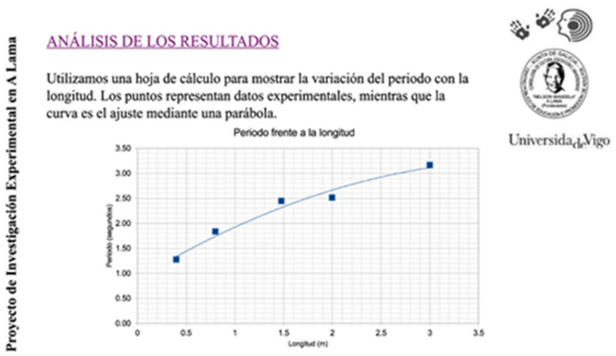

Figure 18. Analysis of the results showing the variation of the period with length

4.6. Heron's fountain

This mini-project arose from a suggestion by one of the students. He mentioned in class that Hero of Alexandria, in the 1st century, invented a model of a fountain that worked 'under pressure' without supplementary energy. It was then decided to incorporate this idea, which could be implemented with low-cost materials available in the school [24-25].

As can be seen in Fig. 19, when the water starts to fall into the bottom bottle, as the level rises, it pushes the air upwards, generating pressure. This pressurised air exits through the tube into the middle bottle and starts to push the liquid down, which exits through the second tube. A 'chain reaction' is created: the water falls back down, pushing the air up into the bottom bottle, which exits through the tube and pushes the water in the middle bottle out of the second hose in a fountain-like stream.

During the design and construction of this prototype, an interesting question arose: Does the fountain work forever? The students discovered that it does not; the operation continues until all the water in the middle bottle has been transferred to the bottom bottle. When this happens, we have to invert the fountain so that all the water returns from the bottom bottle to the middle bottle. Then we put a small amount of water in the top bottle and it works again.

Figure 19. Students making final adjustments to their Heron's fountain prototype

4.7. Potato battery

In the context of the Science Club's non-formal education, one of the projects or 'challenges' (Fig. 20) proposed by the pupils was to experimentally test whether it was possible to switch on a lamp or a LED using a battery made from a pair of potatoes or lemons [26-27].

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Figure 20. Students *trying to measure* the electromotive force obtained from a potato battery

A potato battery usually consists of two electrodes made of different metals, for example zinc (Zn) and copper (Cu), inserted into a potato. Oxidation occurs at the anode (negative zinc electrode) and reduction occurs at the cathode (positive copper electrode). The students easily concluded that the potato acts as an electrolyte, containing salts that facilitate the transport of ions.

Using a digital multimeter, they discovered that the potential difference produced by this type of battery is too small. The typical potential difference is about 0.5 V.

However, it was possible to have fun powering a very low-power device, such as an LED, by connecting several potatoes in series.

4.8. Determination of vitamin C in food

The aim of this project was to estimate the amount of vitamin C in fruits and vegetables, using simple kitchen equipment and items that can be found in a school laboratory. In our research, vitamin C, present in food, can 'reduce' or counteract an oxidant such as the antiseptic called 'Betadine' or Povidone Iodine [28]. On the other hand, we can determine the presence of iodine in a solution using starch ('Cornstarch'). This produces a characteristic purple/black colour. It is possible to estimate the amount of vitamin C in a solution by measuring the volume of Povidone Iodine needed to react with all the vitamin C present in the food (Fig. 21).

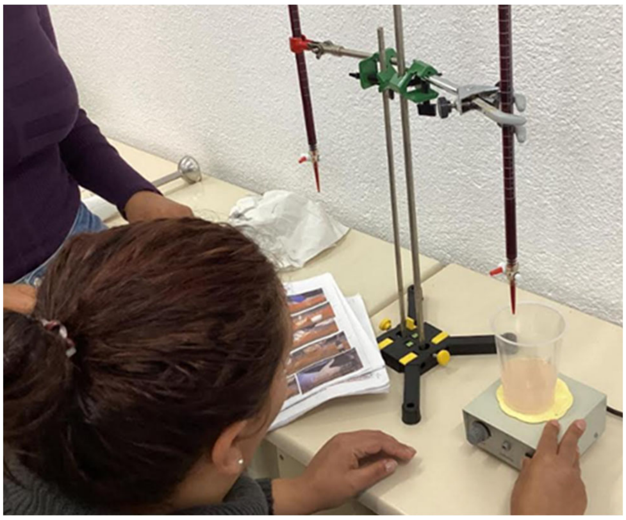

Figure 21. Student performing the iodometry of the food sample

With the first drop of iodine in excess, the characteristic purple/black colour is formed with the starch, which means that there is no ascorbic acid, the vitamin C, left in the solution (Figs. 22-23).

Figure 22. Use of the burette near the endpoint of the titration

Beforehand, it is necessary to know how much iodine solution is needed to oxidise a known amount of vitamin C. This process is known as 'calibration' and can be carried out using a vitamin C tablet from a pharmacy, the ascorbic acid content of which is indicated on the label (Fig. 24). Once the students had obtained the calibration curve, using simple mathematical relationships, they determined how many milligrams of vitamin C per 100 grams of food react with 1 millilitre of iodine. The results are

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roughly in line with values reported in the literature.

Figure 23. Different foods analyzed before and after the endpoint of the titration

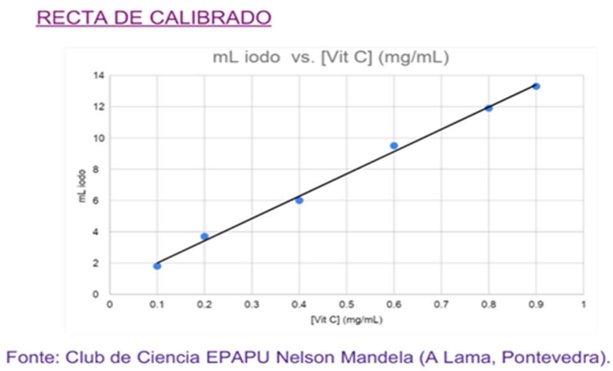

Figure 24. Calibration curve of vitamin C concentration versus milliliters of iodine, obtained by the Science Club working group

5. Summary and conclusions

The students' reception has been positive. During this pilot phase of observation and contact with the students, it was decided to use an interactive diary in which science groups' teacher and external researcher, write comments in response to each other's reflections for triangulation. Thus, for example, the science teacher, who also serves as a validator for this initial pilot phase of action research, notes:

> *"Although I would need more data to provide an objective response, the students' comments are mostly positive, and the results have improved compared to the initial assessment."*

The good reception of the experience by the students is reflected in the field diary entries of the science teacher and the external researcher:

> *"The session started with a practical activity on Newton's second law. Two students carried out the experimental design. They measured the distance and time and determined the acceleration. This activity served both self-regulation and co-regulation. They initiated a discussion among themselves about the technique for isolating acceleration in the equation of uniformly accelerated motion (UAM), and one student went to the blackboard to explain his method. The activity allowed them to correct and improve their initial incorrect answers."*

Or as the external researcher stated,

> *"The next demonstration of a practical activity carried out by the group was the determination of reaction time using the falling time of a ruler. Four students participated in the demonstration. They followed the 'rules' of the test (fingers apart, hand resting on the edge of the table) and reminded their classmates to respect these conditions. The only female student also participated."*

The science teacher and the external researcher stated that

> *"Students start arriving a few minutes after the class bell rings at 9:30 a.m. [...] The first student to arrive is surprised to see me drop a ball from an inclined plane. However, he was familiar with the experiment, as well as others such as the Law of the Pendulum [...] On the other hand, another student initially seems reluctant to come to class, but after 10 minutes, he is fully engaged in the activity. The rest of the students are very receptive to the methodology. Even one student, who was considering changing level, decided not to do so, partly thanks to this type of classroom activity. The atmosphere of camaraderie is positive."*

The science teacher and the external researcher continued,

> *"Another indicator of positive behaviour is the transformation of a pupil's desire not to attend science and technology classes (even though it is his only subject) because of a negative school experience in his childhood. After participating in the*

> *first two sessions, he asked if the activity would continue after the break and expressed his intention to attend every Friday."*

On another occasion, the science teacher agreed with the external researcher's assertion, saying

> *"One student reflects on the results obtained and possible measurement errors. Others discuss the accuracy of data collection and suggest that it would be better if the person who releases the object is the same person who uses the stopwatch to measure the time. They also comment on the difference in movement between the objects used (can and ball) and relate this to the liquid moving inside the soda can, as well as other hypotheses. Scientific thinking flows among the students."*

Numerous field notes from this pilot observation phase of the project highlight the importance of showing participants that most scientific experiments end in failure, and that achieving satisfactory results often takes time and rethinking decisions, as in many situations in life [5]. Below is an entry from a researcher's diary that illustrates the frustration of one group. It is noteworthy that a few weeks later, after re-evaluating the situation with the support of the science teacher, the new Newton prototype car was able to travel several metres while maintaining steering at all times.

> *"Frustration in the Newton car team. The prototype is not moving forward. We ask them to investigate the cause of the anomaly, explaining that this is normal in research work, especially in a STEM methodology. He wants to dismantle the prototype and she remains silent. They have not filled in the project monitoring sheet..."*

This experimental methodological approach of guided scientific enquiry aims to have a positive impact on the incarcerated students. Supported and supervised by both the teacher and an external researcher, they were able to design and implement scientific investigations. They carried out projects that involved supervision and hands-on attention, making them well suited to prison settings.

Although our evidence to date is mainly observational, academic results have improved, and some students perceive the work as meaningful and a source of pride. To conclude this section, it is important to note that some practical aspects that made the proposal difficult were the different cognitive abilities of the participating pupils, something that requires adaptive measures to be taken in the future.

This preliminary study encourages us to conduct further research to clarify the connections between motivational aspects, learning gains and emotions experienced during the inquiry-based learning methodology in this adult education context. For this purpose, we currently have authorization from the Ethics Committee of the University of Vigo [29], dated March 8, 2024 (Evaluation Report No. 0024-F-2024-03-08), as well as permission required to conduct research from the General Secretariat of Penitentiary Institutions of Spain, granted on June 3, 2024.

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Starting Learning about the Biological World

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Abstract. We humans are biological organisms, hence experience biology in action as we live the life processes. However, we live in a world shared with other biological organisms which we beginning to notice and interact with whilst we also learn about the physical world in which we all exist. Thus, learning is acquired through observations f and experiences and later through instructional but it is a gradual beginning with the self and immediate environment. This paper traces this progressive acquisition of biological literacy and capital in the preformal school years.

Keywords. Pre-school, Biology, Literacy, Organisms, Interactions, Interest, Every Day, Free Choice.

1. Introduction

In a natural outdoor setting, children can interact with natural elements like leaves and sticks, engage with tactile experiences such as soil, and foster a connection with the natural world, fostering a sense of appreciation. Moreover, the experience planetary effects on them and the environment through the weather but also experience the earth science of the area, landscapes, and ground coverings for example, providing an experience of then intricate interactions that maintain the living world in a particular environment. Such environments allow children to enhance their creative abilities and critical thinking skills, which are crucial for scientific and technological exploration.

2. Biological literacy

Biological literacy is a relatively recent term of someone being able to use their knowledge of biology and of the method of scientific inquiry.to consider and discuss issues which have a biological content and be able to explain such to others and integrate these ideas into decisions and action if appropriate. Research and literature are focused on the development of understanding of secondary aged children, not on that of earlier learners. Four levels of acquiring in secondary aged learners have been identified [1]. The levels in progressive order are 4 levels, beginning with the nominal level where the hold misconceptions but can identify concepts and expressions as relating to biology. Further development of understanding followed by three more levels. Acquisition of the next level, the functional level, is when learners can define terms accurately. They are able to memorise them.

Frequently in my biology teaching experience in secondary school such occurs and is repeated in written examinations. The structural level follows when a learners can explain biological ideas in their own words and cis able to apply their biological understanding to a new situation. which, are acquired after the former after the former. Competency in this literacy at every level also involves other dimensions shared with other literacies, which are understanding of language, cognitive, social, and development. Yet other biology education researchers [2] recognised the importance of the affective dimension they also identified sustainability, interdisciplinary career awareness and nature of biology.

Observations of children preschool showed what they environment, or a country-based life with variations between. The dialogue generated in a research grant with children revealed that a family visits to parks and allotments as well as observations of urban life in streets all contribute to biological knowledge show the observations the children made [7]. Experiences out of school at venues focusing on plants and animals, zoos, gardens and natural history museums are a source of knwkieldge for children but analysis s of their spontaneous comments reveals the particular aspects of the organs, both structural and behavioural that even the youngest of children on family visits make and interpret. Such are an important source of particularly animal and plant information [8-9]. noticed from their everyday [3].

The earliest awareness of biology and name the early awareness and interpretation on the biological world as foundational isa much neglected part of biological understanding and teaching. The acquisition of biological literacy has to begin when learners encounter the constituents of the biological domain and learn the facts (capital) which they can then use.

3. The biological domain

All new organisms emerge into the world from their parent as in live birth in mammals, form an egg or a seed where food for the developing embryo has been laid by the mother. Hence these young organisms emerge already as members of the biological domain. Thus we humans too are biology in action as living organisms However, such an idea is rarely suggested and recognising, as science educators, that biology relies on physical and environmental phenomena for our systems to work is also an important aspect of acquiring relevant biological holistic literacy as we interact with the rest of the planetary systems.

Children meet biological organisms in their everyday lives and should be an important part of recognising such in free ‘play’ in their environment, planned experiences from these earliest years in play as well as focused interventions. Such are an essential part of any planned learning and should be in any curriculum [4] These early years are critical in laying the foundations for a person’s biological literacy and capital [5].The research I this area has been focused more on animals, such as pet keeping [6]. Children are instinctively intuitive and notice objects, events phenomena and experience and living organisms in action in their everyday which is of many different kinds for different children.It may be confined to a built urban environment.

Thus, when a child arrives in formal learning they have some knowledge, understanding and personal interpretation already. Hence, our role as educators is to use this personal repository which our learners bring and blend it into accepted biology as expected to be learnt. These early learners are, as Professor Ros Driver coined [10] ‘ pupil as scientist-‘, a pupil as active biologist.

When the child arrives in formal learning they have some knowledge, understanding and personal interpretation already. Hence, our role as educators is to use this personal repository which our learners bring and blend it into accepted biology as expected to be learnt. These early learners are, as Professor Ros Driver coined [10] ‘ pupil as scientist’, that is a pupil as active biologist. `Applying her thinking and recognising that educators focus on what children know following a constructive approach uses their experiences and understanding so far [12]. Even the youngest learners gradually acquire through experiences, observations in their own everyday world irrespective of the geographical. A comparative study on children in two towns, one in the USA and one in England showed similar patterns of understanding but the emphasis of most observed types of organisms was a little different according to the locality.

4. The two categories of biological learning

There are two categories of biology which children experiences, the personal and the other! We all experience the personal, we may notice aspects of the ‘Other’ but it is this part which is taught, impersonally, noticed and learnt. Firstly, the personal which is experiential.Secondly, observational outside of themselves, a looking out onto the biology they can notice. In the world outside of self [13].

The learner begins by experiencing and recognising their needs and becoming familiar with their own structure and needs and then identifying structures and needs in ither organisms. In experiential first-hand biology, the early learners begin experiencing and recognising their needs; eating, breathing, excreting, pain, communication, moving in their personal active biology. However, as they begin observing around - using senses: sight, sound, smell, touch, temperature, experiencing life systems in action they encounter other organisms existing in their world. They begin to recognise commonalities of form and function as they begin to make earliest categorizations.

Children are in touch with their everyday environment to varying extents, and that rich experiences can greatly contribute to their knowledge about plants and animals they nocte certain things and make their own sense.

5. The first understandings and interpretations of the biological world

Findings reported [3] indicate that there are three broad categories which children notice in organisms: systems, time, and observations. Once verbal a child comment on what they see. Such often gives rise to some anthropomorphic interpretation of organisms, such as a comment overheard about a drooping flower and stem of

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a flower she clutched in her hand s she walk through grassed unmown filed with her mother, 'The plant is thirsty ' she explained, having noticed plants at home which revived when watered, she explained to her mother.

All visitors interpret these specimens in zoos and museums, including at natural history dioramas and gardens which catch their and often associate with previous experiences [8-9, 13]. Comments are about:

- colours, odd shapes, appendages, behaviours,
- what organisms and biofacts feel like to touch,
- plants they recognise from their own food
- from seeing whole plants in media and as house plants and outside growing.
- animals which resemble those with which they are familiar, particularly pets [6].

Observing organisms and their habitats, as well as their feeding and mating behaviour, is part of the early experience of children and forms part of their early learning before formal educational starts. A two-year-old boy had five words for plants and five for animals in his first fifty words [14].In other words, ecology forms part of the conceptual framework within which a child comprehends the world from the very early stages of life. However, the science of ecology, i.e. the study of the relationships of living organisms between each other and their non-living environment, covers a rather tiny part of most national science education curricula. Indeed, most of the 'ecological' content of science textbooks is in fact about taxonomy, morphology or physiology, rather than ecology per se (i.e. patterns of population growth, dynamics of intra-specific and inter-specific relationships, structure and function of ecological.

Time is observed as a fixed the point of happening in the youngest leaners. They notice occurrences, such as fruit, e.g. apples on a tree which drop off to the ground at a. certain time of the year. Likewise some trees lose their leaves at some times of a year but they grow again at another certain time n.b. these are deciduous in temperate countries, in other climatic regions it is different. Plants die. Seeds don't grow to plants at once. Babies change in their form as they develop some have a whole change off form change such as a complete metamorphosis, caterpillar- pupa- imago, seed-whole plant.

There is a pattern to focused observations through a prolonged interaction, which can be represented in a cyclic sequence or a linear one. This is an observable sequence of interactions [13]. Hence the biological interaction sequence. Which can be represented cyclically [13].

Table 1. The biological interaction sequence

STAGE	ACTION	Biology thinking from own knowledge and experience, pas' observations
1	*Interest caught* by something in environment. Stops, interacts passively or actively	Interest caught by something in environment. e.g. Garden, wood, street, inside home, medias Particularly something moving, organisms biofact different, a smell, ...
2	*What is it?*	Recognition, interpretation from previous knowledge. Plant, Animal, Fungi or biofact? Does it grow/live in particular place e.g. water, ground, air, on another?
3	*Observes*, with senses, looks, listens, smells, touches.	Do I recognize anything? Have I seen this before? Is it like...? Can I name it? Is it like... ?
ONE OF TWO ALTERANTIVES ARE CHOSEN		
LOST INTEREST	OR	ENHANCED INTERES
LEAVES THIS INTERACTION		ENTERS STAGE 4
4	*Focused looks*, ...	What happens if ...? Examines more closely
5	*Looks again*, is ...	Is there another similar, in same kind of place?

The categorisations of children's observations and literacy are influenced by the culture and ecosystem in which they live, although thought various media those of other cultures can also impinge on their knowledge.

6. Conclusions

The foundational biological literacy are the most important part of a child's acquisition of biological understanding. It should be recognised as such by educators. Moreover, learning strategies developed from the starting point of the child and not from the many stages in simplifying then simplifying again and so on of the established biological concepts. The very earliest of learners learn from their own observations. Firstly, as a working organism and secondly noticing the world outside themselves. They name or organisms; make categories; recognize systems; don't grasp time; build on their knowledge and interpretation. It is from these starting recognitions, child generated interactions and interpretations that our strategies for assisting them learn should begin.

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My observations suggest that naturalistic play settings can enhance behaviours like creativity, social interaction, and detailed observation, which are advantageous for early STEM (science, technology, engineering, and mathematics) education.

However, the biological domain is about an integral part in the environment ‘All parts working together in balance is an important learning are for all. Such understanding in our Western communities is becoming crucial to develop. It was pointed out in the early years of this century that understanding of a developing climate crisis and need to develop sustainability in our systems that together is a developing lack of a relationship with our n environments’. We need to actively prevent their nature deficit [15].

In summary Foundational Learners

- interpret other living things according to their understanding
- gradually realising that, whilst all living things have similar needs for life
- solved in differing ways in different organisms-a later understanding which develops in later years of primary school.

Moreover, Biology education cannot stand alone it is an integral component off STEM but the latter is often exclusively physical science, mathematics and engineering. All areas of Biological sciences are integral components of STEM and is frequently overlooked in STEM recognition, discussions and implementation.

These beginning learners of biology are founding their biology capital with which they can develop their biological literacy, vital in these times of the need to mitigate climate change and implement achieving the Sustainable Development goals in their communities and our shared world.

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A New Radio Module for an Ancient Weather Station

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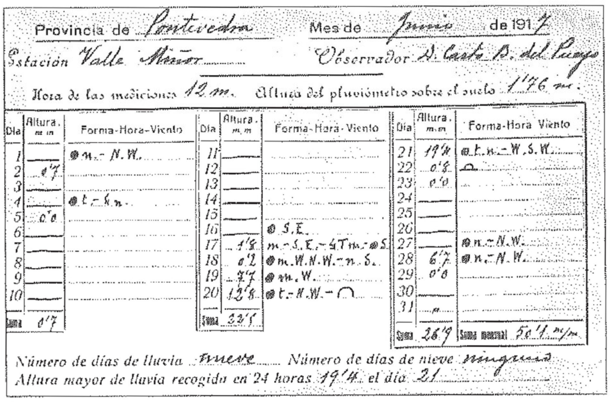
Abstract. This paper presents the process of updating of the automatic weather station at Escolas Proval High School (Nigrán, Spain). The weather station, that was created as early as 1917, was automated in 2005 with a radio module powered by solar energy that transmitted data to a remote server. Currently we are designing new electronic modules with better sensors and radio modules that will greatly improve the performance and transmission distance, opening the door to the acquisition of remote variables like sea water temperature or tidal range.

Keywords. Radio Modules, Weather Station, Electronic Design, Sensors.

1. Introduction

The meteorological history of Val Miñor (a region to the south-west of Galicia) starts in 1917 with the first measurements [1] made at the school created and maintained by the Unión Hispano-Americana Valle Miñor (UHAVM), an association of galician emigrants to Argentina. The data were collected and sent by mail to the Spanish National Institute of Meteorology (INM). Many cards with the manuscript data are still conserved (Fig. 1).



Provincia de Pontevedra Mes de Junio de 1917
Estación Valle Miñor Observador D. Casto B. del Puego
Hora de las mediciones 12 m. Altura del pluviómetro sobre el suelo 1'76 m.

Día	Altura. m m	Forma-Hora-Viento	Día	Altura. m m	Forma-Hora-Viento	Día	Altura. m m	Forma-Hora-Viento
1	—	n.- N.W.	11	—		21	19'4	t.n.- W.S.W.
2	0'7		12	—		22	0'8	
3	—		13	—		23	0'0	
4		t.- n.	14	—		24	—	
5	0'0		15	—		25	—	
6	—		16	—	S.E.	26	—	
7	—		17	1'8	m.- S.E.- 4 Tm.- S.	27	—	n.- N.W.
8	—		18	0'2	m. W.N.W.- n. S.	28	6'7	n.- N.W.
9	—		19	7'7	m. W.	29	0'0	
10	—		20	12'8	t.- N.W.-	30	—	
						31	—	
Suma	0'7		Suma	22'5		Suma	26'9	Suma mensual 50'1 m/m

Número de días de lluvia nueve Número de días de nieve ninguno
Altura mayor de lluvia recogida en 24 horas 19'4 el día 21

Figure 1. Card with meteorological data (1917)

Many years later, in 1980, the old building was reopened as a modern high school and Prof. Salvador Rodríguez Muñoz started a new meteorological project [2] that sent also data to the INM. As the new school was mainly dedicated to vocational training (electronics and administration) it was a logical step to automate the measurements, a didactic project that started in 2005 and continues today. It was a distributed design [3-4] composed of a remote module placed at the meteorological box, that transmits data by a radio link to a second module that transfers the information to a web server [5].

The data, updated every minute, are immediately available to any observer in the form of daily tables and graphs, in contrast to data from a century ago which were published annually. The remote module is powered by two small photovoltaic panels that have been calculated to provide enough energy both in summer and winter. This project received an innovation award granted by the Instituto Enerxético de Galicia (INEGA) in 2007.

The elements of this first automation project (microcontroller, sensors, radio module) have been efficiently working for almost 20 years, but now they are a bit outdated and we think that should be replaced.

Several factors have been considered: the wide use of Arduino in programming education [6], the development of new digital sensors used in our teaching activities and the appearance of new communications modules [7], together with the development of the Internet of Things (IoT), that has greatly facilitated the transmission of information from remote acquisition systems, reaching distances of tens of kilometers with the most efficient modulations such as LoRa.

2. New hardware design

We have started the design of a new module (Fig. 2) compatible with the equipments used by the students in the practices of microcontrollers and programming subjects. This has allowed to create a compact, portable and multipurpose module that can be reused for teaching purposes.

For the definition of the hardware, we have taken as a starting point the requirements of the Cansat Challenge [8], an educational activity of the European Space Agency (ESA) in which we have participated during the course 2022-23.

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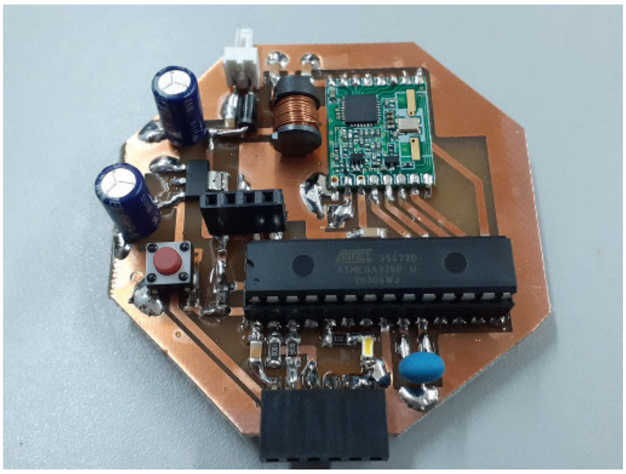

Figure 2. A new prototype of the system

2.1. Microcontroller

The first architecture of the system developed in 2005 was based in an Atmega AT89C4051 microcontroller, a device with limited capabilities and a difficult process of reprogramming. It was soon replaced by the AT89S4051, which included a SPI interface that allowed in-system programming with a specific hardware. The programs had to be built “from scratch” because there were little help and code examples available. Moreover, the existing IDE’s like IAR or Keil had to be purchased from the manufacturers and were expensive. We had been using for several year a free alternative based in Eclipse IDE and SDCC compiler, but was difficult to install and update.

The new electronic scheme consists of an Arduino-compatible microcontroller such as the Atmega328P. The board has a connector that allows the code transfer from a computer via an usb cable. The use of this microcontroller grants access to a wide range of libraries, code examples and information from the Arduino ecosystem that will ease the development of the system.

2.2. Sensors

The temperature and relative humidity sensors are an important part of any weather station. In the previous design we used the Sensirion SHT15, a sensor that provides both measurements with a good range of precision and error. For the new board we are planning to use new sensors like the SHT3x family, specifically the SHT35 [9] that has a very low temperature and relative humidity error (± 0.2ºC in the range 0-100ºC and ± 1.5% RH). These sensors have a very small package (DFN) but there are many commercial boards that can easily be connected to the microcontroller via I2C interface.

For the barometric pressure measurement, the old board had a MPXA6115A analog sensor. This type of sensor had the problem of a high variability due to small changes in supply voltage, temperature or other factors. It also needed an external analog to digital converter to provide digital measurements. For the new design we have chosen a digital sensor like the Bosch BMP180/280 [10], that can be connected via I2C. It could also be used one of the new models recommended by Bosch, like the BMP390.

2.3. Radio Module

A wide variety of digital radio modules is available on the market for the free ISM frequency bands 433/868 Mhz (Europe) or 915 Mhz (USA). We would like to use FSK modulation but also LoRa modulation for long distance transmission. LoRa boards use Semtech circuits, so our new board will be based in one of this circuits like the SX1272 or SX1276.

Many companies produce boards with the required circuits. Among them, HopeRF has modules that are compatible with OOK/FSK modulations and also LoRa modulation. Its modules RFM69HCW (OOK/FSK) and RFM95W (OOK/FSK/LoRa) have the same pinout and dimensions, what allows to mount them in the same board for developments purposes. The RFM95W module is extremely versatile, since it allows to implement OOK, FSK, GFSK, MSK and LoRa modulations by simply changing the communication parameters. By these reasons we have chosen these modules for our system.

Other companies that produce similar modules are NiceRF, Murata or RF Solutions. These modules could be used in future versions of the system.

We have already made the first version of the boards for testing purposes. An example of prototype can be seen in Fig. 3, with all the components on one side of the board and the antenna and ground plane on the other side.

Currently we have made programs for FSK transmission and reception for the RFM69 and

RFM95 modules and also a LoRa version for distance tests.

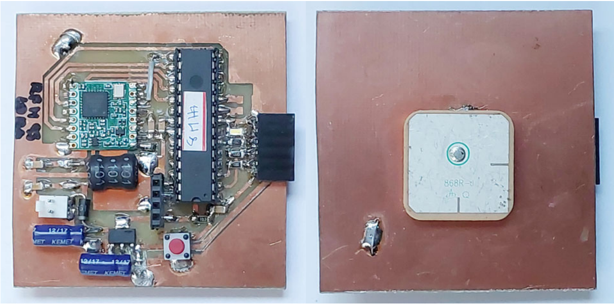

Figure 3. Test board: component side and antenna side

3. First tests and results

During the courses 2022-23 and 2023-24 we had made several tests, first with the FSK modules and last with the RFM95 LoRa modules. We used different types of antennas (like monopoles, patch antennas and commercial Yagi-Uda) and ground planes (Fig. 4) of different sizes to study their influence in the quality of communication and distance achieved.

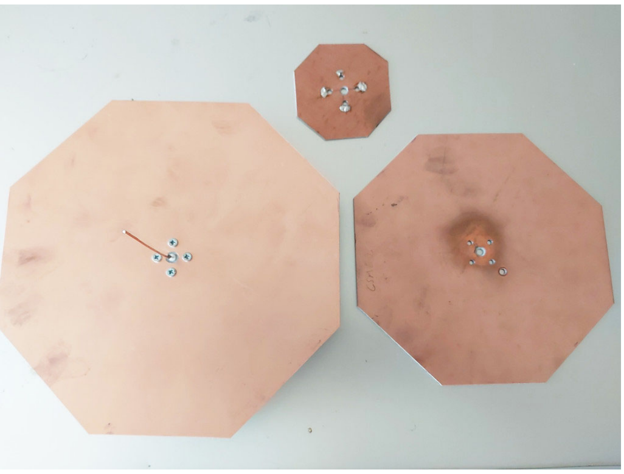

Figure 4. Ground planes and antennas used in the tests

The tests were made in FSK mode with the following parameters: frequency 868.0 MHz, power +20 dBm, bandwidth 25 kHz, frequency deviation 10 kHz and data rate 4800 b/s. The maximum distance achieved under these conditions was more than 2 km with continuous data reception. The typical distances for commercial modules are in the range of a few hundreds of meters (without directional antennas), so this data confirms the validity of our design. Fig. 5 shows the location of the transmitter and receiver for one of the tests and the measurement of the distance achieved. The tests have been made at Praia América in Nigrán, a coastal area with no obstacles and direct visibility between the emitter and the receiver.

Figure 5. Distance test of the radio modules

The results of these tests show that the new elements of hardware can be used to improve the performance of the weather station, increase its working range and allow for a new distributed configuration with both local and remote sensors. In particular, we will continue the design to include new sensors and achieve the distance needed for the measurement of sea water temperature and tidal range with a GNSS (GPS-Galileo) receiver.

4. Educational activities

During the development of this system, we have made many activities with the students. They have collaborated in the design and assembly of the first boards and also in the antenna adjust and measurements (made with a RigExpert AA-600 meter) that have served to completely define the current configuration. Moreover, the centre has participated in the ESA CanSat 2023 Challenge [8], for which this system worked as a backup prototype.

In the next courses it is planned to carry out a program of activities with the students of subjects related to microcontrollers and communications, such as "Microprogrammable Equipment" or "Maintenance of Radio Communication Equipment", in which the students will make development of applications with microcontrollers, programming, handling of technical documentation and maintenance and repair of failures in microprogrammable and communications systems.

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5. Conclusions

This paper presents the process of updating of the automatic weather station at Escolas Proval High School (Nigrán, Spain). Currently we are designing new electronic modules with better sensors and radio modules that will greatly improve the performance and transmission distance.

We have changed the system architecture to an Arduino-compatible microcontroller to benefit from the wide amount of information and libraries already developed for this system. The board includes a radio transceiver module connected directly to the antenna, with a complete ground plane on the back side of the board.

We have chosen new digital sensors to improve the measurement precision and simplify the connection to the microcontroller.

Distance tests have been performed, giving results superior to those of commercial modules in FSK modulation.

In the following courses, a complete practical program based on the use of these modules will be implemented to promote the training of our students in this type of technologies and to facilitate their integration in the labour market.

This design will be used as the basis for updating the institute's weather station, increasing its working range and changing to a new distributed architecture with local and remote sensors for the measurement of new parameters like the sea water temperature and tidal range.

6. Acknowledgements

The authors would like to express their gratitude to the students of the 2022-23 and 2023-24 courses of the Vocational Training Degree "Electronic Maintenance" at Escolas Proval High School who have collaborated in the design and construction of the modules and carrying out the initial tests.

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Distance Education in Ukraine: From COVID-19 to the Long-Last Armed Conflict

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Abstract. The situation in education in Ukraine is considered based on 969 questionnaires filled out by teachers of higher educational institutions in the country. During the COVID-19 pandemic, distance learning has expanded dramatically. Now, more than two years of armed conflict is creating new challenges for education as a whole. Analysis of the survey data shows that the key factors influencing teachers' satisfaction with educational institutions and organization of instruction that determine the quality of teaching are the adaptation of the distance learning system to wartime and comprehensive support for online education. The significance of individual factors is confirmed by regression analysis.

Keywords. Ukraine, Distance Learning, Higher Education, Armed Conflict, Teaching Quality, Satisfaction, Sustainability, COVID-19.

1. Introduction

The war in Ukraine began while the Covid-19 pandemic was still ongoing, and so the national higher education system continued its work, using the educational infrastructure created during the pandemic and relying on upskilling of staff in the field of distance learning. Lockdowns expanded the range of distance learning, which ensured the rapid adaptation of educational institutions to the conditions of martial law with the outbreak of war.

The State Service for the Quality of Education of Ukraine continues to monitor the situation in the field of education through quarterly surveys. A survey conducted in 2022 [1] showed that in just three months after the full-scale invasion, 99.8% of universities switched to distance learning and resumed the educational process mainly in distance mode (81.9%) or in a hybrid mode (17.9%). 74.9% of universities located in relatively safe areas chose a synchronous training format, but universities that continued to operate in areas of active hostilities had to conduct training asynchronously. The survey showed high satisfaction of teachers and students with information support for distance learning. The main problem for universities in war conditions is maintaining contact with all teachers and students. It was found that attendance had dropped by an average of 10% to 60-70% of the total student population. The biggest technical problem was the absence or instability of the Internet, reported by 55% of teachers and 71.3% of students.

Subsequent surveys showed that during the 2022/2023 academic year there was a change in learning formats, in particular, in educational institutions the use of blended learning increased and the use of classroom and distance learning decreased [2]. Every fourth student surveyed (25%) is confident that the quality of teaching has improved in this 2022/2023 academic year, and only 8% of them believe that the quality of teaching has generally worsened. The main tools during the 2022/2023 academic year remain asynchronous tools - messengers (this was noted by 83% of teachers and 88.9% of students). More than two-thirds of teachers and about 40% of students also reported using synchronous learning tools - virtual environments and video conferencing services, which, however, indicates low student engagement in real-time classes.

The next survey conducted in the III quarter 2023 indicates once again that asynchronous tools - messengers - remain the main tools in the conditions of the continuing martial law, in particular during the last year. This was noted by the majority of both teachers (78.8%) and students (87.6%) [3]. It is also observed a growing trend, in the opinion of teaching and research staff, of the role of official websites of educational institutions as a source of information: more than two-thirds of teachers (73.9%) are confident that the websites of educational institutions contain comprehensive and up-to-date information. The use of synchronous learning tools - virtual educational environments and video conferencing services - was indicated by 59.9% of respondents from teachers and 36.8% of students, which confirms the previously expressed opinion about the low involvement of students in real-time classes. The results of the analysis show that the students express some disappointment about

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the time it takes to complete the tasks. 65.7% of them indicated that they have enough time, while 90.8% of teachers note this opportunity. More than a third of students (34.4%) say that they do not have enough time to do homework and prepare for classes. Regarding the safety of the participants of the educational process in the conditions of martial law, both categories of respondents highly appreciate the efforts of the educational institution: 86.1% of students and 92.1% of teachers. This shows a high level of trust in initiatives aimed at guaranteeing safety during studies under martial law.

Early sources of information focused primarily on shortages of equipment for distance learning or blended learning, as well as safety concerns. In addition, no primary factors have yet been identified that can be manipulated to improve the quality of education in the difficult conditions of protracted armed conflict. Various factors are mentioned in a general descriptive manner, although more than two years of war provided plenty of evidence for a more in-depth analysis of this issue.

Thus, the analysis presented in this research paper will help identify effective ways to support higher education in Ukraine, which may also be useful to other countries involved in long-term armed conflicts.

2. Data collection

To collect data on the status of education in Ukraine during the war, a survey was developed using Google Forms. The questionnaires were filled out from November 27, 2023 to December 11, 2023. Email, social networks (Facebook and others) and private contacts were used to invite teachers from higher and vocational education institutions to participate. Data on multiple factors including age, academic rank, distance learning experience, wartime teaching mode, frequency of classroom interruptions due to attacks, damage to infrastructure, etc., institutional support for online learning, student learning outcomes. and their attendance, attitudes of higher education teachers to distance learning during wartime were examined in a survey to identify the factors influencing the satisfaction of teachers, which will ultimately improve the quality of teaching.

3. Results and Discussion

General data are presented in Table 1. A total of 969 respondents completed the questionnaires: 164 (16.9%) men and 805 (83.1%) women. Most of them - 555 people - are employed in higher educational institutions; 414 teachers work in vocational education institutions.

Table 1. Demographic and institutional data

Factors	Answer	Number	%
Gender	Male	164	16.9
	Female	805	83.1
Age	36 - 50	577	59.5
	51 - 59	196	20.2
	Younger 35	110	11.4
	Older 60	86	8.9
Rank	Doktor	79	8,2
	Kandidat	450	46.4
	No	440	45.4
Institution type	Higher	555	57.3
	Vocational	414	42.7
Teaching mode	Blended	466	48.1
	Classroom	316	32.6
	Distance	187	19,3
Experience of distant teaching	Yes	949	97.9
	No	20	2.1
Distance learning system adaptation to wartime	Yes	443	45,7
	Partly	333	34.4
	No	193	19.9
Frequency of instruction interuption	Never	55	5.7
	Rarely	669	69.0
	Frequently	210	21.7
	Very often	35	3.6

At the workplaces of respondents, different forms of instruction are implemented: blended - in 466 institutions, in-classroom - in 316 and distance learning - in 187, with a clear predominance of the blended/distance mode - they are used in 653 institutions.

Most teachers already had experience in distance learning.Most teachers reported that their institutions' distance learning systems were at least partially adapted to wartime conditions. Only 5.7% of educational institutions have never experienced the need to interrupt educational activities due to attacks, infrastructure damage, lack of power supply, etc.

Table 2 contains the data on support of distance learning at respondents' institutions and their satisfaction with the current state of affairs.

Table 2. Level of support of distance teaching and teacher satisfaction

Factors	Answer	Number	%
Level of online education support - hardware (905 respondents answered)	4	265	29.3
	5	235	26.0
	3	161	17.8
	1	138	15.2
	2	106	11.7
Level of online education support – other aspects (911 respondents answered)	5	326	35.8
	4	241	26.4
	3	132	14.5
	1	110	12.1
	2	102	11.2
Satisfaction with current organization of education	Rather yes	542	55.9
	Absolutely yes	243	25.1
	Rather no	163	16.8
	Absolutely no	21	2.2
Preferred mode of teaching	Blended	369	38.1
	Classroom	494	51,0
	Distance	106	10.9

Many respondents rated the level of support for online education in their workplaces as above average (4 or 5 points).

The level of satisfaction with the current organization of education is also high - 81% of respondents are somewhat or absolutely satisfied, while only 10.9% of them prefer the distance format.

Table 3 shows how teachers perceive changes in student learning outcomes and attendance associated with how armed conflict has affected learning opportunities.

More than 60% of teachers noted that learning results had worsened. A similar effect was found at the beginning of the COVID-19 pandemic [4] when distance learning was introduced at very short time. Student attendance was less affected by wartime - 42.3% of respondents reported that it had decreased. It can be assumed that these results are associated with the adaptation of the institutional infrastructure, the level of organization and support of online education (Table 1, Table 2). It should also be noted that attendance data reflects both online and in-classroom attendance.

Table 3. Students' learning outcomes and attendance

Factors	Answer	Number	%
Students' learning outcomes	Improved	71	7.3
	No changes	312	32.2
	Worsening	586	60.5
Students' attendance	Increase	94	9.7
	No changes	465	48.0
	Decrease	410	42.3

Regression analysis was carried out to identify the factors with the strongest influence and assess the statistical significance of the results. The Minitab software was used (https://www.minitab.com/en-us/). Adaptation of the distance learning system to the war situation, support for online education, and changes in student outcomes and attendance were identified as siginicant factors.

Teaching mode was among less significant factors. This result agrees with the data of a survey conducted at the University of Information Technology and Management in Rzeszow, Poland which provided evidence that a wide use of technology "enables educators to implement the educational process regardless of the form of communication" [5]. Previous distance learning experience was also found to be less significant in this analysis, perhaps because almost all respondents had such experience—97.9%.

4. Conclusions

Maintaining the sustainability of education in armed conflict is a major challenge. The current long-term armed conflict in Ukraine has seriously damaged the country's education system. It has become an urgent task now to ensure its functionality under any circumstances. When resources are limited, it is critical to identify key factors and assess their priorities. The authorities need to know the areas of priority effort while developing policy recommendations on technical, administrative, organizational, financial support of education etc. The authorities need to know the areas of priority efforts when developing policy recommendations on technical, administrative, organizational, financial support for education, etc. The results of the study clearly indicate that adaptation and further support of the distance learning system in wartime is a prerequisite for good learning outcomes and student attendance, which has a positive impact on teacher satisfaction. These findings may have broader implications than educational management in armed conflict. There are other long-term emergencies (epidemics, natural disasters, etc.) where normal learning and access to educational institutions are disrupted.

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Gamification and PBL in the Development of Soft Skills: A Hands-on Approach in the IFG Training 4.0 Program as a Sustainability Practice

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Abstract. This study explores the integration of gamification and Project-Based Learning (PBL) in developing soft skills within the context of the Training 4.0 Program at the Federal Institute of Goiás (IFG). The program, aligned with sustainability practices, emphasizes energy efficiency as a central theme and aims to enhance students' soft skills, such as critical thinking, creativity, and teamwork, through hands-on activities. Preliminary results indicate significant improvements in these competencies, demonstrating the effectiveness of the program's approach. The study highlights the importance of combining technical learning with the development of socio-emotional skills to prepare students for the challenges of Industry 4.0. Further research will continue to assess the long-term impacts of these methods on student outcomes.

Keywords. Soft Skills, Sustainability, Training 4.0.

1. Introduction

The development of soft skills has become increasingly relevant in a world marked by rapid technological change and the need for constant adaptation [1]. Skills such as effective communication, critical thinking, teamwork, complex problem-solving, and adaptability are increasingly essential for professionals seeking to stand out and add value in a competitive job market. In addition to complementing technical knowledge, these skills enable individuals to communicate more effectively, collaborate with other teams, and face complex challenges creatively and efficiently [2].

Promoting these skills in the educational context is essential for training well-rounded professionals capable of adapting to the demands of the 21st century. The Federal Institute of Goiás (IFG), aware of this need, implemented in 2023 the Training 4.0 Support Program, developed by the Brazilian Industrial Research and Innovation Company (EMBRAPII) [3], an organization whose purpose is to support partnerships between technological research institutions and industrial companies, aiming to foster innovation in Brazilian industry.

The Training 4.0 Support Program seeks to integrate soft skills development with technical learning through active methodologies such as hands-on activities and Project-Based Learning (PBL). These approaches allow students to apply knowledge in real or simulated situations, providing a dynamic and engaging learning environment. In this context, hands-on, project-centered education is transformative as it immerses students in solution-based learning [4].

In the context of IFG, the theme worked on is energy efficiency, as this is the area of activity of the EMBRAPII unit. With this, the students involved also develop their skills from the perspective of sustainability, one of today's most significant global challenges, which requires innovative solutions that promote the rational and responsible use of natural resources [5]. Energy efficiency is critical for sustainability since it involves optimizing energy use in various sectors, reducing environmental impact, and combating climate change. Addressing public conceptions of energy production and consumption behaviors is paramount in reducing the burning of fossil fuels, which is by far the most significant contributor to climate change [6].

In addition to hands-on practices and PBL, gamification strategies were adopted at IFG. These strategies encourage soft skills development by requiring students to work in teams, communicate their ideas clearly, solve problems creatively, and manage projects effectively in a dynamic, engaging, and effective learning environment where students are encouraged to participate actively. Given this, this article presents the preliminary results of the development of soft skills in the context of Capacitação 4.0 at IFG, highlighting how hands-on practices, PBL, and gamification, centered on the theme of energy efficiency have contributed to the training of professionals who are more well-rounded in terms of mastery of soft skills.

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It's important to note that the program is an ongoing process, and the results obtained so far already demonstrate a significant improvement in the mastery of the established competencies.

The remainder of the paper is organized as follows: Section 2 describes the materials and methods used, Section 3 discusses the preliminary results, Section 4 describes the work planned for the next steps, and Section 5 presents final remarks.

2. Materials and Methods

The objective of the Training 4.0 Support Program is to provide soft skills training via PBL (Problem-Based Learning or Project Based Learning) to students in high school, undergraduate, master's, or doctoral programs, aiming at the student's performance in applied research, focused on industry and in the area of expertise of the Unit accredited by EMBRAPII [7]. As illustrated in Fig. 1, the Program begins with a diagnostic stage that consists of identifying the students' pre-existing soft skills and/or any gaps in their socio-emotional skills and competencies, which can be worked on during their participation in the Program. At IFG, this diagnostic was carried out in the first month of the Program. During this first month, students were introduced to the program content, the active methodologies used, and the general expectations of the Program. Students participated in workshops and introductory activities that allowed them to familiarize themselves with the fundamental concepts of Industry 4.0 and understand the importance of soft skills for success in the modern workplace.

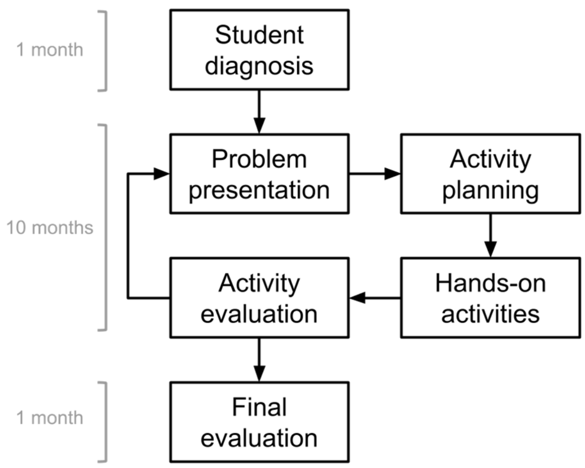

Figure 1. Proposed methodology

Soft skills are represented by competencies, composed of skills to be practiced, so individuals can develop them. 46 skills are established and distributed across the following ten competencies:

- Critical thinking and innovation.
- Active learning and learning strategies.
- Creativity, originality, and initiative.
- Complex problem solving.
- Leadership and social influence.
- Entrepreneurship.
- Emotional intelligence (self-awareness).
- Emotional intelligence (self-regulation).
- Emotional intelligence (social perception).
- Emotional intelligence (relationship skills).

The program requires an individual development plan prepared for each student, accompanied by a schedule of practical activities (hands-on) that respond to the skills identified in the diagnosis, synchronized with the opportunities for practical exercises. The activities have tutors responsible for all aspects of the activities carried out with the students.

The program is guided by a matrix of competencies and processes based on the primary skills required from the perspective of new technologies of Industry 4.0, according to the report The Future of Jobs Report 2018 (World Economic Forum) [8]. In addition to the priority competencies indicated by the forum, the program considers other essential skills for the professional profile of the researcher in the EMBRAPII context, such as entrepreneurship, in addition to some skills linked to emotional intelligence. The matrix is structured using the following items:

- EMBRAPII Operational Maturity
- Operational Excellence System (EOE)
- Typical activities according to EOE
- Competence
- Skill
- Recommendations for hands-on practices

In the methodology adopted, the learning process for each competency begins with presenting a central problem or challenge, which is selected to involve important content and requires integrating different energy efficiency disciplines. Students work in groups, promoting

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collaboration, sharing ideas, and developing interpersonal skills such as communication and leadership. During this process, students investigate the problem, identify what they need to learn, and apply the knowledge acquired to find viable solutions using research, experimentation, and the practical application of theoretical concepts. The program continues to develop the ten essential competencies, one per month, over ten months. Each competency is explored in depth, allowing participants to acquire and improve fundamental skills for Industry 4.0, such as communication, teamwork, critical thinking, and problem-solving. Each month, students are involved in practical activities and projects that require the application of competency in focus. For example, in a month dedicated to developing communication, students might work on presentations, collaborative activities, and simulations that encourage effective information exchange. In a month dedicated to problem-solving, participants are challenged to apply techniques such as design thinking to find creative and innovative solutions to real-world problems.

Each practice culminates in creating a final product, ranging from a presentation or report to a prototype or other tangible solution, demonstrating how the problem was solved. This final product is often presented to an audience, such as peers, teachers, or community representatives, reinforcing the connection to the real world. In addition, the methodology encourages ongoing reflection, where students evaluate what they have learned, how they solved the problems, and how they can improve, promoting more profound and meaningful learning.

The adoption of PBL places students at the center of the learning process, challenging them to solve complex problems and develop projects that have real-world relevance. Unlike traditional approaches, where the focus is on transmitting theoretical content, PBL encourages students to learn actively, working on projects that require the practical application of the knowledge acquired. The curriculum focuses on student-centered learning and problem-solving through teamwork, emphasizing solving real-life problems and developing active learning and problem-solving skills, allowing students to investigate and discuss problems [9].

The entire process developed at the IFG unit is based on gamification, which consists of applying game elements and dynamics in contexts that are not initially playful, such as the workplace [10], education [11], and corporate training [12]. In the educational field, gamification transforms the learning process into a more engaging and interactive experience, using mechanics such as scores, levels, rewards, challenges, and healthy competition to motivate participants. The central idea is to take advantage of the natural appeal of games to promote student engagement and active participation, facilitating learning in a fun and effective way. Gamification also facilitates collaborative learning, essential for developing essential interpersonal skills in Training 4.0.

The final assessment stage takes place in the last month of the program, where all the skills developed throughout the course are assessed in an integrated manner. In this phase, students must develop a final project that encompasses the skills developed over the previous months. This project is presented to a panel of evaluators, which may include professors, industry experts, and other qualified professionals. The final assessment is an opportunity for participants to demonstrate what they have learned, receive constructive feedback, and identify areas for improvement. This stage also assesses students' ability to apply the different skills in an integrated manner in complex situations, preparing them for the real challenges of Industry 4.0.

Students participating in the Training 4.0 Program at IFG are characterized as shown in Tables 1 and 2: The demographic characteristics reveal distinct profiles at different educational levels.

For high school students (Table 1), the majority are male, comprising 58.3% of the group, while females account for 41.7%. The age distribution shows that most students are 17 years old (58.3%), followed by 16 years old (33.3%), with a small proportion being 32 years old (8.3%). The largest group of participants is enrolled in the Mechanics course (58.3%), with other represented fields being Electrotechnics, IT for the Internet, Buildings, Chemical, and Electronics, each accounting for 8.3%.

In contrast, the undergraduate students (Table 2) exhibit a broader age range and a

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diverse distribution of fields of study. Gender distribution remains consistent with the high school group, with 58.3% male and 41.7% female students. The age distribution is varied, with 25% of students being 20 and 21 years old, 33.3% being 22 years old, and 8.3% being 29 and 42 years old, respectively. The most represented courses are Software Engineering (33.3%), followed by Chemical Engineering, Electrical Engineering, and Control and Automation Engineering (each 16.7%). Other courses include Civil Engineering and Information Systems, both at 8.3%.

Table 1. Demographic characteristics of participating students from high school level

Item	Value	Quantity
Gender	Male	7 (58.3%)
	Female	5 (41.7%)
Age	16	4 (33.3%)
	17	7 (58.3%)
	32	1 (8.3%)
Course	Electrotechnics	1 (8.3%)
	IT for the internet	1 (8.3%)
	Mechanics	7 (58.3%)
	Buildings	1 (8.3%)
	Chemical	1 (8.3%)
	Electronics	1 (8.3%)

These characteristics illustrate the diversity in both age and field of study among participants, highlighting the inclusive nature of the Training 4.0 Program, which spans various educational stages and disciplines.

Table 2. Demographic characteristics of participating students from undergraduate level

Item	Value	Quantity
Gender	Male	7 (58.3%)
	Female	5 (41.7%)
Age	20	3 (25%)
	21	3 (25%)
	22	4 (33.3%)
	29	1 (8.3%)
	42	1 (8.3%)
Course	Chemical	2 (16.7%)
	Software engineering	4 (33.3%)
	Civil engineering	1 (8.3%)
	Electrical engineering	2 (16.7%)
	Control and automation engineering	2 (16.7%)
	Information system	1 (8.3%)

3. Preliminary Results

Based on the data analysis, we have analyzed the students' performance on the soft skills competencies at two different time periods: first month of program (T1) and fourth month of program (T2). We provide here an analysis of their progress presented on Figs. 1 and 2.

As can be seen in Fig. 1, at time T1, high school students showed varying levels of proficiency across different soft skills competencies. The strongest areas were emotional intelligence (self-knowledge) at 72.92%, followed by active learning and learning strategies and leadership and social influence,

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both at 70.83%. Students also demonstrated good performance in emotional intelligence (self-regulation) at 68.75% and emotional intelligence (social perception) at 68.06%.

Areas where students had relatively lower scores at T1 included entrepreneurship (62.22%) and critical thinking and innovation (63.43%). Complex problem solving (64.81%) and emotional intelligence (relationship skills) (64.93%) also had lower initial scores.

Comparing the results from T1 to T2, we can observe improvement across most competencies, with one notable exception. The most significant growth was seen in emotional intelligence (social perception), with an increase of 6.60 percentage points, rising from 68.06% to 74.66%. Emotional intelligence (relationship skills) also showed substantial improvement, increasing by 6.12 percentage points from 64.93% to 71.05%.

Other notable improvements include:

- Complex problem solving: increased by 6.02 percentage points (64.81% to 70.83%).
- Emotional intelligence (self-knowledge): improved by 5.55 percentage points (72.92% to 78.47%).
- Active learning and learning strategies: increased by 5.56 percentage points (70.83% to 76.39%).

The competency that showed the least improvement was emotional intelligence (self-regulation), with an increase of 2.43 percentage points (68.75% to 71.18%).

Interestingly, creativity, originality, and initiative showed a decrease of 3.01 percentage points, falling from 67.36% to 64.35%. This is the only competency that declined between T1 and T2.

By T2, the highest-scoring competency was emotional intelligence (self-knowledge) at 78.47%, followed by active learning and learning strategies at 76.39%. The lowest-scoring competency at T2 was creativity, originality, and initiative at 64.35%, which, as mentioned, decreased from T1.

Overall, the data indicates a positive trend in the development of soft skills among high school students, with most competencies showing improvement between T1 and T2. The focused work on critical thinking and innovation, active learning and learning strategies, and complex problem solving appears to have yielded positive results.

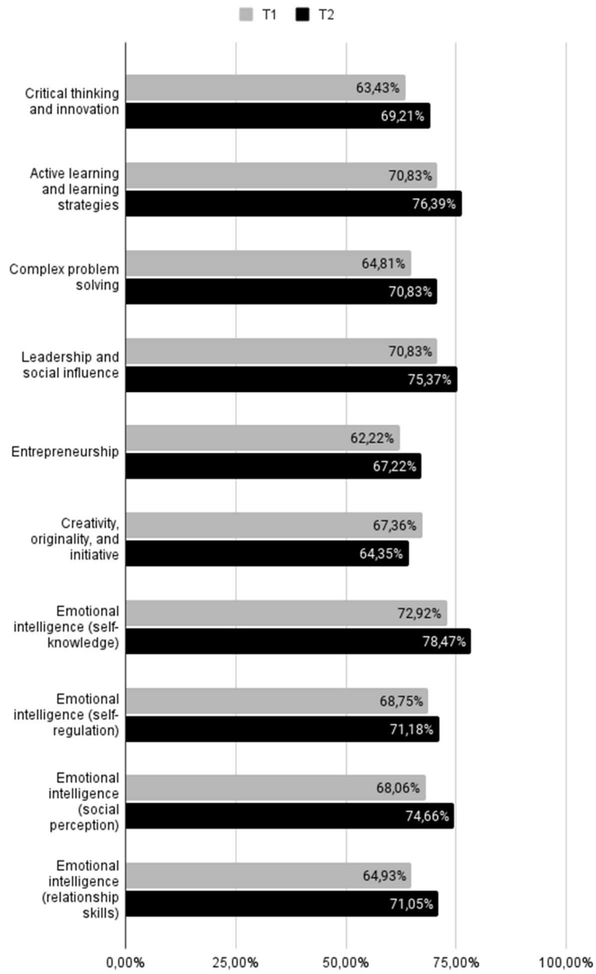

Figure 1. High School students soft skills competency scores: Comparison between time periods T1 and T2

As the program continues for six more months with plans to focus on one competency per month, we can expect further improvements in the other competencies. This targeted approach should lead to more balanced development across all soft skills. However, special attention may be needed for creativity, originality, and initiative, given its unexpected decline.

The continued emphasis on hands-on activities should reinforce learning and practical application of these skills, potentially resulting in even more substantial growth by the end of the program. This phased and focused approach to

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soft skills development demonstrates a well-structured program that promises to significantly enhance high school students' overall competency profile by its conclusion.

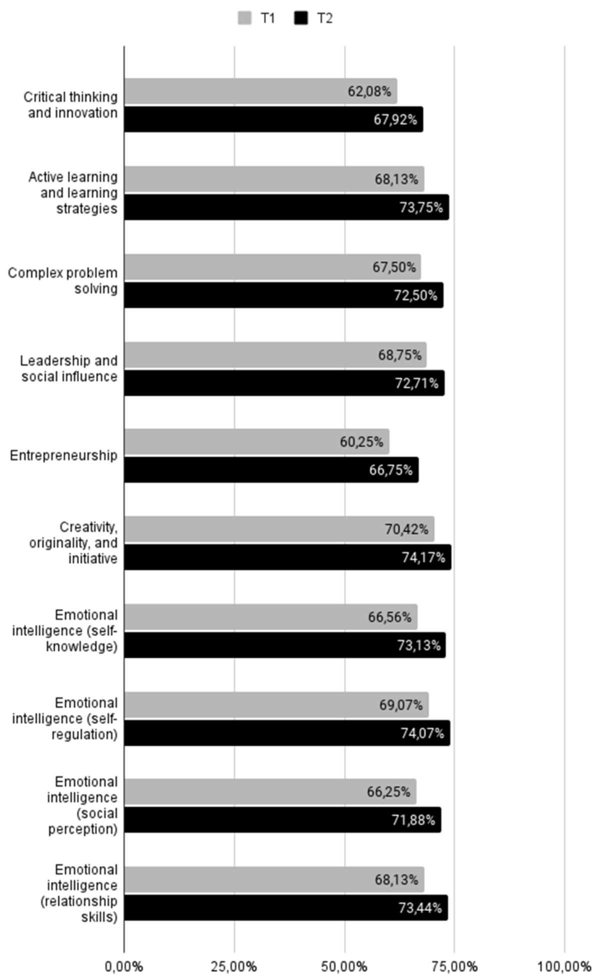

Figure 2. Undergraduate students soft skills competency scores: Comparison between time periods T1 and T2

Regarding the results for undergraduate students, as can be seen in Fig. 2, at time T1, students demonstrated varying levels of proficiency across different soft skills competencies. The strongest areas were creativity, originality, and initiative (70.42%), followed closely by emotional intelligence in self-regulation (69.07%) and leadership and social influence (68.75%). Students also showed good performance in active learning and learning strategies (68.13%) and complex problem solving (67.50%).

Areas where students had relatively lower scores at T1 included critical thinking and innovation (62.08%) and entrepreneurship (60.25%). The various aspects of emotional intelligence showed mixed results, with self-regulation being the highest (69.07%) and social perception the lowest (66.25%).

Comparing the results from T1 to T2, we can observe a consistent improvement across all competencies. The most significant growth was seen in emotional intelligence (self-knowledge), with an increase of 6.57 percentage points, rising from 66.56% to 73.13%. Critical thinking and innovation also showed substantial improvement, increasing by 5.84 percentage points from 62.08% to 67.92%.

Other notable improvements include entrepreneurship, which increased by 6.50 percentage points (60.25% to 66.75%), and active learning and learning strategies, which improved by 5.62 percentage points (68.13% to 73.75%). The competency that showed the least improvement, although still positive, was leadership and social influence, with an increase of 3.96 percentage points (68.75% to 72.71%).

By T2, the highest-scoring competency was creativity, originality, and initiative at 74.17%, followed closely by emotional intelligence (self-regulation) at 74.07%. The lowest-scoring competency at T2 remained entrepreneurship at 66.75%, despite its significant improvement.

Overall, the data indicates a positive trend in the development of soft skills among the students, with all competencies showing improvement between T1 and T2. This suggests that the program and hands-on activities implemented between these two time periods were effective in enhancing students' soft skills across various domains.

The comparison of soft skills development between high school and undergraduate students reveals interesting patterns that may be influenced by age and maturity levels. Both groups demonstrated overall improvement across most competencies, with undergraduates showing consistent progress in all areas. High school students, while generally improving, experienced a decline in one area - creativity, originality, and initiative - which stands out as a significant difference between the two groups.

At the conclusion of the study period (T2), the highest-scoring competencies differed between the groups. Undergraduates excelled in creativity, originality, and initiative, while high school students showed the greatest proficiency in emotional intelligence (self-knowledge). This disparity could be attributed to the greater life experience and personal development of undergraduate students, potentially enhancing their creative and initiative-taking abilities.

Examining the three competencies that received focused attention - critical thinking and innovation, active learning and learning strategies, and complex problem solving - both groups exhibited similar improvements. However, high school students consistently started and ended with slightly higher scores in critical thinking and innovation, as well as active learning and learning strategies. This suggests that younger students may be more receptive to developing these particular skills, possibly due to their ongoing academic environment which emphasizes these areas.

The most notable difference between the two groups was in the area of creativity, originality, and initiative. While undergraduates improved in this competency, high school students experienced a decline. This divergence might be explained by the different stages of cognitive development and life experiences between the two groups. Undergraduate students, with their broader exposure to diverse ideas and challenges, may find it easier to cultivate and express creativity and initiative.

Emotional intelligence components showed interesting variations between the groups. High school students demonstrated a more substantial improvement in social perception compared to undergraduates. This could be indicative of the rapid social development that often occurs during the high school years, as teenagers become more attuned to social cues and interactions.

Entrepreneurship, while starting low for both groups, saw greater improvement among undergraduates. This difference might be attributed to the increased exposure to real-world business concepts and opportunities that college students typically encounter, as well as their more developed abstract thinking skills.

It's worth noting that high school students generally started with higher scores in most competencies at T1, but this gap narrowed or reversed in several areas by T2. This trend could suggest that while younger students might have a natural aptitude or enthusiasm for certain soft skills, the more structured and intensive development during undergraduate studies can lead to significant gains, allowing older students to catch up or surpass their younger counterparts.

In conclusion, while both age groups benefited from the soft skills development program, the patterns of growth and areas of strength differed in ways that seem to reflect their respective stages of cognitive, emotional, and social development. The targeted approach appears effective for both age groups, particularly in the focused competencies. However, the stark contrast in creativity, originality, and initiative between high school and undergraduate students highlights the need for age-appropriate interventions and the potential influence of maturity and life experience on certain soft skills. These findings underscore the importance of tailoring soft skills development programs to the specific needs and developmental stages of different age groups.

4. Next steps

The Training 4.0 program has shown promising results in its initial phase, particularly in the three competencies that have been the focus of hands-on activities:

1. Critical thinking and innovation: This competency showed significant improvement, increasing by 5.78 percentage points (63.43% to 69.21%) for high school students and increasing from 62.08% to 67.92%, a gain of 5.84 percentage points for undergraduate students. This was one of the largest improvements observed, indicating that the targeted activities were effective in enhancing students' abilities in this area.
2. Active learning and learning strategies: Students demonstrated substantial growth in this competency, improving by 5.56 percentage points (70.83% to 76.39%) for high school students and improving from 68.13% to 73.75%, an increase of 5.62 percentage points for undergraduate students. This improvement suggests that the program has successfully fostered better learning

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habits and strategies among participants.

3. Complex problem solving: This skill also saw notable enhancement, increasing by 6.02 percentage points (64.81% to 70.83%) for high schools students and rising from 67.50% to 72.50%, a 5 percentage point increase. The improvement indicates that students are developing stronger analytical and problem-solving capabilities.

It's important to note that these improvements have been achieved in just the first part of the training program, which spans a total of four months. As the program continues, we anticipate even more substantial gains in student skills across all competencies. The plan to focus on one competency per month for the remaining duration of the program is a strategic approach that should yield further positive results.

For the competencies that have not yet been addressed in detail, such as leadership and social influence, entrepreneurship, creativity, and various aspects of emotional intelligence, we expect to see more significant improvements as each becomes the focus of a month's worth of hands-on activities. This targeted approach allows for intensive development in each area, potentially leading to even larger gains than those observed in the initial phase.

By the end of the one-year program, students are likely to show more balanced and comprehensive improvement across all soft skills competencies. The continued emphasis on hands-on activities should reinforce learning and practical application of these skills, potentially resulting in even more substantial growth than what has been observed so far.

This phased and focused approach to soft skills development demonstrates a well-structured program that promises to significantly enhance students' overall competency profile by its conclusion.

5. Final Remarks

The preliminary results of the Training 4.0 Support Program at the Federal Institute of Goiás (IFG) demonstrate promising outcomes in the development of soft skills among students. The program's innovative approach, combining hands-on activities, Project-Based Learning (PBL), and gamification strategies centered around energy efficiency, has shown significant improvements across all measured competencies.

Particularly noteworthy are the advancements in the three competencies that have been the focus of intensive hands-on activities: Critical thinking and innovation, Active learning and learning strategies, and Complex problem solving. These areas showed substantial growth, with improvements ranging from 5 to 5.84 percentage points, indicating the effectiveness of the targeted approach.

The program's initial success underscores the importance of integrating soft skills development with technical learning in preparing students for the challenges of the 21st-century workplace. By focusing on energy efficiency, the program not only enhances students' soft skills but also cultivates their awareness and capabilities in addressing crucial sustainability challenges.

As the program continues for the remaining months, with a plan to focus on one competency per month, we anticipate even more substantial gains across all soft skills. This phased approach allows for intensive development in each area, potentially leading to more balanced and comprehensive improvement in students' overall competency profiles.

The positive outcomes observed thus far validate the program's methodology and highlight the potential of active learning approaches in fostering soft skills development. The integration of technical knowledge with soft skills, particularly in the context of sustainability and energy efficiency, prepares students to be well-rounded professionals capable of addressing complex global challenges.

Moving forward, it will be crucial to continue monitoring and evaluating the program's impact, not only on students' immediate skill development but also on their long-term professional success. Future research could explore the transferability of these skills to real-world scenarios and the program's broader impact on the students' career trajectories.

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Investigative Practices Workshop for Early Childhood Teachers: An Experience Report

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Abstract. The teaching of science in early childhood education is essential for the development of critical and conscious citizens. However, we face a crisis in this field, as evidenced by unsatisfactory results in international assessments like PISA. In light of this scenario, we believe that the Inquiry-Based Learning approach is a promising alternative, as it allows students to become protagonists of their learning, investigating scientific phenomena and actively constructing knowledge in a meaningful way. The objective of this work is to report the experience of a formative workshop conducted with public school teachers, where we explored how the implementation of investigative approaches can enrich the curriculum and facilitate the understanding of concepts that are often abstract for children. During the workshop, participants had the opportunity to handle experimental artifacts, discuss investigative problems, and plan activities that could be implemented in their classrooms. We used a qualitative approach to understand the teachers' reactions, recording their experiences through audio and video recordings. As a result of the workshop, the teachers expressed a range of reactions. While many of them faced difficulties due to a lack of familiarity with complex scientific concepts, overall, there was clear enthusiasm when observing the outcomes of the experimental practices and the confirmation of their hypotheses. We conclude that the implementation of investigative practices can significantly contribute to the formation of critical and engaged citizens, aligning science education with the demands of contemporary society.

Keywords. Inquiry-Based Learning Sequence, Early Years of Elementary Education, Science Teaching, Teacher Training.

1. Introduction

Science teaching in the early years of elementary education is a fundamental component for the development of critical and conscious citizens capable of understanding and interacting with the world around them. However, despite the growing importance of scientific education in contemporary society, there is a noticeable crisis in science teaching in Brazilian schools, evidenced by unsatisfactory results in international assessments like PISA. These results reveal that many students struggle to assimilate scientific concepts and develop critical thinking skills.

Given this scenario, it is essential to rethink the pedagogical practices adopted in classrooms. The Inquiry-Based Learning approach emerges as a promising alternative, allowing students to become protagonists of their own learning, investigating scientific phenomena and actively constructing knowledge in a meaningful way. This methodological approach not only stimulates interest in science but also promotes problem-solving and the appropriation of scientific knowledge through experimentation and reflection.

In this article, we aim to discuss the main challenges faced in science education, the characteristics of Inquiry-Based Learning, and the importance of continuous teacher training for science education. Furthermore, we will present an account of a formative workshop conducted with public school teachers. In this workshop, we sought to demonstrate how the implementation of investigative approaches can enrich the curriculum and facilitate the understanding of concepts that are often abstract for children. In the end, we hope to contribute to the reflection on the need to transform science teaching, making it more dynamic, inclusive, and aligned with the demands of today's society.

2. The challenge of teaching science in the early years

Numerous studies point to the perception that there is a crisis in science education [1-3]. This occurs despite the importance of developing scientific literacy and the many studies that relate the appropriation of scientific knowledge with the formation of critical citizens who are aware of and engaged with the influences and impacts of science in society.

Pozo and Crespo [1] indicate that the crisis in science education is not limited to classrooms but also manifests in the results of research related to science didactics. In this sense, we can certainly extend this understanding to the results of large-scale assessments, such as the Programme for International Student Assessment (PISA), in which the latest evaluation, conducted in 2022, revealed that Brazilian students (403 points) scored below the average of OECD member countries (485 points) [4].

These results align with Pozo and Crespo's [1] observations, which state that the numerous studies they analyzed show that the majority of students do not learn the science being taught to them. The authors add that deficiencies in science learning are demonstrated not only in conceptual aspects but also in the use of reasoning strategies and problem-solving approaches characteristic of scientific work (p.16).

They also highlight that science needs to be taught as a historical and evolving process, encouraging students to engage in the process of scientific knowledge creation, even with all its doubts and uncertainties. This requires students to view learning as a constructive process, seeking meanings and interpretations rather than simply repeating or reproducing established information, thereby becoming mere consumers of information [1].

In this regard, Delizoicov, Angotti, and Pernambuco [5] point to the need for changes in science teaching and the role of teachers in this field across various educational levels. The authors emphasize that the role of science teachers "constitutes a set of knowledge and practices that are not limited to a competent mastery of procedures, concepts, models, and scientific theories" (p.24).

This demands that teachers be in a continuous process of professional development to meet the growing educational demands of the information and knowledge society. This can help ensure that science classes are not only used for acquiring theoretical content but also for fostering and stimulating cognitive abilities for organizing and interpreting information to promote knowledge.

This understanding is reinforced by Pozo and Crespo [1] when they highlight the need to provide students with the opportunity to make sense of the information accessed and achieve critical assimilation in science classes. In this regard, one of the approaches the authors present is the discovery-based teaching method, which resembles the inquiry-based teaching approach, as "teaching is based on experiences that allow students to investigate and reconstruct the main discoveries of science" (p. 252).

Thus, we aim to present in this paper the characteristics of Inquiry-Based Learning and the Inquiry-Based Learning Sequence, a proposal for developing investigative work in the early years.

3. Inquiry-Based Science Teaching: possibilities for investigative work with children

Inquiry-Based Teaching is a didactic approach where students investigate scientific phenomena, develop an interest in science, and share their hypotheses, which are tested and evaluated during investigative activities or practices. The development of investigative activities fosters and creates conditions for problem-solving and the appropriation of scientific knowledge through manipulative action, which can distinguish it from other teaching and learning strategies where knowledge construction occurs solely through transmission and absorption.

Campos and Nigro [6] indicate that inquiry-based teaching is much more than developing a child's observational skills of everyday events; it is about enabling the child to visualize solutions to the problems surrounding them. To achieve this, the child needs to formulate and test hypotheses, which can be done through exploratory, descriptive, or investigative activities.

Thus, Inquiry-Based Teaching aims to stimulate cognitive abilities in students that help them understand that scientific and natural phenomena do not occur in isolation, but rather as a sequence of actions and reactions. From this perspective, the child should think about, and reflect on, the proposed problem in order to find hypotheses that can address their doubts, thus becoming an active participant in the construction of their own knowledge.

Oliveira [7] states that investigative methodologies provide not only content learning but also other essential learnings for the holistic development of students. The author explains that student protagonism in the knowledge construction process occurs when students take responsibility for structuring experimentation, formulating hypotheses, testing them, analyzing, and communicating the results achieved.

From this perspective, the teacher should take on a mediating role in the knowledge construction process, adopting a questioning stance and presenting challenges. Oliveira [7] clarifies that these challenges should respect the students' skills and abilities, relating them to everyday situations so that they can achieve possible solutions. The goal of this approach is for the student to go through, even if in a simplified form, the main stages that scientists perform in their daily work, such as: "thinking about a problem, formulating hypotheses, proposing a work plan to verify the hypotheses, collecting and analyzing results, and finally, communicating the results found" (p.26).

Both Oliveira [7] and Carvalho [8-9] emphasize that linking content with students' realities is important for sparking greater interest and engagement in activities. This contributes to decision-making during investigative processes and allows for the association with real-life situations and the applicability of the generated knowledge to students' realities.

Just as with teachers, an investigative approach also requires a shift in students' attitudes, as they need to move from passively absorbing information transmitted by the teacher to taking an active role in constructing their own knowledge. However, we agree with Oliveira [7] that changing the attitudes of classroom participants is not simple, as it involves breaking away from entrenched practices and school cultures based on traditional methodologies.

Among the possibilities for working with investigative activities, Carvalho [9] presents the Inquiry-Based Learning Sequence (IBLS) as a methodological approach. The author highlights four fundamental points for investigative planning, as shown in Fig. 1.

In line with approaches involving Inquiry-Based Teaching, Carvalho [9] indicates that in an IBLS, three interconnected activities occur simultaneously: initial problematization, which can be experimental or not; systematization of the problem resolution; and contextualization of the knowledge.

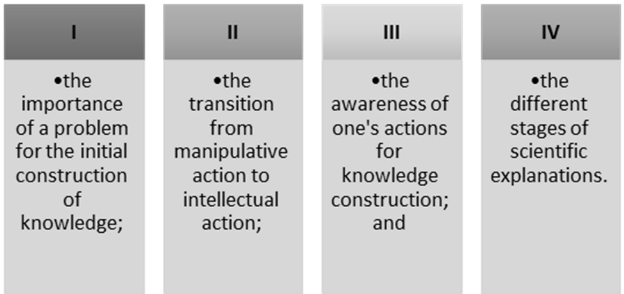

Figure 1. Elements for Investigative Planning

In this regard, Carvalho [8] argues that using the IBLS as a didactic proposal for teaching science in elementary education provides children with the opportunity to build their knowledge through activities that encourage them to question and propose solutions to the presented problems.

According to Carvalho [10], the IBLS is defined as:

> (...) sequences of activities (lessons) covering a topic from the school curriculum, where each activity is planned from the perspective of the material and didactic interactions, aiming to provide students with: conditions to bring their prior knowledge to start new knowledge, develop their own ideas, discuss them with peers and the teacher, move from spontaneous to scientific knowledge, and understand knowledge already structured by previous generations.

The author [8, 10] argues that the IBLS should be developed from the systematization of a series of actions or stages, namely:

1. The teacher proposes the problem: During the planning of an IBLS, the teacher directs their work towards the objective they wish to achieve with the activity. Thus, the activity should begin with the proposal of an investigative problem that is contextualized and

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introduces students to the intended topic.

2. Acting on objects to see how they react: Acting on objects to observe their reactions is the first phase of the child’s manipulative work in developing the IBLS. It is the moment when they interact with the concrete object by handling, manipulating, analyzing, and moving what the teacher has planned and brought to the classroom.
3. Acting on objects to achieve the desired effect: After becoming familiar with the objects, children move on to seeking a solution to the problem presented by the teacher. This is when they will effectively observe the reaction of the object in their search for a solution to the problem. It is not necessarily about solving the problem but finding possible solutions, mentally revisiting their actions, and discussing with peers. It is through experimentally tested and considered correct hypotheses that students will have the opportunity to construct knowledge.
4. Becoming aware of how the desired effect was produced – HOW: The teacher should mediate this discussion by questioning them about HOW they found the solution through the inquiry.
5. Causal explanations – WHY: At this stage, the focus is on verifying the justifications presented by students during the awareness phase of how the desired effect was produced. The teacher should continue the discussion by questioning WHY they found the result or the verification of the hypothesis generated to solve the problem. Carvalho [10] states that causal explanations lead children to search for words and concepts to explain the observed phenomenon, which stimulates the expansion of the child's vocabulary mediated by teaching action.
6. Relating to everyday life: At this stage, the activities developed in the IBLS are related to everyday situations, leading the child to experience and create new meanings to explain the phenomena occurring around them and to understand various phenomena in their daily life.

In addition to focusing on the stages that constitute the IBLS, Carvalho [10] emphasizes the need to create an investigative environment in the classroom to immerse the child in a scientific process or work that gradually promotes a scientific culture. In this direction, Carvalho [8] argues that during the planning of activities, there should be anticipation of possible difficulties students may face and potential questions they might ask. This will help maintain the children's interest in the proposed activity, as well as in moments of dialogue and argumentation, facilitating the interaction between prior knowledge and the experiences provided by the IBLS.

However, despite the advantages and possibilities that investigative approaches bring to science classes, this type of activity is still uncommon in school environments. Various studies [6, 8, 11-14] indicate that this absence is justified by the lack of pedagogical materials and teacher training, which would enable them to plan and develop investigative practices in their classes.

In response to this situation, we proposed a Continuing Education Course to provide the theoretical and methodological foundation necessary to promote Inquiry-Based Teaching in the classrooms of the early years. In this work, we present a focus on the implementation of a formative workshop with teachers from the municipal network of Jataí-GO, where we worked on activities related to the IBLS.

4. Methodological Aspects: A workshop on IBLS with early years teachers

In this research paper, we adopted a qualitative approach, which, according to Bogdan and Biklen [15], is a type of research that allows for a close interaction between the researcher and the research participants. This approach facilitates an understanding of phenomena in their entirety, considering the multiple aspects and contexts that surround them; it also enables an exploration of

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participants' perspectives and experiences in a holistic and interpretative manner.

The holistic perspective in qualitative research means that researchers seek to understand a phenomenon in its entirety, taking into account all its aspects and contexts. Instead of analyzing only isolated parts of the phenomenon, such as individual characteristics or specific variables, this perspective aims to grasp the complexity of the phenomenon in its entirety, recognizing the interactions between different elements and the context in which they occur [15].

The organization of the methodological structure for the development of the formative workshop addressed the demands and gaps identified by the subjects, who were interviewed during an exploratory research conducted in the first semester of 2023. Both the exploratory phase and the execution of the formative process took place in Jataí-GO, in partnership with the Municipal Secretary of Education of Jataí-GO (SME-Jataí/GO).

The choice of this municipal education network was initially based on the fact that the municipality hosts the Post-graduate Program in Education for Science and Mathematics at IFG, which led us to aim to contribute directly to local educational processes by offering a continuing education course to teachers actively teaching in the municipal public network. In particular, the full-time schools: Escola Municipal Professor João Justino de Oliveira and Escola Municipal Isaías Soares.

For data collection and production, audio and video recordings were made during all moments of the workshop. We used a smartphone on a tripod to obtain a frontal view of the participants and the movement of the teacher/researcher. Additionally, we also used a digital voice recorder, strategically placed at the back of the classroom, to ensure the quality of the captured audio.

For data analysis, we employed the Content Analysis technique [16]. This methodology significantly contributes to understanding the meanings of communications with participants, including their manifest or latent content, explicit or hidden significations, through a systematic and rigorous analysis.

This workshop is part of a Continuing Education Course, with a total duration of 84 hours, focused on providing the theoretical and methodological foundation necessary for promoting Inquiry-Based Teaching in the classrooms of the early years. The course is part of a doctoral research project in development at the Post-graduate Program in Education for Science and Mathematics at the Federal Institute of Education, Science, and Technology of Goiás. The course consists of in-person meetings where participants have the opportunity to discuss theoretical frameworks, share classroom experiences, and engage in reflections. It is organized into five interconnected modules, each consisting of thematic in-person meetings for collective discussions and theoretical and methodological contributions. The theoretical-methodological foundation for structuring the formative meetings was based on references from the field [1, 4, 9].

The implementation of the formative workshop, with the theme of the IBLS, was a collaboration with the Pedagogical Coordination of the Full-Time Schools of SME-Jataí/GO, which contacted us and suggested that our formative action be included in the SME-Jataí/GO Planning Week program, held at the beginning of the first semester of 2024. This collaboration enabled the realization of the workshop, bringing together teachers from the two full-time schools, as well as educational agents and support professionals for children with special educational needs.

The formative meeting was planned to last 4 hours, organized into two segments. Initially, we presented and developed the theme of IBLS, outlining the elements and characteristics of Inquiry-Based Teaching. In addition to the theoretical presentation, successful experiences from the Laboratory of Physics Research and Teaching at the University of São Paulo (LaPEF-USP) [17-18] were shared to exemplify the stages of an IBLS during the development of investigative practices with children in the school environment.

In the second segment, we conducted a workshop on investigative practices, in which the participants were divided into 5 groups, corresponding to the school years in which they work. We then distributed the selected experimental artifacts, Fig. 2, and the bibliographic references related to the covered content. For 40 minutes, the participants had the opportunity to study the material and manipulate the experiments to understand the mechanisms of action.

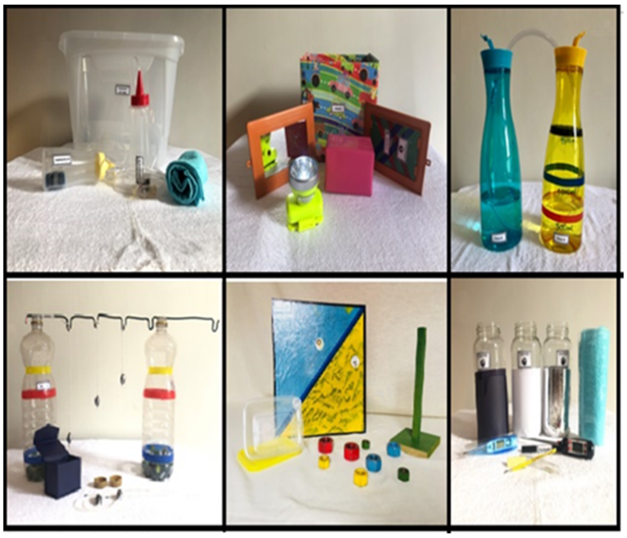

Figure 2. Experimental artifacts for investigative activities

Based on preliminary information related to the participants' difficulties in proposing experimental practices and the analysis of the municipal curriculum guidelines, we brought the following experimental artifacts to this workshop:

- Experimental Artifact 1 – Submarine, adapted from Carvalho [9]
- Experimental Artifact 2 - Light Reflection, adapted from Carvalho [9]
- Experimental Artifact 3 – Communicating Vessels, adapted from Gaspar [19]
- Experimental Artifact 4 – Resonance, adapted from Gaspar [19]
- Experimental Artifact 5 – Balance Plate, adapted from Hilario and Souza [20]
- Experimental Artifact 6 – Heat Absorption by Colors, adapted from Zompero and Laburú [21].

Next, each group was asked to propose an investigative problem and evaluate how they would work with the experiment in their classes, integrating it into the curricular planning, as illustrated in the images in Fig. 3. As the groups progressed with the proposed activity, they presented to the other participants the characteristics of the experimental artifacts, the related scientific content, and how they would develop this activity in the classroom. At the end of the formative meeting, it was required that, in the following months, the participants plan and develop an investigative activity, or an IBLS, in their classes, based on a content from the curriculum of the school year in which they teach.

Figure 3. Activities developed during the IBLS workshop

5. Observed perceptions among participants

During the first part of the training session, while presenting the theoretical and methodological aspects related to the development of an IBLS in science classes, we observed that the participants remained attentive to the presentation, especially regarding the stages of the IBLS and how they could implement these types of activities in their classrooms. To illustrate this development, we showed two videos from LAPEF-USP [17-18], which demonstrated teachers and children engaging in investigative practices.

The participants' comments during the video playback reflected a certain admiration for the involvement and skill of the children in seeking answers to the problems posed by the teachers. Regarding the stages of awareness and causal explanations, our participants focused on the difficulties that teachers face in allowing children to communicate their discoveries and in creating situations that facilitate this communication, given the prevailing culture of knowledge transmission in schools.

In the second part of the workshop, the teachers worked with experimental artifacts, as

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shown in Fig. 2, from the perspective of Inquiry-Based Learning. We distributed artifacts and bibliographic materials to support the understanding of school contents and scientific concepts. We observed moments of silence in the classroom as the participants unanimously dedicated initial attention to reading the textual material to understand the scientific concepts. This demonstrates a concern among the teachers to remain in a continuous learning process.

After the participants had read the bibliographic material, as outlined in the initial stages of an IBLS, we guided them to start manipulating the objects and observing their reactions, moving on to achieve the desired effect. During these moments, the enthusiasm of the teachers was palpable: they reacted with excitement to discoveries and expressed disappointment when errors occurred. This experience allowed us to discuss ways to motivate children and capture their interest in science lessons by employing a more active and dynamic methodological approach.

In groups working with experimental artifacts related to "more complex physics concepts," such as resonance and wave propagation, difficulties with the content or lack of knowledge were clearly evident. These challenges are corroborated by other research indicating deficiencies in teacher training. We intervened in these cases, providing detailed explanations of the mechanisms behind the experiments and emphasizing the need for further study to achieve mastery of the content.

During the phase of sharing their practices, each group presented their experimental artifact, discussed the materials used, and suggested possible substitutions. This session also allowed the teachers to discuss the content and concepts involved in the observed phenomena, as well as the difficulties they encountered or that their students might face. Several groups noted the need to replace some materials in the experiments and discussed potential actions and questions that students might have during the initial stages of the IBLS.

A common aspect in the presentations was the perception of the curriculum expansion possibilities that investigative practices could offer in science classes. Participants observed that, during manipulation, other concepts emerged that could be explored with the children to enhance their understanding of phenomena, such as density, gravity, shadow, and balance. These concepts are often abstract for young children and present comprehension challenges when addressed only through bibliographic or media materials.

In this context, the need to adapt scientific language so that children can understand the concepts and subsequently expand their vocabulary was emphasized. We reinforced the importance of not overly simplifying the language to the point of compromising the development of scientific knowledge, as demonstrated in the videos, where the children themselves bring concepts they experience in their daily lives.

Thus, we can consider that the objectives proposed for the workshop on IBLS with early years teachers were achieved. It was clear from the participants' reactions that they were interested and attentive during the presentation of the IBLS stages, and they became aware of the need to develop strategies that promote autonomy and an active stance among children in the classroom.

6. Final Considerations

Thinking about science education in the early years of elementary school involves understanding its significance in fostering scientific literacy and developing critical, aware citizens who recognize the impact of science on society. However, there is a recognized crisis in science education, as evidenced by unsatisfactory results in assessments like PISA, which indicate that many students struggle to effectively develop scientific concepts and skills.

In this context, we sought to demonstrate that employing an investigative approach in science classes can enhance and facilitate the understanding of scientific concepts, which are often presented in an abstract manner to young children. This approach also encourages the development of autonomy and an active stance in the classroom, creating an investigative environment that fosters curiosity and student engagement in the learning process.

In this research segment, we captured a range of reactions from the participating teachers. These reactions varied from difficulties due to unfamiliarity with the scientific concepts related to the physical phenomena present in the experimental practices, to the excitement experienced while manipulating the artifacts, observing their reactions, and confirming hypotheses.

It is important to highlight that the difficulties encountered by the participants with more complex physics concepts indicate gaps in the teachers' training. This underscores the need for ongoing professional development, such as the one conducted in this study, and for continuous in-depth study to improve content mastery. Finally, the results emphasize the importance of continuous and reflective teacher training, the use of active and investigative methodologies, and the adaptation of materials and language to facilitate children's understanding of scientific concepts. Additionally, they highlight the need to empower teachers to confidently create a learning environment that values student autonomy, promoting more meaningful and engaging learning experiences.

7. Acknowledgments

To the Federal Institute of Education, Science, and Technology of Goiás, which through the Post-graduate Program in Education for Science and Mathematics, provided financial support for participation in the event.

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The Relationship between Moral Sensitivity and Ethical Decision-Making in Chemistry Students

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Abstract. Moral sensitivity is an important variable that influences ethical decision-making. Bearing that in mind, this study aims to identify the extent of moral sensitivity presented by chemistry undergraduates after implementing an activity based on case studies containing ethical dilemmas in scientific research. To obtain data, the resolutions provided by the students were analyzed. The results suggest that the activity effectively contributed to developing moral sensitivity, although to a limited degree. This highlights the need to implement additional practices similar to the one described.

Keywords. Moral Sensitivity, Case Studies, Chemistry Education.

1. Introduction

Aiming at training future chemistry professionals, moral development is crucial [1-2] and can be fostered using case studies. Case studies, in turn, are an active teaching methodology that can lead to discussions on various topics and develop skills such as critical thinking and problem-solving [3-4].

In the context of individual moral development, one of the key frameworks is the Four-Component Model proposed by Rest *et al*. [5], which identifies weaknesses in students' moral development. This model is based on the idea that morality can be cultivated through the following psychological processes: moral sensitivity, moral reasoning, moral commitment, and moral perseverance [6]. Although these components function together, they can be analyzed individually.

According to Ineichen *et al.* [7], moral reasoning is essential for addressing complex problems. It encompasses, among other things, the individual's ability to recognize the moral dimensions of situations being examined, a concept referred to as moral sensitivity.

The need for more approaches involving social, moral, and ethical aspects is clear in the literature [8-9], given that science teachers often focus on theoretical concepts specific to their fields without addressing social and ethical issues.

In light of this, this study aims to identify the extent of moral sensitivity demonstrated by chemistry undergraduates by doing an activity involving the resolution of case studies.

2. Theoretical Framework

To observe the undergraduates' moral sensitivity, the guide "Moral Reasoning in Scientific Research" by Bebeau [6] was used. This guide not only provides information on how to foster the development of morality but also offers analytical tools, such as a grid on moral aspects, which evaluates moral sensitivity. This material is based on the previously mentioned Four-Component Model, which has been addressed in prior works according to each component individually, as demonstrated by Bebeau, Rest, and Narvaez [10].

Regarding moral sensitivity, Bebeau [6, 11] notes that it can be addressed in the classroom through case studies involving ethical dilemmas. Bearing this in mind, we created fictional cases following Bebeau's recommendations [6]. These cases include narratives with moral dimensions, where the dilemma is framed as an action that the protagonist may or may not undertake. Students are tasked with making this decision as part of resolving the case.

Additionally, each case includes an associated grid that divides the moral aspects of each narrative into four categories: points of conflict; interested parties; consequences; and the protagonist's obligations. Points of conflict pertain to the ethical dilemmas presented, whereas the interested parties are the individuals or entities impacted by the protagonist's decisions. Consequences relate to the outcomes of the protagonist's actions and should be listed based on their likelihood of occurring or their potential impact. Finally, the protagonist's obligations refer to what he needs to do both in terms of his responsibilities as a researcher and as a citizen.

According to the moral aspects grid, the extent of an individual's moral sensitivity can be

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determined based on the number of elements they are able to identify in a given situation involving an ethical dilemma. Thus, the more elements identified, the greater the displayed moral sensitivity.

Considering the above, four cases were created to enhance the moral sensitivity of the undergraduates, which allowed for the effective identification of elements within the grid.

3. Methodology

The cases were applied in a Scientific Communication course, offered to undergraduate chemistry students at University of São Paulo, Brazil. All the case narratives followed the same format: they presented a situation that led to an ethical dilemma, where the undergraduates were required to argue what decision the protagonist should make.

Regarding the application of the cases, the steps shown in Fig. 1 were used. In summary, these steps involve an initial reading of the cases, first resolution (Part A), a group discussion with the teacher acting as mediator, and the production of a second resolution (Part B).

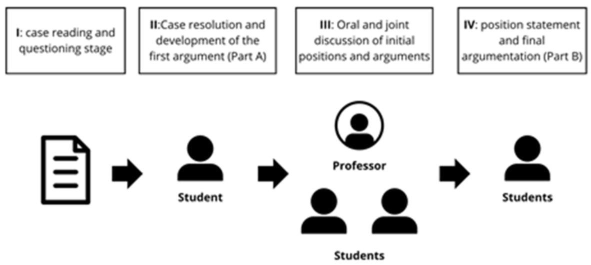

Figure 1. Steps for Applying the Cases The analysis conducted here took into account the two written productions (Parts A and B) of each of the 19 students who participated in the resolution of the first case, titled Authorship in Question. To preserve the students' identities, their names were not assigned.

The case narrative centers on Carlos, an undergraduate student nearing graduation who is preparing to apply for an upcoming master's program. Since Carlos has no published articles, which is a significant factor in the master's selection, his research advisor (Mário) proposes that Carlos agrees to include his name on a paper by a laboratory colleague (Maria) who is about to publish a manuscript. In return, Carlos will have to include Maria's name on his work once it is produced. The dilemma revolves around Carlos's desire to have an article published to improve his chances of entering the master's program while wanting to uphold academic norms and scientific integrity.

The analysis grid for the first case was developed by defining, for the purpose of this work, the elements that fit into each of the previously established categories.

Additionally, the students' resolutions for the case were analyzed using the grid perspective, meaning that the elements from the grid were identified within the text. This analysis was conducted for each of the students' submissions (Parts A and B). To present the results visually and concisely, a graph was created showing the percentage of each type of moral aspect used, considering Parts A and B separately. It is worth noting that the argument excerpts presented here were originally written in Brazilian Portuguese, but they have been translated by us.

4. Results and Discussion

The moral aspects grid included 44 elements: two points of conflict, 10 interested parties, 27 consequences, and five protagonist obligations.

Regarding the dilemma presented in the case study, which is whether the protagonist should accept the advisor's proposal or not, six students were in favor of accepting it, while 13 were opposed. This stance remained unchanged after the classroom discussion. The arguments of two representative students from each position are discussed below, both before and after the discussion.

Student 1, who was against accepting the proposal, identified six elements out of the 44 in the grid in Part A, which accounts for 13.63% of the total. Among these elements, four are categorized as consequences, detailing the impact that the authorship assignment described in the case would have on the protagonist's, lab colleague's, and the advisor's career, as well as its effect on the scientific community.

Additionally, two of the elements are interested parties. For example, referring to the potential negative impacts of the protagonist accepting the proposal, the student notes that

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"...his behavior could be uncovered, potentially tarnishing his name in the 'scientific community' (this situation applies to both), Moreover, both have contributed to making this field increasingly unfair...", indicating that both the protagonist and the scientific community would suffer from this choice.

The student's second argumentation (Part B) presented seven elements, or 15.9% of the total, indicating a slight improvement in the number of identified elements. The distribution of elements remains the same as in Part A, except for the addition of a point of conflict, as the student now describes Carlos's internal conflict as choosing between prioritizing academic development and personal gain or adhering to what he believes is right by respecting scientific norms. The student aligns with the second option, demonstrating deontological ethics, which can be defined as focusing on morality described through rules [12].

According to Sadler and Zeidler [13], moral reasoning presents different patterns: rationalist, intuitive, and emotive. What is observed in the argument of Student 1, and similarly in the resolutions of other participants, is a predominance of the rationalist pattern. This can be seen in a passage from the argument of Student 1 where, referring to the authorship assignment practice described in the case, he states that it is "...a reprehensible and banned practice in the scientific community," indicating that there is a consensus in the community regarding this issue.

Concerning the opinions in favor of the protagonist accepting the proposal, the arguments put forward by Student 2 were used as an example. In Part A, he identified four elements, accounting for 9.1% of the total. Of these, three were categorized as interested parties and one was classified as obligation. Although the extent of moral sensitivity was limited, the student provided an argument based on his interpretation of one of the protagonist's obligations, as seen in the following excerpt: "Carlos should accept the proposal, as, even though he did not assist Maria when writing the article, he previously contributed to the research conducted by his colleague. Additionally, as a member of the research group, he was able to follow the development, analyses, and results obtained...". In this excerpt, he makes it clear that, in his opinion, the assistance Carlos provided within the laboratory setting is sufficient for him to be listed as an author of the manuscript.

One issue with this argument is that the case does not specify how much Carlos assisted Maria. In other words, the student is implying, even if indirectly, that any contribution is sufficient for Carlos to receive authorship, which contrasts with another part of the same argument that states, "It would not be advisable to make this decision if both of them were in different groups," suggesting that a certain "level" of contact between the characters is required.

The second argument (Part B) presented five elements (11.3%), demonstrating greater sensitivity than the first. The elements are distributed in the same way as in Part A, except for the addition of one consequence. In this new argument, Student 2 highlights the importance of maintaining the relationship between Carlos and his advisor, as rejecting the proposal could cause friction and hinder future collaborations. This is evident in the excerpt: "...to maintain a good relationship with his advisor, who made the proposal and could hinder or obstruct Carlos's entry into the master's program, it would be more prudent to accept the proposal."

Another change in the argument from Part A to Part B is the mention of a potential financial difficulty if Carlos fails to gain admission to the master's program, as he would not have a scholarship.

Student 2 also bases his decision on a fictional scenario that assumes people tend to act unethically, specifically the idea that "if others are doing it, I can do it too." This is reflected in the following excerpt: "Other candidates in the master's selection process may have used unethical means to improve their resumes, which would put Carlos at a disadvantage," where he argues that Carlos should accept the proposal because others are likely to do the same.

The examples of resolutions from both groups of students — those opposed to and those in favor of accepting the proposal — show that moral sensitivity was limited in both instances. Nevertheless, the group discussion before Part B played a significant role, leading to a noticeable, though modest, improvement in identifying elements.

Concerning the overall result, which includes all the students, it has been systematized and presented in Fig. 2, showing the frequency of occurrence of the types of elements from the moral sensitivity grid in Part A and Part B.

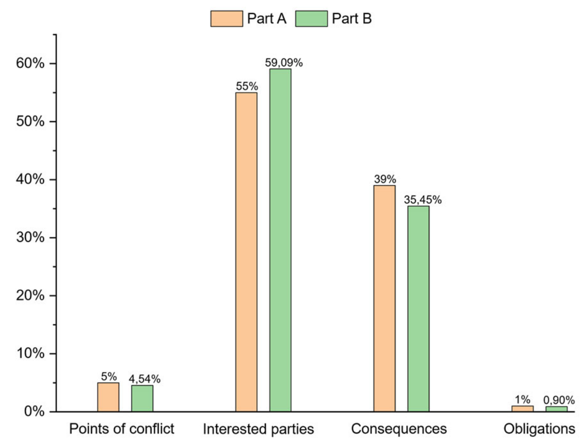

Figure 2. Graphical representation of mentions of *interested parties*, *consequences*, protagonist's *obligations*, and *points of conflict* in the students' responses

It is worth noting that the total number of elements in Part B was 110, while Part A had 100 elements, indicating a slight overall increase in the number of elements. As shown in the graph, interested parties were the most frequently mentioned elements in both Part A and Part B, and they were the only group that saw an increase in frequency from one part to the other. This suggests that the group discussion had a greater impact on the students' perception of who or what would be affected by each decision.

The high frequency of consequences was expected, as there is a natural tendency to base decisions on their potential outcomes, as well as relying on rules and norms [12]. Among the most frequently cited consequences were possible changes in the relationship between Carlos and his advisor, and the potential facilitation of Carlos's admission to the master's program, which are consequences focused on the protagonist and those directly involved in the process (Mario). However, this indicates a limited perspective, as the parties involved range from those directly engaged to the broader community, including the educational institution and the journal receiving the manuscript submission. This suggests that, despite its high frequency, the category of interested parties was used in a meager way.

In respect of the points of conflict, their low occurrence may be related to the fact that the case did not explicitly state the protagonist's dilemma in its text. This, combined with the students' tendency to focus on a single type of argument, usually based on a consequence, means that they may not mention the conflict even if they have identified it. This suggests that it might not be important for undergraduates to cite the conflict when defending their point of view.

Obligations also appeared infrequently in the arguments, which may be due to the students' limited understanding of the character's obligations and how they might influence his actions. Additionally, on several occasions, students highlighted consequences as being more relevant than norms or rules.

The results presented here demonstrate the importance of such work for expanding the moral and ethical education of undergraduates, particularly for enhancing perceptions of specific elements of moral sensitivity, such as points of conflict and obligations.

5. Conclusions

Based on the analyses described earlier, it can be observed that the undergraduates demonstrated limited moral sensitivity, indicating the need for further investigations and activities on this topic within the academic environment to contribute to the formation of future chemistry professionals. This also aligns with the role of the educator in promoting civic engagement.

One possible explanation for the low moral sensitivity observed could be the students' lack of exposure to the academic environment and scientific research, as they are first-year students. This limited exposure makes it challenging to identify people and institutions that would be impacted in the scenarios presented. For example, if a student is unaware that an institution would be affected when a researcher associated with it is depicted, they might not use this situation as an example, potentially overlooking the identification of elements such as *interested parties* (in this case, the educational institution) and *consequences*. Additionally, although some students provided deontological approaches, this was also limited, as many were unfamiliar with the rules and norms related to each case.

One of the most frequently cited points by the students was the relationship between the advisee and their advisor, indicating that this is a decisive aspect when arguing for or against the protagonist's acceptance of the proposal. Among other factors, this is due to the existence of a certain "consent" in the university environment that the professor holds a higher hierarchical position and, therefore, their recommendations are expected to be followed and respected.

In conclusion, this research assessed the extent of moral sensitivity demonstrated by undergraduates after applying case studies. It is important to highlight the significance of the group discussion phase within the case resolution process, as it provided the undergraduates with exposure to diverse perspectives, including elements they might not have identified previously, thereby contributing to the development of their moral sensitivity.

6. Acknowledgements

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Creation of Signs in LIBRAS for Biology and Chemistry Disciplines

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Abstract. The official recognition of the Brazilian Sign Language (Libras) as a means of communication and expression is very recent compared to the Portuguese language, and its consolidation is still evolving. Thus, this research was developed in its first stage with the aim of conceptually analyzing the existing signs-terms that involve the scientific language of Chemistry and Biology and verifying if the created signs provide quality in the interpretation and understanding of scientific concepts. The second stage of the project, based on previous investigative research discussions, led to the production of videos of selected sign-terms as learning objects.

Keywords. Biology, Chemistry, Libras, Signs, Videos.

1. Introduction

Sign language originated in France and has been spreading worldwide since 1857. When people refer to Brazilian Sign Language (Libras), there is often a mistaken belief that it is signaled Portuguese. Libras is the language used by the Brazilian deaf community, defined according to Law No. 10.436 of April 24, 2002, as a form of communication and expression in which the linguistic system has a visual-motor nature with its own grammatical structure, enabling the linguistic development of deaf individuals and facilitating their access to existing knowledge in society [2].

With the inclusion policy based on the World Declaration on Education for All (1990) and the Salamanca Statement (1994), the National Guidelines for Special Education in Basic Education [2] established by Resolution No. 02/2001 of the National Education Council included deaf students in the group of those with communication and signaling difficulties different from other students, ensuring "the accessibility of curricular content through the use of applicable languages and codes, such as the Braille system and sign language, without prejudice to the learning of the Portuguese language [...]". The officialization of Libras by Law No. 10.436/2002, regulated by Decree No. 5.626/2005, its use and dissemination became part of the education of the deaf in Brazil, contributing to the education of these students.

The presence of Libras in the classroom, compared to the Portuguese language, is very recent. Albres (2006) [1] points out that there are concepts without signs in Libras, which makes it challenging for interpreters in the classroom, forcing them to use resources that do not allow deaf students to understand meanings and concepts. Deaf students have Libras as their official (first) language and Portuguese as their second. While hearing individuals use Portuguese for communication, deaf individuals use sign language. Thus, communication between deaf individuals and hearing individuals who do not know Libras is impaired, requiring an interpreter to mediate relations. This problem intensifies when it comes to scientific concepts discussed in Chemistry and Biology, which have their own symbolism and many specific terms. The lack of understanding of these concepts can contribute to a lack of interest and consequently poor academic performance among deaf students.

Therefore, the conceptual analysis (and creation) of Libras signs used for terminologies in these two disciplines is a way to contribute to the relationship between deaf students and scientific knowledge, as it is possible to evaluate whether the signs have appropriate meaning and significance for their learning. Particular attention should be directed to the interpreter concerning the need to fix their gaze on the source of the message, preventing them from making any notes. This occurs during interpretations from sign language to oral language. In the opposite direction, during consecutive interpretations, the interpreter can make notes while receiving the auditory input [22]. According to Marinho (2007) [25], this is one of the significant obstacles for deaf individuals during interpreted classes because they need to keep their eyes anchored on the interpreter without the opportunity to write notes for future reference when alone. According to Leite (2005) [21], professionals' complaints focus on the lack of bilingual didactic glossaries for the Libras-Portuguese language pair and support material that contribute to the interpretation procedures of programmatic content and the students' autonomy during study moments when they are away from their interpreters or teachers. This work has already completed some stages; the first stage involved the conceptual analysis of 65 existing sign-terms for specific terms in Chemistry and Biology and the verification of these created signs regarding the quality of interpretation and understanding of scientific concepts. A survey of Libras signs for the terminologies of these disciplines was conducted in the Illustrated Trilingual Encyclopedic Dictionary of Brazilian Sign Language [9] (table 1), the BSL Glossary provided by the Scottish Sensory Centre of the University of Edinburgh (table 2), the sign language dictionary of the Phala Institute - Center for Deaf Development based in Itatiba - SP, and the Glossary of IFSC - Palhoça Bilingual Campus as supplementary material. For the conceptual analysis, ten meetings were held between Chemistry and Biology teachers and an interpreter to discuss the existing sign-terms.

Table 1. Terms presented in the Trilingual Illustrated Encyclopedic Dictionary [9]

Materials	Steel, sugar, water, bleach, alcohol, aluminum, air, sand, clay, rubber, ice cube, detergent, diamond, foam, iron, rust, phosphorus, gasoline, ice, magnet, milk, magnet, material, metals, oil, gold, oxygen, steel wool, plastic, powder, silver, soap, salt, glass, vinegar, wine.
Processes/Actions	Abort, absorb, mate, measure temperature, shake, agglomerate, heat, suck, ignite, increase, bathe, bubble, condense, freeze, contaminate, melt, disperse, dissolve, divide, hurt, empty, evaporate, extract, boil, filter, float, chill, drip, incinerate, inject, inhale, measure, measure temperature, quantify, mix, modify, grind, multiply, weigh, research, plan, prepare, breathe, take vaccines, vaccinate, vaporize, volatilize.
Instruments/Equipment	Pump, air pump, dropper, spatula, laboratory, magnifying glass, glove, microscope, glasses, sieve, laboratory technician, thermometer, tube.
Material Properties	Pump, air pump, dropper, spatula, laboratory, magnifying glass, glove, microscope, glasses, sieve, laboratory technician, thermometer, tube.
Human Body	Abdomen, forearm, anus, hearing aid, hearing, biceps, mouth, arm, head, hair, brain, body, back, rib, thigh, skull, finger, stomach, femur, liver, throat, intestine, small intestine, large intestine, knee, larynx, tongue, breast, muscle, nose, nerve, bone, ovary, skin, penis, lung, pupil, blood, nail, urine, uterus, vagina, vein, viscera.
Medicine, Health, and Sexuality	Stroke, AIDS, allergy, cancer, stroke, disease, sexually transmitted disease, patient, pain, drugs, erection, sperm, spermatozoid, fever, yellow fever, leprosy, hemorrhage, helminth, hepatitis, herpes, HIV, influenza, osteoporosis, contraceptive pill, pneumonia, male condom, disease prevention, pus, health, sex, syphilis, tuberculosis, life, virus, vitamin.

Table 2. Analysis of Biology Terminologies in LIBRAS Selected from the BSL Glossary, University of Edinburgh

Terminilogy	Comments
ATP (adenosine triphosphate)	The sign does not refer to the energy transfer that occurs in cells, which is ATP's role. The

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	hand configuration uses the numeral "3" and the letter "S".
Animal cell	The hand configuration used for "animal" is the one used in English. However, it is important to note that in some cases, there is a different sign in each country for the same terminology. For example, the sign for animal used in Brazil is different from the one proposed in the glossary. The sign for "cell" is satisfactory as it refers to the shape of the cell, but there is no hand configuration for the nucleus, encompassing also cells that do not have a nucleus.
Bacteria	The sign suggests the simplicity of bacteria, a unicellular and prokaryotic organism. It also refers to the movement of bacteria and their ability to spread.
Carbohydrate	The sign consists of four different hand configurations: the first configuration is the letter "C," referring to carbohydrate; the second configuration suggests the action of carbohydrate in the body, indicating where it acts; and finally, the last two configurations suggest the sign for "sugar," to facilitate students' understanding, as carbohydrates are sugars.
Cell	The sign for this terminology is satisfactory as it demonstrates the shape of the cell, also considering that there are these units without a nucleus. In some signs created for Biology terminologies, this
	generalization should be considered to avoid creating many signs and the erroneous and limited understanding of the concept.
Cell membrane	The sign expresses the location of the membrane in the cell. First, the hand configuration for "cell" is made, and in another hand configuration, the cell membrane in question is pointed out/shown.
Cell wall	The sign suggests that it is not referring to the first cell membrane (plasma membrane) but points/shows this second membrane, which is the cell wall, expressing the existence of an additional membrane. The facial expression complements the sign to emphasize the presence of "something extra," reminding that not all cells have a cell wall.
Chlorophyll	The sign is satisfactory as it refers to the light absorption performed by chlorophyll, its main function during photosynthesis.
Cytoplasm	The sign consists of the hand configuration referring to "cell," followed by a hand configuration with a movement that refers to the fluid and gelatinous aspect of the cytoplasm.
Chloroplast	The sign emphasizes again the importance of the image in the deaf student's learning as it refers to the structure of the chloroplast, demonstrating that the image is important for the construction of the sign. Additionally, facial expression is essential for the meaning of this sign as it represents the

	development of the "stacked coins" structure of the chloroplast.
DNA	The sign refers to the pairing of nitrogenous bases, and there is no hand configuration referring to the double helix structure of DNA. It is suggested to include the helical movement in this hand configuration presented.
Fertilization	In a clear and objective way, the sign refers to the union between gametes.
Embryo	The sign suggests the cell divisions that occur after fertilization, referring to the process that takes place in the formation of the embryo.
Enzyme	The sign refers to the role of the enzyme in the body: breaking/dividing substances into smaller particles.
Fungus	The sign refers to the spread of something, suggesting a relationship with spores, the reproductive structures of fungi. In the execution of this sign, the lip-reading resource is used, where the movement of the lips represents the oral expression of the word.
Gamete	It is considered that the sign represents the concept well as it refers to female and male gametes separately. It is relevant to note that the creation of signs often relates to the sequence of actions involved in a biological phenomenon. Additionally, the gamete sign refers to the fertilization sign.
Gene	The sign refers to the location of genes in the chromosomes.
Homozygous and Heterozygous	The signs refer to genes, showing the identical pair of genes for homozygous and, in another sign, showing the different pair of genes for heterozygous.
Mitochondria	The sign suggests the arrangement of invaginations inside this organelle, referring to the structure of mitochondria.
Nucleus	The sign refers to the location of this component inside the cell.
Organism	The sign refers to a complete system. The sign starts with open hand configurations and ends with the joining of all fingers, suggesting the representation of a system.
Photosynthesis	Initially, the hand configuration refers to light absorption by the plant and then shows, through the next hand configuration, that the final result of photosynthesis is glucose production, which allows plant growth.
Plant cell	The sign refers to "plant," and the next hand configuration represents "cell."
Ribosome	The sign suggests the structure of this organelle, showing the organization of the two subunits that make up the ribosome.
Vertebrate and Invertebrate	The sign for "vertebrate" refers to the presence of the vertebral column and the movement associated with it. The sign for "invertebrate," once again, refers to the vertebral column, followed by the hand configuration and the facial expression of

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	negation, suggesting the absence of this structure.
Virus	It is suggested that the movement represents the contact between the virus and the surface of a cell.
Zygote	Initially, the sign refers to fertilization and then suggests that there is a "division of something," compared to the first cell division that gives rise to the zygote.

Table 3. Analysis of Chemistry Terminologies in LIBRAS Selected from the BSL Glossary (Scotland) and the Instituto Phala Sign Dictionary (Brazil)

Terminology	Comments – BSL Glossary	Comments – Instituto Phala Sign Dictionary
Atom	The sign consists of a hand configuration showing the electron moving in all directions around the nucleus. It also includes a facial expression with a vibrating lip movement referring to motion. We believe this sign represents the concept more satisfactorily than the Brazilian sign as it highlights the electron's movement in various directions around the nucleus.	The sign is formed by a hand configuration that shows the nucleus and limits the electron's movement around the nucleus with a circular hand configuration, referring to the circular trajectory of the electron.
Electron	The sign refers to the nucleus and the circular movement, demonstrating the location and movement of the electron. The sign can cause confusion with the sign for "atom." We also believe that the sign is limited as it only provides information about the electron's movement.	The sign includes a hand configuration referring to energy, performed at the "neutral space" articulation point with a vibrating movement, symbolizing energy. We agree with this sign as it refers to this subatomic particle in isolation.
Proton	The sign refers to the proton's location in the atomic nucleus and also indicates the electric charge of this subatomic particle.	The sign is limited to showing the proton's electric charge. Since we agree with the electron sign being restricted to the particle without referring to the location, we believe this sign satisfactorily represents the concept of "proton."
Neutron	The sign suggests the identification of the atomic nucleus (location of the particle) in an initial hand configuration and then refers to the zero charge of this particle.	In this sign dictionary, it is possible to see an initial hand configuration of the letter "N" and then a movement referring to the particle entering and exiting the nucleus (location).
Nucleus	The sign consists of a closed hand configuration referring to the circular shape of this atomic region, with a vibrating movement.	No Brazilian sign was found for this concept.
Ion	The sign is limited to the positive and negative signs,	No sign was found in the Instituto Phala sign dictionary;

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	demonstrating the electric charges of ions, cations, and anions, respectively. Therefore, it unifies these two chemical species without further information. It was also found that this glossary did not present signs for cation and anion separately.	however, Sousa and Silveira (2011) suggest a sign for this concept: "left hand in static O shape and right hand in horizontal I shape, palm down, close to the right side of the mouth. Move it around the left hand, shaking it quickly."
Positive Ion	No sign was found for this concept in the referred glossary.	The sign refers to the atom but adds another hand configuration of the letter "I" and then a positive sign.
Negative Ion	No sign was found for this concept in the referred glossary.	The sign refers to the atom, followed by a hand configuration of the letter "I" and a negative sign to demonstrate the electric charge of this chemical species and differentiate it from "positive ion."
Bond	The sign consists of a hand configuration referring to two atoms that join together.	No Brazilian sign was found for this concept.
Liquid	The glossary presented two signs for this terminology. The first suggests a macroscopic view of materials in this physical state, showing the movement and fluidity of liquids.	The sign refers to "water" and then shows a movement that refers to the fluidity characteristic of liquids.
Solid	The sign refers to the regular arrangement of atoms in most materials in the solid state and the smaller intermolecular distance compared to other physical states.	The sign refers to the hardness of materials, a property of solids.
Gaseous	The sign brings an atomic view of the physical state in question, referring to the random movement of particles.	The suggested sign refers to volatility, showing a material dispersing in the air. It is suggested that the intention of the sign is to demonstrate a property that macroscopically characterizes the material.
Molecule	The hand configuration refers to two atoms, two particles that bond together.	No sign was found in the Instituto Phala sign dictionary; however, the IFSC – Campus Palhoça Bilingual presents a sign in its glossary where the hand configuration also suggests the union of particles.
Atomic number	The sign refers to the concept of an atom, first making a hand configuration for "number" and then pointing to the atom, showing the protons in the nucleus.	No Brazilian sign was found for this concept.

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Mass number	The sign refers to the concept of an atom, making a hand configuration for "number" and indicating the atomic nucleus. Therefore, the sign informs that the mass number is the sum of protons and neutrons located in the atom's nucleus.	No Brazilian sign was found for this concept.
Periodic Table	The sign for this concept refers to the horizontal rows and vertical columns into which the periodic table is divided, referring to the periods and groups, respectively. It also refers to the chemical elements that make up the table, demonstrating that each element has unique properties.	As observed in the BSL Glossary sign, this sign also refers to the horizontal rows and vertical columns into which the table is divided, referring to the periods and groups. Subsequently, the Brazilian sign for "Chemistry" is performed.
Chemical reaction	The sign refers to transformation, change, referring to the reactants, substances present before the reaction, and products, substances formed after the reaction.	No Brazilian sign was found for this concept.
Carbon	The sign consists of a hand configuration for the letter "C" and also uses facial expression.	No Brazilian sign was found for this concept.
Hydrogen	No sign was found for this concept in the referred glossary.	The hand configuration in "Y" is performed to represent Chemistry, followed by moving the hands to the side, referring to the Periodic Table's systematic arrangement of chemical elements, where the element hydrogen can be located. Finally, the hand configuration for the letter "H," the initial of the chemical element hydrogen, is made.
Oxygen	The sign refers to the breathing process, showing one of the functions of oxygen gas, whose constituent is the chemical element oxygen. This sign may cause confusion between the chemical element oxygen and oxygen gas.	The hand configuration in "Y" is performed to represent Chemistry, followed by moving the hands to the side, referring to the Periodic Table's systematic arrangement of chemical elements, where the element hydrogen can be located. Finally, the hand configuration for the letter "O," the initial of the chemical element oxygen, is made.
Nitrogen	The sign consists of a hand	No Brazilian sign was found for this concept.

	configuration for the letter "N" and uses facial expression.	
Chemical equation	The hand configuration of the sign refers to the union of substances that produce new substances. The movement of the two joined hands shifting to the side shows transformation, change. It is suggested that the sign for chemical reaction more adequately represents the concept of chemical equation and vice versa.	No Brazilian sign was found for this concept.
Reactant	The sign refers to the substances present before the chemical reaction, with the hand configuration to the right and then a movement of the hands to the left side, suggesting transformation into products.	No Brazilian sign was found for this concept.
Product	The sign refers to the substances produced after the chemical transformation, with the hand configuration to the left and then a movement of the hands to the right side, suggesting the location of the products in the chemical	No Brazilian sign was found for this concept.

	equation.	
Solubility	The sign refers to soluble and insoluble, then a hand configuration for alternative, possibility, as a material can be soluble or not, depending on the other material. Facial expression is important in this concept as it refers to the dissolution of something in "soluble" and negative in "insoluble."	No Brazilian sign was found for this concept.
Soluble	Facial expression is fundamental in this sign as it refers to dissolution, and the hand configuration refers to some material that dissolves, breaks down.	No Brazilian sign was found for this concept.
Insoluble	Again, facial expression is fundamental in this sign as it shows a negative, meaning "insoluble" material is that which does not dissolve. The hand configuration refers to some material that dissolves, but then the negative is expressed in the facial expression.	No Brazilian sign was found for this concept.
Solute	In this sign, the facial expression is	No Brazilian sign was found for this concept.

	practically neutral, but the movement of the hands shows the dissolution of the material.	
Solvent	The sign refers to a liquid.	No Brazilian sign was found for this concept.
Solution	The sign refers to solute and then a hand configuration referring to "mixture."	No Brazilian sign was found for this concept.

After completing this investigative research of terminologies, given the lack of specific signs for these disciplines, the project proceeded to its second stage through the construction of the scope of signs. This stage continues with a team of teachers from the addressed areas, an interpreter, and a deaf Libras teacher; as collaborators, an undergraduate student in Literature: Libras (Federal University of Goiás - Goiânia Campus) participated in discussions about the created signs and the subsequent production of videos with the assistance of students from the Bachelor of Cinema and Audiovisual and the Technical Integrated to High School in Audio and Video Production (Federal Institute of Goiás - City of Goiás Campus).

With the inclusion policy, the presence of deaf students at various levels of education has become increasingly frequent. This reality imposes on the educational system the development of methodologies and tools that enable and achieve the inclusion of these students in the teaching-learning process. Providing adequately designed audiovisual materials is a way for deaf individuals to have discursive and critical autonomy in this process [28].

The project's objective is to construct audiovisual materials of selected sign-terms in Biology and Chemistry (atom, atomic models of Dalton, Thomson, Rutherford, and Bohr, homogeneous and heterogeneous materials, prokaryotic and eukaryotic cells, asexual and sexual reproduction, autotrophic and heterotrophic nutrition) as learning objects in deaf education. According to Rocha (2012) [29], the presentation of curricular content through images has become an increasing necessity in pedagogical practice. Our society is not prepared to accommodate deaf individuals, not providing conditions for them to develop and consolidate their language. Thus, we can dismiss claims that deafness causes cognitive and affective limitations, as the true limitation lies in the conditions offered to this deaf individual [12]. Therefore, sign language should be present not only among school agents but also in the materials produced to allow deaf individuals access to the world of knowledge.

2. Methodology / Didactic-pedagogical path

This research aims to contribute to the creation of new Libras signs through audiovisual material, given the difficulties already found in previous research, the scarcity or absence of visual signs for Biology and Chemistry.

Meetings with the working team were held where concepts commonly used in teaching these disciplines were selected by teachers from these areas of knowledge. They were: atom, atomic models of Dalton, Thomson, Rutherford, and Bohr, homogeneous and heterogeneous materials, prokaryotic and eukaryotic cells, asexual and sexual reproduction, autotrophic and heterotrophic nutrition. The choice of these terms is justified as they are basic concepts used in studying these sciences and were not found in the sign language dictionaries consulted during the project's previous stage (Illustrated Trilingual Encyclopedic Dictionary of Brazilian Sign Language, BSL Glossary provided by the Scottish Sensory Centre of the University of Edinburgh, the sign language dictionary of the Phala Institute - Center for Deaf Development, and the Glossary of IFSC - Palhoça Bilingual Campus).

To facilitate the construction of these signs, participants discussed chemical and biological concepts with the teachers of the specific areas, using images and summaries of the content for the creation of Libras signs.

The videos were produced at the Digital Production Center (NPD) located at IFG/Campus City of Goiás by a Bachelor of Cinema and Audiovisual student with the participation of the project's interpreter and other team members. The videos were edited following standardization and scientific rigor;

captions related to the concept addressed and images as non-verbal elements were added.

The images or figures that refer to the concept of the term presented facilitate the deaf person's understanding when watching the video. If the deaf person is defined as a visual subject [34], we can affirm that it is through visuality that academic knowledge would be more easily acquired in deaf education.

These results are partial as the research will continue to be developed to create new signs. The publication of the videos will be requested on the website of the Federal Institute of Education, Science, and Technology/IFG/City of Goiás for access by interested parties (teachers and students) and sharing.

3. Results and discussion

There is support in Brazilian legislation for including students with Special Educational Needs (SEN) in public and private schools. Among the normative instruments, the following can be highlighted: (1) Federal Constitution of Brazil, Art. 206, item I, and Art. 208; (2) Law of Guidelines and Bases of National Education (LDB), No. 9.394/1996, Arts. 58, 59, and 60; (3) National Education Plan (PNE) 2001/2010, goals 2 and 5; (4) National Guidelines for Special Education in Basic Education; (5) Law No. 10.436/2002, which recognizes Brazilian Sign Language as a legal means of communication and expression, regulated by Decree No. 5.626/2005 [2-7]. The increase in deaf students in Basic Education courses is a consequence of the existing inclusion policies. However, there is a need to broaden discussions about the methodological procedures for developing and consolidating Libras signs for scientific and technological areas, especially in Chemistry and Biology.

According to Moraes and colleagues (2004) [26], individuals who have hearing impairments have the same linguistic capacity as hearing individuals. Therefore, we must provide the necessary conditions for deaf students to have access to the world of science. Thus, the present research aimed to conduct a conceptual analysis of existing signs/terms involving the scientific language of Chemistry and Biology and to verify if the created signs allow for quality in the interpretation and understanding of scientific concepts. The deaf teacher conducted conceptual analysis and verification of the created signs' quality and understanding through discussion and evaluation of images and content presented by the teachers. The first stage of the project enabled the creation of signs that were verified by the deaf teacher and validated by the team of teachers and the interpreter. Subsequently, the video production allowed the dissemination of these terms. The work developed aimed at promoting inclusive practices within the educational context, contributing to the learning and autonomy of deaf students in the Basic Education network.

4. Conclusions

The project presents a significant contribution to the teaching of deaf students, considering the creation of signs in Libras for the terms used in the disciplines of Biology and Chemistry and the production of audiovisual material to disseminate these signs. This initiative represents a step forward in inclusive educational practices, allowing access to scientific knowledge in an accessible and meaningful way for deaf students.

Through the project, it was possible to identify gaps in existing sign language dictionaries and propose new signs that were conceptualized and validated through a rigorous process involving teachers from specific areas, interpreters, and a deaf teacher. The production and dissemination of videos ensure that these terms reach a broader audience, facilitating the teaching and learning process.

The work will continue, aiming at the creation of new signs and the continuous improvement of existing ones, contributing to the linguistic and academic development of deaf students and fostering their inclusion in the educational system. The project's outcome contributes to a more inclusive and equitable education, highlighting the importance of collaboration between different professionals and the use of audiovisual resources to overcome language barriers and promote knowledge sharing.

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Lively and Exciting Hand-Made Experiments – Electromagnetic Wave

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Abstract. I introduce hand-made experiments focusing on electromagnetic waves and discuss how they can make Physics classes fun and meaningful. There are three perspectives to create enjoyable and essential lessons on electromagnetic waves. The first perspective is that the black box nature of products and equipment for electromagnetic wave experiment make it difficult to see the principle of electromagnetic wave. One solution is to go back to the experiments at the beginning of the discovery. The second perspective is creating an image of the changing electric and magnetic fields. Experiments that reveal how changes in electric and magnetic fields convey information and how they can be detected are desirable. The final perspective is to make students aware of how they themselves are surrounded by and live with electromagnetic waves.

Keywords. Simple and Essential Experiments, Hand-Made Experiments, Electromagnetic Wave.

1. Introduction

In the past HSci Conferences I showed some simple and essential hand-made experiments in Mechanics, Electromagnetics, Wave and Sound we (Stray Cats group) invented [1-3] and discussed their roles they play in enjoyable and fruitful Physics classes [4-7] Following to these presentations I introduce here some experiments in the field of electromagnetic wave and discuss roles they play in classes and students' activities.

In recent years, we are surrounded by various electromagnetic waves, including light, in which we live. Therefore, education on electromagnetic waves is very important. However, the educational content is not well developed because electromagnetic waves are a difficult concept at the elementary and secondary education levels and experiments are difficult to conduct. Here I propose three perspectives and examples of hand-made experiments to solve these problems and create fun and essential classes on electromagnetic waves.

2. Eliminate the black box

The reason why electromagnetic waves become more difficult is that products and experimental equipment that we use in daily life or in the laboratory are black-boxed. The first perspective is how to eliminate the black boxes that make the phenomena less visible. One solution is to go back to the experiments when they were first discovered. The Hertz's experiment is the most principled and easy-to-understand experiment to uncover the true nature of electromagnetic waves. Students can create an image of a changing electric and magnetic fields that are induced each other and transmitted in the space.

2.1. Hertz's Experiment

Hertz's experiment is a historical experiment in which Hertz proved the existence of electromagnetic wave predicted by Maxwell in 1888. Hertz generated electromagnetic wave by creating intermittent electrical discharges between the gap between the metal spheres of the apparatus shown in Fig. 1. The copper wires connecting to the two metal spheres act as a coil, and the metal plates on both wings act as a capacitor, creating electromagnetic waves through LC resonance between them. The magnetic field created by the coil forms concentric circles around the copper wire. Therefore, the magnetic field of the electromagnetic wave transmitted in the foreground is perpendicular to the copper wire, as shown in Fig. 1.

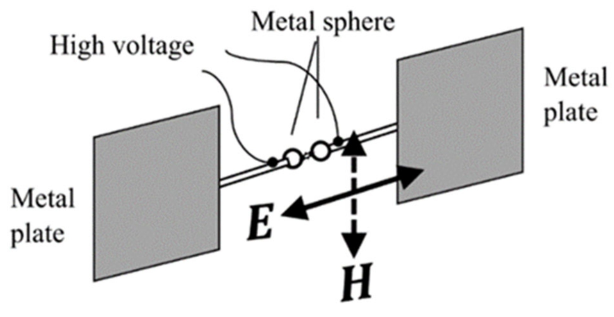

Figure 1. Transmitter of hand-made Hertz's experiment. Electric field is horizontal and magnetic field is vertical

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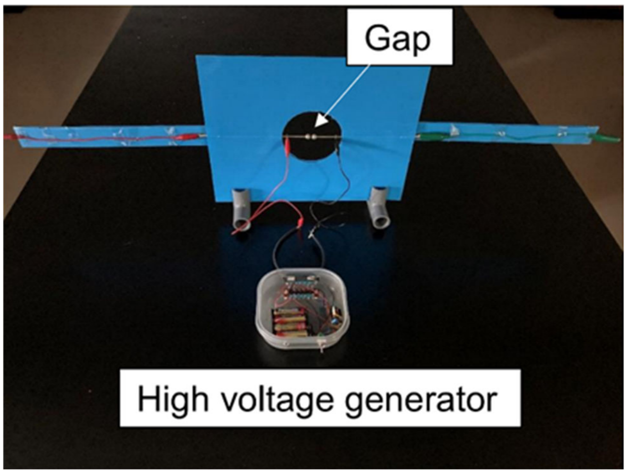

Figure 2. Transmitter of hand-made Hertz's experiment

On the other hand, the electric field produced by the capacitor appears to connect the metal plates. Therefore, for the electromagnetic wave propagating in the foreground, the electric field is oriented parallel to the copper wire as shown in Fig. 1.

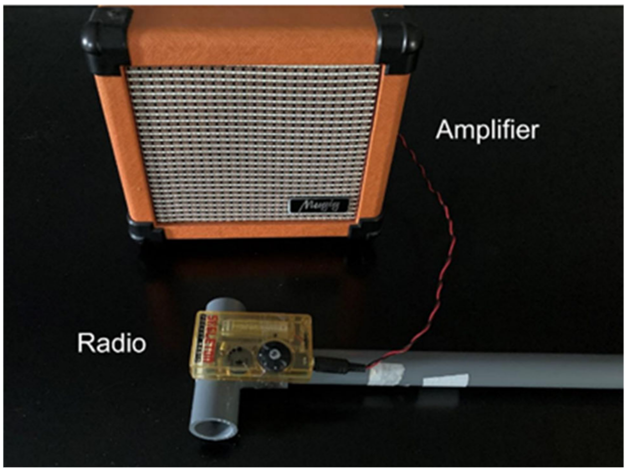

Figure 3. Receiver of hand-made Hertz's experiment

Fig. 2 shows a hand-made electromagnetic wave transmitter for Hertz's experiment. A Cockcroft-Walton circuit with low current was used as the high-voltage generator. As an induction coil also can be used and generates more current and stronger electromagnetic waves, care must be taken because it may cause radio interference in the surroundings. Metal plates are attached to both wings. The size of the metal plate changes the value of C, so the wavelength of the electromagnetic waves can be changed.

One of the ways to show that this is an electromagnetic wave is to show that it creates a stationary wave. A blackboard with iron inside can be used as a reflector of the electromagnetic wave. On the reflector, the magnetic field is theoretically zero because it becomes the node of the stationary wave. The magnetic field weakens with each half wavelength away from the blackboard. Moving a detector, such as a radio (Fig. 3), will show the change of the strength of the signal, The approximate wavelength can be calculated by measuring the distance between neighboring nodes.

3. Create image of changing Electric and Magnetic fields

It is the electric and magnetic fields that form electromagnetic waves, but since neither can be seen, students have only a vague idea of what they are. The second perspective is how to make students realize that the electric and magnetic fields that are the medium of electromagnetic waves are indeed present in space.

For example, in the experiment of static electricity using Van de Graaff, students can realize the electric field when objects are pulled strongly by electrostatic induction. However, since it is a strong electrostatic field using high voltage, it gives a special impression when they learn about an electromagnetic wave. Therefore, we came up with a method to detect even small electric and magnetic fields. That is the electric field and magnetic field communication described below.

3.1. Electric field communication

Fig. 4 is an overview of electric field communication. An electrical signal from a radio is connected to a transformer with 50 turns on the primary and 25,000 turns on the secondary. If the loss is negligible, the voltage is multiplied by a factor of 500, and a signal with an amplitude of 10 V, for an example, can be extracted as a 5,000 V signal. Connect this output to two leads about 2 m apart in the air, and there should be an electric field between the two leads that varies with the electrical signal. If this electric field is picked up at two points, the signal can be caught by the potential difference between them. If you amplify the signal with an amplifier, you will hear the audio signal coming from the original radio, and you can also examine the

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electric field because the sound volume will change depending on the position of the two points.

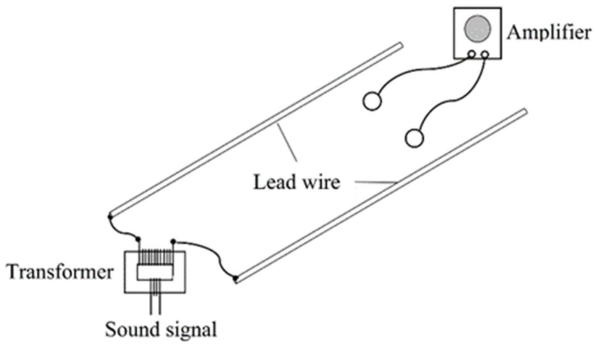

Figure 4. Experiment of Electric field communication

3.2. Magnetic field communication

Magnetic field communication has already been presented at HSci 2018 [6]. Magnetic field communication also uses electrical signal from the radio. This time, however, the audio current from a radio is passed through a huge coil (primary coil) of several meters in diameter and about 20 turs to create a magnetic field in space. This magnetic field is caught by another coil (secondary coil) with about 20 turns and connected to an amplifier to reproduce the sound of the original radio. By changing the direction of the secondary coil and examining the loudness of the sound, the direction of the magnetic field can be determined. By changing the position of the secondary coil, the magnetic field in the space can be examined.

4. Make students aware electromagnetic waves surrounding them

The final perspective is to make students aware of how they themselves are surrounded by and live with electromagnetic waves. The simpler the experiment, the stronger the impression on them. For example, a primitive experiment like a germanium radio. Electromagnetic wave detection experiments using Schottky diodes are also useful to understand how they live surrounded by electromagnetic waves.

4.1. Germanium radio

Germanium radio is the simplest receiver available. The circuit diagram is shown in Fig. 5. It consists of only a diode, coil, capacitor, lead wires, and earphone. It is the best device to demonstrate the mechanism of radio because of its simple mechanism. An antenna that captures electromagnetic wave traveling through space uses either a long lead wire or a coil. A lead wire is used to detect the electric field of electromagnetic waves, while a coil detects the magnetic field of electromagnetic wave. In the case of electric field detection, the reception strength will be strongest if a stationary wave is generated at the antenna. Next is a tuning circuit that extracts only the electrical signals of a specific frequency from the received electrical signals of various frequencies. For this, an LC circuit with a coil and a capacitor is used. If the self-inductance of the coil is L and the capacitance of the capacitor is C, the resonant frequency can be expressed by the following equation:

$$f = \frac{1}{2\pi\sqrt{LC}}$$

The resonant frequency can be changed by varying the magnitude of L or C. Most radios vary the resonant frequency by varying the value of C. The electrical signal selected by the LC circuit is sent to a diode. After being rectified by the diode and only the audio signal is extracted, it is sent to the earphone and converted into sound waves.

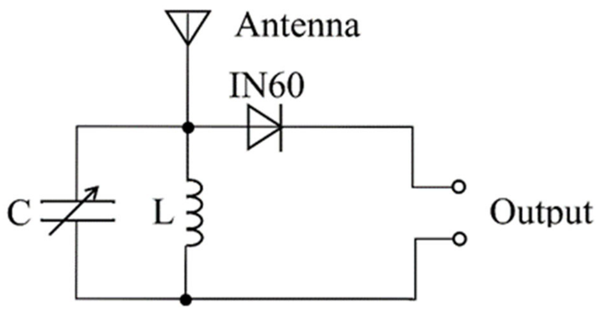

Figure 5. Circuit diagram of a germanium radio

Fig. 6 shows a germanium radio made by using materials around us. Schottky germanium diode IN60 is used in the circuit. The capacitor is made by placing plastic wrap on aluminum foil and placing a metal pot on it. Tuning is done by holding the handle of the pot and moving it horizontally to change the capacitance of the capacitor. Students are amazed at how sound flows from the earphones with such a simple circuit.

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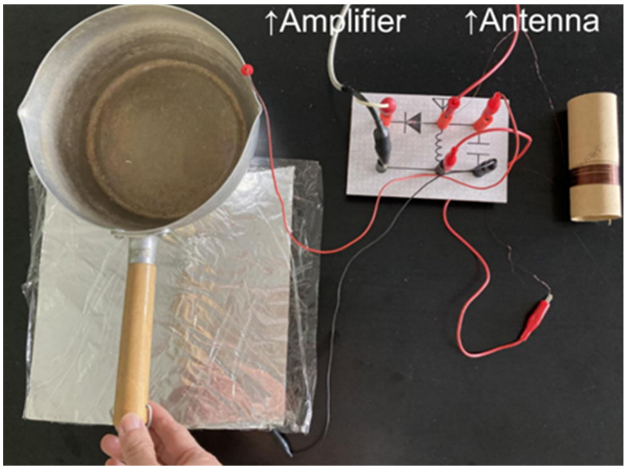

Figure 6. Hand-made germanium radio. Metal pot and aluminum foil are used as electrodes of the capacitor

4.2. Simple electromagnetic wave detector

With a Schottky diode, it is easy to examine electromagnetic waves around us. As in Fig. 7, amplify the signal detected by the Schottky diode by an operational amplifier. By displaying the output on a high-sensitivity ammeter we can determine the strength of the electromagnetic waves. By conducting radio wave detection experiments using this equipment in various locations, such as near microwave ovens, cellular phones and radio towers, students learn how they are surrounded by electromagnetic waves in their daily lives.

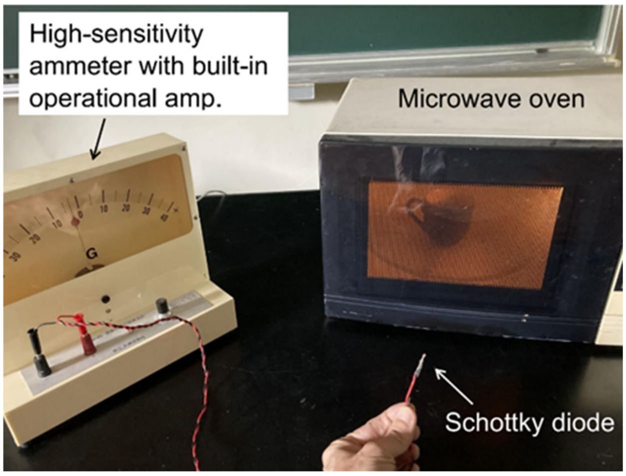

Figure 7. Experiment of detecting electromagnetic wave

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Sustainable Bazaar: Applying Mathematics to Minimize Environmental Impact in Fashion Production

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Abstract. The growing concern about the environmental impact of the fashion industry led to the creation of this "Sustainable Bazaar" project. With the aim of demonstrating how mathematics can be applied to minimize environmental impact. The netnography method is being applied, which is based on searching for information on the internet to collect data, through the use of TDICs and mathematical modeling. The experience involves 40 high school students from the public school system in Uberlândia-MG. In summary, this experience report describes the application of mathematical models to make the bazaar more efficient and sustainable.

Keywords. Environment and TDICs, Basic Education, Mathematical Models.

1. Introduction

Mathematics is not always well accepted by students because they do not understand its application and use in their daily lives, causing a distancing and lack of interest in the subject. However, mathematical modeling is used to approximate the learner to a real situation through models.

Modeling, the art of modeling, is a process that emerges from reason itself and participates in our lives as a form of constitution and expression of knowledge [1]. With this comes the need to find a theme that is solid to interact subject and content.

A very comprehensive topic of fashion & waste, as with a wide variety of clothing models that appear every year, the problem arises: How to minimize the waste generated in clothing production? One possibility to try to minimize the effects caused by the waste we discard would be the creation of a national program to raise awareness among people about preserving the environment.

To achieve this, mathematical modeling is used as a teaching-learning strategy to produce a model that approximates the object of study in which the Information Processing content is covered. Thus, through the use of digital information and communication technologies, its inclusion in the classroom has become essential, according to. "TDICs also encompass a more advanced technology: digital. Through this, it is possible to process any information, which has caused radical changes in people's lives, especially with regard to instant communication and the search for information [2].

With this, the teaching and learning of mathematics is enhanced with the use of TDICs as a means of student engagement to develop the mathematical model. TDIC is being used as a teaching tool to assist communication between teacher and student, through digital platforms being manipulated by computers and smartphones: WhatsApp, Google Form and other applications.

Thus, this research is based on netnography, which is a method or technique "used in studies that involve the internet in relation to the approach to the object of study [3]. Thus, we use the Internet to help collect research data in the field of work, whether in face-to-face or online meetings with teams, communicating and producing content through TDIC to build knowledge.

Therefore, the purpose of this experience report is to create mathematical models that contribute to reducing the environmental impact caused by the waste we produce daily through textile production in high school.

2. Activities carried out

The 2024 Scientific Initiation project of a State High School in Minas Gerais, in the Fair model, with the central theme: "Construction of a Full Democracy: Collective Solutions for Collective Problems", leaving free participation for teachers and students. To make the teaching-learning of mathematics more interesting, we propose the subtheme: "Mathematics and sustainability involving the production of clothes, shoes and accessories". To develop the activities carried out, students registered via institutional email (@student) via Google Form, each team will be formed by a

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group of 5 students, and may later become a group of 10 students.

The planning of activities is divided into meetings:

- 1st Meeting: In this first moment we organize the groups by merging 5 members to 10 participants, we create the WhatsApp group as a means of communication. Then, we started the discussion on the subtopic: "Mathematics and sustainability", and the students decided to hold a sustainable bazaar to minimize the environmental impact.
- 2nd Meeting: It takes place with the aim of distributing tasks among the group members, so the following activities were listed:
    1. Implementation of the Bazaar; Create informative materials to educate visitors about the importance of sustainability and how the bazaar contributes to reducing environmental impact by relating it to the 5Rs of Sustainability - Reduce, Reuse, Recycle, Rethink and Refuse. In this awareness campaign, a group will be responsible for creating the layout of the bazaar containing information for planning and preparation.
    2. Demand and Supply Analysis; In this item, mathematical models will be used to estimate the quantity of items collected, designated values and the appropriate space for the bazaar.

- 3rd Meeting: It will take place for "Space Optimization" with the aim of arranging the environment by categories (clothes, shoes and accessories) to give visibility to the products, arousing public interest.

In this context, "Waste Management" will be discussed, what to do with leftovers for recycling and reusing non-exchanged items. This way, students can reach a consensus on where the waste will be sent, such as settlements, churches or NGOs to help those most in need.

- 4th Meeting: At this point we return to the theme: Mathematics & Sustainability to create a mathematical model to: teach the content of information processing, statistics, tables; Graphics: simple columns, simple bars, circulars being developed in high school. Providing students with the ability to understand the notions of magnitudes and measurements of reality and in solving everyday problem situations and the ability to abstract information into graphical representations and tables, in different contexts.

Mathematics is often interpreted as difficult and decontextualized by society because they are unable to associate its applicability in everyday life, with this emerging mathematical modeling to interact between contents through models with other areas of knowledge.

3. Conclusion

The analysis of the results indicates that the "Sustainable Bazaar" will be successful, even the project in development, from 08/07/2024 to 11/30/2024 in several aspects. In the first stage, students were engaged through the use of TDICs, to register online, communicate via WhatsApp and create a layout containing information to raise awareness among those involved and participants.

In the second and third moments, students will seek scientific support on: fashion, sustainability and waste generated and the application of mathematics to reduce environmental impact, showing that mathematics is present everywhere. Thus, it extracts the data to create a model that meets the content of the mathematics subject by interacting with other areas of knowledge to achieve changes in our attitudes.

In the fourth moment we will have activities developed that will result in mathematical models to assist the understanding and construction of knowledge within statistics, encompassing the arithmetic mean, the median and the mode, making the content more interesting for the student, bringing it closer to reality.

In summary, I leave this report of the "Sustainable Bazaar" project demonstrating that the application of mathematical concepts can effectively contribute to sustainability in fashion and as an anchor for other teachers to be interested in mathematical modeling and the use of TDICs, giving meaning to teaching mathematics learning with the engagement of students and teachers.

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Games in Ecology Teaching: A Documentary Review of the REnBio Journal

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Abstract. This article is derived from a dissertation submitted to the Postgraduate Program in Science Education at the University of Brasília (PPGEduC-UnB). The study utilized qualitative research methods through documentary analysis, grounded in Content Analysis. The primary data source was the *Journal of Biology Education* (REnBio). A total of 15 articles addressing the use of games in ecology education were analyzed. The predominant content covered ecological relationships, biomes, population dynamics and equilibrium, food chains and webs, as well as the relationship between humans and the environment. The majority of the games identified were analog, with a notable emphasis on board games, dice, cards, and quizzes.

Keywords. Ecology, Game Design, Games in Ecology Education, Ludic, Science.

1. Introduction

This article presents an analysis of games addressing ecology content, as published in *REnBio*, the journal of the Brazilian Association for Biology Education (SBEnBio). To achieve this, we explore key pedagogical approaches that integrate games into education, along with a classification of games based on their educational applications.

The primary objective is to analyze the games published in *REnBio* from 2005 to 2022, providing a comprehensive overview of the role of games in ecology education during this period. This analysis is warranted by the need to update the understanding of various educational approaches to teaching ecology, which is relevant not only to educational researchers but also to classroom teachers.

The specific objectives, derived from the general objective, are as follows:

- Conduct a survey of games utilized in ecology education as published in *REnBio*;
- Identify the ecology content addressed by these games;
- Analyze the typology, mechanics, components, and production of the ecology games featured in *REnBio*.

2. Theoretical basis

Ecology is the science dedicated to the study of interactions that determine the distribution, geographic location and abundance of organisms [4]. These variables studied impact living conditions and biodiversity in various ecosystems, as well as human life itself. Therefore, knowledge of ecology is fundamental not only for understanding the phenomenon of life, but also for ensuring a sustainable future for future generations [1].

Given such relevance, it is necessary that significant learning of such concepts occurs, in which the new concepts learned correlate with the previous ones of the student's cognitive structure in a substantive and relevant way [11].

Active teaching methodologies, especially playful ones, stimulate imagination, fantasy, analysis, problem-solving skills and, in some cases, teamwork. One of the most important forms of play is games, which have already been discussed by pedagogical theorists.

For Vygotsky, the game is characterized by an imaginary situation and rules, in which the child uses elements from the environment that surrounds him/her in a fantasy and challenging situation to be overcome, promoting the development of the zone of proximal development through interaction with adults and other children, developing their abilities and internalizing social rules [14].

In turn, Piaget states that learning would begin with sensorimotor games, in which after assimilating a certain movement, the child would repeat that movement for the simple pleasure of repetition, which Piaget classifies as pure assimilation, without accommodation, that is, the synthesis of new knowledge with the previous knowledge of the cognitive subject. As the child grows, such ritualization begins to be associated with imaginary situations in symbolic games, in which the child begins to abstract and attribute meanings to acts and objects, arriving at abstract games of rules [12].

Although Piaget stated that play is pure assimilation, that is, an autotelic act, we affirm that, through analogy, play can indeed generate accommodation and balancing of new concepts to the student's cognitive structure [5].

Games are classified in a taxonomy that divides them into games stricto sensu, in which their purpose is the game itself; and educational games, those in which there is a certain amount of teaching. Educational games are divided into informal, when the teaching intention is accidental, and formal when such intention is intentional. In turn, formal educational games are divided into didactic, when the game is an adaptation of a pre-existing one, and pedagogical when they are new [6].

After such exposition, we characterize the present research below.

3. Materials and methods

The research described in this article is qualitative in nature and is classified as documentary analysis. We examined studies that utilized games to address ecology content, as published in *REnBio*, the journal of the Brazilian Association for Biology Education (SBEnBio). This journal was selected due to its broad scope and national recognition, including its Qualis A1 classification by the Coordination for the Improvement of Higher Education Personnel (CAPES) during the 2017-2020 evaluation period.

The studies were gathered through a two-stage process. In the first stage, we identified relevant works by searching for the following terms in their titles: "game," "ludic," "didactic," "pedagogical," and "educational." After this initial survey, we reviewed the abstracts and selected studies that addressed the use of games in ecology education. The research spanned *REnBio* publications from 2005 to 2022, yielding 103 works, of which 15 specifically focused on ecological themes through the use of games. These articles were found in the editions that included the proceedings of the National Meeting on Biology Education (ENEBIO) from the years 2010, 2012, 2014, and 2016.

The data analysis methodology employed was Bardin's Content Analysis [2]. A vertical analysis was conducted to examine the content addressed and the game elements, while a horizontal analysis was performed to evaluate the prevalence of these games in relation to the total number of articles analyzed.

The analyzed works were identified using alphanumeric codes, as shown in Table 1 below, where "JE" stands for "jogos em ecologia" (games in ecology):

Table 1. Ecology games at REnBio

Code	Article
JE01	Rêgo, S.S. *et al*. O aprendizado de conceitos de ciências através do lúdico: o uso do dominó. Revista da SBEnBio-REnBio, n. 3, p. 3290, 2010.
JE02	Valois, R.S. *et al*. Trilhando conhecimento ecológico: Proposta de uma atividade lúdica de ecologia. Revista da SBEnBio-REnBio, n. 3, p. 3930, 2010.
JE03	Vidal, F.L.K. Cadeia alimentar e equilíbrio populacional abordados por meio de jogo e gráficos. Revista da SBEnBio-REnBio, n. 3, p. 2281, 2010.
JE04	Miyazawa, F.M.; Ursi, S. Avaliação da aprendizagem de conceitos ecológicos a partir da sequência didática "biomas brasileiros". Revista da SBEnBio-REnBio, n. 3, p. 3151, 2010.
JE05	Liaño, G.A.; Buarque De Gusmão, G.A.S. "Desvendando um ecossistema - interações, interferências e suas consequências: uma proposta didática para o ensino de ciências". Revista da SBEnBio-REnBio, n. 3, p. 3442, 2010.
JE06	Junior, A.F. N. *et al*. O lúdico e a prática pedagógica: o caso da produção de um jogo de trilha sobre a organização social de uma colmeia de apis mellifera. Revista da SBEnBio-REnBio, n. 5, 2012.
JE07	Rosa, R.M. *et al*. Elaboração de um jogo didático a partir de uma proposta da disciplina de biologia de populações do curso de biologia da universidade federal de lavras. Revista da SBEnBio-REnBio, n. 5, 2012.
JE08	Oloco de Oliveira, L.A. *et al*. Jogos didáticos: uma proposta do uso do lúdico no ensino de ecologia. Revista da SBEnBio-REnBio, n. 5, 2012.
JE09	Gomes, L.R.; Rocha, D.P; Oliveira, A.B.C. proposta de jogo didático: "caminhos da ecologia". Revista da SBEnBio-REnBio, n. 7, 2014. P. 4845-4852.

JE10	Gallão, M.I. *et al*. Biomas: estudo através de jogo didático. Revista da SBEnBio-REnBio, n. 7, 2014. P. 213-223.
JE11	Neves, M.L.R.C.; Soares, N.R. O jogo como estratégia pedagógica na construção de conceitos em ecologia no ensino médio. Revista da SBEnBio-REnBio, n. 7, 2014. P. 6030-6041.
JE12	Silva, N.C.M. *et al*. Proposta de um jogo de tabuleiro sobre o tema fundamentos da ecologia para ensino médio. Revista da SBEnBio-REnBio, n. 7, 2014. P. 5893-5900.
JE13	Machado, R.F. *et al*. Aplicação do jogo eletrônico calangos no ensino do conceito de nicho ecológico. Revista da SBEnBio-REnBio, n. 7, 2014. P. 6588-6598.
JE14	Silva, J.B.; Vallim, M.A. Conscientização ecológica através de um jogo didático sobre os biomas brasileiros. Revista da SBEnBio-REnBio, n. 7, 2014. P. 4308-4318.
JE15	Nogueira, T.G.; Silva, J.R.F.; Sousa, E.T. O lúdico contribuindo para a compreensão do tema “água” nas aulas de ciências: relato da criação de um jogo. Revista da SBEnBio-REnBio, n. 9, 2016. P. 3435-3442.

Following this characterization of the research, we proceed with the analysis of the games featured in the collected works.

4. Analysis of results

Considering the ecological content and concepts addressed in the games presented in the collected works, we created a graph illustrating the frequency of these occurrences, as detailed in Table 2 below.

Below, we discuss the games, along with their components, mechanics, materials, and the ways in which they addressed the ecological content and concepts highlighted above. This analysis is based on the aforementioned game framework, as well as insights from authors specializing in game design and playfulness in education.

Most of the games analyzed are competitive and rule-based, classifying them as *agon-alea* types, which also fall within the *ludus* spectrum, according to Caillois' typology [3]. The *alea* aspect in these games is manifested through mechanics categorized under the "uncertainty" genre [8], such as dice rolling, flipped cards, or hidden clues. Only one work (JE03) demonstrates an intersection of *mimicry* and *ilynx* within the *paidia* aspect. JE05 and JE08 deviate from this competitive nature, being more cooperative in design. JE05 aligns more closely with the *ludus* spectrum and the *mimicry* typology due to its element of personification. JE13 combines *agon* and *mimicry* from a *ludus* perspective, featuring a solitaire game in which the player competes against the game itself.

Table 2. Concepts covered in the analyzed works

Concepts	Occurrences
Ecological relationships	7
Biomes	6
Population/population balance	4
Food chain and food web	3
Human beings and the environment	3
Ecological community	2
Fundamentals of ecology	2
Matter and biogeochemical cycles	2
Ecological niche	2
Ecosystems	1
Biotic and abiotic factors	1
Energy flow	1
Ecological succession	1

In accordance with the taxonomy proposed by Cleophas, Cavalcanti, and Soares [6], nearly all of the ecology games analyzed are classified as formal educational didactic games, as they were designed with explicit educational objectives and were adaptations of pre-existing games. The exception is JE13, which is categorized as a formal educational pedagogical game, as it shows no indication of inspiration from pre-existing games.

Almost all of the games utilized printed components, a method that offers several advantages, including versatility, malleability, convenience, and low cost. The materials used, such as paper, ink, glue, scissors, printers, and personal computers, along with various software programs like Office, Google Draw, and Adobe Photoshop, contributed to the development of the games' components [7].

The analysis of the surveyed games was grounded in Schell's tetrad [13], which outlines the main aspects of games, encompassing their material, procedural, and subjective elements:

(1) technology, (2) aesthetics, (3) narrative, and (4) mechanics. Technology refers to the materials used, whether paper, wood, metal, software, or hardware. It supports aesthetics, which encompass the appearance and style of the game's components, enhancing player immersion and optimizing the gameplay experience. Mechanics are the rules that dictate what actions are permissible, how they can be executed, and the conditions for victory. The narrative provides the storyline that underpins the game and its progression. Finally, the game's theme ties these elements together, ensuring coherence within the tetrad, particularly in formal educational games, where the theme typically aligns with the educational concepts being addressed.

Among the games analyzed, five (JE02, JE06, JE07, JE09, JE12) included the following components: board, cards, dice, pawns, and quiz elements. The gameplay involved a race in which players moved pawns based on dice rolls. Along the course, special spaces prompted the drawing of cards containing instructions, trivia, or questions. This format closely resembles the game *Perfil* (1988), the Brazilian version of *20 Questions*, created by Scott A. Mednick and Alva Robert Moog. *Perfil* achieved notable success in the Brazilian market, reaching its seventh edition by 2022. These games belong to the Family Mass Market Games category [15] and are competitive with fixed turns [8].

Three of the surveyed games (JE04, JE11, JE15) were card-based, with the primary mechanic being set formation [8], inspired by the *pif-paf* card game, also known by various names such as *cacheta* and *pife*. In these games, players aim to form sets of three cards.

In JE10 and JE14, the main components were a board, cards, and quiz elements. JE10 featured an adaptation of the Biomes Game available on the Experimentoteca website of the University of São Paulo [16]. In this game, players assumed the roles of prominent biologists and collected biome-related clues on cards, which contained information about flora, fauna, and other environmental features. The game bears similarities to *Scotland Yard* (1975), a game of investigation and deduction created by Jay Moriarty. JE10 employed paper-based technology, with worker allocation and paper-and-pen mechanics, making it a competitive game with fixed turns [8]. All components were printed.

In JE14, the game used 40kg paper and EVA foam to create a map-shaped board representing the geographic distribution of Brazilian biomes. Cards with questions and descriptions, along with markers, were used to identify the biomes. The objective was to place the most markers in the correct biome based on the descriptions or questions provided.

JE01 featured a dominoes-style game, a classic according to Woods [15]. The primary mechanic was tile placement [8, 15], allowing students to practice analysis and correlation of content. The game focused on general ecology without emphasizing specific concepts.

JE03 employed a traditional game of tag [9], in which students were marked with colors representing producers, herbivores, and carnivores. This team-based game used real-time action mechanics, with no turns [8]. Categorized as *agon* and *ilynx*, this game falls within the *paidia* spectrum due to its somatic and spontaneous nature. It addressed ecological relationships, food chains, and population balance.

JE05 involved a dynamic simulation and quiz, similar to the friendship web activity, where participants connected strings to represent ecosystems, communities, and food webs. The game addressed various ecological concepts, including anthropic impacts and biotic and abiotic factors. It is categorized under *mimicry* within the *ludus* spectrum and is a cooperative, turn-based game [8].

JE08 reported two games: the Quatis Game, which used paper-and-pen mechanics [8] to create food web representations on a board, and a second game involving painted boxes with organism images that students grouped based on ecological interactions. These cooperative games employed real-time actions [8] and focused on *mimicry* and *ludus* within the Caillois classification [3].

JE13 featured a digital game, the Calangos Game [17], a simulation of a Hutchinsonian ecological niche. Players controlled lizards from the Caatinga biome, attempting to keep them alive as long as possible. The game, a solitary experience with real-time action [8], fits into the *ludus* and *mimicry* categories [3].

In conclusion, the prevalence of analog games, mostly printed by the authors, is evident, with a significant number of games resembling *Perfil*. All aspects of the game framework proposed by Caillois [3] were identified, with a notable emphasis on the *ludus* spectrum, particularly in the *agon* and *alea* categories. However, the variety of game mechanics was limited, with most games being adaptations of pre-existing ones, classifying them as formal educational didactic games. Regarding content, nearly all of the minimum concepts proposed by Cherret [10] were covered. The emergence of digital games aimed at teaching ecology represents a necessary update for educators in line with new information technologies, especially programming, although this shift may take time.

5. Final considerations

Among the 103 games identified in the context of Biology education, 15 (14.56%) are focused specifically on Ecology. This proportion reflects the compelling nature of ecological interactions among living organisms, their interactions with their environment, and the dynamic struggle for survival in natural ecosystems. These phenomena are not only fascinating and spectacular but also hold significant academic, scientific, economic, and social relevance. Consequently, the most discussed ecological concepts within these games include ecological relationships and interactions (46.67%); biomes (40%); population dynamics and population balance (26.67%); food chains and webs (20%); and the interplay between humans and the environment (20%).

The analysis reveals a marked prevalence of analog games, particularly board and card games. These games are followed, though less frequently, by those utilizing paper and pen, somatic games, dynamics-based or traditional games, and digital games. The dominance of analog games can be attributed to their simplicity and the ease with which they can be designed and implemented in educational settings.

Mass Market Games, due to their broad popularity and extensive distribution, present compelling opportunities for the development of formal educational games. Eurogames, which offer a departure from the traditional Profile game format and incorporate a variety of mechanics, also present numerous possibilities for educational applications. These games are characterized by their complexity and the diversity of their gameplay mechanics, which can provide multiple approaches to educational content. However, the intricate nature and component density of Eurogames may pose challenges for their use in classroom settings, particularly at the Elementary and High School levels, where simpler and more accessible games might be preferable.

The necessity of experimenting with these modern games across various educational levels is evident. Such experimentation would help in assessing their suitability, benefits, and limitations within different educational contexts. This includes evaluating both pedagogical and didactic games. Additionally, the production and dissemination of case studies on these educational games are crucial for keeping the Biology teaching community updated with current trends and methodologies. Promoting Active Methodologies, especially those that incorporate playful elements, is essential for enriching the educational resources and approaches available in Brazilian education.

In conclusion, this dissertation offers a comprehensive historical overview of research on the use of games in teaching Ecology, as reflected in the works published in REnBio. It provides an in-depth examination of the research profile, detailed descriptions of the games studied, and insights into the broader academic and practical context. This work underscores the potential for future research and game development, particularly in the domain of Ecology education, and serves as a foundation for analyzing the practical application of these games in classroom settings. By outlining the current state of research and practice, this dissertation contributes to the ongoing discourse on the integration of games in educational practices and supports the evolution of teaching methodologies in the field of Biology.

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Influence of Preparation Types on Moisture and Ash Content in Leek (*Allium ampeloprasum var. porrum*)

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Abstract. Leek (Allium ampeloprasum var. porrum) is popularly known in world cuisine and also has medicinal properties as it contains sulfur compounds such as allicin, enzymes and soluble sugars that can bring benefits to human health. Different types of preparation can influence different nutritional factors such as moisture and ash content. The objective of this work was to verify the influence of the preparations (cooked and braised) of leek on the moisture and ash contents. The results showed that the moisture content varied from 69.89 to 31.50 and the ash content varied from 0.16 to 23.29 in the different parts of the leek, demonstrating that the types of preparation influence the moisture content and ashes.

Keywords. Baked, Braised, Bulb, Sheets.

1. Introduction

The Allium family contains around 500-700 species, which can be edible, medicinal and even ornamental species. All plants in the Allium family are herbaceous, cool-season vegetables [1]. Garlic, like other vegetables, has different types of varieties within the same species, with their own inherent characteristics, the leek or leek (Allium ampeloprasum var. porrum), for example, has a white stalk (bulb), elongated and wide leaves with a dark green color [2]. Its cultivation takes place all over the world, with great adaptability to various types of temperatures, but for best cultivation, the ideal temperature is 20 °C [3-5].

Due to the great appreciation of garlic, it is possible to notice an exponential growth in production in the country. In Brazil, culture has a high economic importance, being responsible for providing employability for several people in its cultivation, giving it the title of one of the countries with the highest consumption. The majority of information consumed is fresh, while the processed form is also in great demand [3, 6].

Therefore, due to the different properties associated with leeks as well as their wide use in cooking and natural medicinal treatments, more in-depth studies regarding the nutritional composition of their different parts are essential in order to prioritize their consumption in full and avoid waste. of its generally discarded parts.

2. Materials and methods

2.1 Raw material

The samples were collected in markets and fairs in the municipality of Morrinhos/Goiás. After obtaining, the samples were taken to the Food Analysis Laboratory of the Instituto Federal Goiano – Campus Morrinhos, Brazil to carry out the analysis.

2.2. Sample preparation

After obtaining the material, the samples were carefully cleaned, the root stem was discarded and the white parts were separated from the green part (Fig. 1). They were then cut into discs approximately 0.5 mm thick and prepared as follows:

Figure 1. Leek preparation: separation of leaves and bulb

2.3. Sample preparation process

The sample preparation process consisted of cooking the different parts of the leek in boiling water for 30 minutes. After cooking, the water was discarded and the cooked parts were subjected to analysis. The other preparation process was the braised form where the leek parts were sautéed in 5g of soybean oil in a refractory until reaching the golden point, simulating home preparation. Soon after, the

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samples went to subsequent analyses. A control sample in natural form was used in the analyses.

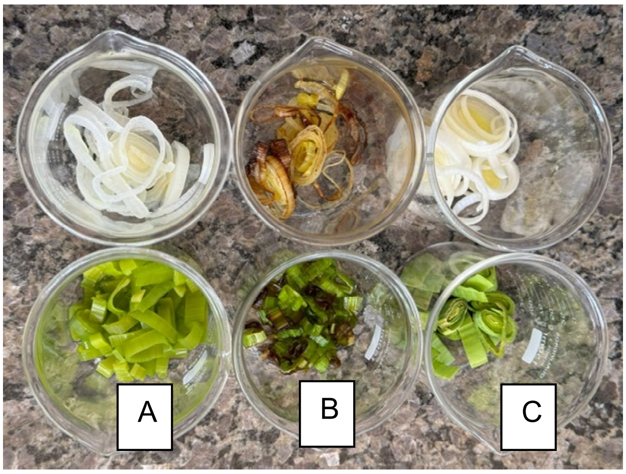

Figure 2. Fresh leek bulb and leaves (A), sautéed (B) and cooked (C)

2.4. Moisture Content Determination

Moisture content was measured based on the standard method according to AOAC [7] by taking 2 g of leek sample, placing it in a petri dish of known weight, and drying it using an electric oven at a temperature of 105 °C for 12 hours (Fig. 3A). The percentage of moisture was calculated according to the following equation (1):

$$\% \text{ of moisture} = Wb - Wa / Wb \times 100 \qquad (1)$$

Wb = the weight of the sample before drying

Wa = the weight of the sample after drying

2.5. Ash determination

The ash percentage was estimated according to the method to AOAC [7] placing 2 g of sample in a weighted ceramic lid and treating them with a temperature of 550 °C for 8 hours (Fig. 3B). The percentage of ash was calculated according to the following equation:

$$\% \text{ of ash} = Wash / WS \times 100 \qquad (2)$$

Wash =Ash weight (g)

WS = Sample weight (g).

All analyzes were performed in triplicate and results were expressed as mean and standard deviation. Statistical analysis was measured using the ANOVA test to compare means using the Tukey test with a significance level of 95%.

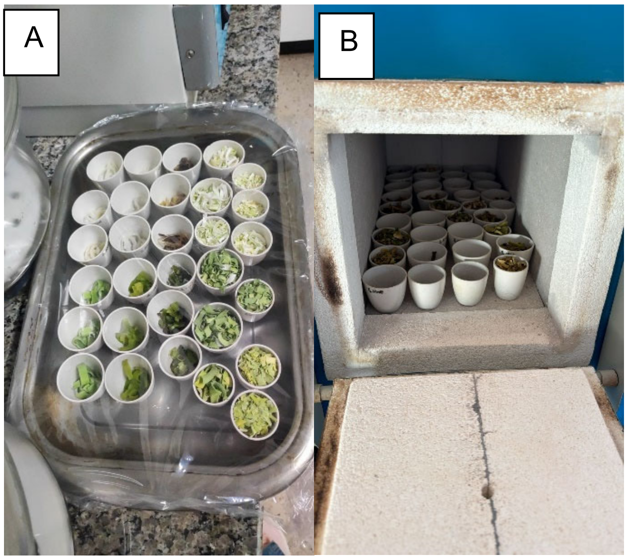

Figure 3. Analysis of moisture (A) and ash (B) of leek leaves and bulb

3. Results and discussion

Moisture content is an important parameter in food products, as it has a direct effect on the texture, colorand sensory acceptability of the food.

Table 1 presents the results of the moisture and ash content in leek leaves subjected to sifferent types of preparation, ranging from 49.12 to 35.50%.

Table 1. Moisture and ash contents in leek leaves under different preparation conditions

	Moisture (%)	Ash (%)
Fresh	44.33 ± 1.99^a	23.59 ± 0.62^a
Cooked	49.12 ± 2.72^a	23.23 ± 0.79^a
Sautéed	35.50 ± 0.50^b	22.04 ± 0.82^a

Different lowercase letters indicate that there was a significant difference between the preparations using the Tukey Test ($p < 0.05$)

From the data presented, it was observed that the leaves, when prepared in the sautéed form, significantly reduced ($p<0.05$) the moisture content. This was expected since, upon contact with heated oil, water tends to evaporate and the oil occupies the spaces occupied by water in plant tissues. Regarding ash, there was no significant difference between the treatments used. These findings agree with Ahmed [8] in his research of fried potato.

Table 2 presents the results of the moisture and ash content in the leek bulb subjected to different types of preparation.

Table 2. Moisture and ash contents in the leek bulb under different preparation conditions

	Moisture (%)	Ash (%)
Fresh	69.39±0.94[a]	0.47±0.07[a]
Cooked	68.97±5.27[a]	0.16±0.03[b]
Sautéed	59,58±0.61[b]	0.66±0.01[a]

Different lowercase letters indicate that there was a significant difference between the preparations using the Tukey Test ($p < 0.05$)

Ash content refers to the inorganic residue left behind after the complete combustion of organic matter and is primarily composed of minerals present in food.

The range of ash content in Table 2, from 0.16% to 0.66%, indicates the variability in mineral content among the bulbo do alho poró samples. The decrease in ash content after refogado is consistent with the findings of Tian [9], and can be attributed to the leaching of water-soluble minerals.

Sensorially, a higher moisture content in foods provides a softer texture, while lipids provide a firmer texture and a characteristic flavor. Therefore, preparing leeks under different conditions will give the different parts (leaf and bulb) similar sensory and chemical characteristics.

4. Conclusions

Notoriously, the way it is prepared changes the moisture content in the different parts of the leek (leaf and bulb). For the parts that went through the braising process, it was observed that the moisture content decreased and, consequently, the ash content increased when compared to the others. This will influence the flavor and texture of the leek.

However, it is important to note that further research may be needed to confirm these findings and explore potential health effects of each prepare method.

5. Acknowledgements

To the “Instituto Federal de Educação, Ciência e Tecnologia Goiano” (IF Goiano), for the technical, scientific and financial support.

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Acid-Base and Redox Reactions: Didactic Experiments and Laboratory Exercises

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Abstract. Chemical concepts such as acid, base, proton, reduction, oxidation or transfer of electrons are often the most difficult to understand because they are neither visible nor tangibles. Therefore, these chemical concepts are not easy to explain in a group of students. A great way to understand such distant concepts is by making the invisible visible, so this work introduces two didactic experiments related to acid-base reaction and redox reaction to make them a little more “tangible” and easier to understanding.

These educational exercises could be easily adapted to any educational level, from primary to high school. Moreover, through of these experiments, teachers could introduce diverse relevant concepts about chemical reactions, which are normally included in the curriculum of science.

Furthermore, this work would encourage school science teachers to use practical experiments as pedagogical tools to consolidate and integrate the knowledge that students receive in theoretical classes.

Keywords. Acid, Base, Redox, Oxidation, Reduction, Transfer of Protons or Electrons.

1. Introduction

Two of the main types of chemical reactions are acid-base reactions and oxidation-reduction reactions. Both of them involve the transfer of fundamental particules between reactants. Concretely, acid-base reactions involve the transfer of hydrogen ions, or protons, from one chemical species (acids) to anothers (bases) in aqueous solutions. Meanwhile, oxidation-reduction reactions, commonly known as redox reactions, involve the transfer of electrons from one species (reducing agents) to another species (oxidizing agents) accompanied by oxidation-state changes (atoms change their oxidation numbers).

2. Acid-base reaction

This didactic experiment is about the acid-base reaction between acetic acid of the vinegar and sodium bicarbonate, but it also about the elements necessaries for fire.

2.1. Material

Vinegar; Sodium bicarbonate; Bottle; Tablespoon; Candle; Lighter or matches.

2.2. Experimental part

In a 500 mL bottle, we add vinegar until it is half-full (Fig. 1A). Then we carefully add 1 tablespoon of sodium bicarbonate (Fig. 1B). We will observe a lot of effervescence (Fig. 1C). This is because the acetic acid of the vinegar reacts with the bicarbonate giving the salt sodium acetate and carbonic acid that quickly decomposes into carbon dioxide and water. The gas that comes out of the mixture is carbon dioxide.

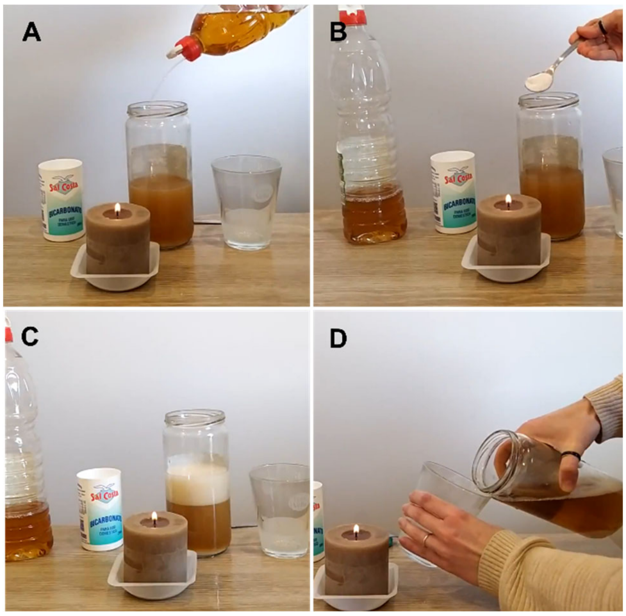

Figure 1. Acid-base reaction. (A) We half-fill a bottle with vinegar. (B) We add 1 tablespoon of sodium bicarbonate to the bottle. (C) We waint some minuts until the effervescence calm down to ensure that the top part of the bottle is full of carbon dioxide. (D) We carfully pour the formed carbon dioxide into the glass, making sure that no liquid falls from the bottle into the glass

If we pour the contents of an apparently empty glass on a lit candle, it does not go out. In reality, the glass is not empty, it is full of air and air is composed by 21 % of oxygen. Therefore,

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we are pouring over the lit candle, oxygen so it continues to burn.

Because carbon dioxide is denser than air, it is able to displace air. As carbon dioxide is formed, the top of the bottle will fill up. We can carefully pour this carbon dioxide into the glass, making sure that no liquid falls from the bottle into the glass (Fig. 1D). With patience, we can fill the entire glass with carbon dioxide. It can take half a minute or even 1 minute if we use a large glass.

Regarding the lit candle, it stays litting if there are present three elements in the right conditions to create the fourth component, the fire itself. These three elements are an oxidizing agent, which is normally oxygen, heat, and fuel source. They are frequently referred to as the "fire triangle." Add in the fourth element, the chemical reaction, and you actually have a fire "tetrahedron." The important thing to remember is the following: if we take any of these four elements away, we will not have a fire or the fire will be extinguished.

Once the glass is full of carbon dioxide, we can pour it over the burning candle and observe how quickly the candle goes out due to lack of oxygen.

If you generate enough carbon dioxide and can fill a large glass with this gas, you can extinguish not only two lit candles but also three lit candles.

3. Redox reaction

This didactic experiment is about a redox reaction between iodine and vitamin C presents in different fruits.

3.1. Material

Fruits: orange, lemon, pineaple, mango and apple; Iodine; Water; Recipient; Brushes; White pice of paper or cartoon.

3.2. Experimental part

We prepared juices of some pieces of fruits (Fig. 2A). Concretely, we squeezed an orange and a lemon to obtain their juices. We also cut a pineapple, a mango and an apple and with the help of a fork, we extracted the juices. These juices have Vitamin C.

We also prepare a lughole solution mixing the same volume of iodine with the same volume of water. This solution has a brown color. We paint a white paper with the lughole solution (Fig. 2B). If the paper contains free starch, it turns to black-blue. The color is the result of the formation of the starch-iodine complex. Iodine is known in chemistry as an indicator. Indicators are chemicals that make observable changes when they are exposed to other chemicals.

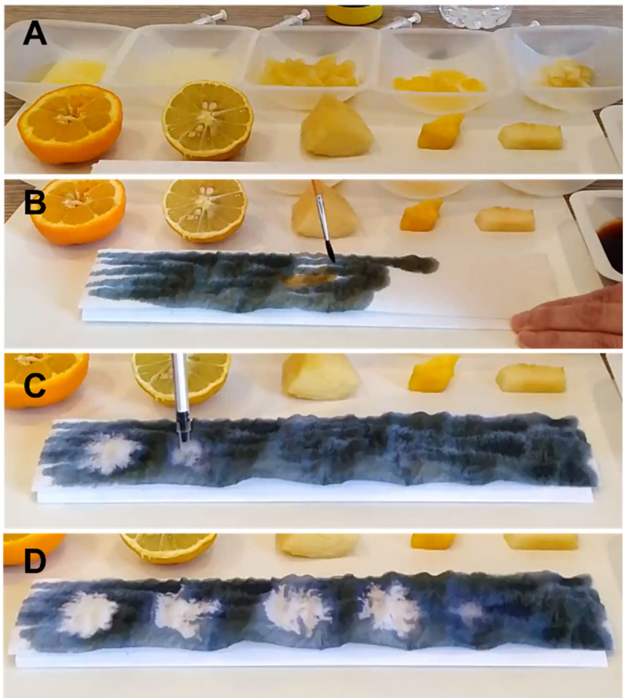

Figure 2. Redox reaction. (A) We prepare juices from am orange, lemon, pinnaple, mango and apple. (B) We prepare a lughol solution and paint a white piece of paper with it. (C) We add drop-by-drop fuit juice on the surface of the painted paper. (D) We observe a colorless spot in the place that we added the juice

As it is said before, this experiment is about a redox reaction between iodine and vitamin C. Let's talk about Vitamin C. This compound is chemically known as L-ascorbic acid, is an important nutrient that provides support to body structures, contributes to wound healing and aids the immune system in preventing infection. It is also an essential antioxidant needed by the human body.

We take orange juice with a syringe and we added drop by drop the juice on the surface of the painted paper (Fig. 2C). The Vitamin C present in the juice acts as a reducing agent and reduces iodine to iodide ions. They are colorless in solution. Thus, we observed a colorless spot

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in the place that we added the juice. We do the same for the other fruit juices. As more quantity of Vitamin C has the juice, more quickly is reduce the iodine, bigger is the colorless spot formed and less drops of juice we need to observe the change of color on the surface of the paper (Fig. 2D).

After performing this experiment, we can conclude in a quality way that orange has more Vitamin C than lemon, lemon more than pineapple, pineapple more than mango and finally mango more than apple. In the case of apple's juice, we should wait some seconds to see clearly the change of color on the surface of the paper.

You could use other fruits to check if they have vitamin C and vegetables such as pepper.

4. Conclusions

These experiments can be related, according to educational level, with two of the main types of chemical reactions: acid-base and redox reactions. Moreover, both experiments can be done using both basic equipment and chemicals found in a normal laboratory, helping science teachers perform experiments that have all the characteristics of excellent classroom demonstrations because of their high degree of safety, ready availability of materials, visual interest and relative simplicity. The benefits of using practical experiments as educational tools are diverse [2-6]. When science teacher explain experiments and help students to perform them, students improve their understanding of theoretical knowledge through experimentation and also gain confidence in their abilities [11-13]. Moreover, experiments become clear for students because scientific concepts and techniques are gradually introduced by their teachers. On the other hand, an excellent way that science teachers have to increase knowledge of chemistry and biology among students is to include educational practice in their routine.

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When the Aids are not at Hand

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Abstract. Sometimes it happens that you need to perform physics experiments in a place where you do not have the appropriate aids. For example, if you want to experiment at a conference in Brazil and you are coming from Europe. In that case, you have to experiment with what is available. This means that you work with simple, inexpensive aids that you can easily get. Such experiments can ultimately be more effective in teaching than similar experiments conducted with expensive apparatus. Children get along better with simple aids and, importantly, they can acquire them themselves and make experiments at home. In our paper we will give some ideas for just such improvised experiments.

Keywords. Improvised Physics Experiments, Home Made Aids.

1. Introduction

Experiments are an integral part of teaching physics. A well-chosen experiment often explains to students what they would not understand from a verbal explanation. In addition, experiments are a useful means of enlivening learning, helping to keep students' attention and, last but not least, they can motivate students to study the problem independently. Experimenting at school is relatively easy. Teacher has a cabinet with tools, a classroom and everything he or she needs. But what to do if we want to experiment outside the school? Alternatively, what if the school does not have the necessary equipment?

Even in this case we do not have to give up experimenting. We can improvise and experiment with common things that are available almost everywhere. It is seemingly an unwanted situation, something less effective. But the opposite can be true. Unlike expensive sophisticated apparatus, improvised aids can be closer to students, they can easily understand them and they can repeat the experiments at home, invent their variations, etc. In the end, the results of such teaching may be better and students may be more interested in physics than in a well-equipped and expensive physics classroom.

The authors of this article have no problem with quality equipment at their home workplace. On the contrary, we have top of the line equipment that almost no school in the Czech Republic can afford. Nevertheless, we like experiments with simple aids and often include them in our teaching. We would like to share some selected simple experiments with the readers of this article. In the following, we describe a few experiments that can be performed anywhere and at any time. Many of these experiments are certainly familiar in various variations, but we hope that the reader will find at least some inspiration for improvised experimentation in the paper.

2. Description of a few selected improvised experiments

We try to describe the experiments in a uniform style. We always provide a list and description of the aids, brief instructions for the experiment, an explanation (or at least a hint of an explanation), and accompany the description with a photograph or simple picture.

2.1. Experiments with straws

2.1.1. Electrostatics with straws

Aids: plastic straws, paper tissues, drinking glass, thread, sheet of paper, scissors, aluminium foil, can (e.g. from olives), coca cola can (or similar), piece of polystyrene.

Note: In some countries (mainly in Europe), the production of plastic straws has been stoped. But we assume that you can still get plastic straws.

Instructions: Plastic straws are perfect for electrostatics experiments. Here are some ideas:

Wipe the straw with a tissue and put it against the wall (cupboard, door...). The straw sticks to the wall, door, etc.

Tie the straw to the thread to form a torsion pendulum. Wipe it with a tissue. Bring the other wiped straw closer to it. The straw on the thread rotates away from the other straw (the straws repel each other).

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Instead of a straw, bring a glass wiped with a tissue. The straw and the glass attract (see Fig. 1).

Hold the two wiped straws horizontally above each other. Hold them by the edges (see Fig. 2). Feel the top straw “float” above the bottom straw. The repulsive force between the straws is very well felt in this case. (You can try to calculate it. Measure the distance between the straws, weigh the straw, and you will surely figure out the rest.)

Figure 1. Electrically charged straw and glass attract each other

You can also make a simple electroscope. Cut a strip of kitchen aluminium foil and fold it over the rim of a suitable tin can (e.g. from olives). Place the can on a polystyrene plate to isolate it from the table. When you wipe the electroscope with a charged straw, the aluminium leaf deflects.

More experiments with plastic straws: With a charged straw you can attract pieces of aluminium foil (electrostatic induction), pieces of paper (electrostatic polarization) or you can move a (empty) beverage can (see Fig. 3).

Explanation: Plastic straws, when wiped with a tissue, are charged with a negative electric charge. When placed against a wall, an attractive force is generated due to the polarization of the wall material. When two charged straws approach each other, they are repelled. They have the same electrical charge. The glass is positively charged after wiping with a tissue. So, it attracts negatively charged straw.

Oddly enough, Coulomb's law can be used to calculate the magnitude of the repulsive force between the straws, even though the straws are not point electrical charges.

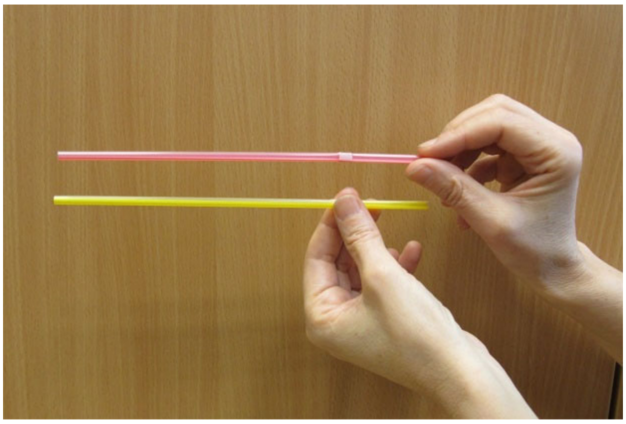

Figure 2. Electrically charged straws repel each other

Figure 3. Electrostatic induction with a beverage can (it moves to the straw)

2.1.2. Flying straws

You can use a straw of any material for the next experiment. Tell the students to throw the straw and see how it flies. The straw does not have very good flight properties. Now you will "teach it to fly". Glue two paper rings to the straw. The smaller one to the front, the larger one to the back (see Fig. 4). Now the straw flies much better. Students can try different sizes of rings.

The improved flight characteristics of the straw after the paper rings have been glued on can be explained by the air flow around the straw and rings. However, this is a complex problem, so we recommend just saying that the aerodynamics of real bodies is a complex discipline and goes beyond high school physics.

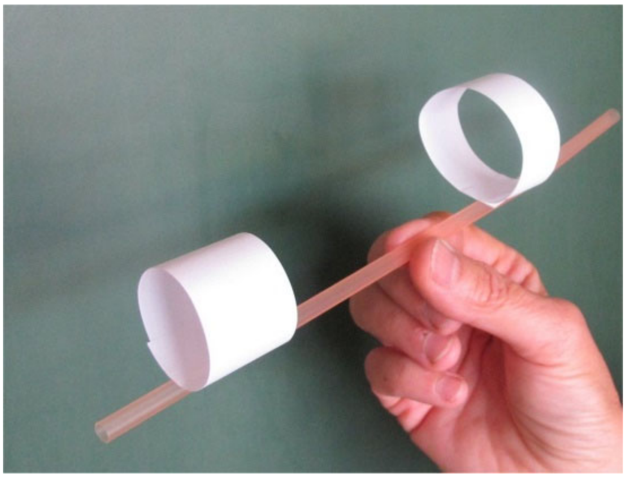

Figure 4. Flaying straw

Figure 5. Water sprayer

2.1.3. Straw as water sprayer

Aids: straw, cup or glass of water, scissors.

Instructions: Cut the straw in two parts. Insert one part into the glass of water and blow the other part of the straw, held roughly horizontally (or slightly angled upwards), over the top of the submerged straw (see Fig. 5). A stream of fine water droplets is sprayed into the surroundings.

Explanation: There is less pressure in the flowing air than in the surrounding still air. The water is forced by atmospheric pressure out of the straw above which the pressure is lower and the flowing air sprays it into the surroundings.

2.2. Magnus cylinder and other falling objects

Aids: bigger sheet of paper, scissors, glue, board approximately 1 m long, templates for cutting out paper helicopter, rabbit and cones (see attachment).

2.2.1. Magnus cyllinder

Instructions: Glue the paper into a cylinder with a radius of 5 cm - 10 cm. Your helper holds the board at an angle and you let the paper roll down the board (see Fig. 6). The roll will unexpectedly curve under the board.

Figure 6. Magnus cylinder

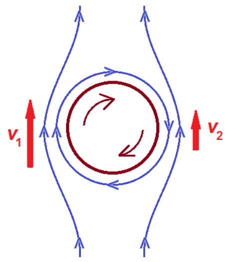

Figure 7. Airflow around the falling cylinder

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Explanation: The falling rotating cylinder rips off the air in its vicinity. This causes air to flow to the right and left of the falling cylinder at different speeds. This results in different air pressure to the left and right. The cylinder is therefore pushed under the board (see Fig. 7).

2.2.2. Falling connes, paper helicopter and rabbit

Instructions: Using the template for paper cone (Fig. 8), make two identical paper cones. Enlarge the pattern on A4 paper, cut out the shape, paint the blue coloured part with glue and glue the cone together.

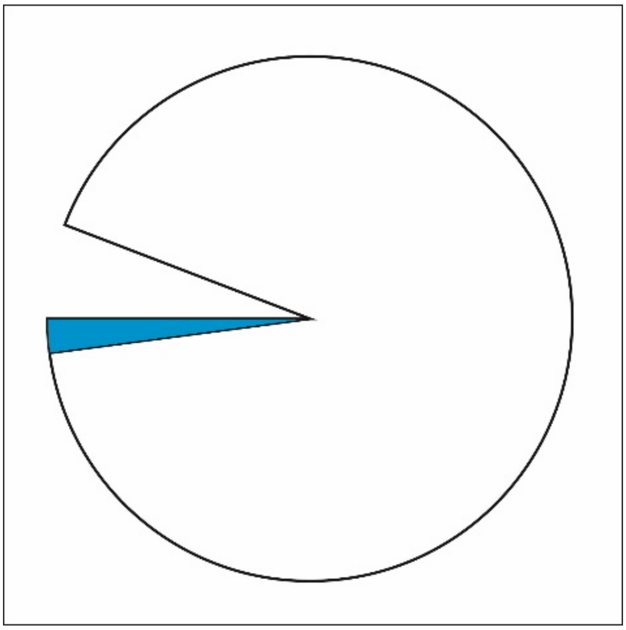

Figure 8. Template for paper cone

First, hold both cones at the same height and let them fall to the ground. The cones fall side by side and hit the ground together.

Now hold the cones a few centimetres (approximately 10 cm) above each other and drop them to the ground (see Fig. 9). The upper cone will fall faster and catch up with the lower cone during the fall. You can repeat the same thing by reversing the order of the cones. The top cone catches up with the bottom cone again.

Using template (Fig. 10) make paper helicopter and rabbit. Make them bigger, cut them out, glue the helicopter and weight the rabbit at the bottom with a paper clip (see Fig. 11).

Drop the objects from a greater height to the ground. They will rotate as they fall, the speed of the fall will not be great. Their falling will certainly be fun (especially for smaller children).

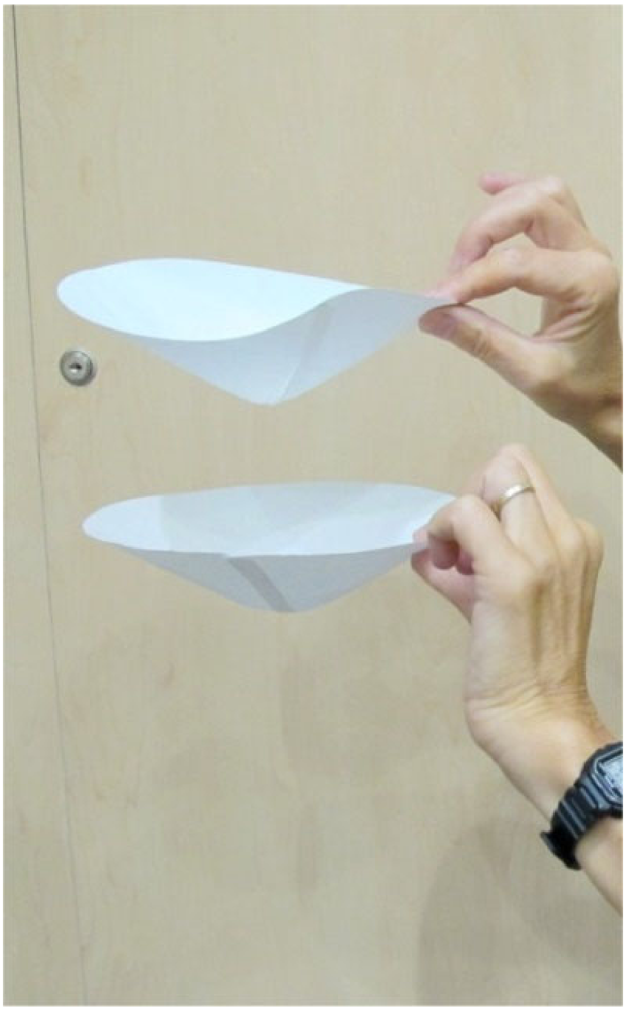

Figure 9. Falling cones ready to fall

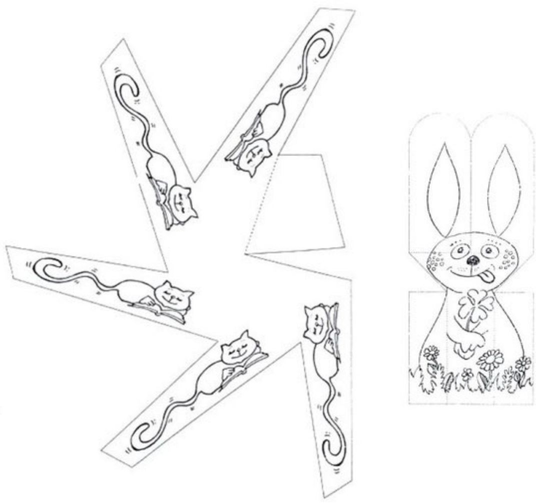

Figure 10. Template for helicopter and rabbit

Explanation: The lower cone "cuts the air" and allows the upper cone to move faster. But the air

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flow around the cone is a complex process, so our explanation is only a hint of what is happening.

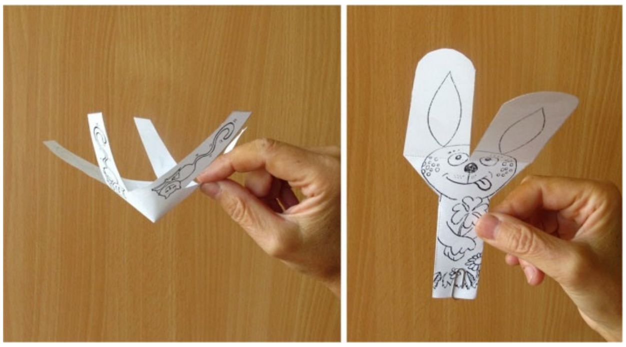

Figure 11. Falling paper helicopter and rabbit

The helicopter and the rabbit have a similar shape. In both cases, they form a kind of rotor that is spun by the air as they fall. At low speeds, the drag force of the air is already equal to the force of gravity and the movement towards the ground is slow.

2.3. Diffraction with laser pointer or even without it

Aids: laser pointer, optical diffraction grating from school collections, fine colander, hair.

Instructions: The laser pointer is an excellent tool for demonstrating various optical phenomena. We will describe some experiments with diffraction of light.

If you have a diffraction grating (it is a common equipment of physics cabinets), just shine the laser pointer perpendicularly on it and you will get a diffraction pattern. It is advisable to shine the laser beam perpendicular to the wall and place the grating in a stand (see Fig. 12). If you measure the distance of the grating from the wall and the distance of adjacent interference maxima, you can calculate the wavelength of the laser (if you know the number of grooves per mm), or vice versa - from the known wavelength of the laser light you can calculate the number of grooves per 1 mm.

If you do not have a grid, you can shine the laser pointer through the fine colander. The diffraction pattern will be more complicated because instead of a linear grid you have a "planar grid". The maxima will be close together and the pattern should have the same symmetry as the mesh of the colander.

You will also get a diffraction pattern if you shine the laser beam on the stretched single hair. Hold the hair about one metre in front of the wall. You can observe the diffraction even if you do not have any tools at hand. Just look against the wall through the gap between the pads of your thumb and forefinger. If the gap between your fingers is small enough you will see dark interference fringes between your fingers.

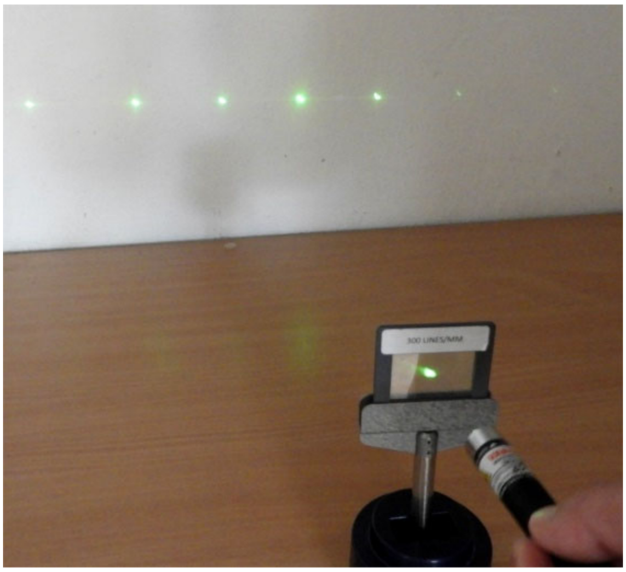

Figure 12. Diffraction pattern obtained using laser pointer and grating 300 lines/mm

Explanation: In all cases, the condition for light diffraction is fulfilled - the obstacle distances are comparable to the wavelength of light. In the case of the hair, it is diffraction at the edge. In the case of a colander, we can also speak of a series of diffractions at the edge (at the edges of the wires that form the mesh of the colander).

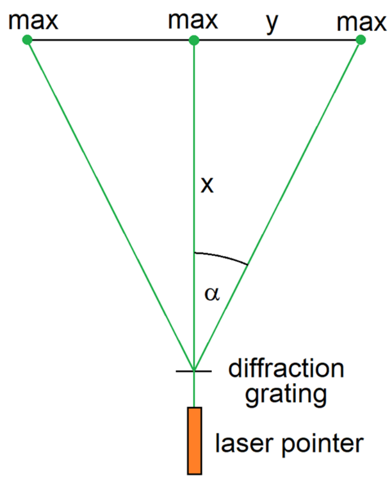

Figure 13. Scheme of the experimental setup for calculating the grid constant (or laser wavelength)

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The above-mentioned calculation of the laser wavelength or the number of grooves per mm can be done as follows (see Fig. 13).

For diffraction on a grating, the well-known equation (1) can be written:

$$b \sin \alpha = n\lambda \,, \qquad (1)$$

where *b* is the distance of adjacent grid grooves, λ the wavelength, *n* order of maximum and α angle between the direction of the zero and the corresponding maximum. In the case of a first order maximum, *n* = 1, and alpha is the angle between the direction to the zero and the first maximum. By measuring the alpha angle we can determine the parameter *b* if we know the wavelength or determine the wavelength if we know the number of grooves per 1 mm (from which we can easily calculate *b*).

The alpha angle can be measured, for example, by placing the grid at a distance *x* = 1 m from the wall (see Fig. 13). In this case, if we measure the distance between the zero and the first maximum (marked *y* in Fig. 13), and *y* is measured in meters, *y* is just equal to the value of the tangent alpha. (Because tg α = y/x, and *x* = 1 m.)

2.4. Optics with a hole in the paper

Aids: sheet of paper, pin, candle.

Instructions: The following experiment can introduce students to important principles of optical imaging. Use a pin to make a 1 mm hole in the sheet of paper (near its corner).

Light the candle and shine the flame through the hole in the paper onto the wall. Hold the paper close to the wall (a few centimetres away). Look carefully at the picture of the flame on the wall - it is inverted in relation to the flame itself. Repeat the experiment with a larger hole (e.g. 3 mm diameter). Notice that the image of the flame is now blurrier but brighter.

Explanation: Let us illustrate the propagation of light using rays (see Fig. 14). The rays coming from the top and bottom of the flame cross in the hole and thus an inverted image is created on the wall.

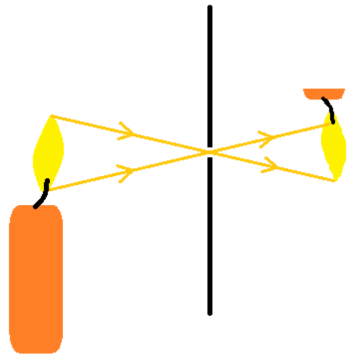

Figure 14. The principle of displaying a candle through a hole in paper.

Let's imagine that we are displaying a single luminous point of a flame (e.g. at its tip). On the wall, this point appears as a small area if the hole is small and as a larger area if the hole is larger. The image therefore consists of small circular areas and is therefore blurred. In the case of a small pinhole, the blurring is negligible and we see a relatively sharp image. However, little light passes through the small hole, so the image is not very bright. In the case of a large pinhole, the image is blurrier but brighter. In this way we can demonstrate the principle of aperture in a camera.

2.5. Camera obscura

Aids: a large yoghurt cup, sheet of normal and translucent paper, glue, scissors.

Instructions: We can improve the previous experiment by making a simple pinhole chamber (called camera obscura). Make a hole in the bottom of the yoghurt cup with a diameter of about 5 mm. Cut out a rectangle from paper and make a series of holes with different diameters (e.g. 1 mm, 2 mm and 3 mm). Use this paper to cover the hole in the bottom of the cup. Glue two more strips of paper to the bottom, then pull the paper with the holes through them. We can now set the hole size to 1 mm, 2 mm or 3 mm (see Fig. 15 - left). Cover the open side of the cup with transparent paper. If we point the pinhole at the lit candle in the dark, we can see the inverted image of the candle on the translucent paper (see Fig. 15 - right).

Figure 15. Camera obscura

Explanation: Our pinhole chamber is an improvement on what we did in the previous experiment. The hole in the paper is replaced by a hole in the bottom of the cup, and instead of projecting it on the wall, we view the image of the candle on the "screen" of the pinhole chamber. The principle of displaying the candle on the camera "screen" is the same as indicated in Fig. 14. By changing the size of the pinhole we can observe that a small pinhole produces a sharp but low-light image, a large pinhole a blurrier but brighter image.

2.6. Bimetal replacement

Aids: sheet of paper, kitchen aluminum foil, glue, candle.

Instructions: We often use so-called bimetal to demonstrate thermal expansion. The bimetal consists of two strips of different metals joined together. When the temperature changes, the bimetal strip bends.

Bimetal can be easily replaced by a simple alternative. Glue a sheet of paper and aluminium foil together. Weight it all down and let it dry well. After drying, cut the strips. What we have made could be called paper-metal.

Gently warm the belt with the candle flame. Be careful that the belt does not catch fire. The belt bends as it heats (see Fig. 16).

Explanation: The explanation is the same as for the bimetal. Paper and aluminium have different coefficient of thermal expansion. Because they are tightly bound together, they must bend when the temperature changes.

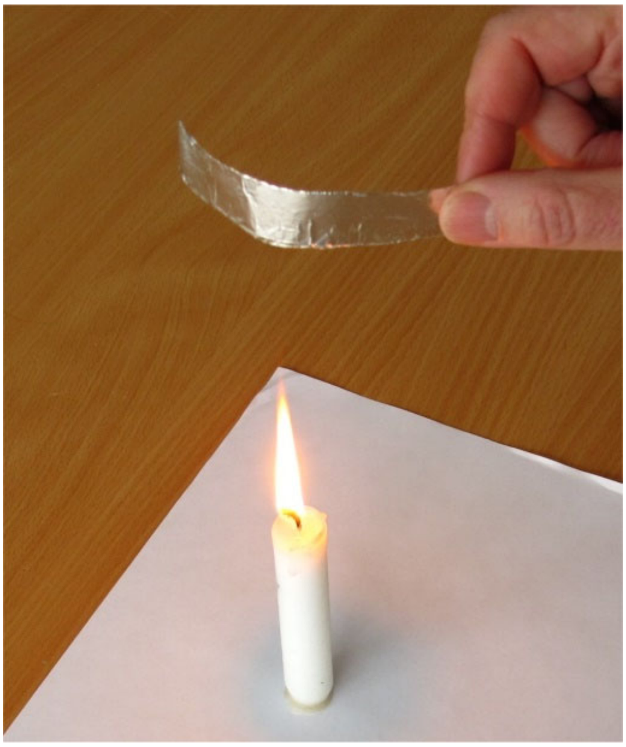

Figure 16. Bending paper-metal

2.7. How does the hole in the sheet of metal change when heated?

Aids: metal marble about 3 cm in diameter, piece of sheet metal with a circular hole slightly smaller than the diameter of the marble, burner or candle (see Fig. 17).

Instructions: This experiment is somewhat out of the range of improvised experiments. The aids for it have to be made in advance and quite precisely. Get a metal marble for the experiment. Drill (cut) a circular hole in a suitable piece of sheet metal that is slightly smaller in diameter than the marble. When you place the marble in the hole, it will not fall through it.

Ask the students what happens to the hole in the sheet when the sheet is heated. There are three possibilities: the hole gets bigger, the hole stays the same, the hole gets smaller. After discussing this problem, show that the marle does not fall through the hole in the sheet metal. Then heat the sheet over the burner (holding the sheet in the tongs) and reinsert the marble into the hole. This time it will fall through. The diameter of the hole has therefore increased as the sheet metal is heated.

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Figure 17. Aids for the experiment

Explanation: The result of the experiment may come as a surprise. People often think that the hole will shrink when the sheet metal is heated. But that is a mistake.

You can justify the result as follows:

The sheet expands in all directions when heated. If you did not put a hole in it, but drew a circle on it, its radius would increase when heated. The circle would represent our hole. So, it must have gotten bigger.

You can imagine concentric rings of sheet metal around the hole. Each one stretches its circumference as it heats up. So, the hole gets bigger.

2.8. The principle of the Davy lamp

Aids: candle, two identical small colanders, beaker, butane (see Fig. 18).

Instructions: First, briefly inform the students what Davy lamp was. Humphry Davy invented it as a safe source of light for the mines. When flammable and explosive methane gas appeared in the mine, Davy lamp lit up, alerting the miners to the danger. But it did not ignite the surrounding gas, as a conventional miner's burner would.

The first experiment will show the basic principle used by Davy lamp. Light a candle and hold a colander over its flame. Move the colander downwards. Note that the flame burns only towards the net of the colander. When you put your hand over the colander, you can feel that the temperature is not too high.

The second experiment will show how Davy lamp worked. Fill the beaker with butane. (Use a butane container for filling lighters for this purpose.) This represents a mine containing a dangerous flammable gas.

Stick a small piece of thin candle between two colanders. This can be done using melted wax. Light the candle and press the colanders well together to make a model of a glowing Davy lamp. Place the colanders in the beaker with butane. The light is on, but the gas in the vicinity has not been ignited. Take the "Davy lamp" out of the beaker and drop a burning match into it. The butane will ignite.

Figure 18. Principle of Davy lamp - aids

Explanation: The wires that make up the strainer mesh are well thermally conductive. They transfer heat from the candle flame to the rest of the colander. The temperature above the mesh does not reach the ignition temperature of paraffin vapour or butane.

2.9. Other experiments based on the same principle as Davy lamp

Many other interesting experiments are based on the same physical principle - temperature reduction due to thermal conductivity. Let us mention two of them.

2.9.1. Non-flamamble paper

Aids: a metal rod (e.g. from a laboratory stand), strip of paper a few decimetres long (e.g. cut from the edge of a newspaper), burner or candle, matches.

Instructions: Wrap a strip of paper tightly around the metal rod (as shown in Fig. 19). Try to light the paper on the rod over a burner or candle. It will not succeed.

Figure 19. Non-flamamble paper

Explanation: The metal rod conducts the heat from the point of contact with the flame. The temperature at this point does not reach the ignition temperature of the paper.

2.9.2. Extinguishing the candle flame

Aids: iron wire about 1 mm in diameter, candle, matches.

Instructions: Make a flame extinguisher out of wire (see Fig. 20). Light the candle, place the coil of the extinguisher over the flame and move it slowly downwards. Note that the flame burns only to the edge of the spiral (see Fig. 21).

Explanation: Thermal conductivity also plays a role here. Wire is a good conductor of heat and quickly conducts heat from the place where it touches the flame. The temperature at the point of contact between the coil and the flame does not reach the ignition temperature of paraffin vapour.

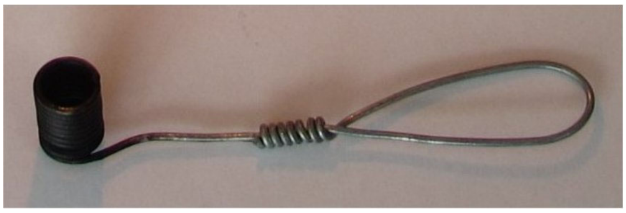

Figure 20. Flame extinguisher

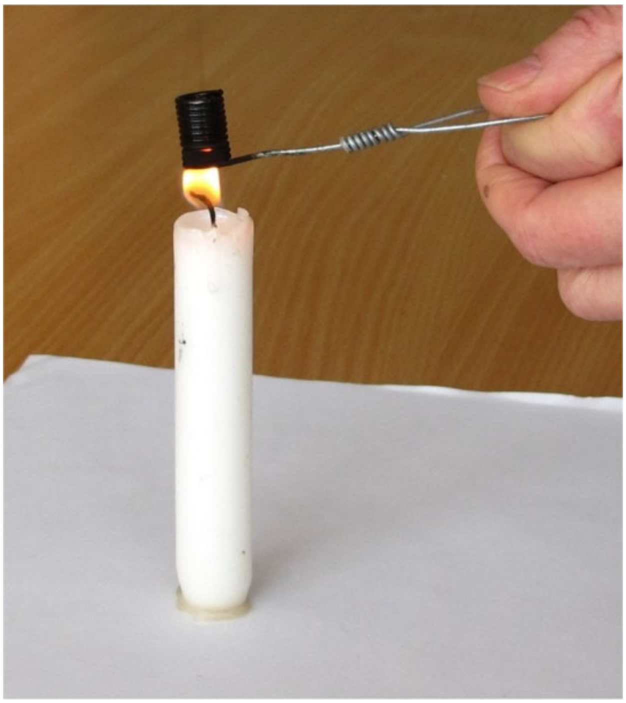

Figure 21. Extinguishing the candle flame

3. Conclusion remarks

From the few examples given, it can be seen that experimentation is possible with a minimum of aids. Improvised experiments are often more interesting for students than experiments with expensive professional equipment, as we have seen many times in our teaching practice. So let us not avoid them and include them in our teaching as a parallel to experiments with professional aids.

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An Escape-Room about Carbohydrate Metabolism Prepared for Chemical Students

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Abstract. Our consolidated teaching group (GINDOC-UB/180) developed various self-learning games, including crosswords, word searches, mazes, and logic puzzles, which students enjoyed for practicing biochemistry. Building on this success, we created an Escape-room focused on carbohydrate metabolism, combining different games. Using Google Forms, we designed personalized quizzes with various question types, requiring answers to proceed. The Escape-room covered topics like general carbohydrate metabolism, digestion, glycolysis, enzyme regulation, pyruvate fates, glyconeogenesis, futile cycles, the pentose-phosphate pathway, and glycogen metabolism. This approach aimed to enhance student engagement and understanding of metabolic processes while assessing their satisfaction with the learning experience.

Keywords. Carbohydrate Metabolism, Google Drive, Chemical Students, Escape-Room.

1. Introduction

In our consolidated teaching group (GINDOC-UB/180), we develop several games related to our teaching and use them for students self-learning [1-2]. These games include crossword puzzles, word search puzzles [3], knight's tour games [4], connect-the-dots, mazes or labyrinths [5], coded translation [6], matching two sets, Amidakuji, and logic games. These games have been very successful for students, who enjoyed them and used them to practice biochemistry. Building on this success, we combined different games to create an Escape-room about carbohydrate metabolism. An Escape-room is an adventure game where players solve puzzles, to complete the game, while learning about the metabolism through reading introductory pages, sailing through websides, or watching videos. In previous works, we have created similar games for the Krebs cycle [7] and for electronic transport and oxidative phosphorylation [8].

2. Methodology

To conduct the Escape-room, we used Google Drive Form. Google Forms collects information from students through personalized quizzes [9]. Forms are divided into sections and each section allow for variousl question types: short answer, paragraph, multiple choice grids, checkboxes, drop-down menus, file upload, linear scale, multiple choice grids, checkbox grids, date, and time. Questions used as codes were marked as mandatory, requiring students to answer them to be able to proceed to the next section. Short answers questions (numeric or alphanumeric) were commonly used.

3. Results

The Escape-room for carbohydrate metabolism was divided in several sections, each containing a game or a video, covering:

- General carbohydrate metabolism (phases 1 and 2).- Include a general overview of carbohydrate metabolism.
- Digestion of carbohydrates.- Describes the digestion enzymes involved and monosaccharide transport into enterocytes.
- Glycolysis.- Detail the complete anaerobic pathway.
- Standard Free Gibbs energy and irreversible reactions.- Explores how standard free energy (ΔG) can be used to identify irreversible reactions that regulate carbohydrate metabolism.
- Glycolytic enzyme regulating and phosphofructokinase-2 reaction.- Analyzes the role of fructose-2,6-bisphosphate in regulating both glycolisis and gluconeogenesis.
- Fates of pyruvate.- Discusses aerobic and anaerobic glycolisis, and includes lactic acid and ethanol fermentation.
- Incorporation of other carbohydrate into glycolysis.- Explains how fructose, galactose, mannose and glycerol can enter the glycolytic pathway.
- Gluconeogenesis.- Analyzes the location of enzymes involved, and the standard free Gibbs energy values of reactions.
- Futile cycles.- Explores the concept of futile cycles and their role in ATP hydrolisis as a mechanism for heat

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generation.

- Pentose-phosphate pathway.- Discusses the pathway as a source of ribose (for DNA synthesis) and NADPH (for fatty acid synthesis).
- Synthesis and degradation of glycogen.- Describes the structure and location of glycogen storage in muscle and liver.
- General questions to students.- In addition of the above topics, this section includes questions to gauge student satisfaction with the Escape-room experience.

3.1. General carbohydrate metabolism

In this Section, we ask some open questions to students, and we presented an Introduction of the general metabolism (Fig. 1).

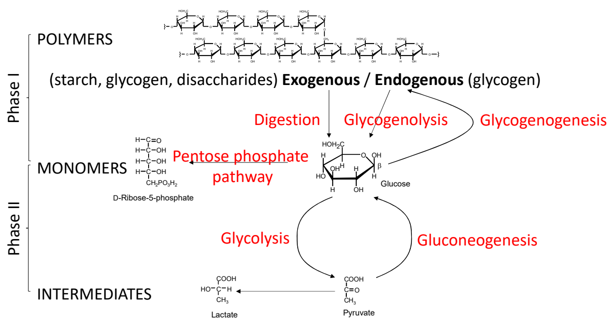


Figure 1. Phases 1 and 2 of carbohydrate metabolism

General metabolism is classified in catabolism and anabolism. Catabolic reactions generate simple compounds from complex ones, obtaining energy in the form of ATP. Anabolic reactions require energy to occur and generate complex compound from simple ones. Metabolism is classified in 3 phases: a first phase that links polymers with monomers; a second phase that connects the monomers with pyruvate; and a third phase common to all the main biomolecules [10]. For carbohydrate, we considered only phases 1 and 2.

Phase 1 catabolism for exogenous polisaccharides is named digestion, whereas for endogenous glycogen is named glycogenolysis and the anabolism is named glycogenogenesis. Phase 2 catabolism contains glycolysis and anabolism contains glyconeogenesis, whereas pentose phosphate pathway is an amfibolic pathways, depending on synthesis of degradation of glucose-6-phosphate.

3.2. Digestion of carbohydrate

In this Section, we ask the students to connect to a Canadian Sugar Institute Nutrition Information Service's YouTube video [11], and ask them to introduce as a key word at what time in the video is it mentioned that the brain needs glucose as energy fuel. The brain requires glucose or ketone bodies to work properly, and this is explained in the video. Time should be calculated in seconds, and a variation between 80 and 100 seconds Is accepted to change section.

3.3. Glycolysis

In this Section, we considered anaerobic and aerobic glycolysis, but also lactic and ethanol fermentation. Hereby, we ask the first E.C. numbers [12] for all the enzymes used from glucose to lactate (i.e. for lactic fermentation, or for anaerobic glycolysis. The keyword to change Section is 25245125421.

3.4. Standard free Gibbs energy and irreversible reactions

By giving the standard free Gibbs energy values for all the glycolytic reactions (Table 1), it is possible to identify which are the more irreversible reactions (i.e. the regulatory reactions) for glycolysis. These enzymes are hexokinase/glucokinase, phosphofructokinase 1, and pyruvate kinase.

Table 1. Standard free Gibbs energy for glycolytic enzymes

Enzyme	ΔGº (kcal/mol)
Hexokinase / Glucokinase	– 4,0
Glucose-phosphate isomerase	+ 0,4
Phosphofructokinase-1	– 3,4
Aldolase	+ 5,7
Triose-phosphate isomerase	+ 1,8
Glyceraldehyde-3-phosphate dehydrogenase	+ 1,5
Phosphoglycerate kinase	– 4,5
Phosphoglycerate mutase	+ 1,1
Enolase	+ 0,4
Pyruvate kinase	– 7,5
Lactate dehydrogenase	– 6,0

This Section asks the students to calculate the energetic yield of ATP per mol of glucose for the anaerobic glycolysis (calculed in %) for standard conditions. It should be calculated the standard free Gibbs energy value from glucose to lactate and considering the standard free Gibbs energy value from ATP hydrolysis as – 7,3 kcal/mol and that 2 moles of ATP are obtained for each glucose, the energetic yield should be calculated as 100·2 7,3/29,5 = 49,50%. A number between 49 and 50 is accepted as a key word.

3.5. Glycolytic enzyme regulating and phosphofructokinase 2

In this Section, after an introduction about glycolytic regulation enzymes (i.e. hexokinase/glucokinase, phosphofructokinase 1, and pyruvate kinase), and an explanation about fructose-2,6-diphosphate as a regulatory intermediate, there is a laberynth with answers and questions. The correct answer of the question connects the square to another square, and taking the letters over the arrows connecting those squares can form the key word to pass to the following Section: FERMENTATION.

3.6. Fates of pyruvate

This Section contains a knight tour's game. The sentence obtained after taking the syllables beginning from the left top and moving through all the 5x5 grid with the chess knight tour's, the following sentence is obtained: "Anaerobic respiration makes lactatre without using oxygen, as no NADH is produced" (Fig. 3). This sentence will be the key word to follow to next Section.

3.7. Incorporation of other carbohydrate into glycolysis

This Section contains an Amidakuji game, which connects two sets (carbohydrate: glucose, fructose, manose, galactose and glycerol) numbered with numbers with some statements with letters (a/b). Each carbohydrate should be related to a letter, and the key word is: 1b2a3a4b5a.

3.8. Gluconeogenesis

Hereby, we present also a laberynth with answers and questions, as for the glycolytic enzymes. The regulatory enzymes for gluconeogenesis are glucose-6-phosphatase, fructose-1,6-diphosphatase and phosphoenolpyruvate carboxy kinase / pyruvate carboxy kinase. This games allow the students to learn from the questions, as if they don't know the answer they can learn from the key word that they should obtain. By correctly answering the laberynth questions, the key word obtained is: FUTILECYCLE.

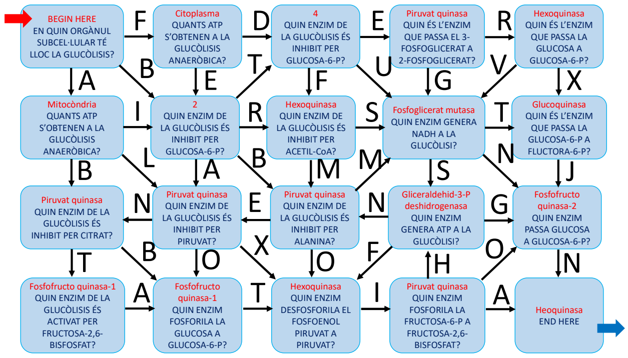
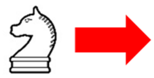


Figure 2. Laberith with questions and answers



AN	U	MAKES	NO	RO
DU	AS	AE	SING	LAC
OUT	TION	CED	BIC	NADH
GEN,	PRO	PI	TATE	OX
RA	WITH	Y	IS	RES

Figure 3. Knight tour's game in a 5x5 grid

3.9. Futile cycles

In this Section, a word search quiz is shown, and this game contains the names of glycolytic and gluconeogenic enzymes. The key word is the enzyme that does not appears in the word find puzzle. This enzyme is GLUCOSE-6-PHOSPHATASE, which is the key word to pass to the following Section.

3.10. Pentose phosphate pathway

In this Section we relate two sets (needs of the cells: 1. More ribose-5-phosphate than NADPH; 2. Similar needs of ribose-5-phosphate and NADPH; 3. More NADPH than ribose-5-phosphate; 4. NADPH and ATP) and some metabolic figures. The student must relate which pathway corresponds to the needs of metabolites from this pathway (Fig. 5). The correct answer is: 1C2D3A4B.

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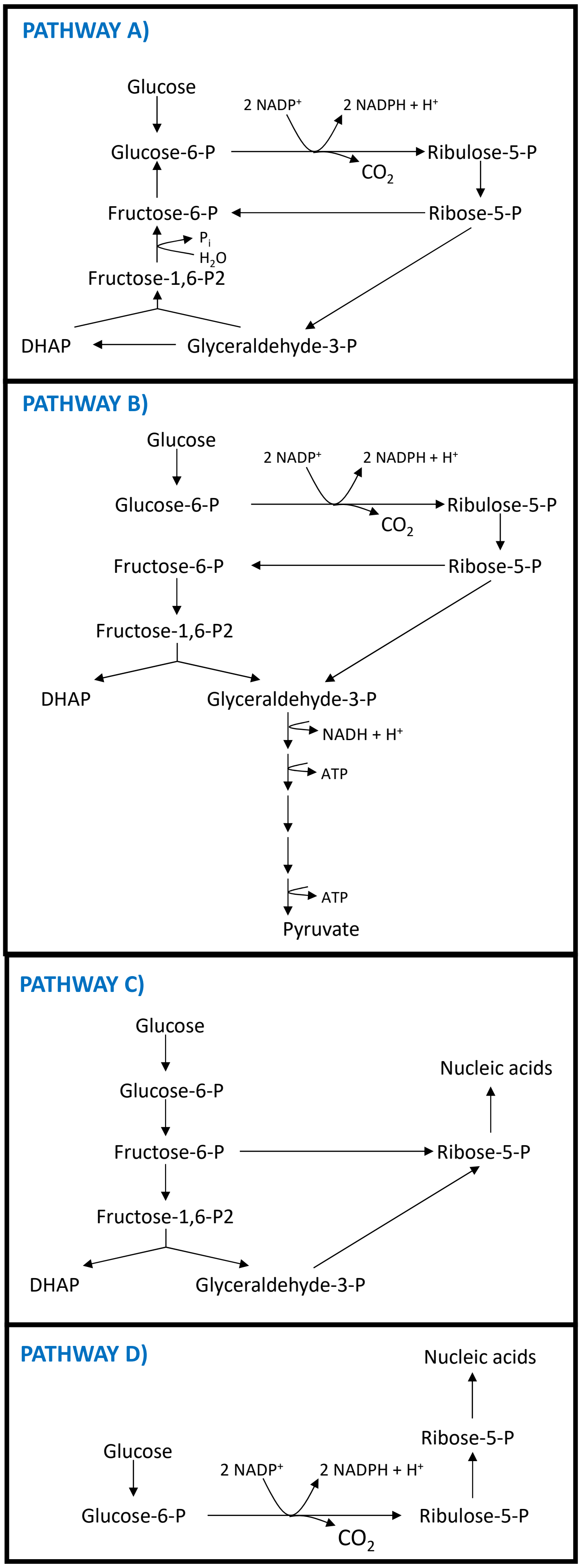

Figure 4. Different pathways for pentose-phosphate pathway, depending on the needs of the cell

3.11. Synthesis and degradation of glycogen

This Section contains a video regarding the structure, the synthesis and degradation of glycogen, which was hang by Ósmosis in YouTube [12]. In muscle it is not possible to generate glucose, as there is no glucose-6-phosphatase. We ask the students at what time in the video is it mentioned that the muscle has no glucose-6-phosphatase? Time should be calculated in seconds, and a variation between 388 and 468 seconds Is accepted to change section.

3.12. General questions to students

The final Section contains several questions about the game, in order that students could explain how long it took to reach the end of the Escape-room, but also some questions regarding:

- If they liked the Escape-room
- The difficulty of the Escape-room
- If it was useful for them to learn concepts
- If it was amusing for them to play the Escape-room
- If it was interesting
- If they got stuck in a specific game

All the students valorate very positive the game, and some of them find the Escape-room very interesting to study Biochemistry.

4. Acknowledgements

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Introductory Study: How Children Represent Vegetables on Drawings from an Organic Garden

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Abstract. This paper aims to encourage the gradual introduction of natural science in pre-school, children (4 to 5 years old) accompanying the neurodevelopment, the cognition and behaviour of the child in identifying edible vegetables from an organic garden at school. It also provides some reflections on the maturation of the brain and sensory organs compatible with abstract concept approaches and principles of observation methodology with meaning. Including registration of data on drawings from pupils 4 to 5 years old in a school in Southern Brazil.

Keywords. Emergent Science Education, Vegetables, Mental Model, Drawings.

1. Introduction

An organic garden is a live laboratory by means of which pupils have a close contact with nature processes through doing them (throwing seeds, replanting seedlings in the nearby flowerbeds, rich with dead leaves, used coffee power, red California earthworms in the ground. It also provides an opportunity to observe the growing of vegetables and herbs [1]

The space for planting, either on flowerbeds or pots turns the preschools more comfortable to be in and to join in learning activities, which are remembered for a long time. Many educators recall these things from when they were children even in hard situations during The Second World War and living in a ghetto [2].

This study aims to analyse the mental model [3] of what pupils´ think is a plant in two visits to the school organic garden.

This approach of actual hands-on involvement allows researchers to collect information about the interest and emotion the children have to an organic garden and learning of basic science [4].

Biological organisms are an essential part of environment, but there are few studies of how children perceive these organisms, such as plants. Plants as a whole are essential for environment surviving, but some people show ("plant blindness"), or an inability to recognize the importance of plants to the world environment [5].

Tunnicliffe (2001) reported that a group pf primary school students (7 to 10 years old) visited a Botanical Garden in England [6]. Their spontaneous conversations were analysed. The principle topics made from their previous understanding were: leaves, flowers, fruit and a few everyday names of plants which they observed.

Science experiences and learning during the early years is a strong motivation for creating science representations. During pre-school years science learning means building their first ideas from their experiences and observations that will develop with age and opportunities. Thus keeping a child 's interest and innate curiosity as well as their discovery and value of the environment [7].

2. Material and methods

A pre-school in Curitiba area Southern Brazil, (Escola Municipal Lirio Jacomel, Rua Manaca, no number, Bairro Jardim Karla) was contacted which teach to 4 to 5 year old children. The headmaster and pedagogical co-ordinator were asked to send parents a consent form to sign, authorizing the use of their children´s drawings in a scientific study. The first researcher asked the children to draw on a blank sheet of A4 paper (using black or colour pencil) what they expected to find at the organic garden. Two weeks later the same task was asked after the children had made their visit. A similar study was carried out in Spain [8].

3. Theoretical framework

Spaces to grow plants in pre-schools either in flowerbeds, pots or climbing plants (passion-flower, chayote) are valuable didactic resources for practical classes enhancing the school curricula providing children with first hand experiences with livings things and their processes. It may be considered the first steps to later understand how ecosystems function [9].

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School educators have noticed that organic gardens have positively influenced the pre-school pupils eating vegetables and fruit [10]. Furthermore, drawings can be a useful tool and activity to develop science learning [11-12].

When researchers compare the drawings made by pupils in the range of four and five years olds of their expectations and their recollections of the first and second visit at the school organic garden, a number of changes were observed by the researchers. These changes offer insights how children perceive the world around them and what salient features they had previously expected to see and what they did see and remember. Educators can learn how such experiential their interpretations and what they notice which may influence their future thinking and creativity.

For instance, it seems the drawings done after the first visit to the organic garden, are generally more detailed than those done before. One of the reasons could be because children have actually observed plants in the organic garden. Drawings are more colourful as children are able to see the natural colours for themselves [13].

Drawings done after the visit include comparisons as children start to understand similarities and differences between plants. In this occasion pupils may include new elements into the scenery such as garden tools, a wheelbarrow, workers, how plants are arranged in the flower-garden, which were other features of this garden use of symbols on their drawings as a bright circle to represent the Sun, an articulate stain to represent a flower. Not all young children draw a Sun in their imaginative drawings very stylised you can not interpret this as anything else. Just one invertebrate was noticed on the drawings collected [14]. Only one drawing of the Sun was represented in the first visit [15]. However, it seems these children´s drawings are a real experience but did not all put in the Sun. Some children drew themselves in the first visit drawings were not the same in the second visit. Attending the pre-school is irregular, as children are brought to school by parents or a special transportation.

Comparing drawings of an impersonal idea of a garden before a visit and the drawing of their recollections of their own visit in which they were actively involved and keep the data in their memory. Thus, some pupils pay attention with a focus and take advantage of this action.

4. Results

Twenty-two drawings were collected in the first visit the organic garden. They were sorted out according to sex, drawing characteristics and if any drawing explanation (Table1). The same procedure was applied to thirty-six collected drawings in the second visit to the organic garden (Table 2). Taking separately some drawings collected from the first visit the organic garden, they are presented as follows.

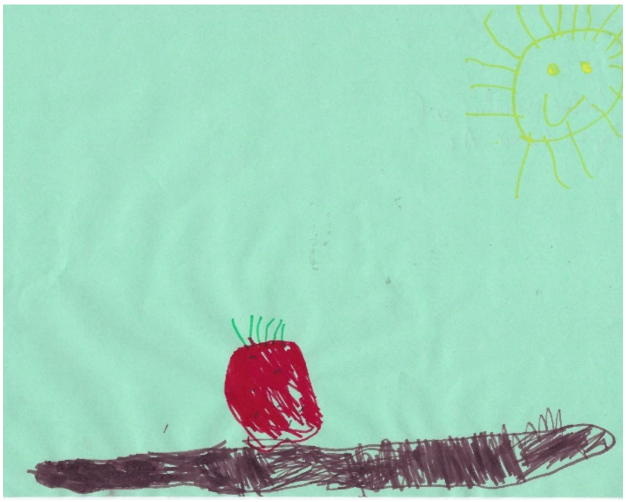

Figure 1. Drawing done by a girl, 5 years old which she said represents the ground a plant which is a beetroot and above the Sun

Figure 2. Drawing done by a boy, 5 years old and he said they represent vegetables on the organic garden

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Figure3. Drawing done by a girl, 5 years old and she said they are vegetables with leaves

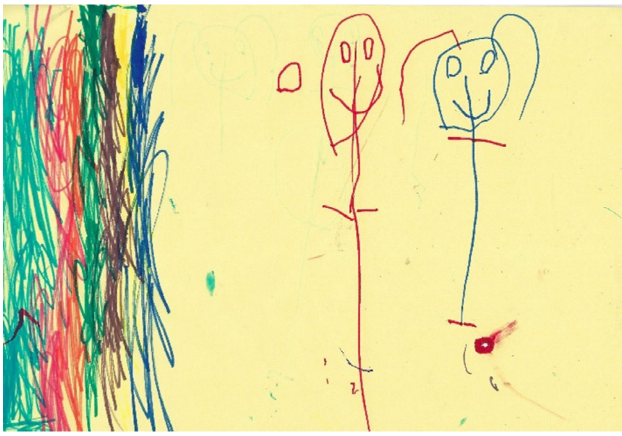

Figure 4. Drawing done by a girl, 5 years old and she said she is with a friend at the organic garden

Figure 5. Drawing done by a boy, 5 years old and he said the ground is represented by green colour, the red vegetable is a cucumber, and the sky is blue, his age is pictured as a mixture of colours

Taking separately some drawings collected after in the second visit to the organic garden, they are presented as follows:

Figure 6. Drawing done by a girl 5 years old and she said her drawing represents the organic garden

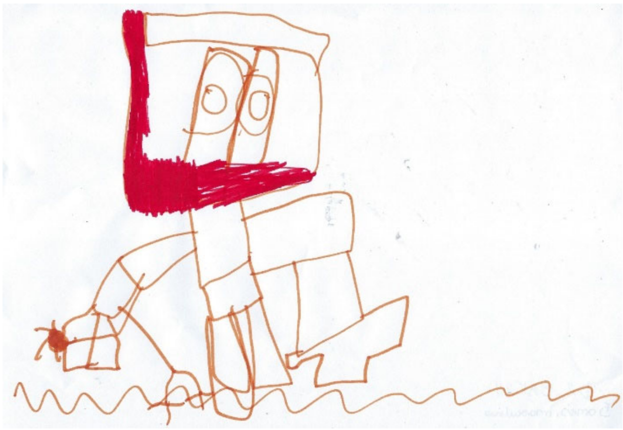

Figure 7. Drawing done by a boy, 5 years old and he said he is stepping on the ground of the organic garden

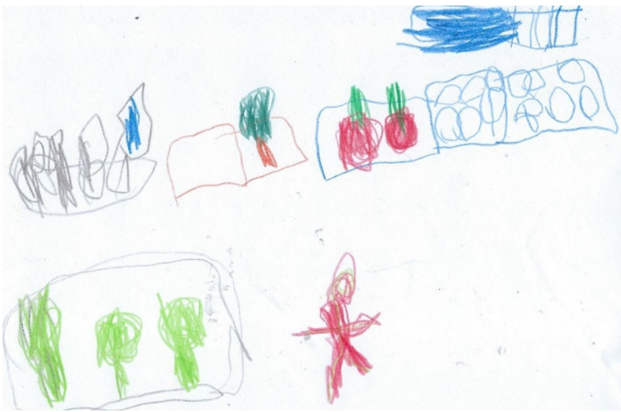

Figure 8. Drawing done by a girl, 5 years old she said her drawing represents carrots, beetroots, lettuce planted on the ground at the organic garden

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Figure 9. Drawing done by a boy, 4 years old, and he said it represents some lettuces, carrots and beetroots planted on the ground of the organic garden and the clouds above

School attendance was irregular due to bus transportation. Children did rarely draw a whole plant with roots, but parts of plants (leaves) like those which humans eat. Several drawings e.g. Figs. 4, 7 and 10 personalised their drawings by drawing representations of themselves.

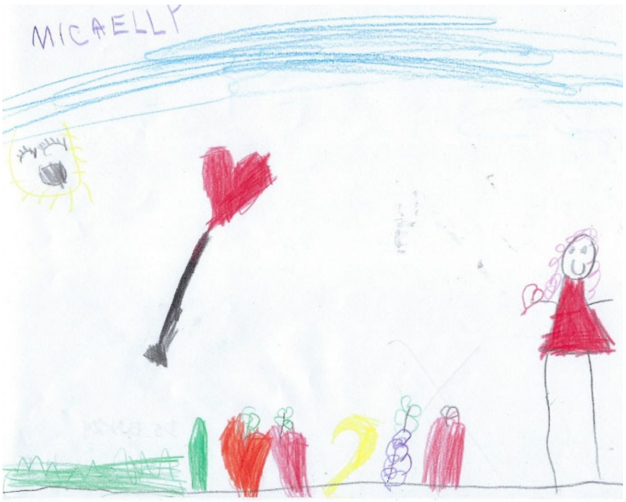

Figure 10. Drawing done by a 5 years old girl and she said it represents a lettuce, beetroots, and herself watching the vegetables growing on the organic garden

Most children live in small flats and they do not have gardens to plant seeds of vegetables. They are not familiar what a plant is as they have at school vegetables in salads during the meals. During the first visit there was only one explanation on animals in the garden "caterpillar on a lettuce" different to what was found in another study [14] and they decided to picture themselves on the drawings. Table 1 and Table 2 just analysed the 2 samples, one is larger them the other as for reason of bus transport or brought by car to school by parents as mentioned earlier.

Figure 11. Partial view of the organic garden. There is a small lemon tree and at the back diapers drying from younger children from the same school

Figure 12. The same photo of the organic garden shot from another angle

Table 1. Analysing drawings from the first visit to the organic garden (F=female, male= male)

Sex	Age	Drawing characteristics	Explain drawing
F	5	Ground, vegetable, Sun	no
M	5	Scribble	no
M	4	Scribble	no
M	5	Scribble	no
F	4	Vegetables	a lettuce
F	4	Vegetables	a lettuce
F	5	Vegetables	some carrots
F	5	Ground, depicts people	scribble of a boy and a girl
M	5	Flower-ground with carrots	depicts a rabbit
M	5	Scribble	depicts an apple
F	4	Scribble of a girl	depicts herself, green leaves around
M	5	A vegetable	depicts a lettuce
M	5	Scribbles	a lot of people in an organic garden
M	5	Scribbles	A caterpillar on vegetables
F	5	Scribbles	A cauliflower
F	4	Scribbles	depicts the organic garden
M	4	Scribbles	depicts various vegetables
F	5	Scribbles	depicts various vegetables
M	5	Scribbles	depicts carrots
M	5	Scribbles	some vegetables
M	5	Scribbles	depicts carrots

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Table 2. Analysing drawings from the second visit the organic garden (F=female, M=male)

Sex	Age	Drawing characteristics	Explain drawing
F	5	Scribble	No
M	5	Scribble shaping vegetables	No
M	5	Scribble	No
M	5	A man robot	No
F	5	Scribble	No
M	4	Scribble	No
M	5	Scribble	No
M	5	Sun scribble, shaping vegetables	No
M	5	Scribble	No
F	5	Scribble	No
M	5	A line of scribble vegetables	No
M	5	Scribble clouds	No
M	4	A line of scribble vegetables	No
M	5	Scribble	No
M	4	Scribble	No
M	5	Scribble	No
F	4	A scribble of the organic garden	No
F	4	A scribble of a tree	No
M	5	A scribble of a blue sky	No
M	5	A scribble of blue sky, vegetables	No
M	5	A scribble of the organic garden	No
M	5	Scribble	No
M	5	Scribble	No
F	4	Scribble	No
F	5	Ground floor of organic garden, teacher´s silhouette	No
M	4	A scribble of vegetable shapes	No
F	5	A scribble of blue sky, Sun, herself	No
F	4	Scribble	No
F	4	Scribble	No
M	5	Scribble	No
F	5	Scribble of Sun	No
M	5	Scribble of Sun, vegetable shapes	No
M	4	Scribble of ground floor	No
M	5	Colourful scribble	No
M	5	Scribble of vegetables	No
F	4	Scribble of Sun, vegetables, and flower shape	No

These pupils do have a firm concept of what is a vegetable is from home as they see them raw, as well as salad served during lunch at school. There is only 2 small trees near the organic garden, which they did not draw.

5. Discussion

The results of this study show that analysis of the drawings from the first and second visit is different, The second visit drawings reflect what children noticed in addition. This paper aims to suggest activities during pre-school such as the observation of nature and relationships of plants and natural phenomena as rain and sun. It also values previous knowledge the child may bring from home. Pupils learn better when oriented by a teacher in a real situation and not only from a book or sheet of paper with instructions.

6. Conclusion

This introductory study with a small sample of pupils had in mind to establish some procedures to be used by the teacher in the classroom and eventually use in the school backyard as a “hands on “activities. It is also a way to help pupils to eat salad and vegetables during their meals at school and at home.

Suggestions to teachers to be use at School:

- What is a plant
- Ask children to tell you what plants are like
- Show pupils a whole flowering plan, unroot stem, leaves, and flower
- Plants we eat- celery, asparagus, potatoes, manioc/cassava
- Plants we eat-roots- carrot, turnip
- Plants we ear-buds and flowers- cauliflowers, broccoli
- Plants we eat-fruits-bananas, oranges, apple, mango, melon
- Plants we eat seeds- Brazilian nuts

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Empowering Environmental Awareness through Art: A Creative Approach to Solid Waste Education in Elementary Schools

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Abstract. This study explored using art as a pedagogical tool to promote environmental education among 6th grade students, focusing on urban solid waste management. A practical and feasible didactic sequence was developed and implemented, combining practical activities and interactive discussions. The results showed that art effectively engaged students, increased their environmental awareness, and stimulated creativity and critical thinking. The research concluded that integrating art into environmental education is an effective and replicable approach to fostering environmental responsibility and developing students' essential competencies.

Keywords. Art, Environmental Education, Solid Waste, Critical Thinking, Pedagogy.

1. Introduction

Environmental education has established itself as essential in educating citizens capable of significantly intervening in their communities to promote sustainable development [1]. In a scenario where climate change, pollution, and environmental degradation are increasingly relevant global issues, incorporating environmental education at all levels of education has become essential [2]. According to Krasny & Roth [3], environmental education should be integrated into the school curriculum to promote understanding of the interconnections between ecological and social systems, preparing students to face contemporary environmental challenges.

In Brazil, Law No. 9,795/99, which establishes the National Policy on Environmental Education, highlights environmental education as an essential and permanent component of national education to be integrated into school curricula interdisciplinary [4]. Despite this legal framework, progress in the effective implementation of environmental education in Brazilian schools still faces challenges, as pointed out by Cararo *et al*. [5] and Dos-Santos *et al*. [6], which highlights the need for more integrated and contextual pedagogical practices.

In this context, using art as a pedagogical tool in environmental education has significant potential to engage students creatively and reflectively [7], allowing students to express their perceptions and understand the complex relationships between society and nature. According to Inwood & Taylor [8], arts education can facilitate the development of a critical awareness of environmental issues by providing a space for reflection on the interdependence between human beings and the natural environment. Furthermore, Fragkoulis & Koutsoukos [7] argue that integrating art with environmental education can foster an environmental ethic in students by approaching them with ecological issues sensitively and engagingly.

However, the use of art in environmental education is still underexplored in conventional pedagogical practices, especially in basic education. As Jónsdóttir [9] and Türkoğlu [10] point out, art can act as an effective means to mediate the understanding of complex environmental issues. Still, its application in the classroom is often limited to isolated activities without a deeper connection to the curriculum. This indicates a gap in the formation of critical environmental awareness among students, which can be addressed through a pedagogical approach that systematically integrates art into environmental education.

Given this, the present study aims to investigate the contributions of art as a pedagogical tool in environmental education, focusing on urban solid waste management. The research question that guides the study is: What is the role of teaching art as an instrument of environmental education for students in the final years of elementary school? To answer this question, the following objectives were established: (i) to understand students' environmental perceptions on the topic of solid waste; (ii) to evaluate the contributions of art as a tool for students' critical education; (iii) to build a didactic sequence to address the theme proposed in the Art discipline, using active learning methodologies; and (iv) analyze the

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results of the implementation of the didactic sequence.

2. Methodological procedures

2.1. Research approach and design

The research adopted a qualitative, exploratory, and descriptive approach, allowing an in-depth understanding of students' perceptions and the learning dynamics generated by the proposed didactic sequence. The choice of a qualitative approach is justified by the subjective nature of the teaching and learning processes involved, especially when investigating aspects such as aesthetic sensitivity, critical perception, and environmental engagement, which are best captured through interpretative and descriptive methods.

The research was conducted in a public state school located in the city of Itumbiara, Goiás. This institution was chosen due to its proximity to the researcher and the school's availability and interest in participating in projects integrating art and environmental education. The school has adequate physical infrastructure for the proposed activities, including classrooms, a library, and an outdoor area for the final exhibition of the student's work.

2.2. Participants

The study participants were 24 students in the 6th grade of elementary school, aged 11 to 14, with 13 boys and 11 girls. This age group was chosen because students transition between the early and final elementary school years. It makes them particularly receptive to new pedagogical approaches and themes that challenge them to reflect on the world around them.

To ensure the students' ethical participation, the study was submitted to and approved by the Ethics Committee of the Federal Institute of Goiano (approval number 5.934.786). All students and their guardians were informed about the research objectives and signed the Informed Consent Form (ICF). The participants' anonymity was guaranteed at all stages of the research.

2.3. Development of the didactic sequence

The didactic sequence was planned to be implemented in the Art subject over six sessions, each lasting 50 minutes. The methodology adopted followed the principles of active learning methodologies, which place students at the center of the educational process and encourage them to construct knowledge actively.

2.3.1. First session: contextualization and initial diagnosis

The first session contextualized the theme and applied a preliminary questionnaire to assess students' knowledge and perceptions of urban solid waste management. The questionnaire consisted of open and closed questions, allowing students to express their ideas and opinions freely. This step was crucial to identify students' prior knowledge and to plan subsequent activities to meet their needs and interests.

2.3.2. Second session: discussion of the documentary "Waste Land"

The documentary "Waste Land" depicts Brazilian plastic artist Vik Muniz's work with waste pickers at the Jardim Gramacho landfill in Rio de Janeiro, shown and discussed in the second session. "Waste Land" was directed by Lucy Walker in collaboration with João Jardim and Karen Harley. The documentary was selected for its relevance to the theme of solid waste and its ability to visually and emotionally illustrate how art can transform social and environmental realities. After the screening, students participated in a guided discussion, where they were encouraged to reflect on the messages conveyed by the documentary and relate them to their own experiences and perceptions of waste and recycling

2.3.3. Third session: station rotation

The third session was structured based on the Station Rotation methodology, a pedagogical practice that allows students to explore different aspects of a theme through diverse activities conducted at small workstations. The stations included:

- ✓ ***Station 1 - Biography and works of Vik Muniz***: At this station, students explored the life and work of Vik Muniz, focusing on his innovative artistic techniques and use of recyclable materials in his creations. The activity was conducted through an interactive visual presentation, where students could see examples of Muniz's works and discuss how he uses art to address social and environmental issues.

- ✓ ***Station 2 - Impact of solid waste in Itumbiara***: Students analyzed photos of the Itumbiara/GO landfill, discussing the amount of solid waste produced in the city and the environmental consequences of this waste accumulation. The activity was complemented with data on waste production in the city, providing a factual basis for the discussion.

- ✓ ***Station 3 - The 5 Rs of sustainability***: At this station, students participated in a group dynamic to discuss and apply the concepts of the 5 Rs (rethink, refuse, reduce, reuse, and recycle) in their daily lives. The activity included creating posters illustrating how each Rs could be implemented at home and school.

2.3.4. Fourth and Fifth Sessions: Craft and Paper Mache Workshop

In the following two sessions, students participated in a hands-on workshop where they created artwork using recyclable materials (Fig. 1). The choice of manual and artistic activities aimed to provide students with a direct experience of how waste can be transformed into valuable resources. The paper mache technique created sculptures and decorative objects, stimulating students' creativity and reinforcing the message that trash can be reused and transformed sustainably.

2.3.5. Sixth Session: exhibition and final evaluation

The sixth and final session was dedicated to exhibiting the students' work, which allowed for appreciation and reflection on the creative process (Fig. 2) and the concepts discussed throughout the didactic sequence. After the exhibition, students completed a final questionnaire, similar to the preliminary one, to assess changes in their perceptions and knowledge about the theme of solid waste.

Figure 1. Representative Image of Students' Engagement in Creating Art with Recyclable Materials during the Craft and Paper Mache Workshops

Figure 2. The final session will display students' creative works using recyclable materials

2.4. Data collection and analysis

Data were collected through the questionnaires administered before and after the intervention and the researcher's observations during the activities. The questionnaire responses were analyzed using the content analysis technique proposed by Bardin (2006). This technique allowed for categorizing the responses and identifying patterns and changes in students' perceptions throughout the didactic sequence.

The data analysis was conducted in two main stages: (i) analyzing the preliminary questionnaire responses to identify students' initial knowledge and perceptions and (ii) comparing the preliminary and final questionnaire responses to evaluate the changes after the intervention. The emerging thematic categories, such as "environmental awareness," "creativity," "individual responsibility," and "importance of recycling," were analyzed in depth, providing a detailed understanding of the contributions of art to environmental education.

3. Results and Discussion

The research indicated that the use of art as a pedagogical tool had a significant impact on students' environmental awareness. Initially, the preliminary questionnaire revealed that many students had a limited understanding of solid waste management, with superficial perceptions about the importance of recycling and little critical engagement regarding their consumption habits. The responses often mentioned basic waste separation as the leading relevant environmental practice without considering, as discussed by Phonthanukitithaworn *et al*. [11], other aspects of the 5 Rs concept (rethink, reduce, reuse, recycle, and refuse) or individual responsibility in the generation and disposal of waste.

After implementing the art-based didactic sequence, the results of the final questionnaire indicated a substantial change in students' perceptions. There was a clear increase in the understanding of the concepts discussed, with an increasing number of students mentioning the importance of rethinking their consumption habits, reducing waste production, and adopting more sustainable practices in their daily routines. The screening of the documentary Waste Land played a key role in this process, cited by several students as a crucial point in their understanding of the social and environmental impact of waste. This documentary, directed by Lucy Walker in collaboration with João Jardim and Karen Harley, received international attention, being nominated for an Oscar for Best Documentary in 2011 and winning awards at several festivals, including the Sundance Film Festival [12]. Through the work of Vik Muniz, who transformed waste into art in collaboration with waste pickers in Jardim Gramacho, the documentary offered a powerful insight into how waste can be creatively reused, stimulating deep reflection on disposal and recycling practices. The Rotating Stations methodology proved effective in providing a diverse and interactive approach to learning. This methodology allowed students to explore different aspects of solid waste in a dynamic and participatory way, consistent with the approaches suggested by Kelly [13] for teaching complex topics. Analysis of the discussions that took place at each station indicated that students began to perceive waste not only as a problem but also as an opportunity to create innovative solutions, a concept that is in line with the idea of education for sustainability advocated by Huckle [14], Foster [15] and Güler *et al*. [16]. This change in perspective reinforces the notion that sustainability requires creativity and engagement from all members of society [17].

The craft workshops, which used recyclable materials to create works of art, played a central role in the pedagogical practice, engaging students in a concrete and meaningful way. Using recyclable materials as a pedagogical resource is supported by studies such as those by Thornes [18] and Poımenıdıs [19], who argue that art can be a powerful means of communication and social transformation, especially in educational contexts. Students reported that the experience of transforming waste into art gave them a new perspective on the value of discarded materials, leading them to recognize the potential for reuse and transformation of waste. This type of hands-on approach helped students develop a more complex and critical understanding of issues related to disposal and recycling, as discussed by Papanek [20] in his work on ecological design and social responsibility.

The final exhibition of students' work was crucial to consolidating learning. The public appreciation of the artworks created by students, displayed in an environment that involved their peers and families, reinforced their sense of accomplishment and provided an opportunity to share their reflections and learning. In addition, the exhibition served as a formative assessment tool, allowing students to reflect on the creative process and the ideas expressed through art, an aspect that Freire [21] considered essential for developing critical consciousness. The practice of publicly exhibiting works is also supported by Eisner [22], who suggests that sharing artworks broadens the understanding and appreciation of both the creator and the viewer, fostering a collaborative learning environment.

Content analysis of the questionnaire responses revealed important insights into the changes in students' perceptions. The category "environmental awareness" showed significant evolution, with students demonstrating a more holistic understanding of solid waste, including social, economic, and environmental aspects. Furthermore, the "creativity" category also stood out, with students recognizing the importance of thinking innovatively and critically to solve complex environmental problems, which corroborates Gardner's [17] ideas about the relationship between creativity and problem-solving. Finally, the research highlighted the potential of art as a pedagogical tool capable of overcoming the limitations of traditional teaching approaches, which often focus on theoretical and decontextualized content. By providing a sensory and emotional experience, art facilitates understanding complex concepts and fosters a deeper connection between students and the content being addressed. Sunassee *et al*. [23] argue that the arts can influence behaviors and worldviews, making them a valuable tool for environmental education. In this sense, art not only complements but also expands pedagogical possibilities, creating a space where learning can be experienced in a more integrated and meaningful way.

4. Conclusion

In conclusion, our study demonstrated that integrating art as a pedagogical tool in environmental education promoted a significant increase in students' understanding and engagement in the topic of urban solid waste. By offering an approach that combines creativity and critical reflection, artistic activities not only facilitated the understanding of complex concepts but also stimulated a behavior change, leading students to adopt more sustainable and conscious practices in their daily lives. The practical and sensory experience provided by art proved to be effective in overcoming the limitations of traditional approaches, promoting more meaningful learning connected to social and environmental realities. These results indicate that art plays a crucial role in environmental education, acting as a catalyst for the transformation of students' perceptions and attitudes toward the environment.

5. Acknowledgements

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Construction of the Acoustic Chamber and Execution Protocol for Germination and Growth of Cherry-Tomato Seedlings

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Abstract. Sound is a mechanical wave divided into frequency, pitch, duration and intensity, which has been studied in the perception of this wave by plants. The construction of the acoustic chamber, which is capable of providing thermal and acoustic insulation, allows it to be used without sound escaping. The aim is to describe its construction in detail and the materials used. On the other hand, a protocol was also drawn up for cherry tomato seedlings, consisting of germination and growth experiments, in order to understand the signal-response mediated by the vibrations.

Keywords. Asepsis, Anechoic Chamber, Sound Insulation, Vibration.

1. Introduction

The mechanical wave that has been discussed in plant signal-response integration is sound. This can be explained by the frequency, height, duration and intensity of each vibration, allowing this wave to be perceived and propagated systemically in the plant, activating structures such as: stomata, plasma membrane, roots and even phloem and xylem fluids [3, 8, 10].

Plant physiology allows the identification of physical stimuli induced by environmental conditions, such as wind, temperature, light and humidity, as well as mechanical stimuli, rain and touch, and chemical stimuli such as responses from chemical volatiles, CO2 concentration and plant hormones [13], treated as essential and efficient conditions for plant growth.

Physiological stimuli in plants are called phytoacoustic signaling [7], bioacoustic signaling [2] and ecoacoustic signaling [12]. They are described in different ways but have the same function: to obtain physiological and molecular responses in plants' ability to emit and respond to vibrations at different frequencies and intensities, understanding the relationship between organisms and the environment.

Based on these considerations, this research followed a qualitative approach with an explanatory design, with the aim of building an acoustic chamber and a protocol for developing the germination and growth experiment of cherry-tomato seedlings.

2. Material and Methods

The design consisted of building an acoustic chamber in order to isolate any vibrations that could interfere with the cherry tomato seed germination experiment that would be carried out later. In addition, a protocol was constructed which follows the rules of asepsis and is carried out in a laboratory under controlled conditions [4].

2.1. Construction of the acoustic chamber

The acoustic chamber consists of two 10 mm thick plywood boxes. The outer box is 62x62x86 cm and the inner box is 45x45x76 cm. Each box has its own lid. The lid of the outer box has dimensions of 66x66 cm, with edges of 2 cm for fitting and the lid of the inner box has dimensions of 47x47 cm, with an edge height of 2 cm, according to [9].

The walls and bottom of the outer box were lined with glass wool, which helps with thermal insulation and acoustic insulation due to sound absorption as a result of the porosity of the wool, i.e. the wave comes into contact with the wool and is then absorbed [6], adapted from [9]. Newspaper was then covered under the wool to prevent contact with the skin when the chamber was opened or handled. Afterwards, glass wool was added to the outer lid and then newspaper was placed under the wool, leaving the sides of the edge for the sponge rubber to be inserted in order to prevent sound escaping.

The inner box will just be inserted inside the outer box to serve as the working space for the experiment. A pair of small, portable 2.5w x 2 speakers with a sensitivity of 80db, a frequency of 90Hz-20kHz, with an input for a notebook and a voltage of 200V were added to the inner lid. Then the LED strip was inserted, with a power of 9W, voltage of 110-240V, frequency of 60Hz, luminous flux of 950lm (lumens), maintaining an ambient temperature of 25°C to 28°C, cool white color, with a color temperature of 6500K, luminous efficiency of 106lm/W, dimensions of 26 mm x 600 mm.

At the intersection of the wires to the outer and inner box, a vertical cut was made and then with the wires inserted, adhesive silicone was added to prevent sound escaping and external interference

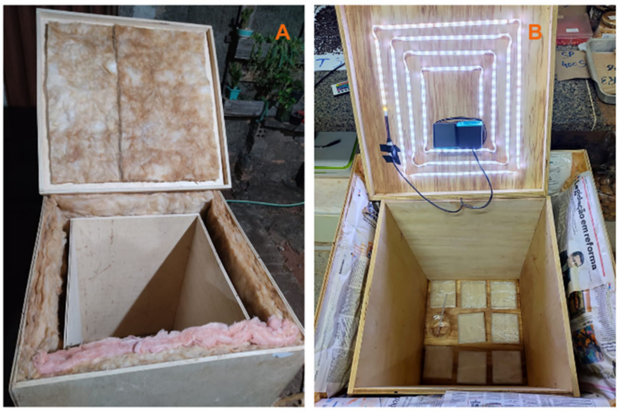

Figure 1. A) Acoustic chamber showing the outer box covered in glass wool and the inner box plus the outer cover. B) Fully assembled acoustic chamber, showing the inner lid and the presence of the LED light and speaker

2.2. Execution and asepsis protocol

The execution protocol was designed based on the development of the experiments that would take place later, with two treatments: treatment with the use of acoustic vibration and treatment without the use of acoustic vibration. For comparison of germination and seedling growth of the cultivar of choice, which in this case, the protocol was built for cherry tomato seeds, adapted from [5, 7, 14].

The entire protocol was developed using as a basis the experiments carried out by [1] in an adapted form. The protocol is divided into 6 stages: 1) choice of seeds; 2) asepsis of seeds; 3) asepsis of materials; 4) germination experiment; 5) growth experiment and 6) use of the acoustic chamber.

In the seed asepsis stage, the desired type of seed must first be chosen, in this case it will be cherry tomato, and all the necessary information must be noted down, such as place of purchase, city, batch, harvest, purity, germination rate, shelf life and line. Next, the seeds should be separated under a magnifying glass, for a maximum of 2 minutes per seed under the incidence of light so as not to interfere with germination. Next, the number of seeds required for use in the experiment should be selected, taking into account that some loss may occur. In this case, 250 seeds were selected, of which 240 seeds will be used.

The seeds were aseptically washed in the laminar flow chamber by immersing them in a 1% sodium hypochlorite solution for one minute, then in 70% alcohol for another minute and then washed three times, each for one minute, with autoclaved distilled water. They were then placed on filter paper that had already been prepared in the autoclave so that they could dry naturally while still in the laminar flow chamber, to avoid contamination.

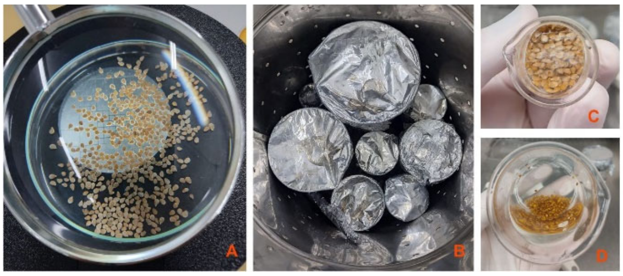

Figure 2. A) Selection of seeds. B) Asepsis with distilled water, tweezers, blotting paper, 1% sodium hypochlorite and beckers. C) Asepsis of the seeds in the laminar flow chamber with 1% sodium hypochlorite. D) Washing the seeds with autoclaved distilled water

Figure 3. Complete closed acoustic chamber, identifying the use of the notebook to transmit the acoustic vibration

The materials were aseptically sterilized in the gerbox, emerged in 70% alcohol and commercial sodium hypochlorite for 20 minutes, and then left in ultraviolet light in the laminar flow chamber for another 20 minutes. The blotting paper was sterilized in the autoclave for 20 minutes, along with the materials needed to carry out the experiment.

The acoustic chamber was aseptically cleaned with sodium hypochlorite, Qboa and 70% alcohol, after which it was left to dry so as not to moisten the walls.

In the germination experiment, the selected and sterilized seeds were sown on sterile blotting paper (already inside the gerbox) moistened in a ratio of 1:2.5 (one gram of blotting paper to 2.5 ml of sterile distilled water), and in 5 horizontal rows to 6 vertical rows. A total of 8 gerboxes with 30 seeds in each box. These were determined and marked.

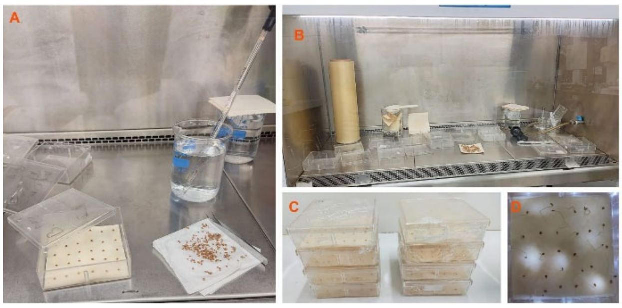

Figure 4. A) Cherry tomato seeds sown in the gerbox. B) Use of the vertical laminar flow chamber to set up the germination experiment. C) All the cherry tomato seeds sown in the 8 gerboxes. D) Germination after 6 days of treatment using vibration in the acoustic chamber

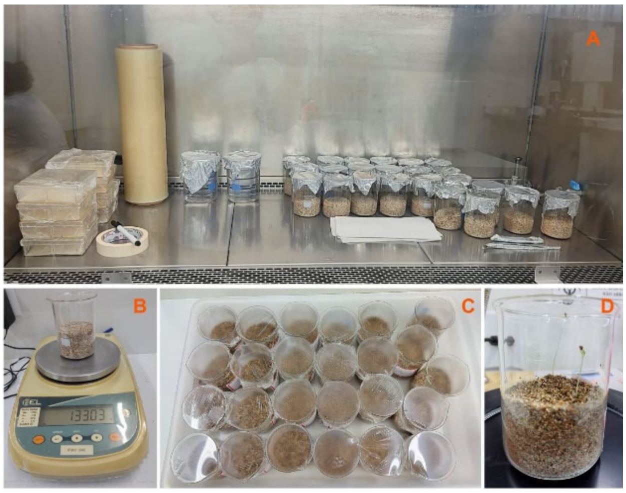

Figure 5. A) Laminar flow chamber with all the materials to read the germination experiment and start the growth experiment. B) Weighing the vermiculite substrate for autoclaving. C) All the beckers with two cherry tomato seedlings each. D) Growth after 10 days of treatment using vibration in the acoustic chamber

In the growth experiment, 50 germinated seedlings from the previous germination experiment were selected and transplanted into the 250ml glass beaker with the fine vermiculite substrate. This was previously sterilized in the autoclave for 20 minutes. Thus, 25 repetitions were carried out, totaling 25 beakers with two seedlings each, ending with 50 seedlings for the experiment.

When using the acoustic chamber, both the germination and growth experiments should follow the same procedure. The control treatment was carried out without any vibration, using only the light from the LED strip, with a photoperiod of 12 hours/day and monitoring for 6 days and 10 days. The treatment using vibration, in this case classical music, had a photoperiod of 12 hours/day and was monitored for 10 days.

With the protocol set up, all you have to do is carry out the experiment.

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Note:

The construction of the acoustic chamber was developed to carry out the cherry tomato germination and growth experiments with acoustic vibrations. As well as the execution protocol, which was written based on the experiment to be carried out, however, it can be used for other cultivars and adapted according to the requirements of each one.

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Scientific Literacy: Narratives of the Scientific Initiation Experimentation of Students in the First Year of High School at the Federal Institute of Goiás

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Abstract. This paper is a presentation of the thesis study on Scientific Literacy of High School Students, a dialogical analysis from the perspective of Librarianship and Education through the narratives of the Field Diary. The research will investigate the benefits of access to scientific literacy for young people. The methodology is descriptive-qualitative. The aim is to investigate the benefits of Scientific Literacy for the pedagogical development of young people. It presents the structure of the thesis, the final product of which will be aimed at educators interested in the literacy and scientific training of young researchers, starting early in secondary school.

Keywords. Information Literacy, Science, Education, Scientific Literacy.

1. Introduction

This text presents the theme, justifications, objectives and methodology of the Doctoral Thesis of the Postgraduate Program in Education - Contemporary Context and Popular Demands, of the Federal Rural University of Rio de Janeiro, which has its origins in the professional work of the author, who is a librarian at the IF Goiano, and especially in the trajectory of studies and investigations, working with the idea of the global system of Science and Technology and, at the same time, seeking sufficient cultural training to produce critical and reflective analyses of objects, be they advances in science and technology, the ways in which scientific communication itself takes place at the Federal Institute of Education, Science and Technology Goiano, at the same time, seeking sufficient cultural training to produce critical and reflective analyses of objects, be they advances in science and technology, the ways in which scientific communication itself takes place at the Federal Institute of Education, Science and Technology - IF Goiano, or artistic and cultural events, always seeking their interconnection, acting in scientific and cultural dissemination.

The theme of this thesis was born out of the craft of training new scientists in the advent of the world of scientific information and communication. The object of the research is the study of phenomena linked to scientific culture, proposing a dialogical study of the phenomena and benefits of early scientific literacy, through narratives in field diaries, which will be the data collection and analysis device. The narratives will be captured in the diaries, during the practices of the formative processes in didactic experiments of access to scientific initiation of high school students of the Hidrolândia Campus in order to contribute to the comprehension, understanding and explanation of the dynamics of the subjects' relationships while they experience doing science. Information literacy is intrinsically related to doing science and refers to the human capacity to understand and use information generated on the internet in a critical and strategic way.

When we talk about the concept, we are talking about a set of skills needed to navigate well in the information age and use technological and digital resources for relevant applications, so a person who is literate in scientific information has developed both the skills of reading and writing and of using the technologies available today and can both learn and solidify what has been learned, both reading and writing using the technologies of today's world and being able to assimilate and solidify the learning.Information literacy, as an important training device for recognizing networks, connections, relationships and local and global patterns of cultural interdependence, is an essential condition for empowering people, improving their understanding of the reality in which they live and enabling them to intervene constructively in it, to participate in the aforementioned social project. Despite the intense discussions about information literacy and the unanimous view that it should be included in all social efforts to provide continuing education for all citizens, there is still the challenge of overcoming the immense difficulties involved in implementing it in basic education, which implies a joint effort by society as a whole” [1].

The multiple possibilities and expressive offers of information need to be consumed,

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criticized, assimilated and then put into practice. It is in this context that the skills of information, pedagogical and scientific literacy become increasingly necessary and, together with the best didactic strategies aimed at promoting learning, teaching becomes a strategy. The sciences are constantly evolving and renewing themselves, growing and strengthening as they appropriate and deepen their studies of their objects. Scientific thinking is one of the fundamental pillars of modern society. It is a systematic and rational approach to understanding the natural world and the laws that govern it. Through the use of logic, proof and the scientific method, scientists seek to discover the truth about the world around us.

Science and doing science have a much wider application, including areas such as education, politics, economics and even personal relationships. Through scientific thinking, we can evaluate information critically, identify prejudices and preconceptions, and make informed decisions and behave accordingly. The development of scientific thinking is essential to ensure that students become informed and critical citizens. In addition, scientific initiation and the application of the strategies and didactics of scientific doing are key elements for success in a scientific career, allowing students to develop essential skills such as critical analysis, problem-solving and clear, objective communication.

The research is multi-referential since it will use resources and epistemic bases from the Information Sciences and Education, making a dialogical study between the two, to converge on a product that helps with information literacy in basic education. In terms of methodological procedures, the study is a descriptive survey with a qualitative approach and an exhaustive bibliographic design. The data collection and analysis device is the narratives in the research field diary. We sought to point out the possibilities of application and contribution of this investigation to the development of research in the area, making use of a flexible/adaptable methodology, allowing its use with various multidisciplinary approaches, field research through discourse analysis.

The thesis aims to explore the importance of developing scientific thinking through the application of strategies and didactics of science, scientific doing and scientific initiation, going far beyond method or the application of technical standards. Through this research, I hope to provide valuable information for educators, students and researchers interested in elevating their scientific skills and promoting a more influential, critical society. Early on, ahead of the traditional moulds for the first years of high school.

2. Discussion and results

Literacy is a pedagogical practice that promotes autonomy, listening and dialogue, acceptance and respect in the relationships between people, educators and students. Paulo Freire teaches us that part of dialogising is the understanding by all the subjects who take part in the educational process of contexts and daily lives that are historically and culturally forged from contradictions which, in practice, of everyday life define situations from a perspective in which the “obstacles to be overcome in and by the educational process from the methodological path that involves coding-problematization-decoding, which must be deciphered and perceived consciously and critically by the people being educated to overcome a posture of immobility in the face of such realities.

> “Finally, there is no real dialogue if there is no real thinking in its subjects. Critical thinking. Thinking that, while not accepting the world-human dichotomy, recognizes an unbreakable solidarity between them. This is thinking that perceives reality as a process that grasps it in constant becoming and not as something static. It does not dichotomize itself in action. It is permanently “bathed” in temporality, the risks of which it does not fear. It is opposed to naive thinking, which sees “historical time as a weight, as a stratification of the acquisitions and experiences of the past”, with the result that the present must be something normalized and well-behaved. For naive thinking, the important thing is accommodation to this normalized today. For critical thinking, the permanent transformation of reality, for the permanent humanization of men. For critical thinking, Pierre Furter would say, “the goal will no longer be to eliminate the risks of temporality by clinging to guaranteed space, but to time space. The universe does not reveal itself to me (says Furter) in space, imposing on me a massive presence to which I can only adapt, but with a field, a domain, which takes shape to the extent of my action. For naive thinking, the goal is to cling to this guaranteed space, adjusting to it and, by denying temporality, denying itself. Only dialogue, which implies critical thinking, is also capable of generating it. Without it, there is no communication and without it, there is no true education. By overcoming the educator-learner

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> contradiction, it is established as a gnosiological situation, in which the subjects focus their cognizing act on the cognizable object that mediates them [2].

To analyse the functionality of this study, it is necessary to be clear about the competences in relation to the dialogical study of scientific practice of adolescents starting secondary school at the Goiano Institute of Education, Science and Technology-IF Goiano.

The cross-curricular proposals in teaching that point to horizontal and vertical integrations of information literacy, teaching and learning practices as an instrument for promoting scientific initiation, capable of stimulating in adolescents starting secondary school the awakening to the subject who makes science, who understands its processes, expanding the training skills of these young students. The fact that students, from the outset, critically analyse a portion of reality to problematize it and, given the different possibilities, choose that aspect which they consider most relevant for study at that moment, becomes decisive for their engagement in the continuity of the process.

They feel co-responsible for building knowledge about the problem and alternatives for overcoming it, which reduces the perception of external control over the academic activity and contributes to the gradual constitution of their autonomy. - Along the way, due to the characteristics of the stages and all the technical, scientific and empirical information they access and use to carry out the activities, the students are encouraged to confirm their previous beliefs, values and concepts, or to question or even reformulate them as a result of new learning. - The whole process allows them to become aware of the complexity of the social phenomena involved in the study. - Activities that involve high-level mental operations, such as analysis and synthesis, for example, and all other operations that go beyond memorization, stimulate the development of critical thinking. - Students' creative thinking is stimulated at every stage of the process. - Students are also mobilized for social, political and ethical learning, which contributes to the formation of a citizen. - These actions are methodologically guided by the teacher, who takes on the role of conducting and carefully articulating the process. This means acting as a mediator and not as the provider of all information or the author of all decisions. - Associated with this perspective of pedagogical conduct are the actions of monitoring, support and constant feedback from the teacher, with a view to achieving the goals of solving the chosen problem and consequently intervening in the part of reality [3].

The methodological strategy is the diaries produced by the researcher, the Narratives in the form of a Field Diary. “The field diary is a personal device that allows us to reflect and record what happened, encouraging the researcher to investigate their own actions by systematically recording and analysing their actions and reactions, as well as their feelings, impressions, interpretations, explanations, failures, hypotheses and concerns involved in these actions [4].

The Field Diary will be produced during didactic experimentation in activities with young students attending high school, or the first year of an undergraduate course, in formal learning spaces in shared regency in the discipline of scientific methodology, in MOOC courses (Massive Open Online Courses) and other course formats, in medium-term training and workshops, and by personalized accompaniment to a focus group of this study about a comprehensive teaching plan inserted in the scientific method, its strategy, way of doing and possibilities.

> “Recognizing the significant production in the field, we would like to point out that recently there has been a search to re-signify knowledge about Didactics, to build approaches and perspectives that offer elements to face the current challenges of school education. This is what we have been identifying in the research we have carried out through the group we coordinate, as well as the discussions we have witnessed and/or participated in different academic spaces about the current configuration of the field of Didactics.
> [...] Conceiving educational processes as historically situated, articulating education with other social processes, systematically working on the theory-practice relationship, fostering processes to build autonomous, competent, supportive subjects capable of being subjects of rights on a personal and collective level, capable of building stories and betting on a different world and society, using active, participatory, personalized and multidimensional methodologies, articulating the cognitive, affective, playful, cultural, social, economic and political dimensions of education.

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Didactic experimentation is a concept that involves pedagogical practice and the construction of knowledge through experimentation and interaction between individuals. It is an approach that seeks to innovate and enrich the educational process, considering the diversity of contexts and subjects involved. It is important that didactics be comprehensive, considering political, technical and human aspects in the teaching-learning process, leading to the formation of critical individuals committed to social transformation.

The pedagogical experimentation activity, with the use of direct insertion of teaching and learning techniques based on science methods, in addition to the use and application of standards, will be carried out with high school students who have no previous experience of language, communication and scientific initiation practices. The proposal consists of teaching classes, workshops and mentoring in scientific initiation. The main objective is to introduce students to the most common terms, practices and methods of scientific practice, focusing specifically on projects related to environmental education in the joint classes with Scientific Methodology and Environment (pedagogical residency for scientific initiation (integrated regency).

Scientific literacy plays a crucial role in students' education, enabling them to understand and use scientific knowledge in a critical and reflective way. From basic education onwards, it is essential to develop skills related to science and scientific practice. When we explore the concept of knowledge, we realize that science and scientific development are intrinsically linked to the ability to uncover, explore and apprehend objects through knowledge. Those who acquire this knowledge appropriate the objects studied, transforming them into concepts and reconstituting them in their minds. This process of scientific literacy not only broadens understanding of the world, but also enables students to become autonomous and active citizens, capable of understanding and participating in social transformations.

Research into the scientific literacy of young students in basic education can extend to creation, becoming a potential space for (re)signification and the production of discourses. That the didactic experimentation of scientific processes can be associated to the benefit of building teaching strategies, among which is the constitution of a training system in which the student acts as a researcher, awakening broad reflections. It is necessary to look for ways to democratize the training of scientists, to educate young people in a way that goes beyond reading and writing to reflecting and, by reflecting, perceiving the ills of society and becoming restless and moving based on the elements of scientific practice to change reality and the problems that arise.

3. Acknowledgements

I would like to thank the Federal Institute of Goiás, the professors Drª Lilian Rosana Rabelo and Dr. Jackson Zucki, who shared with me the teaching of the classes that took part in this study. I would also like to thank my supervisor, Professor Clézio dos Santos, who wrote this article with me and has guided me along the paths of this research, which seeks to work with the training of researchers during basic school education.

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Sustainable Science

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Abstract. Are current science teaching approaches sustainable and suitable for the issues facing our children? The paper discusses ideas for a change to more relevant science education.

Keywords. Sustainable Science, Curriculum Change, Rethinking Purpose of Schooling, Skills Development.

1. What is sustainable science?

The word sustainable is quite difficult to define. It is suggested that sustain means to hold up, to support, to maintain, or will maintain, to keep, and to keep up [1]. Hence sustainability becomes that which supports. So if we talk about sustainable science, what are we supporting? I believe this means ensuring that science is relevant and particularly that what we are teaching our young people will be of use to them in the future. And this is especially important for the next generation in particular so what can we do for children up to the age of eleven?

2. Where are we now - what are we teaching and why?

The science curriculum [2] pre age 11 in England is to some extent a watered down version of what to expect later at secondary school. The primary science curriculum is split into sections which relate to biology, chemistry, and physics. Most of this will be covered more fully later at secondary level, so why are we not concentrating on the science that is happening around children every day? This would be far more relevant particularly if children are allowed to make their own observations and explore their own environments in this time of changing climates.

3. Early Years Foundation Programme

In England, Early Years children can attend Nursery schools up to the age of five with some financial provision being made so all children can at least have some time in a learning environment. Whilst the Government states that their Early Learning Goals are not mandatory it is generally recognized that children learn best through play, modelling on adult behaviour, and observing each other linked with some guided learning from adults. Children need to learn the skills of working together in a community; be able to explain their play through active learning and be able to think creatively and critically [4]. The goals suggest that they explore their natural environment and the world around them. By the time young children reach more formal school at age 5, they should have acquired some basic skills for life.

4. KS1 (age 5-7) and KS2) age 7-11) in England

On reaching age 5 children in England start formal education which is a world away from the freedom they enjoyed at nursery school. They are expected to sit at desks and participate in our National Curriculum [2] which divides subjects into separate entities. Our latest English primary science curriculum states that children should observe, explore, ask questions as well as working together and evaluate evidence. The curriculum also suggests science is integrated into other subjects but in practice this is not always obvious. In theory the curriculum is fine but the amount of time allocated per week for science– sometimes per fortnight- is insufficient to allow the freedom required to observe, or ask questions.

A further issue is that whilst our primary teachers are willing to learn, very few have any science background beyond GCSE at age 16. Science is not always incorporated across the curriculum using the tools of maths, reading, writing and IT and it frequently becomes an almost tick box session. There is little time for the development of the skills learnt earlier which would benefit the whole curriculum. Many secondary school teachers of science find they are teaching 11-year-old children from a range of different schools all with different approaches towards science. These secondary teachers would really prefer that the incoming pupils had good science skills - alongside good communication, patience and the ability to work together.

We need to develop a good skills base in our primary year children, which sets them up to benefit from in their new schools, and which will be of use for the rest of their lives.

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5. How can we do this?

The first thing is to identify what science issues are relevant and how to understand the variations that are occurring at the present time. Our planet is changing in a number of ways. Our world climate is fluctuating for several reasons. This may be due to anthropomorphic influences, could be part of the natural cycle of climate, or a mixture of both, but either way we need to understand the linkages and changes as this will affect just about everything. Global changes will be and are already quite significant. Periods of drier, hotter weather bringing drought; periods of devastating rain bringing floods; the possibility of sea level rises, the reduction of the polar ice caps. Will the world's population need to look at a smaller habitable land area? Where can we grow food? So shouldn't we be preparing future generations to understand how and why these changes are occurring, how and why the linkages between these changes matter and what might be the future outcomes?

6. Where to start?

We know that there will probably be droughts – so children need to know about the importance of water for life, hence the water cycle is a good beginning. They need a simple understanding of where water is stored underground and how it can be made available. This is particularly important in their own environment. They should appreciate the necessity to collect and store surface water for future use and explore how to recycle and clean water locally if natural water storage is not appropriate. Searching for suitable storage areas in their own area could be fun. Converting sea water to potable drinking water - how appropriate is this in their region?

We also know that storms and heavy rainfall are becoming more intense so children should have an idea of the vulnerability of living in certain areas. and how to alleviate problems of flooding and high winds through examining building shapes and where they are sited. Sea level rises are inevitable so some knowledge of coastal areas likely to be inundated could be useful. Looking at local and world maps to try to define these places can be daunting but interesting. Some knowledge of why floods occur, perhaps by playing with soils and rocks to see their permeability, can be done in a classroom

Within these points plant adaptation to changing growing conditions can be investigated – by simple means - even keeping a yearly diary of changes in growing, flowering and fruiting times in their own areas. Classroom experiments of changing growing conditions are fun and easy to undertake, and children can make their own predictions of what conditions enable growth or prevent it.

Should we be changing our eating habits to more vegetarian options – would this be a healthy option? Can our bodies gain enough proteins and vitamins for growth with a different diet?

There really are many ways we can look at likely coming issues and only a few have been outlined here. Children themselves will identify upcoming problems and will want to investigate ways of combating them given the opportunity. In doing so they will use important scientific and social skills – exploring, observing, recording, discussing and communicating at their level.

7. The need for curriculum change

So perhaps a change to curriculum approach is needed. I believe Earth Science is an excellent starting point from which to develop learning programmes which can be used across the whole primary school [4]. Using the topics Earth, Water, Air and Land all subjects could be integrated at all stages, through science, history geography, art whatever, using the important tools of mathematics, reading, communication and technology. Useful background followed up by discussions and ideas of projecting changes will give rise to creative thought.

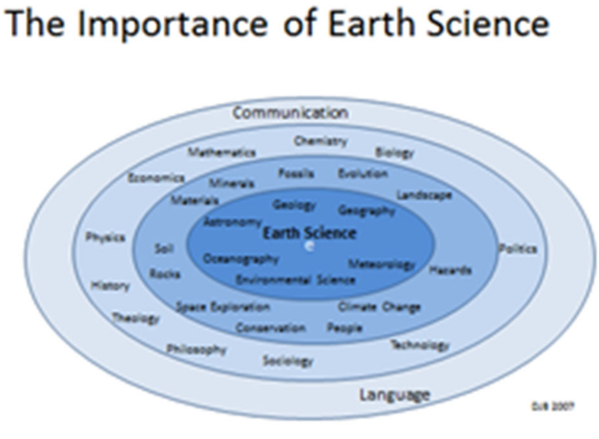

Figure 1. The importance of Earth Science to the curriculum [4]

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8. The Purpose of Schools

Perhaps it is not just science teaching that Perhaps it is not just science teaching that needs to adapt to new ideas and techniques. There are moves afoot to change overall teaching approaches in schools worldwide. We have long had Montessori and Steiner schools with their different techniques. Now it seems there are other ideas being implemented. A recent book, [6] offers a number of forward-looking ideas about schools and their future curricula. Whilst presumably we will still need to learn the tools of education (the reading, writing and arithmetic and these days IT) in order to progress with learning and understanding, there are different ideas about what the curriculum itself should entail. In Helsinki, Finland for example, schools use their city as a learning environment: parks, playgrounds, museums, theatres, cultural buildings and libraries are part of the every day learning environment. Nature and ecosystems alongside creative arts are embedded in the curriculum for all children, not just those in elite schools. One headmaster acquaintance in Finland was talking five years ago about reducing the number of days students spent in an actual classroom to possibly one or two a week. Ideas about change abound but these are not always practicable in many countries .Another book [7] extolls the virtues of schools as institutions for socializing but also suggests that curricula must change to be more relevant. Covid showed that there were different ways of promoting learning other than within the classroom and it is suggested that schools could be learning hubs within other learning environments with flexible school attendance. These ideas are going to require great initiatives to make them work on a large scale although many individual establishments are finding ways to change. The authors say that the concept of school is relevant to the future but in different ways.

9. Conclusions

It is difficult to predict what and how quickly changes are going to come about, but one thing is sure, and that is that we need to prepare our young people for a different world. They need to understand the preciousness of water, the sensitive nature of plants and the soil, the importance of keeping our atmosphere as pure as possible and the delicate balance of life as we know it on our planet. In other words, we must change our teaching approach to our upcoming generation to enable them to become sustainable scientists. We need to give them the skills to help them be less afraid of the future.

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Research on Experimental Activities in Chemistry in the Educational Context in Brazilian and Foreign Journals

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Abstract. Practical classes are fundamental in the teaching of chemistry, as they present close relation to active methodologies, which are teaching strategies that value the students' autonomy and self-directed learning. From this perspective it is developed in this work an analysis of the scientific literature on experimental activities in Chemestry classes in order to evaluate the potential of this methodological strategy.

Keywords. Chemistry Teaching. Experimental Activity. Practical Class.

1. Introduction

Experimentation in Chemistry teaching is an aspect scarcely explored in the country's schools. It can be said that much of the students' lack of interest in the subject is precisely due to the lack of assimilation of the theoretical and practical knowledge. Practical classes involving experimentation align the context of active methodologies, which are teaching strategies that aim to give students a central role in learning through teaching with instructional activities, that is, practices where the student builds their learning.

The present work aims to explore and analyze scientific productions focused on experimental activities in Chemistry teaching. Highlighting the importance of teaching Chemistry with experimentation and practical activities, which is essential. Without such active methodologies teaching Chemistry can become just a vague illusory knowledge.

Practical classes involving experimentation align with the framework of active methodologies, that are teaching strategies aiming the students' learning autonomy through institutional activities. By these practices the students build their learning. The active methodologies emphasize the student's learning role, and direct, participatory and reflective involvement in all stages of the process, experimenting, drawing, creating having the guidance of a teacher [1].

2. Data collection, Results and Discussion

In the present study, all 51 articles assembled present aspects aimed at improving education in the field of Chemistry from 2019 to 2024, with an approach of didactic proposals for specific content, internship reports in education and history of Chemistry (Table 1). To search for the articles, first it was applied the term "experimental activities in chemistry teaching" and all relevant materials were collected. Subsequently, a brief analysis by reading the materials was conducted, only articles with proposals and reports on practical teaching in the field of chemistry were chosen. The searches were conducted using Google Scholar and the journals' oen portal. In sum, 26 journals were examined classified under webqualis A1, A2, A3, A4 and B1 for 2014, in Education field, including four international and twenty-two national journals.

Table 1. Quantitative articles on practical teaching in the area of chemistry by periodical

Jounals	Analyzed Period	Quantitative
Alexandria	2019 - 2024	3
Amazônia	2019 - 2024	1
Docência do Ensino Superior	2019 - 2024	1
EaD em Foco	2019 - 2024	1
Educação em Foco	2019 - 2024	1
Educación química	2019 - 2024	1
ENCITEC - Ensino de Ciências e Tecnologia em Revista	2019 - 2024	2
Holos	2019 - 2024	1
Informática na Educação: Teoria e Prática	2019 - 2024	1
Insignare Scientia	2019 - 2024	2
Interritórios	2019 - 2024	1
Pesquiseduca	2019 - 2024	1
Química nova	2019 - 2024	11
REAMEC	2019 - 2024	1
RECH- Revista Ensino de	2019 - 2024	1

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Ciências e Humanidades		
REDEQUIM	2019 - 2024	12
REnCiMa	2019 - 2024	1
REPPE: Revista do Programa de Pós-Graduação em Ensino	2019 - 2024	1
Revista Brasileira de Pesquisa em Educação em Ciências	2019 - 2024	1
Revista de Educação, Ciências e Matemática	2019 - 2024	1
Revista EAI	2019 - 2024	1
Revista Educação Especial	2019 - 2024	1
Revista Eixo	2019 - 2024	1
Revista Electrónica de Enseñanza de las Ciencias	2019 - 2024	1
Revista Prática Docente	2019 - 2024	1
Revista Vivências	2019 - 2024	1
Total de artigos:		51

The aticles on basic education are more numerous, a total of sixteen studies, in contrast, for higher education and teacher training the numbers are close, there are eleven and twelve studies, respectively (Table 2).

Table 2. Number of articles by the level of education assembled in the search

Education levels	Quantitative
Basic eduation	16
Higher education	11
Teacher training	12
Literature review	12

Most articles gathered in this research encompass proposals and/or reports on practical activities over a wide range of topics in Chemestry Education.

- Physical Chemestry: The focus of the articles is similar, with both addressing proposals in electrochemistry, matter, and energy for teaching [2-5].
- Analytical Chemistry: widely exploredd topic, several articles cover different aspects of analytical chemistry, including qualitative, quantitative and instrumental approaches [6-10].
- Organic chemistry: numerous teaching proposals are covered, focusing on the extraction of organic matter from plants, such as extracts and oils [11-19].
- Chemistry Education: a large number of articles address analyses, experiments, proposals and surveys of chemistry education in a general sense, without specifying particular areas of knowledge, and focusing on didactics and teaching methodologies.[20-52].

A frequent inference in the studies is the relevance of experimentation for Chemistry teaching. Consistently, the studies that present teaching proposals and add practical ways of working with content report that such methodologies encourage student engagement, improving learning more effectively than theoretical and monotonous instruction. Internship reports also reinforce the importance of using experimental activities in teaching. Similarly, it is noted that pre-service teachers are strongly convinced of the benefits of experimentation for the chemistry discipline.

Soon, it is anticipated that the use of these active methodologies, with the broad application of experimental activities, will help overcome superficial Chemistry teaching.

3. Conclusions

In general, the research was extremely satisfactory. It is a great pleasure to note that students and future Chemistry teachers understand the importance of experimentation in teaching the subject. Training beings who think and do science is fundamental for the good development of a country. Experimentation goes beyond teaching at school. It connects students in educational growth with the real world, as everything we use and touch involves Chemistry.

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Developing STEM Skills and Understanding in Holistic STEM through STEM, STEM-E and STEM Phonics in Pre-School Play

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Abstract. Whilst interactions with everyday objects and those designed for children, toys, children use actions which can be identified as being inherent ion Memetic o, engineering or sconce concept. These single actions or observations often in the case of biological and earth science, are small individual called STEM phonics, which with the child's experience can consolidate into further understanding. IN childhood the experiences of STEM are HOLISTIC. They interactions follow. Sequence, identifiable in the Play Cycle which is fully developed after the STEM -E (Experiences) basic stage in the first two years of life when they are learning these basic skills of action and outcome and observation. The challenge is to assist early years practitioners to recognise these STEM and the progressive development of skills in the pre primary and younger learners.

Keywords Preschool, Play, Everyday Holistic, Phonics.

1. Introduction

The climate emergency and the identification of the Sustainable Development Goals UNESCO's 2023 Agenda for Sustainability [1]. It is a crucial call for implementation. However, whilst immediate actions can be made, it is imperative that countries develop an SDG competent and an aware society, understanding the issues and ways of mitigation is necessary. Such requires an understanding of STEM -, Science Technology and Mathematics, which embraces Engineering and Information technology, in societies. Such understanding can be actively encouraged from a child's earliest years and developed in both the formal, schools, and informal learning environments, such as museums, science centres and communities and the universal medias.

There has been in this century (Written 2024) a move not only to discuss STEM but to add additional areas of knowledge and practice, to the acronym. particularly an oft used one is STEAM, with the A standing for Art or the ARTs. STEAMD, D- drama or disability, STREAM, R = Religion or robotics. Have been suggested and used. However, practitioners who have worked with early learners in the STEM sphere of the curriculum recognise how these areas are naturally included in STEM practice as too is developing and using language literacies in communications, recording and sharing findings and achievements in STEM activities.

Hence, this paper refers to STEM embracing these above adult defined areas within the design and practice of observations and activities. All these other subject areas come into a child's early learning and it is not necessary to talk about anything other than STEM in much primary work, they are all embraced in science [2]. Practitioners who have worked with early primary aged children know how much basic engineering basic skills and capabilities [3] and some technologies are used in play. Moreover, as was suggested in the Play Cycle [4] play interactions follow a sequence of inquiry and discovery, solving challenges [5] the children meet. For instance, children use different tools, different tools including digital ones, in handling objects, particularly early toys they experience various mathematical concepts particularly shape, similarities, order, as well as a variety of sciences although in a lot of early years playing the interaction with objects is particularly playing with toys or household objects or bio and geofacts outside. Recently some practitioner researchers wrote,

> '*Through constructive play, children explore science in action, use mathematics through counting and comparing sizes and shapes, apply their imagination and curiosity by creatively exploring the world around them, and cooperate and communicate their understandings of their own environment.*' [6]

STEM observations and interpretation as well as practice begin in the earliest years. Here the laying the foundations for future competency the early years are defined by UNESCO as being from birth to 8 years more and more people are counting the 1st 1001 [7] days as the most from conception to the 2nd birthday as the most important time in a child's development there are two distinct phases in learning this first of all this from birth at home where it's the family the community and the culture including daycare

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and nursery pre formal school secondly this formal school which is increasingly starting at three with a pre-primary curriculum.

The child's Instinctive actions emerge as Children intuitively' play' with that which catches their interest [8]. Play is what children do, it is their occupation or work [9]. It is not 'messing about ' or recreational as the term is used by adults for their choice of recreational activities in their non employed time.

2. Playing to learn life skills to survive and serve an apprenticeship for adult essential skills

One of the big problems with all this early learning is the adults were once children but have forgotten and have become embedded in the separations of the aspects of experiences into of subjects, sciences, mathematics, technology or engineering in its various forms. what we also forget is that the school is not the sole place where children learn STEM is all around us in our everyday so children and their adults are experiencing STEM in action every day of their lives but do not realise it and these are essentially experiences which need to complement the future theoretical learning in school. The many types of play that been identified by professionals include reenactment and recapitulation [10]. However, children use their experiences as another living organism to interpret some of their play, hence recapitulation play [11] can be thought of as instinctive play. It is actions by the child based on their lived experiences as an animal. In these recapitulation actions where eat they are acting from their experience as an organism, they instinctively need shelter, food, a means of defence, so when children start building dens even if it's hiding in a cardboard box as their special place, they are instinctively doing what other animals will do to instinctively to survive.

There is also apprenticeship. The reenactment which incorporates in STEM in the actions and items used of adult activities such as cooking or finding food, using weapons for example in hunting societies [12] when playing in toy kitchens at home or in a play place. They are using items small replicas of what their adults use and are imitating the adult behaviours. In fact, they are serving an apprenticeship just as for instance kittens of cats practise essential skills for survival in adulthood when they have to hunt and kill their own food [11].

3. Holistic STEM

In the earliest of years the child's interactions with objects, including toys are HOLISTIC STEM [2]. Can we encourage HOLISTIC STEM proving experiences and later teach? Children from the earliest of years are unaware of the subject barriers that adults who seem to specialise in one particular subject and exclude all others we need to ensure that pre primary children have access to their own STEM interaction opportunities and when we have children in school that we don't perpetuate this myth of different subject areas but recognise how they all fit together in everyday happenings of course we adults control to a certain extent the experiences that our children have by what we choose to facilitate or put out for them so if we put up building blocks you're encouraging some basic maths engineering and science actions if you put out simple balance and they interact there beginning to find out about balance levers and it can lead onto measurement of weighing things. These individual small actions are STEM phonics [2]. The learner becomes progressively competent in these skills an understanding the outcome from their use. Incrementally building a concept of a Force. Eventually the Learner recognises them all as a force [12].

4. Active STEM

STEM involvement in early years is active. A very important aspect of holistic STEM is the using STEM words for the children but as actions words, not names. We often talk things as nouns in STEM, such as push pool which is what children do a great deal when they' are interacting in STEM, naming the action a child is making with a toy or other object. Instead of naming the action as a noun we can name the active action. We should say 'You're pushing you're pulling'. Even if they are nonverbal the children need to hear these STEM action words whilst making movements for dancing in free playing for example. Children are all making STEM actions and you can say STEM verbs twisting, jumping or exploring a wood, climbing trees. owing this all helps the children to develop an understanding of active STEM in their lives [13].

Children incorporate basic maths activities instinctively in their play interactions. They gradually recognise, as they become aware of individual items that several items together one the same as another one can be called two. They gradually learn names of numbers. One of the most important things in this early play is spatial awareness shapes being able to fold paper for example and these are indicators of engineering habits of mind. Learning the names of numbers as many parents and practitioners do delight in teaching children is not developing their STEM understanding, merely increasing their vocabulary,

Much of a child's early experiences and learning of STEM occur with interacting with everyday objects, many of which are culturally specific. This everyday STEM consists of there are small activities in everyday settings of everyday actions which all contribute to a science concept. Such are referred to by researchers as these 'small science' such as playing with mirrors or recognising that some of children's observations are counter intuitive such as the sun moving across the sky [14].

5. The forgotten STEM component: Biomes and biodiversity -The living world

STEM embraces the biological and environmental sciences. But such are frequently marginalised, ignored, within the emphasis of play research focusing on physical sciences. It is interesting, yet concerning, that with the increasing with the acceptance of climate change and the sustainable development goals [1] We need to recognise environmental factors affecting the ecosystems and hence biodiversity, to reflect the biology and earth science and environmental sciences all very observational. And experienced by young children. However, there is far less research carried out in this area, most of which is most often focused on a physical science approach and the challenge is to develop approaches and experiences for children in their earliest years but to also watch their instinctive free choice responses in the outside environment so the identifying these small actions that children make and observations that they make their small experiences are STEM phonics just as in teaching reading with the phonics well the children learn the small units of sounds it will combine to make a word so children are experiencing the small bites if you like of stem which one day will merge together into an understanding of a concept. Recognition of this early start in stem understanding developing competences has hitherto been ignored.

6. Conclusion

I put it to you that we have a mission to recognise this vital stage in learning and if children haven't had these opportunities before they enter into the formal education setting the opportunities need to be provided for them before they can go on to a system which I called think and do where you pose a situation and then such as a glass of water full standing next to a glass of water empty and then challenge them to effect the outcome which. Is the next stage which is two glasses with equal amounts of water, so they are then using the skills and understanding they have acquired earlier to solve the problem.

The recognition and development of active everyday STEM is the challenge for this twenty first century. Are we up to it?

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Study on Oscillations in Brazilian and International Publications

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Abstract. This article presents an overview of the literature on the teaching of oscillations in both national and international journals, aiming to evaluate its relevance in the field of scientific education. The results indicate the experimental approach to this subject is highly recommended by researchers, mainly concerning its contributions to students' engagement and their learning in science classes.

Keywords. Oscillations, Harmonic Oscillator.

1. Introduction

Educators at elementar, secondary, and higher education levels meet a significant challenge: sparkling students' interest in subjects like Physics, Chemestry and Math. A viable alternative to enhance learning in these areas is to develop experimental activities in the classroom to allow students to connect theoretical and practical knowledge. These initiatives can become a highly effective pedagogical approach for stimulating students' participation and engagement in the study of oscillators.

In this study, a literature review was conducted on studies published in national and international journals in the field of education, emphasizing their importance in research on oscillations. The purpose is to assemble the acquired knowledge and analyze whether the discussion of oscillators is being addressed properly, as well as to emphasize the relevance of contextualizing theory through experiments, particularly concerning the study of oscillations.

By integrating hands-on activities that require students' participation, class becomes more dynamic and enriching, with greater potential to stimulate students' creativity, as they can observe in practice the concepts previously discussed in class [1-3]. In recent years, this approach has been the theme of several discussions and applications in studies, such as research on oscillations. The study and control of oscillations are of great importance in physics and engineering. Many everyday issues faced by scientists and engineers are addressed, either analogously or literally, through oscillatory movements. The description of such movements has a significant influence on the mathematical and conceptual education of students [4-5].

In the present work, it was selected for analysis 10 renowned national publications and 15 international ones with A1, A2 and B1 rankings.

Thus, the articles have undergone preliminary reading to filter only those that addressed research results related to oscillation issues

2. Results and Discussion

The collection of articles from the publications' search engines covered from the earliest editions up to the year 2024, as a result 27 articles were selected for study (Table 1) being 19 national and 8 international ones. In all research conducted, the initial criteria was that the articles should include the theme "oscillations" in some way, whether in the title, abstract, keywords, or full text.

Table 1. Quantitative articles on oscillations by publication

Jounals	Period	Quantitative
Alexandria	**2008-2024**	**0**
Caderno Brasileiro de Ensino de Física(CBEF)	1984-2024	7
Ciência & Ensino (C&Ens)	**1996-2019**	**0**
Ciência & Educação (C&Ed)	1998-2019	0
Ensaio	**1999-2024**	**0**
Experiências em Ensino de Ciências (EEC)	2006-2020	0
Investigações em Ensino de Ciências (IEC)	**2004-2024**	**0**
Química Nova na Escola (QNE)	1995-2024	0
Revista Brasileira de Ensino de Física (RBEF)	**1979-2024**	**12**
Revista Brasileira de Pesquisa em Educação em Ciências (RBPEC)	2001-2024	0

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Cultural Studies of Science Education (CSSE)	**2006-2024**	**0**
Enseñanza de las Ciencias	1993-2024	1
Góndola: Enseñanza y Aprendizaje de las Ciencias (GEAC)	**2006-2024**	**2**
International Journal of Science and Mathematical Education (IJSME)	2003-2024	0
International Journal of Science Education (IJSE)	**1987-2024**	**0**
Journal of Research in Science Teaching (JRST)	1963-2024	0
Journal of Science Education and Technology (JSET)	**1992-2024**	**0**
Research in Science & Technological Education (RSTE)	1983-2024	0
Research in Science Education (RSE)	**1971-2024**	**0**
Revista de Enseñanza de la Física (REF)	1985-2024	2
Revista Electrónica de Enseñanza de las Ciencias (REEC)	**2002-2024**	**1**
Revista Electrónica de Investigación en Educación em Ciencias (REIEC)	2008-2023	1
Revista Eureka sobre Enseñanza y Divulgación de las Ciencias (REEDC)	**2004-2024**	**1**
Science & Education (S&E)	1992-2004	0
Science Education (SE)	**1930-2024**	**0**
Total of articles:		**27**

Regarding the different levels of education, most of the article's target on higher education, furthermore, it is evident that there are no articles dedicated to vocational education, indicating a need for investment in this area (Table 2).

Table 2: Number of articles by educational levels

Education levels	Quantitative
Ensino básico	**5**
Ensino superior	15
Ensino básico e superior	**6**
Formação de professores	1
Ensino profissionalizante	**0**

Most articles that were analysed in this research addresses proposals and/or reports regarding to three central themes.

- Mass-spring system: The articles have similar focuses, both discussing mass - spring systems with an emphasis on harmonic oscillatiions [3-17].
- Simple pendulum: A significant number of studies investigate various educational and experimental methodologies and approaches related to the simple pendulum [18-30].
- Willberforce pendulum: The article explores the Willberforce pendulum, focusing on its coupled oscillations and suggesting an experimental setup adapted for informal educational contexts [31].

In most cases, studies that contextualize the theory of oscillations through practical experiments have promoted more student engagement, enhancing learning compared to more theoretical and tedious teaching.

3. Conclusions

Overall, the research portayed very positive results. The explanation of oscillatory movements still plays an important role in students' scientific education, as well as connecting to a solution of everyday applied issues. It is rewarding to notice how much students and educators recognize the relevance of the experimental approach to the subject in the process of teaching and learning Science.

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Impact of History of Science in Students' Science Works of Secondary and High School

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Abstract. Science is always subject to change, is alive, and the history of science reveals the process of its construction. The history of science studies temporal development of scientific and technological human societies. Since 2002, the Official College of Catalan Chemists has been developing some activities aimed at increasing students' interest in the history of chemistry and the history of science. These activities link the history of chemistry, the history of science, to nowadays. The aim of this article is to analyze the results obtained after secondary research works evaluation and highlight the importance of science. Secondary science teachers could make an introduction about history of science in their classroom at any educational levels.

Keywords. Science, History, Research Work, Education, Young Students.

1. Introduction

At the beginning of the century, Catalan students from secondary school (ESO) and high school could learn the atom and radioactivity, Darwin's theory and penicillin discovery, the law of gravity or electricity, etc. However, they usually didn't know who made that law or discovery, neither when it happened or how it was found.

Furthermore, students often made some malicious questions. Why was spontaneous generation believed in? Why are there some people who believe that the earth is flat? Why was Galileo's heliocentric theory not recognized earlier?. Questions about the scientific theories, scientific method and "Scientific Revolution". Why scientific theories that were accepted immediatly and held for centuries as a real then were displaced for new ones?

After analyzing this shocking situation with primary, secondary and university science teachers, the Official College of Catalan Chemists (COQC, acronyms in Catalan) [1] designed some activities to change these bad circumstances, some to be done in the classroom with students and others out of school and aimed at the whole population.

These activities, related to the society in which discoveries ocurred, began in the academic year 2002-2003 and have been done continuously until this last year.

In order to be able to evaluate the effectiveness of these activities and their educational consequences, authors analyzed more than 2.000 research works from students age 16 to 18. These works are compulsiory in Catalan secondary school curriculum.

In 2012 [2] and in 2015 [3], results from the first analysis were presented and indicated that we were on the right track but it was necessary not to give up and to continue working along these activities.

Since 2014 to 2024 we have analyzed more than 250 research works made by Compulsory Secondary School Students, ESO (age 16, their last year) and 850 works from High School students (age 18, their last year). The authors have been responsible for the assessment of these works.

Here we want to present and analyze the results until 2024 and make a short summary of all the activities developed and highlight the importance of the history of sciences.

2. History of science and its importance

The history of science studies temporal development of scientific and technological human societies. It also examines the impact that science and technology have historically had on culture, economics, and policy dissemination [4]. Science is always subject to change, is alive, and the history of science reveals the process of its construction. On the chemistry creation and its history we must recognize the concepts and ideas of Asimov [5] and Bensaude [6].

Usually, the history of science has answered questions about what science is and how it works. In this context, many controversies have

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appeared when philosophy of science has been asked by sudden changes of a theory.

Sir Herbert Butterfield (1900 Yorkshire, Regne Unit – 1979 Sawston, Regne Unit) was a “Knight and historian” for University of Cambridge [7]. He said “We cannot construct a respectable history of Europe ... without the history of science”. Studying the history of science (chemistry) is the only way to increase students and society interest in chemistry and, of course, interest in science.

In addition, Thomas Kuhn (1922 Cincinnati, Ohio – 1996 Cambridge, Massachusetts) an American historian and philosopher of science was influential in both academic and popular circles, he introduced the new term “paradigm shift” [8]. Competing paradigms are often incommensurable. He proposed, the History of Science (Chemistry) produces a crucial transformation in the image of science and chemistry in young students. Furthermore, these future scientists could spread a new and better science and chemistry’s image to their family and friends.The authors believe that these two historians provide insights that cannot be improved and are important when dealing with the history of science.

3. Activities

As many of these activities have already been published in the HSCI conferences and other meetings focused specifically in history of science [9], here we will only make a brief introduction and some references.

Some of these activities are done in the classroom or in the school's science laboratory as theatre or the history of science theatralized, history with experiments, controversies and conferences.

While others can be done elsewhere, out of school, as museums, radio programs or summer courses.

Finally, some activities are related to several COQC publications, books and journal articles about the history of chemistry and the history of science that could be useful to secondary school science teachers, if they want to use it in their teaching.

These activities shown in Fig. 1 were carried out by COQC scientists.

Theatre History of Science
History with experiments
Controversies
Conferences
Museums
Radio programs
Summer Courses
History of science in NPQ

Figure 1. Activities developed by COQC, from 2003 to the present

3.1. Theatre or the History of Science theatralized

In 2002, Professor Leopoldo de Meis (1938-2014) [10] prepared a play about the history of science in front of secondary school science teachers. Authors attended this play because of collaboration with the Professor de Meis on science education project.

To stimulate Catalan secondary school students’ interest in science we reproduced part of de Meis play. We filmed different history of science periods with students as actors [11].

Fig. 2, shows different moments of the filming with the Greek thinkers, Galileo and the Catholic Church and the infectious diseases and penicillin.

Figure 2. The secondary students playing the role of scientists

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3.2. History with lab experiments

The history of chemistry is marked by specific experiments and we invited students to explore the fascinating history of chemistry with the help of some experiments. They can travel through the most important jumps in chemistry knowledge, these jumps have made move on society. At the same time, these particular experiments can be a teaching tool for high school teachers to introduce students to the world of chemistry and the history of chemistry, and arouse their interest in science [12].

Experiments were proposed to follow the evolution of chemistry over time. Fig. 3, shows one of these particular experiments, the brass obtaining (Bronze is an alloy of copper, Cu, and tin, Sn, while brass is an alloy of copper, Cu, and zinc, Zn).

Figure 3. Obtaining brass with a coin of copper (Cu), basic solution of zinc (Zn) and heat (fire)

Fig. 4 shows the leaps in the history of chemistry related to the experiments proposed by the study of the history of chemistry.

These experiments are (apart obtaining brass): Working with gases, the appearance of blown glass that allowed them to be transferred and stored. Electrolysis, Volta's electric cell linked chemistry and electricity, this made it possible to pass electricity through matter and discover by electrolysis new chemical elements. Spectroscopy, because of Newton's discovery of the decomposition of white light, it is possible to study the colors of the flame when certain chemical elements are heated.

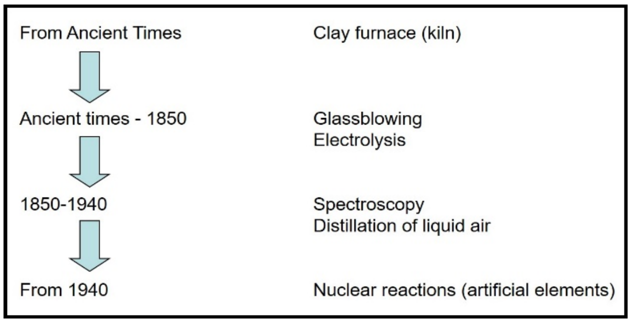

Figure 4. Leaps in the history of chemistry

3.3. Controversies

Several scientific controversies have illustrated the history of science: the exceptionality of the Greek philosophers, the role of the medieval alchemists, Galileo Galilei vs Catholic religion (the relationships between science and religion), Lavoisier vs phlogiston, Lamarck vs Darwin’s evolutionary theory, Pasteur vs spontaneous generation [13].

The history of science offers many examples like these, which focused in the proper direction, can make science learning more attractive and reinforcing the interest for science in secondary school students.

Some questions and ethical controversies posed by students are: “Cloning is highly controversial, are designed babies possible?, Should cloning humans be legal?”, “Controversial topics about GMOs” or “Should euthanasia be legal?”. In few years scientists must solve these controversies.

3.4. Conferences and talks

Every year the Catalan primary and secondary schools ask the COQC to hold speakers for seminars on chemistry/science and its history. The most requested in recent years are:

- The history of the periodic table. The spectroscopy and the chemical elements [14]. The origin of chemical elements and molecules [15]

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- Women in science. Marie Curie, the discoverer of radioactivity. Rosalind Franklin, made a crucial contribution to the discovery of the double helix structure of DNA.
- The history of science, radioactivity, the atom, medicines, graphene,

3.5. Museums and Radio Programs

These activities were done outside the scope of the school but secondary school teachers can always take advantage of them to bring new things to their classes.

Visiting a science museum is an excellent opportunity for secondary school students as well as their families. In all places there are some "science museum", perhaps an old pharmacy, an old shop perfums or an old soap factory, and others [16-17]. There are many places with an important historical science legacy.

Figure 5. Moments of the radio program

Usually, our radio program “Playing History of Science” [18-19] was weekly. We play science and its history with ESO and High school students who actively participated in each program. The competitive part was about history of science.

Visits a science museum or a radio program are usually preceded by a preparatory work in the classroom, instructed by science secondary school teachers. Their students have to do some preliminary work on the visit, answering a questionnaire or else finding new information by Internet.

3.6. Summer courses

In an effort to increase the knowledge and the interest in history of science in Catalan science teachers, students and whole society, we proposed at the University of Barcelona to do “Flavors and small bites of the history of Chemistry”, a summer course about the History of Science [20].

In addition every summer, the COQC is undertaking courses (Chemistry, biochemistry, science) to update secondary school teachers. These summer courses, recognized by the Department of Education of the Generalitat de Catalunya, always have a good part of the history of science [21].

These summer courses help secondary and High school science teachers in disseminating the history of science. In addition, summer courses can offer them stimulating new issues to increase students’ interest on science and the history of science.

3.7. History of Science in NPQ

“A brief history of energy” [22], “A little history of chemistry for young and old” [23] and “Little history of Catalan Chemistry” [24 and Fig. 6 left] are books partially or fully covered by the COQC.

These books are given to primary and secondary school students and teachers when COQC scientists perform an activity on the history of chemistry and science.

On the other hand, the NPQ is the official magazine of the COQC and it contains the news of the Nobel Prizes in science [25] (chemistry, physics and medicine) as well as articles dedicated to the history of scientists and science [26 and Fig. 7].

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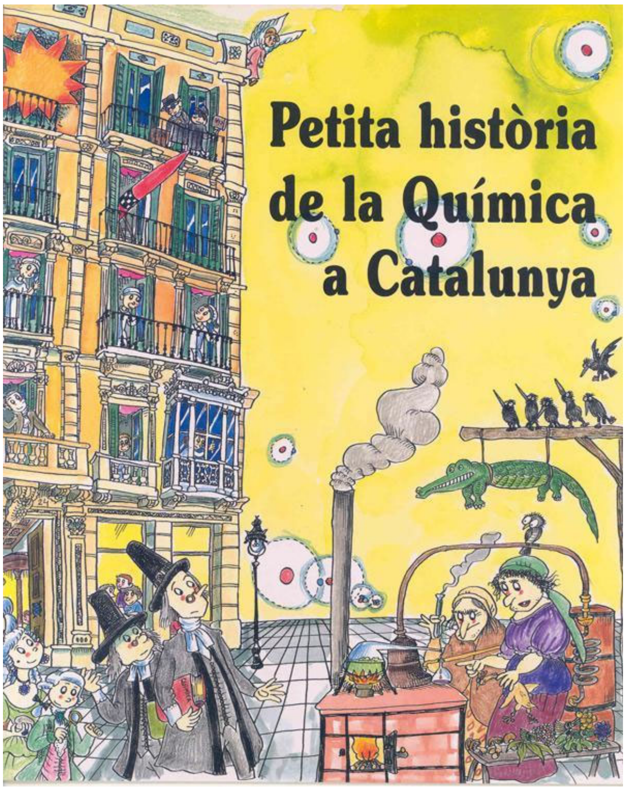

Figure 6. Little history of Catalan Chemistry

4. Results

In order to be able to evaluate activities effectiveness and their educational importance, more than 250 research works made by ESO students and more than 850 research works done by High School students were analized the last 10 years.

All results obtained are in Fig. 8. In this you can observe that the presence of the history of science in research works since 2015 to the present is constantly growing. However, there is one exception, no work was analyzed in the 2019-2020 academic year due to the COVID complications. Additionally, the values obtained the last four years, all around the 65% of presence of history of science in secondary research works are the maximum value we can reach (authors opinion).

It should be mentioned that all students must do these research projects, some to finish secondary school (Compulsory education) and others to finish High school and, perhaps, enter at the university.

Figure 7. Nobel Prize winners in 2023 (above) and NPQ 502 (below)

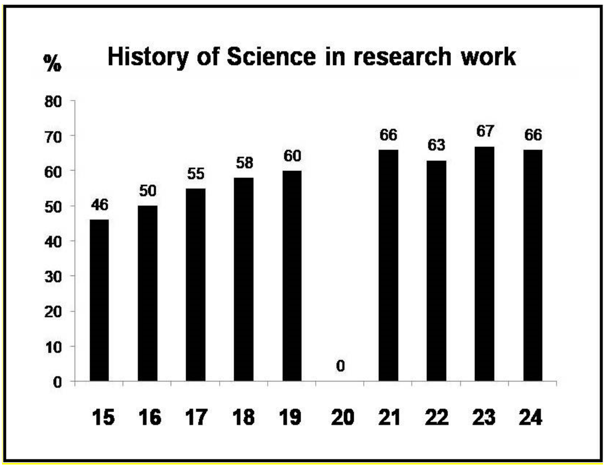

Figure 8. Percentage of History of Science in Secondary Scientific Works from 2015 to 2024

In January and February the authors hold workshops on science at the University of

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Barcelona laboratories [27]. One designed for ESO students and another for High school students. In addition, different surveys, depending on educational level, were prepared with questions on scientists knowledge as “Do you know why Marie Curie is so important as a scientist?”. Students' perception of the history of science they learn in classroom. Table 1 shows the results of the last two years.

Survey	*2022-2023 and 2023-2024*	
	ESO (15-16)	*HS (17-18)*
	Number >600	*Number >1400*
M. Curie	*0,58*	*0,86*
A. Fleming	*0,53*	*0,77*
L. Margulis	*0,42*	*0,59*
S. Ochoa	*0,05*	*0,36*
R. Franklin	*0,42*	*0,64*
A.Lavoisier	*0,11*	*0,91*
	Students’ perception	
	0,32	**0,72**

Table 1. Survey about six scientists and students’ perception on the amount of history of science in classroom (HS is High School)

The results in Table 1 show an important difference in scientists’ knowledge between students in the last year of ESO and those in High School. It should be noted that at ESO Severo Ochoa and Lavoisier are complete strangers. While 1 out of 10 ESO students know who Lavoisier was, in a couple of years, in the last year of high school, 9 out of 10 get to know him.

Furthermore, students’ perception how the history of science goes in classroom is important so, in ESO only rise to the 32% of presence while in High School it is 72%. It is clear that currently, in science teaching in High School, emphasis is placed on the history of science.

5. Conclusions

Some of these activities have also been carried out with first-year university students, in chemistry and Biochemistry degrees. The results of this experience, like those of secondary schools, indicated that the history of science was increased in the university students' works [28-29].

Catalan teachers at Compulsory Secondary Education (ESO, students age 12-16) and High Education (students age 16-18) have expanded their science classes with a part of the History of Science. However, one of the main objections to the introduction of “The History of Science” into school curricula concerns the lack of time available in current curricula.

If we want to bring the history of science closer to students and teachers, we must humanize scientists and to examine the discoveries and errors they did in their contemporary context [30].

This means that for high school science students Lavoisier was the father of chemistry, but for some ESO students Lavoisier was the scientist who his head was cut off. Other example, Marie Curie is known by High School science students because she discovered the radioactivity and won two Nobel Prizes. However, some ESO students only remembered her because she was a Polish and died by cancer.

Controversies can give a lot of play in class. If the science teacher can argue [13-31] or defend the two opposing positions in a scientific controversy raised by the students, this can improve interest in science and its history in their science classroom.

The COQC has always been concerned with bringing chemistry and its history to our society [32]. All these efforts were in order to foster the curiosity and interest in science in both students and teachers.

Increase students’ interest in science and its history, leads them to being more responsible in their own life. As adults, they will be able to make more responsible decisions about climate change, nutrition, vaccines and water pollution (for example).

6. Acknowledgements

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Evaluation of Heavy Metal Content in Plastic Bags Used as Part of Food Cooking Containers: A Socio-educational Sustainability Perspective in Mozambique

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Abstract. In Mozambique, rudimentary food preparation practices are still common. A common habit is the use of plastic bags for preparing foods such as tubers, meat and rice, particularly among families with relatively low financial resources. These bags are often used because they are cheap, easy to handle, flexible and offer good thermal insulation. Nevertheless, the practice of using plastic bags in cooking raises serious public health concerns. This is due to the fact that many of these plastics contain heavy metals added during manufacturing to improve their physical and chemical properties. When heated, these metals can migrate into food, posing a significant health risk. Among the most worrying metals are cadmium (Cd), lead (Pb), mercury (Hg), chromium (Cr), zinc (Zn), copper (Cu), nickel (Ni) and arsenic (As).

International legislation establishes strict standards for plastic materials intended for contact with food, with the aim of ensuring that they do not pose health risks. Thus, Mozambique is a country where educational policies for disseminating and monitoring the presence of heavy metals in plastic bags are defective, exposing the population to unnecessary risks.

Among the 17 Sustainable Development Goals defined on September 25, 2015, by the United Nations General Assembly, Goal 4 aims to “Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all”, including early childhood, elementary, secondary, higher education, technical and professional training. On the other hand, prosperity and health of all human beings require a sustainable approach to development. In this context, it is essential to promote education about safer and more sustainable eating practices. Therefore, pedagogical approaches focused on raising awareness about the dangers of inappropriate use of plastics can encourage families to look for safer alternatives, such as reusable and sustainable containers. Furthermore, reinforcing the importance of sustainability when choosing cooking materials can help reduce dependence on plastics in Mozambican society, promoting healthier eating and environmentally friendly practices. Along these lines, this work evaluates the contents of heavy metals present in lastic bags commonly used for food preparation in Mozambique. The results proved to be higher than the limits established by safety standards, which reinforces the need to adopt practices that do not endanger health and the environment.

Keywords. Plastic Bags, LDPE and HDPE, Food Preparation, Heavy Metals, AAS, Education for Sustainability.

1. Introduction

The thematic of sustainability and sustainable development has gained a great visibility in the debates about the environment and its impacts on ecosystem development just as public health. Several organizations rebound the importance of seeking sustainable models of using plastic bags so that do not cause negative impacts [1-2].

Plastic bags play a great role in the day-to-day life of human beings from industry to our homes. However, how they are used and managed has led to a growing level of concern about environmental safety and health publishes. Over several years, plastic material management strategies have gained space well as sustainable education policies on environment and health. The danger posed by the plastic bags, is not only in the particularity of being a non-degradable material, but also the component of what are constituted, that is, its internal properties, chemical and physical composition of materials [2-3].

Because they are versatile materials resulting from the addition of some additives such as dyes and heavy metals, give them advantageous and attractive properties for more traditional applications, as is the case for their use in food preparation by the Mozambican community, practices adopted to replace the new food-making technologies, such as pressure cookers and hermetic kitchen bags. Metals are a large group of substances present in chemical compounds as positive ions (cations) in solution. All metals with high atomic weight and much greater density than water can be called heavy metals. These have variations in the atomic weight up to 63.5 and 200.6 and occur on the surface of the earth [4-5]. More than 50 elements are considered and classified as heavy metals and are grouped into lanthanides, metalloids, transition metals and actinides [4]. Of this number, around 30 metals and metalloids are extremely toxicological and harmful to humans [6]. Other studies revealed that 17 of these elements have direct, prolonged and harmful impacts on human and environmental health especially when they come into contact with water and food [4, 7]. Therefore, it is almost unknown to talk about the use of plastic bags to prepare food, however, the migration of heavy metals from plastic bags to food when subjected to thermal conditioning is generally known [8-9].

The migration of components from plastic bags to food is controlled by law. International and national legislation establishes specific standards and requirements on plastic materials and articles intended to come into contact with food and these materials used for food must not pose a risk of disease to human health [10-11].

European directive 2002/72/EC establishes that the amount of transfer of constituents from plastic materials to food must not exceed 10 mg/dm2. Likewise, heavy metals such as Pb, Cd, Cr and Hg should not exceed 100 mg/kg all together [12]. Regulation (CEE) No. 315/93 4 establishes that even foods that are contaminated by a contaminant cannot be sold. For example, limits for arsenic (As (III) and As (V)) in salt have been set by the European Commission. Other legislation, such as national legislation in the Netherlands, stipulates that the total concentration of heavy metals such as Cr, Pb, Cd and Hg cannot exceed 100 mg/kg by weight [12-13].

Many legislations are currently also interested in establishing limits for heavy metals such as Zn, Cu, Ni and As, as these metals have remained underexploited for a long time [14]. The lack of attention from researchers meant that there were few investigations into plastic bags, due to their low toxicological potential. Today, therefore, research has revealed that Zn and Cu contents in plastic bags, especially HDPE, reach up to 429 and 130 mg/kg [15]. Research from China and other countries on plastic packaging used in food delivery services also showed that potential health risks were caused by heavy metals such as Zn, Cu, Ni and As, mainly due to toxicity and various diseases such as cell damage, oxidative stress, learning defects, reduced fertility, infertility, spontaneous abortion, behavioral effects, neurotoxicity, anemia and diarrhea were reported to be common in those regions [6, 14].

Considering the public health concerns and the potential risks heavy metals pose in human organism, associate mechanisms that can boarden the concepts of " plastic bags, heavy metals, food preparation, and Mozambican community", integrated to intervention effects and of heavy metal regulatory actions in Mozambican plastic bags, can lead to sustainable and that they do not endanger public health. Therefore, there is a need for formation of new socio-educational perspectives with not only investigative approaches, but that promote a scientific education about the presence of heavy metals in plastics and consequently adoption in more sustainable ways of their application.

In Mozambique, one of the significant challenges is the absence of heavy metal monitoring in different polymer materials, mainly in the plastic bags used for daily shopping. As a result, the need to evaluate the concentration of heavy metals in plastic bags and increase awareness about potential risks becomes urgent. In different entire world teaching establishments, the need for integrating curriculum units that deal transverse topics, promoting and proposing practices contributing to sustainable development in nature is strengthened. This challenge therefore becomes an educational tool capable of shaping the understanding of the student and stimulating the quality of reflection on different practices in our community [3, 16].

In line with United Nations Sustainable Development Goal 4, ensure inclusive and equitable quality education and promote lifelong learning opportunities for all, including early childhood, primary secondary education, higher education, technical and vocational training it is a right for everyone. With this, we intend to reach the entire world with approaches to quality

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sustainable development, giving our society opportunities to adopt safe practices in their daily activities.

2. Objectives

To address the previous concerns, we present the following objective. With this work we aim to evaluate de heavy metals contents in the plastic bags used as food cooking containers in the socio-educational perspective, enabling to promote safer and sustainable practices of food cooking in Mozambique.

3. Methodology

To determine the heavy metals contents in plastic bags, samples made of high and low density polyethylene (HDPE and LDPE respectively) were collected in supermarkets, whole sale markets, grocery stores, hardware stores and clothing stores in Mozambique, which are commonly used for food preparation by the local communities.

Figure 1. Some examples of the plastic bags sample used

To access the contents of heavy metals of these plastic bags, Atomic Absorption spectroscopy was performed. This spectroscopic technique helps determine amounts of elements in a sample by measuring the radiation absorbed by the chemical element of interest [17]. It is a very powerful, specific technique with excellent detection limits [6]. AAS measures the absorption of light by specific elements in the gas phase at a specific wavelength, allowing their concentration to be determined.

For the quantification of materials by the AAS technique a protocol procedure was fundamentally necessary to obey that secured the transformation of solid samples into liquids. This methodologic path was conducted in the research laboratory of the Chemistry school in the UMinho, where the student-surveyor executed and recorded the development of the activity, starting from the preparation of the samples (digestion of 0.10 g plastic in 20 mL of nitric acid (HNO_3) and hydrochloric acid (HCl) and the withdrawal of the solution to the analysis by the technique.

4. Results

In the AAS assays, common heavy metals found in plastics, such as cadmium, copper, lead and zinc were quantified. The results revealed distinct metal contents for each sample type analyzed. The presence of these metals in the plastic bags highlights the need for further assessment, especially because in large quantities, these metals may pose significant health risks, particularly lead and cadmium known for its high toxicity.

Table 1 presents some of the results obtained from the quantification of heavy metal contents in the plastic bags for the LDPE samples. Of these results, we can see that Cu and Zn metals, have high concentration levels relative to Cd and Pb. When compared with those said in other studies as well as legislations, they exceed on broad scales, as shown in the Table 1 [12, 14, 18].

Table 1. Some examples of the results obtained by AAS for LDPE plastic bags

Sample	*Code*	*Results (mg/kg)*				*Total (mg/kg)*
		Cd	*Cu*	*Pb*	*Zn*	
LDPE	cod.01	80	90	60	340	570
	cod.02	8	50	60	100	218
	cod.03	8	880	60	104	1054
	cod.07	80	68	60	500	708
	cod.08	8	440	60	360	868
	other studies	74	54	12	158	298

The results of the tests of the HDPE samples, are shown in Table 2. The table shows more contents for metals such as Zn and Cu, however, the sample cod. 06 is that it shows higher concentration of the metal element Pb.

The results presented in these tables clearly advise to change the current status and to begin

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adopting good food preparation practices in Mozambique as well as the sustainable use of plastic bags.

This paradigm of sustainability in our country can be promoted by implementing scientific education that enhances and promotes awareness of the dangers that heavy metals can cause to the body. However, educators and researchers can develop pedagogical proposals that contribute significantly to the dissemination of the unsustainable effects that these practices represent. Combined with the legislation discussed in this work, safer paths can be adopted as well as the creation of a law that controls the incorporation of heavy metals in Mozambican plastic bags. This challenge could seed policies that control the import of plastic materials into the country through regulatory entities.

Table 2. Some examples of the results obtained by AAS for HDPE plastic bags

Sample	**Code**	***Results (mg/kg)***				***Total*** *(mg/kg)*
		Cd	***Cu***	***Pb***	***Zn***	
HDPE	cod.04	80	96	60	1380	1618
	cod.05	8	69	60	360	497
	cod.06	80	50	1620	520	2270
	cod.11	80	200	60	940	1280
	cod.13	8	132	60	240	440
	other studies	74	212	71	430	787

5. Conclusions and Reflections

The aim of relating public health and environmental problems in educational perspectives leads us to think critically about good sustainable development strategies, which reflect on how to live the present and the future in friendly conditions. However, the results presented in this work reveal the importance of studying plastic bags as materials used in our daily lives and also promote sustainable development as well as the adoption of practices that are both environmentally friendly and protective of public health. The analyzes revealed that all samples contained high levels of Cu(II) and Zn(II). Sample Cod.06 had the highest Pb(II) content, with a value of 1620 mg/kg. Samples Cod.03, Cod.04, Cod.06, presented levels of Cu(II), Zn(II) and Pb(II) significantly exceeding the values referenced in national and international legislation1 (ISO, Germany and Switzerland), thus such as those presented by Jiang *et al*. These findings indicate that the use of plastic bags for cooking food could pose a significant risk of heavy metal contamination, highlighting the importance of strict regulation and ongoing monitoring of these materials.

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Tackling the Urban Heat Islands Phenomenon. Development of Co-axial Fibers with Phase Change Materials

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Abstract. Urban heat islands (UHI) represent a growing challenge due to the current world's global warming trend affecting the health and quality of life of citizens. Furthermore, UHI does add up to climate change and undermine environmental sustainability in a rather negative way. The population, in general, and in particular our students and youngsters, should be aware of this problem and of the possible solutions that are in development aiming the mitigation of this effect. In this chapter, we will briefly present a research work developed at the University of Minho, with the participation of the Federal Institute Goiano, in the development of advanced materials with thermoregulation properties to be incorporated in road pavements and building construction materials.

This study investigates the development of co-axial fibers composed of phase change materials (PCMs) to be used in building materials as thermoregulation agents under the latent heat principle. Co-axial phase change fibers (PCFs) were developed, with cellulose acetate (CA) as the sheath and polyethylene glycol (PEG) as the core, using the wet-spinning technique. The analyses confirmed a sheath-core morphology and thermal capacity of PCFs. These innovative materials offer a practical approach to mitigating thermal impact in urban environments.

Keywords. Cool Building Materials, Phase Change Fibers, Sustainability, Urban Heat Islands.

1. Introduction

Global warming and the growth of cities are intensifying the phenomenon known as urban heat islands (UHIs), which lead to higher temperatures in urban areas when compared to surrounding rural areas (Fig.1) [1], adding up to global warming and affecting rather negatively environmental sustainability. This happens because civil engineering materials used in the construction of buildings and roads in our cities absorb and retain a large amount of heat, making days hotter and causing thermal discomfort for citizens. In addition, rising temperatures can impact the health and quality of life of those living in urban cities. Therefore, it is important to develop sustainable solutions to face this challenge [2].

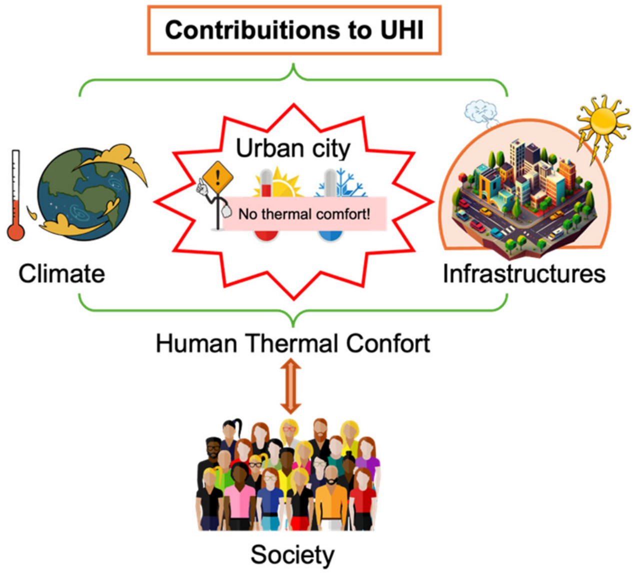

Figure 1. Problematic effects caused by Urban Heat Islands (UHI)

An alternative to mitigate the effect of UHIs is the employment of PCMs in civil engineering materials. Under the latent heat principle, these materials can "store" heat when temperatures are high and "release" it when the temperature in the environment cools down, acting as thermal regulators [3]. When incorporated into building materials such as mortar and concrete, PCMs help to balance the internal temperature of urban buildings, reducing thermal variations and mitigating the effect of UHIs, promoting thermal comfort for citizens.

This is because PCMs work on the principle of latent heat [4], which is the energy used to change the phase of the material (from solid to liquid, for example) without changing its temperature, Fig. 2. By comparison, water boils at 100°C and, during boiling, the temperature does not increase until all the water has turned into vapour. Similarly, water freezes at 0°C, and any energy withdrawn at this point solidifies the water without changing its temperature.

Thus, in urban buildings, heat transfer normally occurs through sensible heat, resulting in rapid temperature variations. However, by adding PCMs that change phase at the temperatures of use, this transfer slows down as the PCM absorbs or releases energy to complete its phase change, stabilising the thermal environment and reducing energy consumption for heaters and air conditioning.

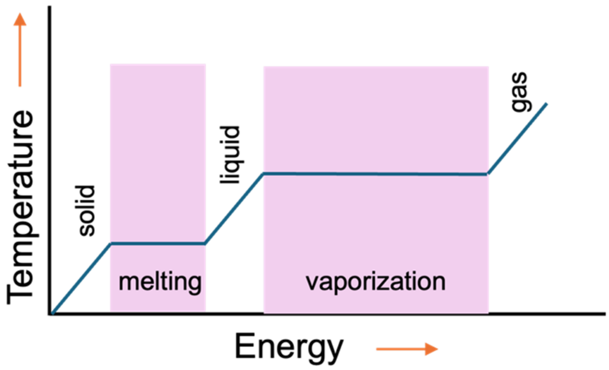

Figure 2. Explanation of the principle of the latent heat for materials

Recently, the development of co-axial fibers with phase change materials (PCFs) has shown great potential for application in construction materials for civil engineering [5]. This technique ensures that the phase change material is well "trapped" inside the fiber, without leaks and with good thermal stability [6].

Research on these innovative PCFs shows how important it is to integrate sustainable solutions in civil construction. The use of PCFs not only improves thermal comfort in urban cities, reducing the effect of UHIs, but can also increase the durability of construction materials. Scientific education is essential to raise awareness of new technologies capable of promoting the search for smarter and more sustainable solutions for the environment.

This work aims to study the production, testing and applicability of PCFs through optical, chemical and thermal analysis, highlighting their positive impact on thermal regulation in urban areas. By providing an overview of the use of phase change materials, it aims to encourage research and implementation of sustainable practices in the construction sector.

2. Materials and Methods

2.1. Materials

Co-axial polymer phase change fibers (PCFs) were produced using a laboratory method called wet-spinning. The following materials were used for this purpose:

- Cellulose acetate (CA): a powder derived from cellulose, a natural component found in plants [7]. It is environmentally safe and is used to form the outer part of the fibers, creating a protective coating. Commercial CA (with an acetyl content of 39.8 wt. %, average Mn = 30,000 and Mn = 50,000, Sig-ma-Aldrich, St. Louis, MO, USA) was selected because it is a natural, non-toxic material and is widely used in fiber production.
- Polyethylene glycol (PEG): one of the most used PCMs [8]. It was chosen for the core of the PCFs due to having several qualities: it stores heat well, it is chemically stable (does not react easily with other substances), and changes phase (solid to liquid and vice versa) over a wide temperature range. Polyethylene glycol (PEG 400 and PEG 800, H(OCH2CH2)nOH, Thermo Fisher Scientific, Waltham, MA, USA), Melting Point (MP) = 4-8 °C (PEG 400) and MP = 20 - 23 °C (PEG 800), has a phase change process without changing the temperature of the material during its transition, as a result of latent heat.
- Solvents (DMF and deionized water): DMF (N,N-Dimethylformamide, 99.8%, Sigma-Aldrich, St. Louis, MO, USA) was used to dissolve the CA and deionized water (dH_2O) to dissolve the PEG, allowing these materials to mix and form the PCFs.

Thus, in short, the CA protects the fiber, while the PEGs in the core store and release heat, making these PCFs useful for achieving temperature control in a variety of environments.

2.2. Fibers Production

The 10-30 wt.% CA and 90 wt.% PEG 400 and 60 wt.% PEG 800 solutions were prepared by dissolving the materials in their respective solvents (DMF for CA and deionized water for PEGs) overnight. Both solutions were continuously stirred at 50 °C on magnetic stir

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plates overnight.

A complete wet-spinning system was used to produce the PCFs (Fig. 3). This system included two syringe pumps to eject the solutions, a co-axial needle with attached syringes, a coagulation bath with dH_2O at 20 °C, and an automatic collector to gather the fibers [6]. The CA solution was ejected from the syringe at a rate of 0.165 mL/min and, upon contact with the coagulation bath, coagulated and formed a protective layer around the PEG solution, which was ejected at a rate of 0.140 mL/min and 0.150 mL/min. To facilitate fiber collection, the collector was adjusted to operate at a velocity of 5 rpm.

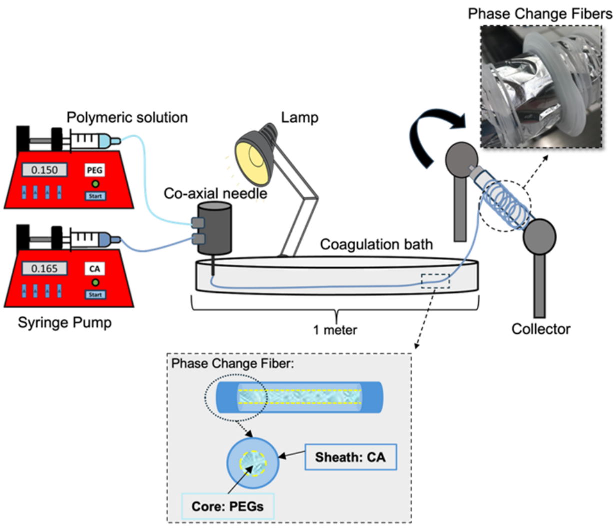

Figure 3. The schematic view of the co-axial setup and the parameters for the wet-spinning process

The functionalized PCFs were named using an alphanumeric string, i.e., PCF_x/a_b_c. Where "PCF" represents "phase change fibers". "x" represents the molecular weight of the CA (Mn 30,000 or 50,000). While "a" indicates the type of PEG used (Mn 400 or Mn 800), the letter "b" represents the concentration of the respective PEGs (60-90 wt.%), and finally, the letter "c" represents the ejection velocity of the two PEGs (0.140-0.150 mL/min).

2.3. Bright-field Microscope

The morphology of PCFs for the detection of a co-axial system will be analyzed. Images were taken at 5× magnification using a Leica DM IL LED bright field microscope (Leica Microsystems, Weetzlar, Germany).

2.4. Fourier-Transform Infrared Spectroscopy (FTIR)

The chemical compositions of the PCFs were analyzed by attenuated total reflectance Fourier transform infrared spectroscopy (ATR-FTIR) using an IRAffinity-1S (Shimadzu, Kyoto, Japan) coupled with a HATR 10 accessory with a diamond crystal. The spectra were performed in a wavenumber range of 400 to 4000 cm^{-1}, with a scan velocity of 200 scans, with a resolution of 2 cm^{-1}.

2.5. Thermogravimetric Analysis (TGA)

To evaluate and characterize the thermal properties of the samples, thermogravimetric analysis (TGA) was performed. This analysis involved the study of the mass loss of both the virgin materials (CA and PEGs) and their respective PCFs until complete combustion.

The measurements were performed using a Hitachi STA 7200 system (Fukuoka, Japan). An empty crucible was used as a reference during the analysis. All samples were exposed to a nitrogen (N_2) atmosphere at a flow rate of 200 mL/min and were heated at a rate of 10 °C/min within a temperature range of 30 °C to 500 °C.

3. Results and Discussion

3.1. Morphology

After the production of the four different co-axial fibers with phase change materials (PCFs), they were analyzed by Bright-field microscopy to verify their morphologies and confirm the formation of a sheath-core structure (Fig. 4 and Fig.5).

It was observed that the PCFs produced with (CA, Mn 50,000) had a flatter shape compared to the PCFs manufactured with (CA, Mn 30,000). This difference can be explained by the lower concentration and viscosity of the 10 wt.% CA solution (Mn 50,000), in contrast to the higher concentration and viscosity solution used to produce the PCFs with 30 wt.% CA (Mn 30,000) [6].

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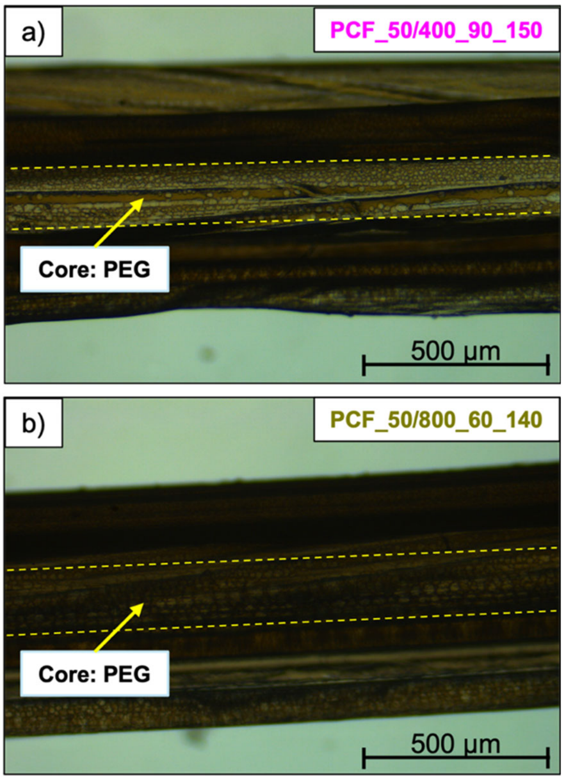

Figure 4. Micrographs of the morphology of PCFs incorporated with PEGs obtained by Bright-field microscopy. (a) PCF_50/400_90_150; (b) PCF_50/800_60_140

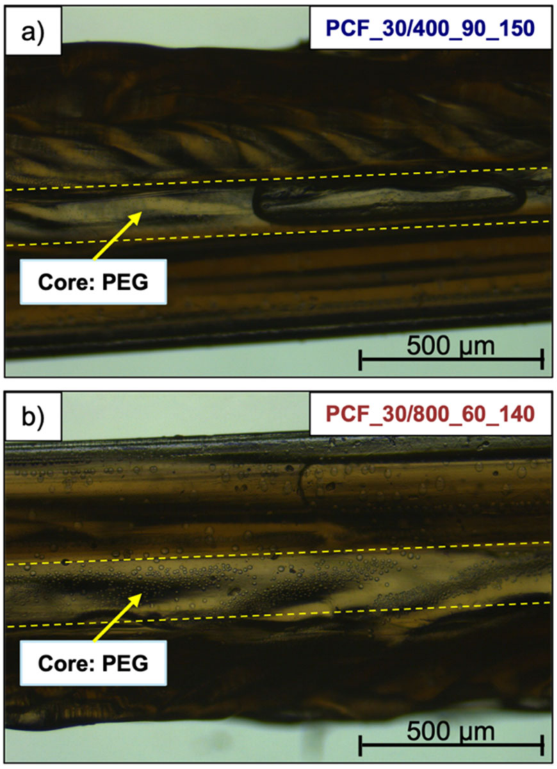

Figure 5. Micrographs of the morphology of PCFs incorporated with PEGs obtained by Bright-field microscopy. (a) PCF_30/400_90_150; (b) PCF_30/800_60_140

In addition, it was noted that the core formed by the polyethylene glycols (PEGs 400 and 800) was well-defined and visible. This well-formed core is due to PEGs being soluble in distilled water (dH_2O). When the CA polymer solution, which is insoluble in dH_2O, meets the coagulation bath (dH_2O), rapid coagulation occurs, forming a protective sheath. PEG, when in contact with the inner edge of the sheath, does not mix with it, resulting in the efficient creation of a core and a sheath.

3.2. Chemical analysis

An FTIR analysis was performed to confirm the presence of virgin materials within the PCFs. Each of the peaks represents a specific amount of energy that was absorbed and transmitted to the spectrum, and by comparing them to the unaltered virgin materials, it is possible to identify which chemical bonds are present in their molecules through their corresponding peaks. The spectrum with the PCFs identified characteristic peaks of both materials, Fig.6.

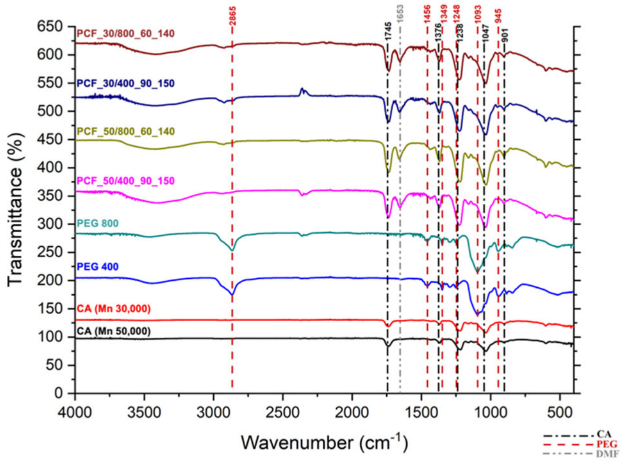

Figure 6. ATR-FTIR spectra of the respective PCFs and virgin materials

Peaks at 1745 cm^{-1}, 1376 cm^{-1}, 1238 cm^{-1}, 1047 cm^{-1} and 901 cm^{-1} correspond to the distinctive peaks of CA and represent the stretching vibrations of the carbonyl C=O, C-O bonds in the ester group, stretching of C-O-C bonds and the movement of the glycosidic rings in cellulose, respectively [5]. 2865 cm^{-1}, 1456 cm^{-1}, 1349 cm^{-1}, 1248 cm^{-1}, 1093 cm^{-1} and 945 cm^{-1} are peaks associated with both PEG peaks and represent the stretching of the C-H bonds; 1456 cm^{-1} with the C-H bending vibrations; and 1349 cm^{-1} with the stretching of the C-O bonds, the stretching of the C-O-C bonds and the skeletal vibrations of the polymer structure, respectively [9], [10]. Finally, the peak at 1653 cm^{-1} indicates the DMF peak, which corresponds to the stretching vibration of the C=O carbonyl [11].

3.3. Thermal analysis

TGA analysis was performed to evaluate and compare the degradation temperatures until burning (weight loss) of the virgin materials and the PCFs in question. This test helps to understand to what extent the materials can withstand heat before they start to decompose. The analysis performed on the virgin materials, Fig. 7, revealed that cellulose acetate (CA) loses weight between approximately 315 °C and 390 °C [6], while polyethylene glycol (PEG) shows significant differences between its two types: PEG 400 starts degradation around 234 °C and ends at approximately 350 °C [9], while PEG 800 starts degrading at 300 °C and goes up to 400 °C [10]. These variations are due to PEG 800 having longer and more stable polymer chains, requiring more energy to break its chemical bonds, compared to PEG 400.

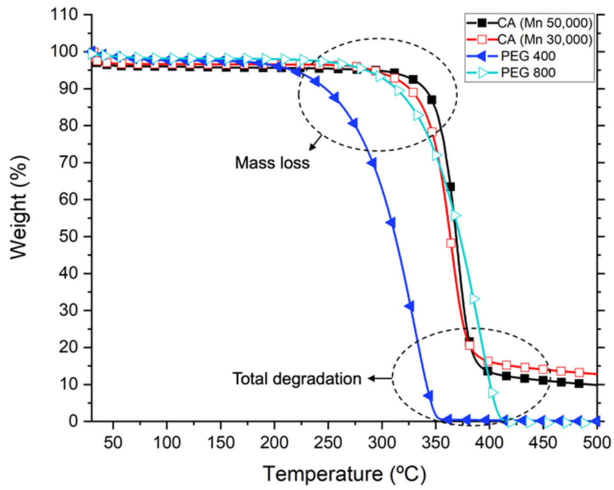

Figure 7. TGA of virgin materials CA and PEGs

The TGA analysis, Fig. 8, details the behavior of the PCFs produced in relation to the mass loss which occurred until it was reached a state of full degradation. It is possible to observe the first degradation stage at around 100 °C in all samples, which can be explained by the elimination of water molecules (dH_2O) and the DMF solvent [12]. After this first mass loss, there is thermal stability up to approximately 250 °C when the PCF_50/400_90_150 and PCF_30/400_90_150 fibers begin to degrade up to approximately 380 °C. The PCFs containing PEG 800 (PCF_50/800_60_140 and PCF_30/800_60_140) undergo this process at higher temperatures, with degradations occurring between 275 °C and 410 °C.

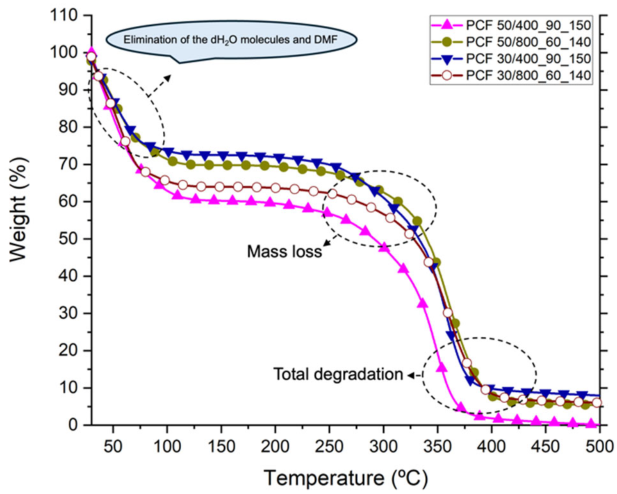

Figure 8. TGA of the PCFs

This difference in degradation temperatures can be attributed to two main factors: the molecular weight of the polymer chains and the phase change process of PEGs (400 and 800). PEG 800 has longer and more stable polymer chains in comparison to PEG 400, which results in a higher requirement of heat energy needed to begin its degradation process [13]. In addition, the melting point of the two types of PEGs is different: while PEG 400 begins to melt between 4 °C and 8 °C, PEG 800 has a higher melting point, between 20 °C and 23 °C [9], [10]

Based on these results, PCFs with PEG 400 have a greater potential to be applied in building materials that target regulating temperature during winter, since its melting point is lower. On the other hand, PCFs with PEG 800 are more suitable for summer, when temperatures are higher, due to their higher melting point and higher thermal resistance.

4. Conclusions

In the study, reported in this chapter, aiming at the development of an advanced solution to tackle the UHI effect, innovative phase change fibers, PCFs, were produced through the wet-spinning technique. These fibers were composed of cellulose acetate (CA, Mn 50,000 and Mn 30,000) in the sheath, while the core was composed of two PEGs (400 and 800). The main objective of the research was to evaluate the use of these PCFs for future incorporation into civil construction materials to mitigate problems such as UHI and to promote sustainability.

From the results, it was possible to confirm that the PCFs present a well-defined sheath and core structure, with some differences in morphology related to the concentration and viscosity of the two molecular weights of CA. Chemical analysis, ATR-FTIR, verified the presence of virgin materials in the structure of the PCFs through their characteristic peaks. Thermal analysis showed that PCFs incorporated with PEG 800 degrade at higher temperatures than those of PEG 400. These differences can be attributed to the higher molecular weight and phase change temperature of PEGs, thus presenting different applications for civil engineering materials.

The use of these PCFs incorporated in building materials is promising to mitigate the urban heat island effect, promoting sustainability and contributing to the improvement of the quality of life of citizens in urban areas. For future works, more thermal testing, such as as Differential Scanning Calorimetry (DSC) and mechanical analysis, should be conducted with the end goal being the incorporation of the PCFs themselves in cementitious materials for civil engineering applications.

5. Acknowledgements

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Content of Total Phenolic Compounds in Ora-Pro-Nóbis Leaves Subjected to Different Drying Conditions

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Abstract. As the drying process affects food, the objective of the present work was to investigate how different drying methods (oven and infrared) at different temperatures affect the quality of 'ora-pro-nóbis' leaves. The leaves were dried in an oven at temperatures of 50, 60 and 70 ºC and in infrared at temperatures of 125, 135 and 145 °C. The levels of phenolic compounds were evaluated in all drying methods and temperatures. The results for the content of phenolic compounds varied between 115.08 and 417.07g GAE/100g of sample. The data showed that the content of phenolic compounds is influenced by both the temperature and the drying method used.

Keywords. Bioactive Compounds, Drying Oven, Infra-Red.

1. Introduction

Pereskia aculeata Miller, popularly known as ‘ora-pro-nobis’ (OPN), is a type of Brazilian cactus. Belonging to the Cactaceae family and the Preskioideae subfamily, it is native to South America and adapted to low altitudes [1]. Its succulent leaves are great sources of protein (around 26%), which is much higher than other vegetables normally used as foods such as beans, corn and cabbage, in addition to presenting important levels of minerals, dietary fiber, vitamin A and C. and folic acid [2].

Considered an ‘unconventional’ plant, it is popularly known as ‘meat for the poor’ due to its high protein content. Its protein constitution has essential and non-essential amino acids with a high content of lysine [3], an amino acid found in animal proteins. The concentrations of these essential and non-essential amino acids are close to or higher than those recommended by the FAO (Food and Agriculture Organization) for human diets, with emphasis on tryptophan, which is one of the most abundant [4].

Dehydration is a food preservation method, which consists of removing free water from food, leading to a reduction in water activity [5]. Dehydrating turmeric leaves is an effective processing alternative, as it not only increases the shelf life of the product, but also reduces storage costs. Oven drying is one of the most common, simple and low-cost dehydration methods to implement, but it can cause major sensory changes in food products [6]. Some studies have confirmed that the drying process also preserves nutritional quality, such as the content of phenolic compounds in turmeric longa leaves studied by Chan *et al*. [7] and mint leaves (Mentha piperita L.) studied by Uribe, Marín, Vega-Gálvez, Quispe-Fuentes and Rodriguez [8]. Dhaouadi *et al.* [9] found high antioxidant activity and phenolic compounds in dried leaves of Lawsonia inermis L.

In view of the above, this work aimed to evaluate the content of phenolic compounds in the drying of ‘ora-pro-nobis’ leaves using different drying methods (air circulation, infrared).

2. Materials and methods

2.1 Raw material

The ‘ora-pro-nóbis’ raw material was collected on the premises of the Instituto Federal Goiano – Campus Morrinhos. After collecting the leaves, they were taken to the Bakery Laboratory to prepare the flour.

Drying of ‘ora-pro-nóbis’ leaves was carried out using the following processes:

- ✓ Drying in an oven with air circulation;
- ✓ Infrared drying.

After drying, the leaves were crushed in a colloidal mill and sieved. The flours from the different drying processes were stored in polyethylene plastic bags at freezing temperatures until analysis.

2.2. Preparation of hydroethanolic extracts

They were prepared according to the method proposed by Parry *et al*. [10]. 1g of the sample was weighed in an Erlenmaeyer and 50 mL of PA ethyl alcohol was added. This mixture was homogenized for 15 minutes on a shaking table at 300 rpm and then centrifuged for 15 minutes

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at 1500 rpm. The supernatant was removed and placed in a 100 mL flask and the volume was completed with distilled water.

2.3. Determination of Total Phenolic Compounds (TFC)

They were evaluated by spectrophotometry using Folin-Ciocalteu reagent and gallic acid standard curve according to the method described by Singleton and Rossi [11]. This method is based on the reduction of phosphomolybdic and phosphotungstic acids in an alkaline solution and is the most used for determining total phenolic compounds in foods. The blue color produced by the reduction of the Folin-Ciocalteu reagent by phenolics was measured spectrophotometrically, at a wavelength of 765nm. The results were expressed in g GAE/100 g of sample.

2.4. Statistical Analysis

The results were expressed as the mean values and the standard deviation of the independent variables. Analysis of variance (ANOVA) was used to compare means with a significance level of 95% using the Tukey test. All statistical analyzes were performed using the software (Statistica, Version 12; Stat Soft, Tulsa, OK).

3. Results and Discussion

The standard curve was performed using gallic acid in concentrations ranging from 10 mg to 48 mg. The straight-line equation was obtained using the Excel 2019 program, as shown in Fig. 1.

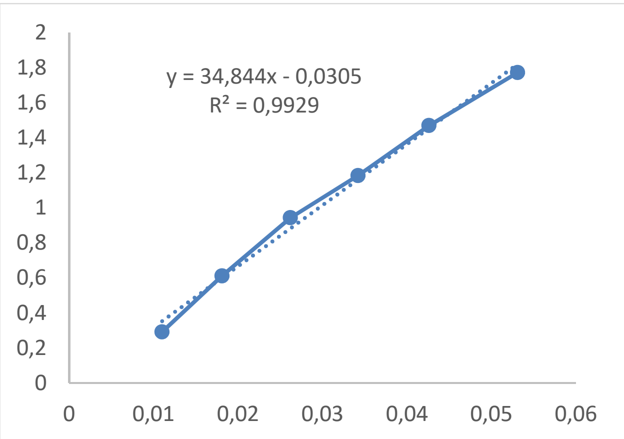

Figure 1. Graph of the gallic acid standard curve, with straight line equation (Source: author's own)

After obtaining the straight-line equation, the total phenolic compounds in dried 'ora-pro-nóbis' leaves were determined using different methods and at different temperatures. The results are expressed in Table 1, where different lowercase letters indicate that there was a significant difference between temperatures using the same drying method and uppercase letters indicate that there was a significant difference considering different drying methods using the Tukey Test ($p < 0.05$).

Table 1. Content of total phenolic compounds in ora-pro-nóbis leaves subjected to different drying methods and at different temperatures

	Drying / conditions (°C/min)	Total Phelonic Compounds g GAE/100g of sample
Drying oven	50 °C/330 min	117.32±0.00
	60 °C/180 min	417.07±0.04
	70°C/150 min	248.14±0.00
Infrared	125 °C/34 min	265.42±0.05
	135°C/30 min	154.88±0.01
	145 °C/26 min	115.08±0.02

Two statistical tests were carried out: the first compared the effect of temperature in the same drying method and the second compared all temperatures in different drying methods. The results showed that the drying temperature of 60 °C using the oven method with air circulation was the one with the highest content of phenolic compounds.

The drying standard was to obtain 'ora-pro-nóbis' leaf flour with a moisture content of 15%, recommended by Brazilian legislation. As a result, drying times varied, as shown in Table 1.

When comparing the content of phenolic compounds using the oven method at a temperature of 60 °C, it was observed that there was a decrease of 40.53% when drying at 70 °C and a decrease of 71.87% when drying at 50 °C. While, when drying using the infrared method, the lowest temperature (125 °C) was the one that obtained the highest content of phenolic compounds and there was a decrease of 41.64% and 56.64% for drying at temperatures of 135 and 145 °C, respectively. Silva *et al.*[12], when drying 'ora-pro-nóbis' leaves in hot air, they concluded that temperatures of 100 °C are ideal for obtaining higher levels of phenolic compounds and antioxidant capacity.

Phenolic composition is influenced by many factors, such as species, location, harvest conditions, and drying and extraction methods [13]. Nguyen *et al*. [14] found in highest concentration after hot-air drying, when compared with other methods (sun, microwave, vacuum and freeze drying). According to these authors, the changes in content of phenolic compounds can be attributed to the activation or inactivation of oxidative enzymes, release of bound phenolics, and partial degradation of polymers, such as lignin, so, phenolic compounds exhibit different stress sensitivities during the drying process.

4. Conclusions

In the present study, the phenolic content of ora-pr-nóbis pulp was characterized under different types and drying conditions. These studies resulted in results that can be useful to increase knowledge about ora-pro-nóbis leaves, promoting the cultivation and use of these important species. Our study reinforces the importance of using non-conventional edible plants as valuable nutritional sources for low-income populations, in addition to supporting their potential use as a source of natural antioxidants and nutraceuticals.

5. Acknowledgements

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Nutritional Interventions in the Preparation of Food Served to Elderly Residents in a Long-Term Care Institution

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Abstract. This study aims to analyze the quality of the meals offered to the elderly residents of the “Lar Espírita José Passos” in Morrinhos, Goiás. A qualitative diagnosis was carried out by the multidisciplinary team, focusing on the quality of food due to the increase in the number of elderly with diabetes, hypertension and some cases of dementia, and the concern for everyone's health, requiring improvement in the quality of meals, with the inclusion of wheat flours, fibers, use of fruits and vegetables. In addition, the reduction of sugar and salt in preparations can positively impact the health and reduce diseases.

Keywords. Food an Nutritional, Fibers, Meals, Diabets Sustentability.

1. Introduction

1.1. Elderly nutrition and long-term care

Aging is a dynamic, progressive and natural process in which morphological, biochemical, physiological, behavioral and psychosocial changes occur [1] resulting in the loss of the ability to adapt to environmental, biological, socio-affective and political stimuli, as well as in the way of eating. These changes leave the elderly more vulnerable to malnutrition (malnutrition, obesity...), chronic non-communicable diseases, such as diabetes, heart disease and cancer [2], which impacts their life expectancy, morbidity and mortality [3]. In this sense, the elderly should be concerned with their diet, seeking to have a healthy diet, since their food intake is important to understand the changes in the nutritional status of this group to advise a healthy diet and delay visual, motor, cognitive, and gustatory changes [4]. In addition, reduced appetite, smell, ability to ingest, digest, absorb and metabolize nutrients from food are observed [5-7].

The “Lar Espírita José Passos” is a Long-Term Care Institution for the Elderly aims to offer residential a long-term care to elderly people of both sexes, aged 60 or over, who are in social vulnerability, so that they receive care for their general well-being, health, food and leisure. Counting on service in the social area, physiotherapy and nursing, seeking to offer a dignified life, integrated into the community, strengthening family ties and friendships [8].

1.2. Food and nutrition education (FNE) activities

Food and nutrition education is a tool that seeks the prevention and control of chronic non-communicable diseases and nutritional deficiencies of all age groups, the appreciation of different expressions of food culture, the strengthening of regional habits, the reduction of food waste, the promotion of sustainable consumption and healthy eating with a focus on food and nutritional security and health promotion. Its guiding principles are defined by the "Reference Framework" and are based on social, environmental and economic sustainability; addressing the food system as a whole; valuing local food culture and respecting the diversity of opinions and perspectives, considering the legitimacy of knowledge of different natures; food and food as references; the appreciation of cooking as an emancipatory practice; the promotion of self-care and autonomy; education in addressing the food system as a whole; valuing local food culture and respecting the diversity of opinions and perspectives, considering the legitimacy of knowledge of different natures; food and food as references; the appreciation of cooking as an emancipatory practice; the promotion of self-care and autonomy; education as a permanent process that generates autonomy and active and informed participation of the subjects; diversity in practice scenarios; intersectoriality and the planning, evaluation and monitoring of actions [9].

1.3. Diet and fiber supplementation

Found that dietary fiber intake was positively related to cognitive function in U.S. older adults [10], and different sources of fiber intake, especially vegetable and fruit fibers, may be related to different dimensions of cognitive function [11], which revealed a long-term benefit of consuming vegetables and fruits (especially foods rich in dietary fiber) on cognitive performance and suggested that fiber intake was associated with better cognitive function.

In addition, dietary fiber can also prevent hypertension [12], which contribute to the maintenance of healthy cognitive function in older adults

2. Methods

2.1. Study design and participants

From the perspective of integrating academic knowledge with popular knowledge, with social and solidarity action and considering society as an active subject and holder of knowledge, the present work is a report of an experience carried out at the Lar Espírita José Passos, located in the city of Morrinhos, Goiás, Brazil, with the elderly who live, the kitchen team and the management team. The “Lar Espiríta José Passos” is a Long-Term Care Institution for the Elderly, and the sample studied is 67 elderly people, 40 men and 27 women, with an age group of over 60 years old in a situation of vulnerability or social risk, victimized by situations that attack their physical and mental integrity, or who have been abandoned or whose family members do not have conditions of shelter. The kitchen team has 9 assistants and chefs, who work in the 12x36 regime, responsible for preparing the 6 meals served daily, being breakfast, lunch, afternoon, dinner and supper. The team composed of nutritionists, students and professors from IFgoiano followed from March to August 2024, qualitatively, making a diagnosis, observing the quality of the food served and the health of the elderly. The management team reported that there has been an increase in the number of elderly people with diabetes and hypertension and currently has 34 hypertensive, 22 diabedic and 9 pre-diabetic patients and the concern for everyone's health, requiring an improvement in the quality of the meals served daily.

3. Results and Discussion

3.1. Diagnostic of meals

A follow-up of the meals was carried out and it was observed that among the 6 meals offered, few options of whole grain products and fibers were inserted, and there were many options of foods with high carbohydrate content, such as bread and butter every day and crackers most days in the afternoon snack, and few products with the addition of wholemeal flours. They have always been concerned with serving 2 options of salads and vegetables daily for lunch and vegetables for soup, served almost every day at supper. The team is already aware that vegetables should be served in cuts, chopped to prevent choking and facilitate chewing. The kitchen team has difficulty controlling and standardizing the addition of sugar in juices, coffees, milk and other prepared products and in the addition of salt to meals. It was also observed that they have donations of various products, from fruits and vegetables, fruit pulps, cakes, breads and various types of snacks, also making it difficult to comply with the menu options. For diabetics, juices and coffees with synthetic sweeteners based on sodium saccharin and aspartame are offered, which in addition to not having a good composition, generate a very strong bitter residual in the flavor of the food.

3.2 Orientation and training of the kitchen staff

A training was carried out by the project's Nutritionist and Food Engineer, for the kitchen team, focusing on quality and responsibility with the production of food served at the Home for the Elderly, and over time, our body naturally undergoes metabolic, physiological, cognitive, psychological changes, among others. Nutrition and adequate hydration in old age aim to minimize the "side effects" of this aging, seeking a calmer and healthier selenity in which the digestion and absorption of nutrients are not so compromised as to trigger chronic diseases. The importance of the cut and texture of the preparations offered was highlighted. In old age it is common to have dental problems (use of prosthesis, absence of teeth), difficulty in chewing, swallowing, so it was recommended to offer food (especially vegetables) in small cuts (minced) and well cooked and if necessary mashed. The importance of standardizing the amount of sugar and salt in meals was discussed with the kitchen team, which directly impacts their health. It was also addressed about the health and personal hygiene of each one, food hygiene, utensils, environmental, Good Practices to offer a microbiologically safe food, since at this stage of life the immune system can be compromised and more susceptible to foodborne diseases.

3.2. Intervention in the menu and nutritional adjustments

An intervention through the team's nutritionist was carried out, together with the nutritionist of the Spiritist Home José Passos, aiming at the well-being and better nutrition of the elderly, the following changes in the menu were proposed:

1. Insertion of foods that are sources of calcium (milk and dairy products), in the collation and afternoon snacks: calcium is extremely important for the maintenance of bone density in the elderly. Ex: milk enriched with fruit, bread with cheese, pâtés with vegetables, natural yogurt with fruits, porridge;
2. Increased fiber intake, since at this stage of life there is a decrease in intestinal transit motility, which can trigger intestinal constipation, blood glucose peaks. In this sense, the insertion of two types of salads was advised, at least 1 garnish based on sautéed vegetables, use of fibers such as psyllium, chia, flaxseed (add to natural refreshments, milk...) and three portions of fruit per day;
3. Due to problems such as blood glucose spikes, insulin resistance and diabetes was advised: reduction of sugar in soft drinks, greengrocers, coffee; the use of natural sweeteners such as stevia, sorbitol, xylitol and erythrol; replacement of white wheat flour with oat, almond and flaxseed flours: (rich in omega-3, coconut flour, chia flour, chickpea flour (lower glycemic index than other flours, rich in protein), quinoa flour, passion fruit flour, white bean flour, eggplant flour, whole wheat flour;
4. Add fruit and vegetable-based cakes to snacks such as orange, lemon, carrot cakes and use of peels and vegetables in the preparation of savory pies;
5. Add or associate a protein source (cheeses, meats...) in snacks (e.g. biscuits with tuna pate, bread with egg);
6. Due to arterial hypertension, kidney problems, sarcpenic malnutrition, cardiovascular diseases among other diseases, it was advised to reduce salt and oil in the preparations, opting for baked and fried foods; use natural seasonings such as oregano, basil, parsley, chives;
7. To improve the protein supply and nutritional quality of food the addition of lentils, chickpeas, peas, white beans to salads, broths, soups, blanched beans was recommended;
8. Thinking about anemia, he instructed the insertion of fruits that are sources of vitamin C after lunch and dinner to improve/optimize the absorption of iron from the preparations;
9. To improve hydration, he instructed the offer of unsweetened teas, water flavored with mint, pineapple, orange, Rosemary.

Foods considered nutritionally poor, such as ultra-processed foods, which should be replaced by vitamin-rich foods and minerals, such as fruits, vegetables and legumes can help minimize much of the negative impacts [13].

Recent studies conducted in Brazil have shown tram that the intake of vitamins and minerals in elderly people are below the recommended values data. Both found high prevalence of inadequacy mainly of vitamins A, E and D and minerals such as calcium, magnesium and iron [14-15]. The strategy of initially planning changes qualitative dances in food can, satisfy factorily, it provides largest size of vitamins and minerals [13].

Vegetable fiber intake may have a beneficial effect on cognitive function, especially good for learning ability, processing speed, sustained attention, working memory, and overall cognitive function, while fruit fiber intake may have a good effect on processing speed, sustained attention, working memory [10].

Vegetable waste is a source of carbohydrates, proteins, minerals, vitamins, organic acids, pigments, and can be used to add value to other products, thus avoiding and minimizing the disposal of large amounts of waste by food industries and could remedy malnutrition of people in a situation of food insecurity [16-17], and can be used for the production of flours with high nutritional content and incorporated into preparations.

The mechanism of the relationship between dietary fiber intake and cognitive function may be the primary mechanism of the relationship between dietary fiber and cognitive function. Dietary fiber can produce bacterial fermentation

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products, including short-chain fatty acids (SCFAs). Second, soluble fibers can play a role as prebiotics and can proliferate health-promoting bacteria [18], while insoluble fibers can promote insulin sensitivity and decrease the rate of nutrient absorption [19-20], which can also benefit blood glucose level and cognitive performance.

These actions aimed to provide the elderly with adequate nutritional guidance, promote self-care and encourage the adoption of healthy habits, contributing to improve the quality of life and the and the healthy aging of this population.

4. Conclusion

In the final considerations of this work, we highlight the importance of nutritional monitoring and quality in food production, with the ingestion of figs and the use of fruits and vegetables in the context of the elderly. The composition of the foods served at meals, such as the addition of fiber, reduction of sugar and salt in the preparations, changes in textures and shapes can positively impact the health of the elderly, improving quality of life and cognitive functions, reducing diabetes, hypertension and dementia. Quantitative studies are suggested to evaluate the improvement in the quality of life of elderly residents.

5. Acknowledgements

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Spatio-Temporal Dynamics of Land Use and Ocupation in the Municipality of Rubiataba (GO) from 1985 to 2022

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Abstract. This study evaluates land use and land cover changes in Rubiataba, Goiás, from 1985 to 2022, focusing on the impacts of agricultural expansion. Using data from MapBiomas and geoprocessing techniques, we analyzed shifts in land use categories, revealing a predominance of agricultural land, which slightly decreased from 86.1% to 85.6%. Significant conversions occurred from exposed soil and vegetation to agriculture, while forest areas increased by 8.7%. Water bodies expanded by 173.8%. The findings underscore the environmental concerns of monoculture expansion and emphasize the need for conservation strategies to address soil degradation and biodiversity loss.

Keywords. Qgis, Geoprocessing, Sugarcane.

1. Introduction

The city of Rubiataba is located in the microregion of Ceres, in the state of Goiás, and is an important sugarcane producer (Souza, 2015). The population was estimated at 19,788 according to the 2022 census data (IBGE, 2022). The municipality's growth is directly linked to the expansion of the sugar and ethanol industry, driven by the establishment of a sugarcane mill in the early 1980s (Silva, 2017).

Figure 1. Location of the municipality of Rubiataba in the state of Goiás

The São Patrício Valley region, located in the microregion of Ceres, highlights its economic importance due to the sugar and ethanolenterprises established there. This economic prominence is a direct result of tax incentive programs implemented in the region, which have promoted sugarcane cultivation. However, this has also led to land concentration and economic stagnation in the area (IFG, 2013).

In this context, there is considerable environmental concern in the region, primarily due to the expansion of sugarcane monoculture, which now occupies extensive areas (Valle, 2016). The occupation of the Cerrado biome has led to the development of population centers and economic growth, as a significant portion of Brazil's food and biofuels are produced in this biome (Rocha, 2012).

The agricultural expansion and deforestation in the Brazilian Cerrado have raised significant environmental concerns, particularly due to the increased release of greenhouse gases, loss of biodiversity, and soil degradation (Grecchi, 2014). The unregulated exploitation of natural resources jeopardizes the region's ability to provide essential environmental services (Fengler *et al*., 2015) and underscores the need for land-use planning that considers the environmental potentials and vulnerabilities associated with human activities (Crepani *et al*., 2001).

Therefore, land management is a crucial step toward the orderly and sustainable use of natural resources, facilitated by interdisciplinary discussions and proposals (Lima, 2011). Studies on environmental fragility and vulnerability seek to identify areas most susceptible to natural and anthropogenic impacts by evaluating landscape characteristics such as topography, soil type, climate, and land use. The use of geoprocessing techniques and Geographic Information Systems (GIS) enables a better understanding of the environmental impacts caused, thereby supporting environmental planning. In this context, the present study aimed to evaluate the changes in land use and occupation in the municipality of Rubiataba from 1985 to 2022.

2. Methodology

In this study, data from the Brazilian Institute of Geography and Statistics (IBGE) were used to delineate the municipality's areas. Land use and land cover change maps were obtained from the MapBiomas Project, specifically from Collection 8 of the Annual Land Cover and Use Mapping, covering the period from 1985 to 2022. These data were accessed using the Google Earth Engine platform via the tool available at MapBiomas. Land use and land cover were reclassified into five main categories: Class 1, including forest formations, grassland formations, and wetlands; Class 2, covering exposed soil; Class 3, associated with agricultural uses such as forestry, pastures, sugarcane, soy, and mixed uses; Class 4, referring to urban areas; and Class 5, encompassing water bodies, including rivers, lakes, and the ocean.

The spatial analysis was conducted to generate maps and tables illustrating changes in land use and land cover over the evaluated period in the city of Rubiataba (GO), based on data extracted from the MapBiomas Project. A Sankey diagram was created using the R environment to represent the rates of change in land use classes. This diagram provides a clear and objective visualization of alterations in land use classes across the analyzed time intervals.

The study's methodology involved the application of geoprocessing techniques to manipulate data obtained via Google Earth Engine and the MapBiomas Project, using QGIS software. The R environment was employed to graphically illustrate the data. Changes in land use and land cover were quantified by assessing the initial area, losses, and gains for each class over five time intervals: 1985 to 1990, 1990 to 2000, 2000 to 2010, and 2010 to 2022. For data analysis, QGIS software version 3.28.5 (QGIS, 2023), R version 4.2.3 (R CORE TEAM, 2016), and Excel were used.

Within this context, there is significant and the increase of sugarcane monoculture has become a major environmental concern in the region, with this crop now occupying extensive areas of the territory (Valle, 2016). The expansion into the Cerrado biome has facilitated the development of population centers and economic growth, as a significant portion of Brazil’s food and biofuels are produced within this biome (Rocha, 2012).

3. Results

The Sankey diagram illustrates the dynamic changes in land use and land cover in the city of Rubiataba between 1985 and 2022. Agricultural land use has been predominant, comprising approximately 86.1% of the area in 1985 and 85.6% in 2022 (Table 1). The sank diagram reveals a significant conversion of areas from exposed soil and vegetation to agricultural use over the studied period (Fig. 2).

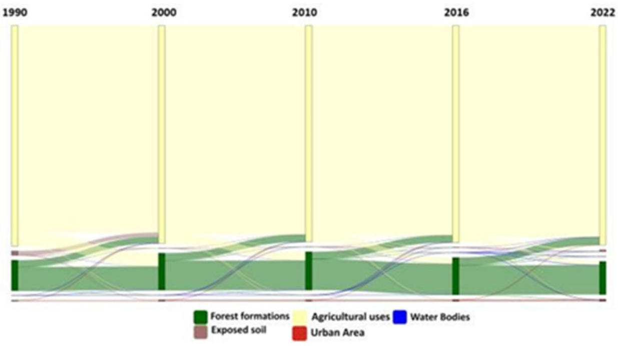

Figure 2. Sankey diagram illustrating the conversions of land use classes during thestudy period

Notably, there was substantial conversion from agricultural use to forest formations, particularly between 1985 and 1994, a trend that continued throughout the years analyzed. It is evident that some areas classified as natural formations are, in fact, secondary forest formations, mainly due to the conversion of agricultural areas (Fig. 2). Forest formations in Rubiataba increased by 8.7% from 1985 to 2022. The replacement of natural forests with plantations in the Cerrado region can have detrimental environmental impacts, including biodiversity loss, soil degradation, alterations in the hydrological cycle, greenhouse gas emissions, and social consequences (Grasser *et al*., 2021).

Table 1. Quantitative data in hectares for land use and occupation classes: Forest Formation, Exposed Soil, Agricultural Uses, Urban Area, Water Bodies

	1985	1994	2003	2012	2022
FF	8917,7	10856,9	11254,5	10952,7	9692,5
ES	1280,1	55,4	65,1	105,9	519,8
AU	64646,2	63793,4	63376,4	63547,0	64294,2
UA	222,2	347,1	362,3	422,8	524,0
WB	20,6	34,0	28,5	58,4	56,4

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4. Conclusion

The study identified a decresead in exposed soil areas, with significant conversions primarily into forest formations and agricultural use. Agricultural expansion was the principal factor of these land use changes. Additionally, there was a notable increase in the area of water bodies. To mitigate adverse impacts, it is essential to implement soil conservation practices and adopt effective conservation strategies for natural areas, particularly those affected by agricultural activities.

5. Acknowledgements

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Green Areas of the City of Goiânia (GO). Historical Comparison of the Area Occupied by the City's Main Parks: Buritis Forest, Flamboyant Park and Cerrado Park

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Abstract. The city of Goiânia, Goiás, holds the title of the greenest city in Brazil, according to the 2010 IBGE census. Although it was designed to resemble an English garden, real estate development due to economic interests has encroached upon its green areas, reducing the number of wooded spaces. The objective of this study is to analyze the historical occupation of the green areas of three parks in the city of Goiânia: 'Buritis Forest', 'Flamboyant Park' and 'Cerrado Park', considering private interests. A qualitative research methodology will be applied) through a bibliographic survey and historical comparisons.

Keywords. Preservation, Green Area, Goiânia, Occupation.

1. Introduction

Global warming and the growth of cities are The green areas of a city represent the potential for better preservation of the natural resources within the urban environment, since they promote animal and plant biodiversity in addition to aiding in drainage and other local environmental processes [1].

According to the Municipal Environmental Agency [2], in 2021 there were 191 urban parks and forests in the city of Goiânia. Based on this infrastructure landowners and real estate agents, as key actors in socio-spatial configuration, have developed marketing strategies to enhance the value of certain green areas in the city [3].

Consequently, these spaces became associated with a high standard of living, attracting the interest of affluent populations, and public space began to be seen as a commodity to be exploited. In the search for the viability of this market, powerful lobbies have emerged, capable of influencing the creation and alteration of laws such as zoning and land use laws [4].

This trend runs counter to be sustainability guidelines, as construction activities are the primary contributors to negative impacts such as increased urban waste, flooding, and pollution of water resources, among other issues [5].

The growth in population and the verticalization of these areas have led to significant changes in resource consumption, air quality, waste generation, and even the microclimate of the region [6]. This paper aims to demonstrate that the green areas initially planned for Goiânia have experienced significant reduction due to the harmful interaction interactions between estate market and the environment, and that the occupation of areas near parks in this city occurs cyclically: the original parks have endured prolonged periods of real estate speculation and are now exhausted; parks created in the last 20 years have seen their resources rapidly consumed; and future parks are likely to be designed as a means of adding value to regions intended to be high-end. To this end, this study analyzes three of the city's main green spaces: Buritis Forest, Flamboyant Park and Cerrado Park.

2. Development

2.1. Buritis Forest

The establishment of Buritis Forest (originally Buritis Park) was approved by Decree-Law No. 90- A on July 30, 1938. One of the objectives was to protect the source of the Buriti stream. The area planned for the park was 38 hectares. However, in the project executed by Coimbra Bueno, the area was reduced to only 11.6 hectares. The difference between the initial project and the implemented one is illustrated in Fig. 1. In addition to the reduction that occurred during the implementation of the area, due to the neglect of public agencies regarding the environment, another significant loss of area occurred with Decree-Law No. 574, dated May 12, 1947, which allocated part of the area designated for Buritis Forest for the construction of private schools (Atheneu Dom Bosco and São José Externship) and public agencies (Forum, Court of Justice, and Legislative Assembly), as well as for housing allocation and illegal

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occupation of lots. Developments in the West sectors and, later, in the Marista Sector further reduced the park's boundaries, leaving only 30% of the originally planned area [7].

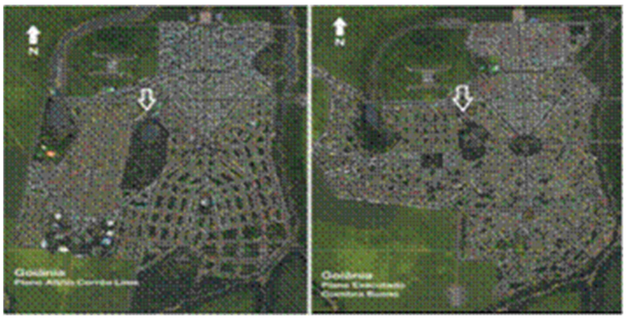

Figure 1. Comparison between the original plan (Atílio Corrêa) and the executed plan (Coimbra Bueno) of Buritis Forest (Source: Cunha e Diniz, 2018)

Figure 2. Redistribution of Areas Designated for Buritis Forest (Source: Mota e Rezende, 2015)

The degradation and division of the remaining area continued, starting from the revitalization projects by landscape architect Fernando Chacel (1972) and the Municipal Planning Institute (1972), up to the occupation of the park's surroundings by luxury condominiums. The most recent human interventions occurred in the 1990s and early 2000s, when new trees were planted, existing buildings were demolished and repurposed, and the park's recreational and leisure facilities were renovated [8]. In 1994, Buritis Forest was designated as a protected area through Decree nº 2.109 of September 13, as a public initiative to incorporate environmental discourse and prevent further deforestation, prohibiting the construction of new buildings around the park [9].

2.1.1. Loss of Area of Buritis Forest

According to information from the Municipal Department of Planning and Urbanism of Goiânia, in the original 1933 proposal, Buritis Forest was planned to cover an area of 400,000 m². By 2023, approximately 124,800 m² remained, with only 10% of its native forest. The following graph provides a visual representation of the park's area loss.

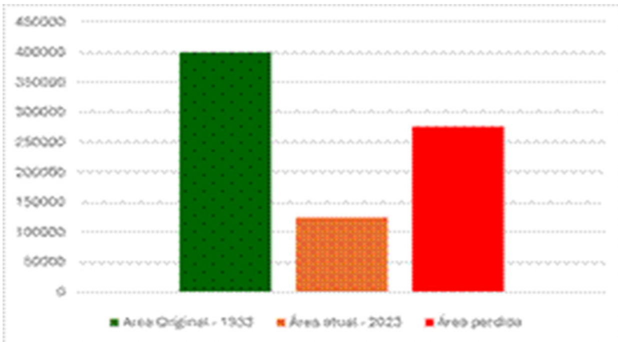

Figure 3. Loss of Area of Buritis Forest (m²): 1933 – 2023 (Prepared by the authors based on data from SEPLAM, 2023)

Comparison of the Area of Buritis Forest Across Each Decade:

Figure 4. Aerial View of Buritis Forest in the 1960s (Source: SEPLAN Archive, 2023)

Figure 5. Aerial View of Buritis Forest in the 1980s (Source: SEPLAN Archive, 2023)

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Figure 6. Aerial View of Buritis Forest in the 1990s (Source: SEPLAN Archive, 2023)

Figure 7. Aerial View of Buritis Forest in the Present (Source: Google Earth, 2024)

Figure 8. Residential Surroundings of Buritis Forest, Located in the West Neighborhood in Goiânia (GO) (Source: Carneiro, 2010)

2.2. Flamboyant Park

Using the mechanism of private subdivision for urbanization in the municipality, farmer Lourival Louza divided and developed a sector of the city, Jardim Goiás, in 1950. Francisco Maia, the engineer hired to execute the project, had ideas similar to those of Attilio Corrêa, aiming to bring aspects of the countryside to the city in order to make it more rational [8]. The original project for Jardim Goiás, which includes Flamboyant Park, is shown in Fig. 9.

Figure 9. Original Project of Jardim Goiás (1953) (Source: Reis e Aragushi, 2022)

Until the 1970s, the occupation of Jardim Goiás was insignificant. The area was occupied by irregular settlements on the banks of the Botafogo Stream and the Areião and Vila Lobó invasions. Lourival Louza intelligently provided land for the construction of large facilities such as the Estádio Serra Dourada (a major project that caused serious environmental and drainage problems), the Autódromo Internacional de Goiânia (an area near Jardim Goiás donated by Louza), and the City Hall. The area, however, remained sparsely populated, and its occupation only accelerated in the 1980s when he built and opened the first shopping mall in the capital, the Flamboyant Shopping Center, also a regional facility. The construction of large-scale facilities permitted by the zoning law itself required changes to the local urban fabric. The implementation of Carrefour Hypermarket (1988) and Walmart (2005) further overloaded the avenues that cross the neighborhood [10].

Figure 10. Flamboyant Park Area with Some Developments in Its Surroundings (Source: Flamboyant Park management plan picture of Municipal Agency of Environment, 2007)

Flamboyant Park is currently a municipal conservation unit, located in Jardim Goiás, Southeast Region of the city, a new sector under

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expansion, with great appreciation and real estate speculation, close to the Flamboyant Shopping Mall.

Figure 11. Residential Surroundings of Flamboyant Park, Located in the Jardim Goiás Neighborhood (Source: Zanardo, 2021)

2.2.1. Loss of Green Area of Jardim Goiás

According to the Council of Architecture and Urbanism of Goiás (CAU-GO), the neighborhood was designed to be a garden city with 14.6% of open spaces, corresponding to 374,663 m² of parks, public gardens, and landscaped squares. In the 1990s, with the advent of the Plano Real, which accelerated real estate investments in the city, the process of verticalization of the neighborhood began, with the construction of buildings of more than twenty stories [8].

With the aim of strengthening the commercialization of these properties, the urban space was revalued with the inauguration of Flamboyant Park in 2007, with an area of 125,572.71 m², and its creation aimed to recover and preserve the source areas of the Sumidouro and Botafogo streams. At the time of its inauguration, there were 39 high-rise buildings in the neighborhood. Just two years later, 31 more towers had been built, and by the end of 2018, there were already 136 high-rise condominium towers in the area [11]. This evolution of urban occupation around Flamboyant Park can be seen in the Fig. 12.

The large number of buildings around Flamboyant Park has once again led to environmental degradation in the area, with problems such as soil degradation, damage to the spring, accumulation of garbage in the lake region, occupation of buffer zones, impairment of access of sunlight and wind to vegetation areas, and reduction in the volume of water bodies [12]. The following graph presents a visual demonstration of the loss of green areas in Goiás Garden.

Figure 12. Top view of the Flamboyant Park in 2007 (A) and 2018 (B) (Source: Reis e Aragushi, 2022)

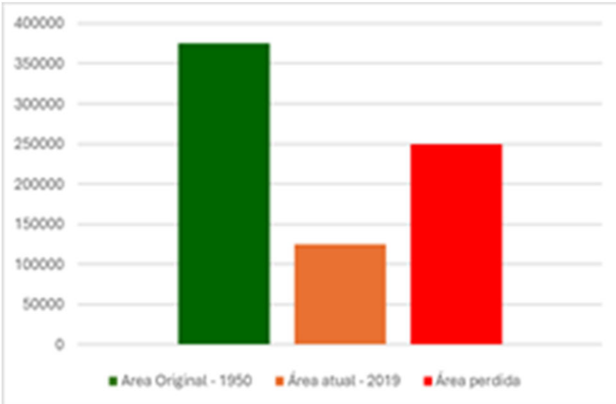

Figure 13. Loss of green area in Goiás Garden (m²): 1933 - 2023. (Prepared by the authors based on data from SEPLAM (2023))

2.3. Cerrado Park

Cerrado Park is the newest of the areas analyzed, and its project was launched by the City of Goiânia in 2013 through Law 9,360/13. This is a public-private partnership (PPP) with the company EuroAmerica Incorporações and a project by architect Guilherme Takeda. The park is located near the City Hall and has 706,000 square meters, making it one of the largest environmental conservation areas in the capital. One of the project's promotional images can be seen in Fig. 15.

Park had not yet been implemented until 2021, while the Euro Park real estate development already had three of its eight towers delivered. In addition to the future public park to be implemented in the region, the condominium building complex will have a private park of more than 7,000 m² set up by the construction company.

According to source [13], the Cerrado Park has its reserve located in the Parque Lozandes neighborhood, where the Alphaville, Jardins, and Portal do Sol condominiums are concentrated.

Figure 14. Cerrado Park Project (2015) (Source: Souza, 2023)

Figure 15. Cerrado Park: Project of 2015 (A) and Top view in 2021 (B) (Source: Reis e Aragushi, 2022)

The advertising of a residential building in this region, the EuroPark Residencial, uses the real estate appreciation itself to promote the property, stating with the slogan “a park changes everything” that the implementation of urban parks increases the price of real estate, “increases the sophistication” of the place, brings “shopping malls, gastronomy, and creates new postcards in the city”.

Figure 16. Location of Cerrado Park (Source: Mota, 2023)

The commercial points out that the transformations in the neighborhoods, after the parks or improvements were implemented, brought high-standard services, “designer brand stores” (Idem) to the regions, opening space for the city’s growth, since these are the places where the “high purchasing power” of the city is concentrated[13].

Therefore, we can observe the way in which the real estate market appropriates urban parks to promote verticalization – and provide “privileged views” – generate real estate speculation and act selectively in certain areas of the city that result in segregation [14].

Consequently, access to public parks becomes symbolically restricted, as a social condition is imposed, since these begin to receive, mostly, the upper class population, as in the case presented of Flamboyant Park [13].

Table 1. Aspects, problems, and perspectives of the functional, environmental, and aesthetic aspects of Cerrado Park (Source: Souza, 2023)

Aspects		Problems	Potentialities
Functional	Infrastruc-ture	There is no sidewalks around its perimeter; Little signage on the trails; No lighting inside; There is no access control.	The area is Served by collective public transport.
	Mobility	No accessibility; Vehicles park in inappropriate locations.	The use of bicycles as a sport and form of transportation already exists; Close to public facilities and other recreation areas.
Aenviron-mental	Vege-tation	Reducion of 60% in the area allocated to the park; Lack of maintenance, resulting in places with a shortage of plants.	Lots of preserved native vegetation.
	Hydro-graphy	Free access to bodies of water, it is not possible to know the use that takes place there.	Respected Environmental Protection Area with dense natural coverage.
Aesthetics	Lands- cape	Confused and abandoned look.	Presence of free areas possible to intervene.
Existing project (2015)		Very aggressive uses, invading the APP provided for by the City Master Plan.	Diversification of activities; Maintains the ecological bias of the trails.

3.1. Loss of green area of Cerrado Park

[15] presents a study and diagnosis of the Cerrado Park, highlighted in the Table 1.

3. Conclusions

The environmental benefits expected from the implementation of public parks include the protection of springs and sources, increased thermal comfort, balanced air humidity, air pollution control, and improved quality of life for the population. These benefits are politically correct, as, in addition to these, there is a financial motivation driven by the real estate appreciation that the implementation of a park in the region provides.

Here, we observe a paradox: while parks increase property values, the excess of buildings ultimately exhausts the parks' infrastructure, distorting their initial objectives. In this sense, the development of public-private partnerships in the city of Goiânia has contributed to the decharacterization of green areas and the loss of their capacity to preserve natural resources. As demonstrated in this review article, analyzing the historical evolution of occupation near three of the city's main parks reveals the exhaustion of the original parks, which have already undergone a long period of real estate speculation and appreciation of their areas.

The data collected shows that the area lost in Buritis Forest since its creation has reached a worrying 69%, meaning that two-thirds of the original area has been lost. The same pattern is observed in Goias Garden, where the loss reached 66%, also equivalent to two-thirds of the original area, indicating that real estate investments have been prioritized at the expense of the quality of life of the inhabitants. Cerrado Park was also considered a local priority at the beginning of its construction plan, representing 80% of the subdivision and surrounding the entire perimeter of the area reserved for the current construction of the City Hall, suffering the expropriation of more than half of its original area, designated for other constructions of public institutions. In short, it can be seen that the changes made to the green areas affect the site in several aspects - morphologically and functionally - denaturing its function of environmental preservation and conservation of local biodiversity, while focusing exclusively on economic interests.

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Science, Arts and Philosophy Education as Tools for Confronting Neoliberalism: The Role of Natural Science Teachers

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Abstract: The principles of neoliberalism have socioeconomic influences that have further exacerbated inequalities in our country by minimizing the state's responsibilities in the economy. Reflecting on this, we align our reasoning to consider how education in natural sciences can help in the formation of individuals for autonomy and serve as a tool for counter-hegemonic resistance against neoliberal principles. To understand how neoliberalism operates, we recognize that its maintenance is rooted in ideologies that perpetuate comparisons between those who hold power and those who do not, as well as reinforcing the idea that one must consume more to assert themselves in society. As a result, individuals, in a less reflective manner, become the "other" compared to those possessing these attributes and are positioned on the margins of society. However, the present text seeks to show the role of the natural sciences teacher in the process of re-signifying individuals as political beings capable of emancipating themselves from the dominating neoliberal system.

Keywords. Science Teaching, Role of the Teacher, Science Education.

1. Introdution: What's the matter?

Neoliberalism has so many socioeconomic influences and it has enhanced social inequalities in society. In this context, we need to present some reflections on whether education in natural sciences can contribute to autonomy and civic participation, or even serve as a tool for necessary resistance against neoliberalism ideology.

We need to better understand how neoliberalism works, namely by tracing its meaning and understanding that its maintenance is based on a comparison between those who have ideological power and those who do not. Secondly, they impose the ideal of consuming more in order to assert themselves in society. Then, those who don't follow the imposed norms become the "other" and are pushed to the margins of society [1]. This is why we are analyzing the role of the natural science teacher and their role in promoting an education that is emancipatory of the neoliberal system.

So, they will know out that the place of this "other" is defined, as well as their body, their home, their food, their living conditions and well-being, where they live, which doctor they go to, what brand of clothes they wear, etc. All of these, in Brazilian education, are directly or indirectly objects of study in science classes, either in a curricular way (Medicines, Hygiene, Beauty and Cleaning Products, etc.), or as contextualization or examples.

Some teachers have undergone a training that made them conscious of their role in the lives of their students. For these educators, dialogue and discussions about life experiences are crucial. They teach by walking alongside their students, helping them to become independent thinkers. These educators lead by example, encouraging their students to reflect on their own lives and consider how they can contribute to a better world. They aim to live according to their beliefs, guided by love and mutual respect. In such an environment, everyone can participate and make decisions with autonomy and knowledge, but together [2].

However, in the logic of capital, the "other" who is deprived of autonomy, often in situations where their rights are denied and subjugated; If we had a more conscious formation we would be up to us, teachers of natural sciences to take a humanized and ethical view of our job, and this needs to be the object of analysis, discussed, thought about and repositioned in actions committed to the emancipatory education of subjects, the "other" with rights and duties, equal opportunities and chances.

Science educators could grapple with the production of sociocultural and anthropological studies of science education with their students. And work thematics that their students could select and discurs about social troubles,related with science or technology that have impact in environmental or health. It could be so important for develop critical thought for basic education.

We think it could be so important in a time marked by complex and contradictory policy frameworks for science education. If the science knowledge will be critically understood maybe it could help our students to see better divergent ways of these policies, so that was almost times induced by neoliberalism ideology [6].

2. Methodological path

This research has a qualitative approach, aiming through bibliographic analysis to provide a broader coverage of observations on the object, which is science education and the role of the natural sciences teacher in maintaining or dismantling the neoliberalism ideology. We will therefore use official bibliographic sources, such books, articles available in the journals of the Coordination for the Improvement of Higher Education Personnel (CAPES) and other historical documents from the last twenty years.

These documents could serve as basis for the arguments presented here, showing that thinking about the role of science education in building a society that aims to reduce inequalities can involve training and raising awareness among teachers of natural sciences if they have the knowledge and engagement necessary.

For this way, teacher trainers need to be aware of the processes and strategies that neoliberal policies use so that their ideologies go unnoticed and are naturalized. So many teachers who work in this area of knowledge and who are unaware of these resources end up serving to reinforce this policy and end up excluding those who so desperately need to take refuge in the scientific and technological knowledge that surrounds them for understand how stooks work [5].

If people know more science, maybe they could make some right judgments and reflect about their choice. They will have more understanding of science and technology in this world and be able to make conscious decisions during an excess of unfounded information. If they could see the intentional neoliberal ideological bias towards diverting attention or even confusing less enlightened people, we could make the change, and the world will be better for everybody. The educator in science could work by promoting some strategies that could help their students to be able to know and make conscious choices, maybe they did not make so mistakes. They were not inducted by media-to do so many shoppe for fill better in their life, the consumerism idea could blind people. And they could make some reflections about the globalization processes promoted ideologically in the world and they could think more about their choices and the implications they may have in their life and in the environment.

Thus, this text we have produced seeks to substantiate our discussions and perceptions of what has been evidenced in the critical training of teachers of natural sciences and the importance of these teachers knowing what lies behind neoliberalism and reflecting on issues that can help us work towards a more critical and emancipatory teaching of natural sciences.

Some authors will establish a critique of curricular policies by visualizing elements of neoliberalism and postmodernism in which there is an intentional imposition of capital on school decisions and practices that obey the logic of capital to the detriment of human values. This author also reaffirms the forces that are in dispute in teacher training, in which we can reflect by reaffirming the intentionality of such polarized disputes around Brazilian education [3] "[...] we have neoliberal pragmatism; another, the epistemological and cultural relativism instigated by postmodernism." With the prevalence of these 'forces, what remains as socially naturalized thinking is "[...] a radical and profound devaluation of theoretical knowledge in teacher practice and training" [3].

Educators need to be conscious of this in their initial and continued training. However, how can they escape the ideological interests that dominate the Brazilian educational curriculum and teacher professional training? We will discuss some ideas about this based on socio-historical pedagogy [4]. Arts and Philosophy are so important for humain formation, but in this moment our enphazy is in Scientifique education and the role of theses educators.

3. Development

Right from the student's initial contact with science lessons, the teacher can try to establish an environment in his or her classes that is conducive to deep reflection on the neoliberal ideologies that are instilled and often naturalized. And so, through dialog and reflection, we can provide moments of deconstruction of prejudices and glimpse the world with greater criticality and Hands-on Science. Science Education and Sustainability, empathy, greater love and respect between people [2].

It is in this sense that we draw on the thinking of Karl Marx (1818-1883) in relation to the place determined as being that of the “other”. In his own terms, he said that “It is not the consciousness of men that determines their being; on the contrary, it is their social being that determines their consciousness” [4]. Therefore, this speech serves to argue that it is not the subject who is known in a general and natural way as being the “other” of the dominator, but rather the dominator who, by defining the role of this individual based on his interests and aiming for his submission, devotion and servitude, shapes his social consciousness. In this way, they are conditioned to constant alienation, where they are liquefied into ignorance of themselves and their place on the periphery of capital.

About science education, shaped in conjunction with scientific practice today, is carried out using the methods and instruments of that time, so that “[...] science allows us to analyze the world around us and see beyond what our eyes can see” [5]. When instrumentalized for the purposes of mercantile domination, science ends up being a fertile environment for the reproduction of ideologies of domination.

Knowing that the production of scientific knowledge and the dissemination of this knowledge are “mediations that constitute social being” [6], we can infer, as educators and subjects of change, that scientific research and scientific education are therefore contaminated by contradictions. There are those who make scientific knowledge and those who use this knowledge to make material life, both financed by capital and about expropriation of "others"[4].

It is up to us to ask ourselves: how can scientific practice and science education work together in the fight against neoliberal influence? And in this sense, it is important to reflect on the role of the natural science teacher in this process of education, which is made and unmade as contexts change (historical, social, political). Not only that, but we should also question how conceptions of the teaching-learning process can be a “game changer”, by comparing the differences between subjects and thinking about more equitable conditions, according to the educational needs of each one and the role that scientific knowledge can play in their real/material lives. In short, to honestly rethink what kind of school and science education we are doing or failing to do.

4. Some Considerations

We believe that the training of natural science teachers is very important for the empowerment of subjects. With this in mind, we need to think about historical and philosophical aspects, as well as educational resources that can help us as agents in the fight against neoliberal hegemonic ideas, based on misinformation and Fake News. In this way, we will make science classes more than just a pile of formulas and laws, but also a place for disputing knowledge that can produce changes in the social sphere of each student and in the establishment of a more democratic education that promotes citizenship for the Brazilian people.

Students can become more active participants in their own education when educators implement active methodologies in their pedagogical practices. We can become true partners in learning if we move away from a prescriptive and ideologically driven curriculum shaped by neoliberal principles.

Despite these policies and strategies of neoliberal, we could have scientific and humanitarian/ethical knowledge on some matter that could help us get a better understanding of what is a good choice for our society and what else is not important for our health's quality and a harmonic life with others. So, we will put take our decisions in a secure way [7].

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Solar Energy and Sustainability: The Portuguese Situation

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Abstract. The use of renewable energies and in particular solar energy harvesting is of critical importance to tackle the current global warming crisis and ensure environmental sustainability and sustainable development in general. The main goal of this chapter is to provide an overview about the evolution of the photovoltaic industry on a global scale, highlighting some characteristics of the Portuguese photovoltaic market, which arises from the political and economic environment. The sustainable development trends in the photovoltaic industry are also discussed, both from the perspective of the Portuguese market and worldwide. The article also discusses the issue of the Covid-19's impact on the photovoltaic industry. Issues related to the state of maturity of the different solar photovoltaic technologies are also emphasized, as well as the expected market share of those different technologies. The information presented herein will be of great importance to educators and science teachers and everyone involved in raising the awareness and literacy on sustainable development.

Keywords. Climate Change, Photovoltaic Market, Renewable Energies, Solar Cells, Sustanability.

1. Introduction

Over the past decade the world witnessed a huge population growth combined with a significant increase in industrial activities taking advantage from diverse scientific and technological advances. These events contributed significantly to the improvement of the economic conditions of the populations, which caused a profound change in their consumption habits, namely through the purchase of motor vehicles, housing, household appliances, various electronic devices, etc., which are characteristic of the countries that are being modernized; as a result, world demand for energy has increased and will continue to increase quite significantly. As a consequence, the resources available in the world are getting depleted in an unsustainable way [1]. On a global scale, the energy economy, in particular that of industrialized countries, is mainly based on the use of energy from fossil sources such as coal, oil and natural gas, as well as nuclear energy. Satisfying humanity's energy needs through the use of fossil sources presents many problems. The fossil materials long buried under the surface of the planet Earth are the main responsible for the ecosystems pollution (and diseases in the surrounding populations) because of the emission (into the air and water) of various gases generated from its burning [2]. So far, these problems are still not recognised by all, but they will bring many difficulties for the future generations and preclude a sustainable development. Actually, the use of non-renewable energy sources would not indubitably meet energy demand since they are exhaustible and limited sources of energy (i.e. a fossil source can only continue to be utilized until the moment it runs out) [3]. Moreover, the persistent use of non-renewable energy sources may compose one of the main causes of climate change, which in turn, can contribute to the occurrence of huge natural disasters with significant damage to the ecosystems of planet Earth [4]. In this sense, it is crucial to move in the direction of looking for eco-friendly energy sources to improve the future world and its sustainable development. Among the several renewable sources of energy (for example, wind, hydro, waves, etc.), solar energy is the most abundant, inexhaustible and freely available energy source that enables the management of long-term problems that may arise with the satisfaction of future energy needs (energy crises).

Photovoltaics (PV) involve the technology that generates electrical energy from light energy. The word “photo” means light (that we can relate to “photons”, i.e. packets of energy) and “voltaic” is related to electricity. A photovoltaic cell, also known as a "solar cell", is made from a semiconductor material that produces electricity when subjected to the action of incident light, that is, when its surface is impacted by photons. The semiconductor material must have the ability to absorb a large part of the solar spectrum. Depending on the material's optoelectronic properties, light is absorbed in a region close to its surface and

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electron-hole pairs are generated in such a way that if their recombination is prevented, they can reach the junction where they are separated by an electric field.

The principles underlying the operation of a conventional photovoltaic cell have been widely described in many works [5-6] and therefore will not be addressed again in this article. Although the photovoltaic effect was observed in 1839 by the French scientist Edmund Becquerel [7], its understanding was only achieved from the concepts and development of quantum theory of light and solid state physics. The first commercial application of photovoltaic devices took place in the 1950s within the space industry in order to power the orbital satellites of the US space programs. Since then, PV has made very significant progress both in the development of new/emergent technologies and in prices and installed capacity on a global scale. Although the majority of PV cells currently used by the photovoltaic market are based on silicon semiconductor material, PV cells made from other types of semiconductor materials are already a reality today and, relatively soon, are expected to be able to compete with silicon PV cells, both in performance and cost.

This article focusing on a sustainability perspective discusses the stage of development of the photovoltaic industry from a world market perspective and emphasizes the Portuguese case. In addition, future trends in the PV market are also discussed as well as the current solar PV technologies available on the global market as well as those expected to dominate the market in the near future.

The main novelties of this article are related to the specific situation of the solar PV in Portugal, the recent problem of Covid-19's impact on the solar PV industry and also by the comparison made about the main PV technologies, with emphasis on the passivated emitter rear contact cells (PERC), because they appear as the most promising can.

2. The photovoltaic energy sector – a comparison to a global scale and Portugal's position

It is recognized that solar PV represents one of the most relevant renewable energy sectors in Portugal, due to the levels of irradiance observed in the country; however, only in recent years this energy sector has become an important strategic vector of the Portuguese energy mix. In this context, photovoltaic systems fall within the scope of the great purpose of the energy transition that Portugal assumed in 2016, which aims to achieve carbon neutrality in 2050 through a drastic reduction of greenhouse gas (GHG) emissions. Despite the excellent level of solar radiation as well as the good Portuguese weather conditions represent a national added value compared to most other European countries, it was found that only from 2007 the country has implemented a true path in the field of photovoltaic systems with the aim of producing electricity from renewable sources. It was a late awakening; however, over the past decade the evolution of Portuguese photovoltaic capacity has been quite reasonable as shown in Fig. 1, which was plotted based on the statistics of the International Renewable Energy Agency (IRENA) [8]. According to 2019 data on renewable capacity, IRENA places Portugal in the modest 17th place in the ranking of European countries (including the EU-28) in terms of the accumulated value of installed photovoltaic power, which is a median position when compared to many other European countries.

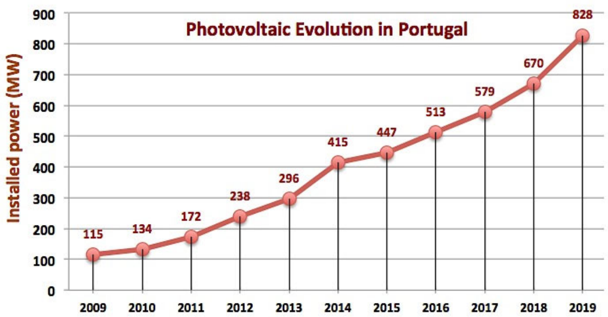

Figure 1. Evolution of Portuguese photovoltaic installed capacity over the last decade [8]

Apparently, from 2018 the trend line shown in Fig. 1 suggests that photovoltaic installed capacity may increase significantly in the coming years. In fact, according to statistics from Solar Power Europe 2019 [9], the data relating to the expected increase of photovoltaic capacity in some European countries in the 2018-2023-time period is quite significant, as shown in Table 1.

Table 1 reveals that for the period from 2018 to 2023, Portugal shows an excellent record since it appears to be the European country that should enrol the second largest increase in photovoltaic capacity (note that in 2023 the value of installed photovoltaic capacity should be about seven times higher than that recorded in 2018). This forecast analysis is very close to reality because the plan of the Portuguese Government aims to promote an acceleration of investments in solar PV, taking advantage of the trend in the cost reduction of existing technology (mainly based on silicon) and thus, favouring the large scale investments without resorting to the old strategy characterized by advantageously government subsidized tariffs, as occurred in the past with the first solar plants that gave exaggerated economic benefits to the great promoters.

Table 1. European photovoltaic capacity

Country	2018 Total capacity (MW)	2023 Expected total capacity (MW)	2019-2023 Added capacity (MW)
Germany	45920	72611	26691
Spain	5915	25367	19452
Netherlands	4181	20059	15878
France	8920	22259	13339
Italy	19877	29498	9621
Ukraine	2004	7963	5959
Turkey	5062	10562	5500
Portugal	670	4525	3865
Hungary	797	3580	2783
U. K.	12962	15674	2712
Poland	464	3139	2675
Ireland	50	2667	2617
Belgium	4075	6367	2292
Russia	518	2770	2252
Sweden	2205	4292	2087

Meanwhile, it is important to remember that in July 2019 Portugal shook the PV world market when 1292 MW were auctioned at a record price. Among the 64 participating companies, the big winners of the auction were the Spanish Iberdrola and the French Total Solar, who managed a good part of the projects they had applied for. The price at which Portugal closed this photovoltaic solar auction was around 0.02 €/kWh (roughly half the price of the Iberian Electricity Market), which contributes to making the country an excellent example. In fact, PV energy auctions allow the country to have a greater ability to attract investments of very large financial amounts, which help the development of productive infrastructures, while giving the promoters stable contracts, thus guaranteeing the return on the investment made.

However, it is important to show some care in relation to the sustainability and profitability of projects that offer this price magnitude for the sale of energy. In fact, assuming that a solar plant will be able to operate 25% of the time, each installed megawatt will be able to produce 6 MWh per day and therefore 2190 MWh per year. If electricity is sold at a price of 20 Euros per MWh, in 15 years this plant will be able to generate a turnover of 657 thousand Euros per MW. Nowadays, the cost of installing large-scale solar plants is around 600 thousand Euros per MW, which means that this revenue would pay, at most, the cost of solar panels, but would be insufficient to cover the cost of project financing.

Even so, during the third quarter of 2020, Portugal had a second auction of solar energy, which conferred around 700 MW (concentrated in south Portugal regions of Alentejo and Algarve) of new renewable capacity, adding to the 1292 MW already awarded in the first auction in July 2019. According to the statements by the Portuguese Minister of Environment during the inauguration of the Solar Photovoltaic Park at Monte Real Air Base, the demand for the new solar auction at the end of August was 10 times higher than the offer, exceeding all expectations, thus showing the strategic interest that the photovoltaic industry represents for Portugal. Actually, it is in the renewables sector (where solar PV is included) that the greatest contribution to the challenge of energy transition is expected, which involves the implementation of active policies leading to a true decarbonisation process and a new paradigm for the Portuguese energy mix, provided that tariff prices are expected to decrease significantly.

3. Development trends in the photovoltaic industry

It is expected that, over the next decade, the participation of the solar PV industry to the global energy mix will continue to grow because it will be driven by a number of different factors. Among them, and perhaps one of the most important, refers to the political strategies drawn up by the different European (and global) governments that must be truly favourable to the concept of sustainable development. In fact, over the past few decades, the global economic

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growth model has generated major imbalances. If on the one hand the capacity to generate wealth has increased worldwide, on the other, poverty, environmental degradation and ecosystem pollution have also grown significantly. Unfortunately, during the last few years, many of the world's most developed countries have adopted as their preferred energy model the one that mostly uses energy from fossil sources, namely coal, oil and natural gas for the generation of electricity and heat.

In terms of primary energy, Portugal still has a huge external dependence, which is clearly higher than the average of the other European Union countries. However, from the perspective of the concept of sustainable development, an energy model based on fossil energy sources is no longer defensible since, in addition to using limited resources, its intense use causes severe environmental damage. In this sense, if Portugal's purpose is to implement policies that lead to the energy transition in order to achieve a significant reduction in greenhouse gas (GHG) emissions, then the bet on renewable energies (where solar PV represents one of its segments) corresponds to the greatest contribution to the 2021-2030 decade in terms of reducing emissions, where the energy transition plays a decisive role in the process that catalyses the transformation towards a society based on carbon neutrality (neutral balance in terms of emissions / GHG capture).

In 2016, Portugal assumed the objective of achieving carbon neutrality in 2050. The recommended strategies for the realization of this goal are forged in the Roadmap for Carbon Neutrality 2050. In this sense, Portugal has defined political and technological options that are quite favourable to the growth of different sources of renewable energy; therefore, it is expected that the solar PV segment will assume an even more relevant role in the Portuguese panorama due to the huge solar resource available in the country. It is important to remember that Portugal made a commitment to the European Commission to reach the target of 47% renewable energy in the gross final energy consumption by the year 2030.

The evolution of the photovoltaic industry has been truly remarkable, having achieved, in recent years, several important goals in terms of installations (including those not connected to the grid), cost reductions and significant technological progress [10]. Fig. 2 shows, in a time sequence, the main goals achieved by the solar PV industry.

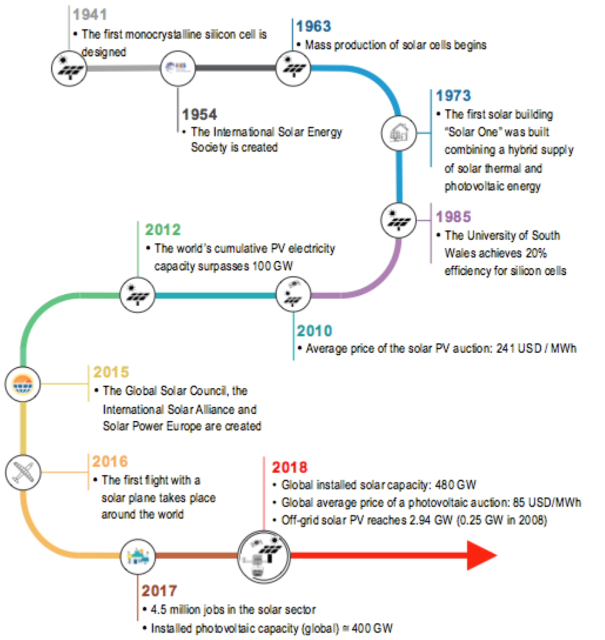

Figure 2. Key milestones achieved by the solar PV industry, adapted from [10]

The solar PV segment has proven to be one of the most innovative renewable technologies over the last few decades with a steady sustainable development. By the end of 2018, the global installed capacity of solar PV reached 480 GW (Fig. 3), representing the second-largest source of renewable electricity generation, just after the wind sector. Once again, in the last year, solar PV dominated total renewable and power capacity additions (reaching around 94 GW), adding twice as much capacity as wind and more than all fossil and nuclear fuels combined [10].

Considering the broad availability of resources, the market potential and cost competitiveness, it is predictable that, during the next decade, solar PV will act as the main “engine” for the sustainable global growth of renewable energies in different regions of the world. Taking the current cumulative installed capacity values as a starting point, solar PV installations are expected to grow almost six times over the next ten years, globally reaching a cumulative capacity of 2840 GW in 2030 and rising to 8516 GW in 2050 [8, 11], as shown in Fig. 3.

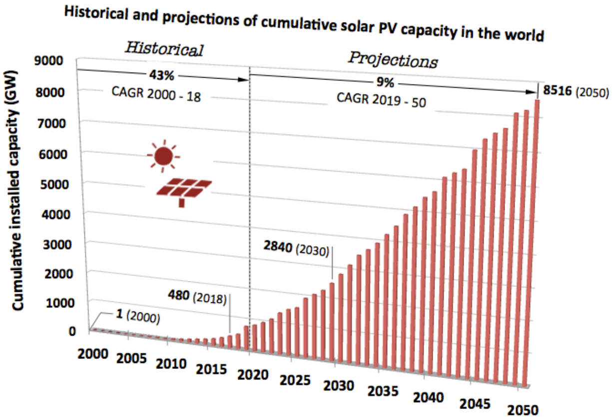

Figure 3. Historical values and future projections of cumulative installed solar PV capacity (includes utility-scale (60–80%) and distributed rooftop (40–20%) [8, 11]

When compared to the 2018 values, the cumulative solar PV capacity is expected to increase six-fold by 2030 and in 2050 it will be almost 18 times greater than the existing one in 2018, with a Compound Annual Growth Rate (CAGR) of about 9% by 2050 [8, 11]. The compound annual growth rate is defined as the rate of return that would be required for an investment to grow from its beginning balance to its ending balance, assuming the profits were reinvested at the end of each year of the investment's lifespan. CAGR is calculated according to the Eq. (1).

$$\mathrm{CAGR} = \left(\frac{EV}{BV}\right)^{\frac{1}{n}} - 1, \qquad (1)$$

where EV and BV are the ending and beginning investment values, respectively and n is the investment period in years.

For example, if in 2020 the beginning investment value for a 1 MW solar plant is 600 thousand Euros and if the solar plant operates by 15 years, then for a CAGR of 9%, the EV value can be determined from Eq. (1), that is $\mathrm{EV} = \mathrm{BV} \times (1 + \mathrm{CAGR})^n \Leftrightarrow \mathrm{EV} = 600 \times 10^3 (1 + 0.09)^{15} \cong 2.19 \times 10^6$ €. Assuming that the solar plant operates 25% of the time (i.e. 6 hours per day), each installed megawatt will be able to produce 2190 MWh per year and, consequently, 32850 MWh at the end of 15 years. In this sense, the predictable value for the energy sales price (SP), kept fixed over the 15 years, would be $SP = \frac{EV}{32850} = \frac{2.19\times10^6}{32850} = 66.67$ €/MWh, that is, about 0.067 €/kWh. This price is around three times the lowest bid in Portugal's first PV auction in July 2019, which was about 0.02 €/kWh (itself at the time, a record), showing that IRENA's estimates may be briefly reviewed due to the highly competitive dynamics of the PV market. Although large-scale projects (large power generation systems) are still predominant in 2050, distributed solar PV installations are expected to grow much faster, as they are expected to be strongly driven by public support policies and actions that respond to a greater environmental sensitivity of consumers and, therefore, enabling citizens, companies and other social actors to have a better adhesion to the use of this clean energy source.

4. Main factors affecting the photovoltaic market growth

Besides the issues related to the different policy options, there are other variables of a more technical, economic and social nature that affect the growth of the photovoltaic industry. Indeed, production costs that tend to be much lower, faster innovation, smarter consumers and a growing awareness of the problems related to the phenomenon of global warming are some of the aspects that are directly related to the trends of this market, which definitely will boost the development of photovoltaic systems over the coming years.

5. Impact of Covid-19 on the photovoltaic industry

Due to the several restrictive packages that all European/world governments have implemented since March of this year, which resulted from the pandemic state caused by Covid-19 that spread on a global scale, almost all economic activities were forced to stop and therefore felt a strongly negative impact (however, some sectors more than others).

In the field of solar PV industry, it is more likely to arise short-term delays in the completion of certain projects because they resulted not only from difficulties in materials supply, but also to the demand slowdown because of European lock. For example, in Portugal, the 24 lots that left the 2019 auction have a 36-month deadline for completion. However, this deadline is unlikely to be met, even for reasons related to the financing options provided for in the initial agreements. In fact, the Portuguese Association of Renewable Energies (APREN), defends that the winning companies

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of the lots awarded in the first 2019 solar energy auction should have more time to be able to complete their projects (suggesting about six months). Even so, the Portuguese government recognizes the importance of the goals enshrined in the National Energy and Climate Plan 2030 (PNEC 2030) and appears to be committed to its full compliance, the reason why it claims to be promoting the expansion of renewable energies, where the solar PV sector deserves to be highlighted because of the second solar auction (700 MW) scheduled for the third quarter of this year.

In fact, despite the negative impact of Covid-19, it is expected that in the medium and long term, the photovoltaic sector will have a rapid recovery, especially if the ambitions and transnational goals for energy and climate are preserved. In this case, it is essential that the commitment to the European Green Deal continue to be kept in order to achieve carbon neutrality in 2050. For the time being, it is important that at European level the different member states are able to ensure that, whatever the European stimulus packages, they should privilege clean energy technologies, thus making solar energy a real lever to promote the transition to a new socioeconomic model that is climate neutral, resilient, sustainable and inclusive. This is a concept known as Green Recovery, which represents a very important path for the economy recovery and employment, a view in which all European countries should be strongly committed and determined to implement on land. In this sense, and paradoxically, the pandemic caused by Covid-19 can even be the great opportunity to materialize this huge objective, either through the installation of on-grid or off-grid PV systems.

6. Future prospects in the market of photovoltaic systems

The sustainable development of renewable energies and, consequently, of the solar PV market, still needs support and subsidies from the various national governments where in technical language is called feed-in-tariff (FiT). In fact, FiT is a policy tool designed to accelerate investment in renewable energy technologies by offering long-term contracts to renewable energy producers [12]. In practical terms, FiT corresponds to the payment made to companies or individual citizens who generate their own electricity through methods that do not contribute to the depletion of natural resources and that is proportional to the amount of generated energy. This subsidy policy was largely responsible for the rapid expansion of solar PV in China, Germany and many other countries, including Portugal. However, more recently, different governments have started to drastically reduce the amounts related to these subsidies. For example, when compared to 2016, China has already reduced its tariff by about 45% and Germany has also opted for these cuts, however more targeted at domestic installations, typically for PV systems (40 to 750 kW) placed over the buildings rooftop. The change in government policies is mainly due to the sharp reduction in the costs of PV systems. Actually, the average price of crystalline silicon modules (including mono-/poly-Si) has declined very sharply since 1977 where the price was around 76.70 USD/W to about 0.30 USD/W in 2015 [13], as shown in Fig. 4.

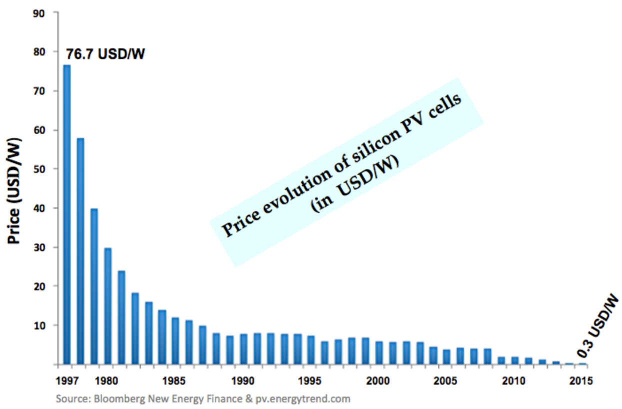

Figure 4. Evolution over time of the average price of crystalline silicon modules (including mono-/poly-Si) from 1977 to 2015 [13]

However, according to the latest data recorded for the European market in June 2020, the average price for crystalline silicon modules was already 0.25 $/W. This trend follows the so-called "Swanson law", a forecast similar to the well-known Moore's Law, which states that the prices of photovoltaic modules fall by about 20% whenever the capacity of the photovoltaic industry is doubled. It is important to highlight an important aspect that relates to the options that have been taken by many governments on a global scale, which translate into a trend increase in the price of electricity; in Europe, the price of domestic electricity has increased moderately over the past decade. Thus, the

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scenario characterized by the increase in the price of electricity associated with the reduction of government subsidies, determines that potential investors in the photovoltaic sector pay more and more attention to the so-called Levelized Cost of Energy (LCOE). In fact, thanks to the decrease in the prices of photovoltaic modules combined with the corresponding increase in their efficiency, it is expected that throughout 2020 the LCOE index will be lower than that of coal and, therefore, there are quite favourable conditions for the growing investment in the solar PV market.

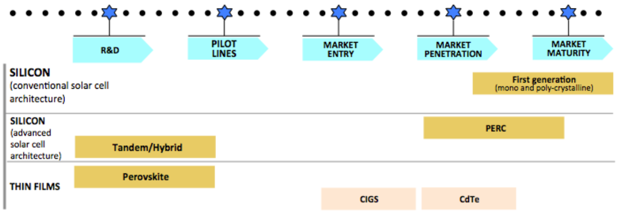

Figure 5. Maturity status of solar photovoltaic technologies in the global market. Notes: CIGS = copper-indium-gallium-diselenide; CdTe = cadmium telluride. PERC = passivated emitter and rear cell/contact, adapted from [10]

However, the growth of the solar PV market depends in large part on the cost reduction of all components (excluding the PV modules) that integrate a photovoltaic system, the so-called balance of system (BoS). In fact, BoS aggregates most of the total costs of the installed PV system and are also those that appear to have the greatest potential for cost reduction. One way to achieve this objective, should be to mobilize all the actors that carry out scientific research and development (R&D) in universities and companies that, as a consequence, can lead to changes in the technology of the solar PV industry. These changes include the use of cheaper and technologically more advanced materials in the manufacture of PV cells (and also the use of less material's amounts) and, therefore, reducing manufacturing costs and increasing the efficiency of PV cells. It is expected that a wide range of technologies will continue to integrate the portfolio of PV technologies. Fig. 5 shows an overview of the maturity state of solar PV technologies in the global market [10].

The first generation technologies, based on the architecture of conventional silicon cells, still hold around 90% of the world photovoltaic production [14]. The continuous cost reduction of crystalline silicon PV cells (thus enabling a very strong competitive position in the global market) has been responsible for the difficult penetration and consolidation of other technologies in the PV market. In this context, passivated emitter rear contact cells (PERC) are one of the most promising advanced silicon PV cell architectures because they are those that currently appear as the major candidates for replacing conventional silicon PV cells. In terms of composition, a PERC cell is not so different from a typical monocrystalline silicon cell; in fact, the main difference (an improvement) lies in the inclusion of a passivation layer (a dielectric material) on the back cell's surface that promotes an increase in the efficiency of the PV solar cell [15].

Actually, the passivation layer improves the overall efficiency of the PV cell in three main ways: 1) it reduces the recombination rate of the electron-hole pairs; 2) increases light absorption; and 3) it enables higher internal reflection; that is, it increases the reflection of light at the base of the PV cell, thus helping the solar rays to pass more often through silicon and, therefore, better promoting the capture of solar radiation [16]. For monocrystalline PV cells, the increase in efficiency that results from the PERC cell architecture varies between 0.8% to 1%, while for polycrystalline PV cells, the increase is slightly less, as it varies from 0.4% - 0.8% [15]. Fig. 6 schematically compares the architecture of conventional silicon PV cells with that of the PERC cell [17].

According to WisolPro, a consultant based in Taiwan [18], the global production of PERC cells is increasing very sharply and it is therefore likely that this type of PV cell technology will soon replace that of the conventional silicon cells. According to the information provided in one of its reports, WisolPro ensures that the global market demand for PERC cells will reach values of the order of 158 GW in 2022, against the 52 GW recorded in 2018. In its most recent forecasts, they predict that the market share of PERC technology will peak in 2022 and that it will tend to stabilize later. At that time, PERC technology should guarantee a global market share of around 70%, which is a very remarkable value [18]; in the opposite direction, the conventional silicon cell technology should decay.

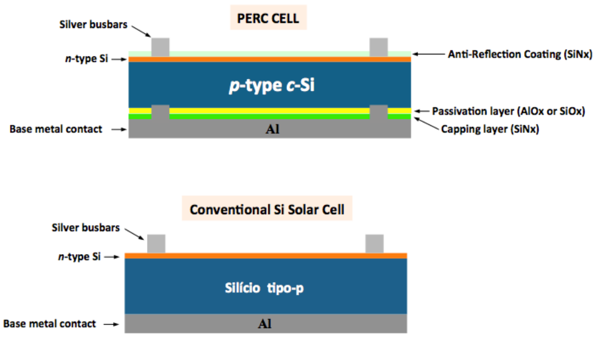

Figure 6. Difference between a p-type PERC and a p-type conventional Si solar cell

Thin film technologies (mostly CIGS, CdTe and Perovskite technologies) as well as Tandem/Hybrid cells are also expected to increase their market share by 2022, although with much lower growth than PERC cells [18]. It is known that CIGS solar cells have already achieved high levels of efficiency (22.9%) that are comparable to commercial crystalline silicon [14]. However, given the required multiple steps to manufacture these solar cells, as well as the complexity of their stoichiometry (associated with the fact that in their composition CIGS solar cells includes indium - a very scarce material), it is predicted that in the short term, the large-scale production of GIGS solar cells, will be severely restricted [19]. Meanwhile, CdTe solar cells have also achieved an efficiency of 21%, very close to CIGS cells. They are characterized by good levels of light absorption and therefore low energy losses [14]. The manufacture of CdTe solar cells involves low temperature, which makes their production very flexible and inexpensive and, therefore, this is the reason why CdTe solar cells are those that currently hold the largest market share of all thin film technologies [19].

Tandem solar cells are stacks of individual cells, one on top of the other, where each of them selectively absorbs a particular range of light wavelengths from the electromagnetic spectrum, leaving the remaining wavelengths to pass through in order to be absorbed (and then converted into electricity) by the cell below. The concept of tandem cell architecture has already been used to manufacture solar cells with the highest efficiency values recorded to date, as they can convert 46% of sunlight into electricity. Unfortunately, the manufacturing processes as well as the materials from which these solar cells are made are very expensive and for that reason, they have not yet reached the market [19].

On the other hand, one of the most promising materials for replacing silicon in solar cells is perovskites, a type of mineral that absorbs light very efficiently. Since perovskite crystals are very easy to obtain in the laboratory environment, in 2018 researchers from the United States and the Republic of Korea were able to manufacture perovskite solar cells with an efficiency of 24.2%, a number close to the silicon's laboratory record of 26.7% [20]. However, perovskites are still in the R&D stage and face two main challenges before reaching market maturity. The first is related to the easy dissolution of crystals, which imposes many limitations to their use in the presence of humidity; the crystals must be protected by specific encapsulation systems. The second challenge is related to the difficulty to achieve high efficiency values when going from a laboratory scale (cells with small areas) to the real scale conditions in which it is necessary to use much larger cell areas.

7. Conclusions

The current global energy production model is still heavily dependent on the use of fossil energy sources such as coal, oil and natural gas. The burning of these substances generates enormous amounts of various polluting gases that are emitted into the air and water, causing major damage to the environment and living organisms. In order to counter the current climate change process, the use of fossil energy sources should be severely restricted in the near future. Being the production of electricity from solar energy sustainable and with minimal environmental impact is a major opportunity, and demand for the growth of the photovoltaic industry and its associated technologies at unprecedented high scale. These factors act as tools to move towards the use of reliable, economical and long-lasting renewable energy sources in order to respond in a sustainable way to the great demand for energy that quickly grows. In this work, an overview of solar energy harvesting and the associated photovoltaic solar cell technologies is presented briefly. In particular, considerations are made about the development trends and sustainability of the photovoltaic industry on global markets focusing on the Portuguese situation. Issues related to

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the state of maturity of the different solar cell technologies and their market share in the global market, are also addressed. The recognition of the role of the photovoltaic energy industry to the sustainability of World's development demands a clear understanding of the economical impact of this industry and the establishment of a sound scientific and technological literacy on the subject of photovoltaic energy production in our modern societies.

8. Acknowledgements

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Creating STEM – Equipment: DIY Solar Lantern

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Abstract. As part of the #ScienceWonders course "Physics of modern microelectronics: how it works" for high school students, a practical session was organized based on the National Technical University "Kharkiv Polytechnic Institute" (NTU "KhPI"). This lesson became a unique opportunity for students and our colleagues from the Czech Republic to learn more about the practical use of solar energy. The participants had the chance to familiarize themselves with the work of professional scientific equipment and independently assemble lanterns powered by solar energy.

In the current conditions, Ukraine and Kharkiv need devices capable of lighting during power outages due to attacks on critical infrastructure. Lanterns on solar batteries are a reliable and environmentally friendly light source in case of a lack of electricity. They can provide minimal lighting in homes, offices, and other spaces that contribute to the safety and comfort of people during emergencies.

The practical implementation of a solar-powered LED lantern is based on using simple, accessible, and understandable parts with the possible use of secondary materials. Installation of the lantern requires a minimum amount of equipment and simple operations, which makes it ideal for schoolchildren. This approach allows for a deeper understanding of the principles of solar energy and stimulates interest in engineering sciences and environmentally friendly technologies.

Using solar energy and creating your lantern became an educational and beneficial experience with actual practical applications in today's challenges.

Preparing for such classes is an essential component of the educational process, which aims to develop practical skills and understand the importance of alternative energy sources. Learning through practical activities contributes to a deeper assimilation of the material and motivates students to study technical disciplines further.

Keywords. Alternative Energy Sources, DIY, Microelectronics Education, Practical Skills, Solar Energy, STEM Education.

1. Introduction

Modern global challenges, particularly the energy crisis, have actualized the need to find and use alternative energy sources. One of the critical solutions in this area is using solar energy, which is environmentally friendly, safe, and renewable. This is especially important for Ukraine, where serious problems with electricity supply arise due to constant attacks on critical infrastructure.

Educational STEM projects [1-7] aimed at high school students have a vast potential to educate a new generation of engineers and scientists capable of implementing modern technologies to solve these problems. One of these projects is the #ScienceWonders course "Physics of Modern Microelectronics," which allows students not only to familiarize themselves with the theoretical foundations of microelectronics but also to learn in practice the principles of using alternative energy by creating their solar lanterns.

This article will consider how such educational projects help students develop practical skills, stimulate interest in engineering, and help prepare young people to solve current environmental and energy challenges.

The project topic is relevant due to the constant challenges of energy security in Ukraine, especially during attacks on critical infrastructure. Modern problems related to power outages necessitate the development of alternative energy sources. Educational projects involving high school students in creating self-made solar lanterns contribute to the formation of important engineering and environmental skills.

As part of the "#ScienceWonders: Physics of modern microelectronics" course, a practical solar energy lesson was organized for high school students based at NTU "KhPI". Pupils worked with professional equipment and independently assembled solar-powered

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lanterns. The lantern set included simple and affordable components, and the assembly process was easy for schoolchildren. Special attention was paid to using secondary materials, making the project ecologically feasible.

2. Design conception

The practical implementation of the proposed LED lantern on a solar battery is based on simple, accessible, and understandable parts, possibly with the secondary use of parts. Installation of the lantern involves a minimum amount of equipment and simple operations. The general electrical schematic diagram of the lantern is shown in Fig. 1.

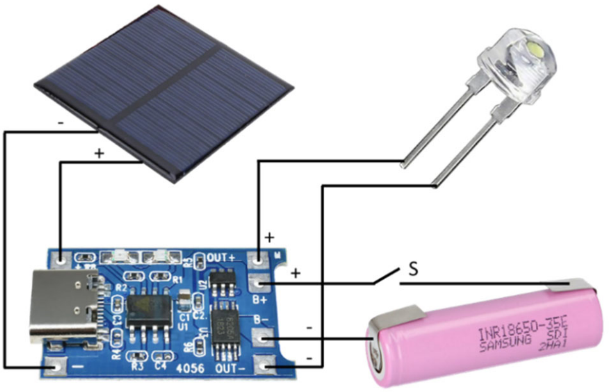

Figure 1. Schematic electrical diagram of a lantern

Main components:

- TP4056 controller (or similar);
- Li-ion battery;
- solar panel 6x6 cm;
- LED 0.5 W, with a wide irradiation angle of 120º

The body of the lantern is made by 3D printing on the FlashForge Finder 3 printer (Fig. 2): the diffuser is made of translucent white ABS plastic, and the cover, which is also the base of the body, is made of PLA plastic.

The specified components were mounted in the given case (Fig. 3). The Li-ion type battery was used from the recycling of used devices to reduce environmental pollution.

As you can see in the Fig. 3, the main components are not extremely miniature and have a clear marking of the polarity of the outputs, which simplifies the implementation of the assembly directly by children with minimal intervention of the teacher in the process.

Fixation of the components in the case is carried out with the help of hot-melt glue, which, unlike, for example, cyanoacrylate glues, does not create dangerous fumes and is therefore more acceptable when organizing work with children.

Figure 2. The plastic body of the lantern is made by 3D printing

Figure 3. Lantern construction

Interestingly, it should be noted that during the first lesson with the children, they were asked to use the substrate on which the diffuser

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was printed (the so-called raft) as a kind of cover, the presence of which allows you to separate the suction with electrical elements and create, in fact, a primary light reflector. This constructive solution is shown in Fig. 3 (top/rigth) - a white square on which a diode is fixed and is this raft. Such an improvised technical solution clearly testifies to the consciousness of modern children who, during creative and educational activities, also have in mind the ecological effect of their actions.

From Fig. 3 (bottom), it can be seen that thanks to the use of an LED with a wide scattering angle and a primary reflector, we have at the output a uniform, although not very powerful, illumination of the working area around the lantern. Tests conducted both by us and by children who took the lantern with them after the classes show that the use of a solar battery really allows you to charge the battery for the duration of daylight hours, and its capacity is sufficient for several hours of use in the dark.

3. Practice: How a Solar Lantern was created

During the hands-on session, "Solar Power in Action: Solar Lantern Using Solar Energy," held on April 20, 2024, participants had the opportunity to build their own solar-powered lantern. The assembly process has been designed to use affordable and environmentally friendly materials, including recycled components. The practice involved a minimum of complex operations, which allowed even high school students to cope easily with the task.

A special atmosphere was added to the class by the participation of a guest from the Czech Republic - a physics teacher, Milan, a former student of Dana Mandlíková, and Zdeněk Drozd. Together with Ukrainian students, Milan went through all the stages of creating a lantern. The students independently soldered boards and wires, made the necessary holes in the case with a Dremel, took measurements, and mounted the components in the case.

The body of the lantern was printed on a 3D printer, which made it possible to create a strong and light structure from PLA and ABS plastic. The use of hot glue to fix the components ensured a safe assembly process. An improvised technical solution, which was proposed by the students themselves, was to use a substrate from a 3D printer to create an additional layer that separated the electrical components from the light part.

After the assembly was completed, the lanterns were tested. The results showed that the solar cell is able to charge the battery during the day, and the battery capacity is enough for several hours of operation in the dark.

Figure 4. How it is made: **Pictures of the process**

4. Conclusions

The project not only increased interest in engineering but also demonstrated the practical application of alternative energy solutions. Students learned to work with technologies and equipment, which gives them an impetus to further study technical disciplines. During the class, high school students gained not only theoretical knowledge but also practical skills, which are important for the future in the context of global energy challenges.

Assembling a solar lantern demonstrated the importance of alternative energy sources in today's world, especially in the absence of electricity. Educational STEM projects of this format have great potential for development both in educational institutions and in real-life conditions, providing students with knowledge and skills that can be useful in critical situations.

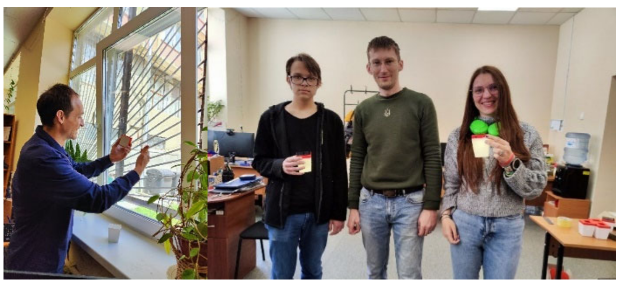

Figure 5. Final results

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Proposal of an Inquiry-Based Activity to Study of One-Dimensional Motion

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Abstract. Research shows that the teaching of Physics in Brazil appears inadequate in preparing students to meet the demands of a reality that would enable them to comprehend and engage with scientific and technological advancements in a manner that allows for informed and critical participation in the society in which they live. It is essential to consider proposals that increase student participation in a more active and critical way. In this context, according to researchers in the field of Physics education, inquiry based activities, which are based on problem-solving (whether experimental or not), are primarily characterized by promoting student engagement in the resolution of activities and providing opportunities for the learning of conceptual and procedural content that involves the construction of scientific knowledge. This is achieved by engaging students in stages such as hypothesis formulation, identification of prior knowledge, communication, and discussion of results with peers. In this work, we propose the development an experimental activity based on the principles of inquiry-based learning, starting from a traditional experimental activity, for the study of one-dimensional motion

Keywords. Inquiry-Based Activity, Teaching Physics, One-Dimensional Motion.

1. Introduction

The challenges facing today's reality point to the need to develop a science education that enables young people to understand and deal with scientific and technological advances in a conscious and responsible way, enabling them to participate and interfere in an informed and critical way in the society in which they live. However, physics teaching in Brazil still seems disconnected from students' reality and does not prepare them to meet the demands of a world in constant transformation, because according to the National Common Curriculum Base (BNCC) [1] “[...] few people apply scientific knowledge and procedures to solve their everyday problems (such as estimating the energy consumption of electrical appliances based on their technical specifications, reading and interpreting food labels, etc.)” (p.547, our tanslation).

Many researchers argue that experimental work, through the learning of scientific content, is a way of creating opportunities for students to develop the necessary skills to act more effectively in society, whatever their field of action [2]. In this sense, Rosa and Rosa [3] warn that the use of experiments in physics classes needs to be done consciously so that it can contribute to the process of training individuals, or it will become yet another inefficient action in the educational process.

Araújo and Abib [4] found that research in the field of physics teaching points to different trends in the use of experiments, while the support materials available to teachers (manuals, textbooks) follow a traditional teaching approach, restricted to demonstrations and theory verification laboratories, which is far removed from current proposals for meaningful physics teaching. This type of approach offers students few opportunities during the process of collecting and analyzing data, as well as for developing hypotheses, since they have to follow a protocol proposed by the teacher, write a report and try to get closer to the results expected by the theory [5].

Another criticism of this type of experimental activity is that most of them are not relevant to the student, because both the problem and the whole process of solving it are already predetermined and setting up the equipment, collecting the data and the necessary calculations take up almost all of the available class time [6]. Thus, according to the author, the student has no time to analyze and interpret the results obtained and even understand the meaning of the activity they have carried out.

It is therefore necessary to think about proposals that increase student participation in activities in a more active and critical way. In this sense, investigative experimental activities can bring students closer to scientific work, not so that they become scientists, but to provide an investigative environment in the classroom so that the teacher can lead students through a simplified process of scientific work [7].

An inquiry-based activity consists of the experimental or intellectual resolution of problems in which it is necessary to carry out actions (defined and developed by the students themselves) that make it possible to analyze variables, collect data, identify influences, formulate explanations and establish limits and conditions for their validity [8]. In this approach, the teacher's role is not to expose concepts and keep the student's reasoning and attention to themselves, because the moment they propose a problem "[...] the task of reasoning passes to the student and their action is no longer to expose, but to guide and direct the students' reflections in the construction of new knowledge" (p.02, our translation) [7].

In this paper, we propose the development of an experimental activity based on the assumptions of inquiry teaching, starting from a traditional experimental activity for the study of one-dimensional movement using an inclined plane, to be used in Physics subjects at the Intituto Federal de Goiás - Câmpus Jataí. We know, as does [9], that developing students' understanding of how to plan an investigation, interpret, analyze and evaluate the results obtained, despite being ambitious and long-term goals, are essential elements in the process of scientific literacy and the development of thinking.

2. Inquiry-based teaching

Approaches to inquiry-based teaching vary according to different authors. Despite this, Zômpero and Laburú [10] have identified points of convergence in terms of their characteristics. These are: all the activities are problem-based,there is student engagement in solving the activity,there are stages of raising hypotheses and identifying prior knowledge, searching for information, communicating and discussing the results with colleagues,they provide opportunities for learning conceptual and procedural content that involves the construction of scientific knowledge,they allow students to play an active intellectual role during lessons.

The use of experiments to help students understand physical concepts is a way of increasing their participation in the learning process, as they move away from a passive stance and start to perceive and act on their object of study, relating it to events and trying to discover the causes of this relationship [11].

Azevedo [12] states that the student's work during an inquiry-based activity cannot just be manipulation or observation, but needs to have the characteristics of scientific work, enabling them to reflect, discuss, explain and report. In addition, the author emphasizes that the objectives of the activity need to be clear to the student, as it is important for them to be able to identify why they are investigating that phenomenon. In this proposal, students solve problems through experiments without following strongly structured scripts or instructions from the teacher, and may or may not find the solution to a problem, because the process is more important than the results [6].

Sasseron [13] warns that teaching aimed at students' argumentation and the construction of their knowledge about natural phenomena from a scientific perspective needs to consider the following guidelines: 1) scientific language is argumentative (it is necessary to justify a point of view in order to transform facts and data into evidence),2) scientific argumentation obeys a structure that can be seen as basically hypothetical-deductive thinking (if / then / therefore) and, therefore, teachers should help their students construct justifications and explanations for the phenomena studied,3) justifications and/or explanations are related to the fields of content being studied, so the more the context is in the student's domain, the more easily they will be able to make causal relationships. The author points out that: "for the teaching of Physics, it is important to consider mathematical language as an essential mode of communication in the construction of ideas and for the dissemination of knowledge" (p.48, our translation).

Another essential aspect that needs to be considered when proposing an inquiry-based activity based is social interaction, which takes into account not only the communication between the teacher and the students, but also the interaction between the students and the problems, themes, information and cultural values of the content being worked on [14].

Finally, it is important to highlight the role of the teacher in an inquiry-based proposal, as it is the teacher who will problematize the content and encourage students to solve problems. To do this, they can transform activities already used in their classes so that they have an investigative approach, because it is the questions presented by the teacher that will instigate student participation [15]. The authors add that these questions:

> [...] they need to encourage investigation, because not just any question will trigger the investigation process on this journey. The questions must generate problems that help students in the process of solving the proposed problem. In other words, they should help to work with information, ideas and knowledge,provide opportunities for hypotheses to be constructed,make explicit the variables that are relevant to the problem being investigated and allow explanations for the problem to be constructed. (p.27, our translation).

3. The process of preparing the activity

The experimental activity presented in this paper was designed to be used in kinematics classes at the Federal Institute of Education, Science and Technology of Goiás (IFG) Jataí Campus.

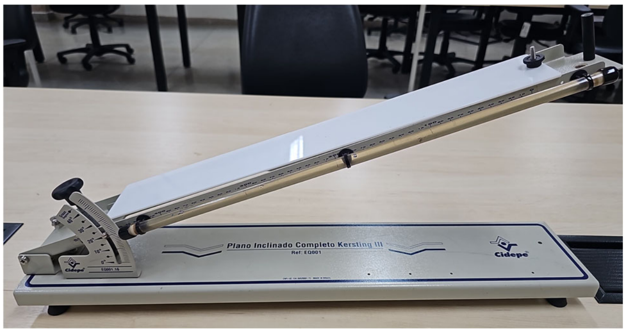

Figure 1. Inclined plane used

One-dimensional kinematics, which is the part of mechanics that describes the movement of a particle in one direction, is content that requires students to use mathematical equations, tables and graphs that represent the behavior of the physical quantities that describe movement as a function of time, such as position, velocity and acceleration. This is content that has historically been studied at the beginning of Physics courses in basic and higher education, generally through theoretical lessons, which focus on solving decontextualized pencil-and-paper exercises and problems that are far removed from the students' reality [16]. It is common for students to have difficulty understanding the meaning of the graphs and mathematical functions that represent the movement of the objects of study, as they are not yet familiar with using mathematical language to express the behavior of physical quantities.

Our proposal was developed from a traditional experiment using equipment consisting of a main support base with an articulated inclined plane whose inclination varies from 0 to 45^{o} which can be seen in Fig. 1.

This plane has a sealed tube containing oil, inside which there is a small steel ball and an air bubble. The steel ball can be moved anywhere in the tube with the help of a magnet, as shown in Fig. 2.

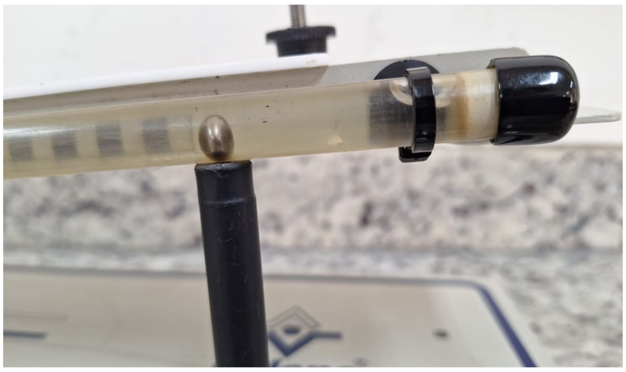

Figure 2. Detail of the inclined plane showing the steel ball, the air bubble and the magnet

According to one of the experiments contained in the experimental guide provided by the company that manufactures this equipment, the students, after setting the inclination of the plane to 15°, must, with the help of a magnet, take the steel ball to different positions on the plane and measure the time it takes to reach the base. Next, they should calculate the average speed of the ball on the different routes, construct graphs of the position as a function of time and the average speed calculated as a function of time. Then, as is common in closed scripts, they use the equation for position as a function of time for uniform movement ($x=x_0+v.t$) using the data obtained from the measurements (average speed and initial position) and check that the data obtained from the measurements confirms that the movement is uniform, comparing the position obtained from the measurements with that predicted by the equation.

In order to transform the above activity, as well as others proposed in the manual, into an inquiry-based experimental activity, we followed the guidelines proposed by Sasseron and Machado [15] who present the following guiding questions:

> What knowledge does the activity provide? What do we want the students to learn? What are the relevant data and information? What problem can be posed? What are the possible hypotheses put forward by the students? How can the hypotheses be tested? What everyday situations can be used to contextualize the problem? What type of investigative activity is best suited to the assembly? (p.72, our translation).

The aim of the activity is for students to understand the different types of rectilinear movement, using mathematical language to justify their results. It should enable them to understand the difference between uniform motion and accelerated motion. To do this, they need to understand that the type of movement described by an object depends on how its position varies over time. As the steel ball is going down an inclined plane, students may initially think that it is uniformly accelerated. As they need to verify their hypothesis, they will have to think about how to measure the position of the object (in this case the steel ball on the inclined plane) as a function of time and check how this position varies over time. To do this, they can organize their data in the form of tables or graphs, which will make it easier to analyze this behavior, or calculate the average speed over short stretches and compare these speeds.

4. Results and Discussion

The inquiry-based experimental activity designed aims to study one-dimensional movement based on the movement of the steel ball and the air bubble inside the oil tube of the inclined plane shown in Fig. 1. Initially, the teacher should divide the class into groups of no more than four students and present the equipment provided to each one, asking them to carefully observe the elements that make it up, indicating the graduated ruler next to the tube with oil, the ball and the air bubble, which is usually not noticed by the students. In addition to the inclined plane, the students are given graph paper, blank paper for taking notes, a ruler and a stopwatch. It's important to mention that the inclined planes should already be level on the table and inclined at 15º and the teacher needs to guide the students so that they don't change this angle.

Next, the teacher poses the problem: *What kind of movement does the steel ball describe as it goes down the tube?* In order to organize the actions of the students, who are not used to open-ended activities, the teacher needs to guide the groups so that they think of a way to solve the problem, discuss with each other what actions need to be taken and then write down the group's plan of action, indicating the procedures and materials that will be used for this purpose. This stage is important for students to systematize their ideas, because the tendency is for them to start making random measurements, without really thinking about whether these measurements are relevant to answering the proposed question.

After this stage, the group begins the process of implementing the action plan, collecting the data they deem necessary. As they already know the definition of uniform rectilinear motion (one whose speed is constant over time) and uniformly varied motion (whose speed varies linearly with time), they are expected to measure the time taken for the ball to reach different positions and then calculate the average speeds over these intervals or graph the position as a function of time. If they choose to calculate the average speed of the ball in small sections, or make a graph, they will notice that the average speed measurements or the behavior of the graph near the start of the movement will be slightly different from the others. As the ball is moving down an inclined plane, it is likely that they will start the activity thinking that it is an accelerated movement. However, as the data is collected, they will realize the characteristics of uniform motion. At the end of the activity, it is possible that some groups will conclude that it is a uniform movement while others may conclude that the movement is initially accelerated, since the ball starts from rest, which will indicate a more in-depth knowledge of the situation. For this to happen, the teacher needs to ask questions during the process, encouraging the students to re-evaluate their actions and critically analyze their results. It is important to mention that in a traditional experiment, where the student has to rigidly follow the steps in the script, carrying out the measurements requested, they will not have the opportunity to realize that the movement of the ball cannot be uniform throughout.

After completing this step, the teacher should ask the students to answer the question: *What kind of movement does the bubble describe as it rises up the tube?* To do this, they are asked to tilt the plane so that the air bubble, which is at the top of the tube, descends to the bottom so that its movement is the opposite of that of the steel ball. The most likely hypothesis for the students is that the air bubble should now move up the plane, decelerating as it goes against the gravitational force. To prove this or that hypothesis, the groups will have to take measurements and come up with an answer. Some groups, as in the first stage, will conclude that it is a uniform movement, while others will realize that the movement becomes uniform after a few moments, since the air bubble also starts from rest.

Finally, the teacher poses the last question: *Based on the results obtained, if we put the ball and the bubble in motion, how can we predict the position at which they will meet?* To answer the question, the students can compare the graphs constructed for the ball and the bubble, or use the equation of position as a function of time that describes the movement of each to find the meeting point. The teacher can ask them to observe the situation experimentally and compare it with the theoretical result obtained. It is up to the teacher to ask questions that help the students understand the differences between them, since the movement is not uniform throughout the whole stretch. It is essential that the teacher asks for a report at the end of the lesson containing the entire procedure carried out by the group, from the hypothesis, the action plan, to the results and conclusions obtained. This stage, known as the systematization of knowledge, is necessary for the students to think and reflect on everything they have done, thus assimilating the conclusions reached by the group and the knowledge acquired.

5. Final Considerations

After studying the theoretical framework underpinning inquiry-based teaching, we can infer that this type of activity offers important opportunities for students' cognitive development, working as an efficient tool for building and learning scientific models and concepts. In addition, it is an efficient proposal for generating conflicts between spontaneous and scientific conceptions and enabling students to participate more actively in their respective learning processes, so that they can really understand the content worked on in class.

The production of the activity presented here started with the transformation of a traditional experimental script into an investigative activity, which required a great deal of commitment and dedication, as it is necessary to develop questions and think about how the student thinks in order to develop questions that help them arrive at the answer to the problem. We hope that the activity we developed will be applied and analyzed by other teachers, so that we can identify its real potential and contributions to the students who take part. For example, “1. Introduction”, should be Arial 12-point boldface, initially capitalized, flush left, with a posterior spacing of 10-points. Use a period (“.”) after the heading number, not a colon. For *long* headings use *a hanging indent* aligning the text to the right of the heading number as shown above.

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The War vs. COVID-19 Lockdown: Compare of Impact on Foreign Students' Performance in Studding of Medical Informatics in TNMU

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Abstract. The current challenges to the system of medical education in Ukraine are noted. The process of development and deploying of distance learning components in educational process at the I. Horbachevsky National Medical University in Ternopil (TNMU) is shown. The key elements of implementation of full-scale distance education workflow at TNMU during the COVID-19 lockdown as well as since 2022 full-scale military invasion in Ukraine are presented. The distance education features of teaching of Medical Informatics and Biostatistics course at TNMU are noted. The experience gained during both latest implementation of full-scale distance education at TNMU is presented. The comparative analysis of students' performance in studding of Medical Informatics and Biostatistics course during both latest fully distance educational periods are presented. Contributions of real-time online communication together with safe environment in better students' learning results under distance education mode are shown.

Keywords. Medical Education, War Threats, COVID Lockdown, Distance Education, Comparative Analysis, Medical Informatics, Students' Performance.

1. Introduction

The system of medical education in Ukrainian is combine high quality and relative affordability comparatively to high-developed countries, and therefore attracts thousands of native and foreign medical students each year [1]. The I. Horbachevsky National Medical University in Ternopil has a fair reputation as educational institution with high quality and prominent reliability of educational services [2]. For years, there was a strong tendency for the number of international students in TNMU to increase, due to factors such as the development of academic mobility and exchange programs, the optimization of enrollment procedures and wide spread of information on overall education quality.

Unfortunately, steady development on medical education process in Ukraine as well as in TNMU has been disrupted twice in recent years. Like in the most other countries, for substantial portions of 2020 and 2021 educational process in Ukraine had been delivered in fully Distance Education (DE) mode because of lockdown measures, caused by SARS-CoV-2 pandemic [3-4].

The beginning of the military aggression by the Russian Federation on February 24th, 2022, cause even bigger disruption for educational process, because the direct conduct of hostilities, and the launching of missile strikes on the Ukrainian territory induced the introduction of martial law and the temporary suspension of tuition at all levels of education. Nevertheless, tuition has been resumed since March 14, 2022 in online format to Ukrainian and foreign students. Although all medical universities had the experience of the full DE learning mode due to the SARS-CoV-2 pandemic, teaching under war conditions revealed specific features: clinical encounters and formal assessments have been largely suspended or cancelled entirely and most of the international students have returned to their home countries [5-7].

The aim of paper is to present results of comparative analysis of performance of international students in learning of Medical Informatics using DE technologies during COVID-19 pandemic lockdown and after full-scale Russian invasion begins respectively.

2. Organization of distance education process at TNMU

Distance Education technologies were used in TNMU since 2006 when LMS Moodle was introduced to evaluate the results of students' self-preparation for practical classes. Scope of the DE usage were constantly extended during next years with employing of more advanced communication technologies services and frameworks, especially Microsoft Office 365 and Google Workspace for Education [3-4, 8-10]. Up to now, Google Suite platform provides corporate e-mail service for TNMU and being used as a centralized user authentication tool for all TNMU information services.

During the COVID-19 lockdown of 2020 in Ukraine and late in 2021 under constant COVID-19 pandemic restrictions, all available in the TNMU distance learning services and capabilities have been used on a full scale [3-4] to implement combined synchronous and asynchronous components of distance learning environment and give students abilities to:

- use training materials posted on the LMS Moodle platform web-site (https://moodle.tdmu.edu.ua) for training;
- submit their assignments in electronic form through Moodle activities like “workshop”, “assignment”, etc.;
- watch educational videos and video-lectures on teachers’ YouTube channels (as per example https://bit.ly/2Mzj7j3).
- communicate with teachers through Google services (texting via Gmail / Chat, and having video-conversations via MS Teams).

Synchronous DE activities additionally have included online MS Teams meetings for each scheduled classes to facilitate students productivity. MS Teams meetings were also used for implementing an “oral” part of exams in addition of test assessment using Moodle quizzes.

3. Teaching the Medical Informatics course at TNMU

The “Medical Informatics” (MI) course at TNMU was introduced in 1997. For two decades, MI course at TNMU was offered to the 2nd year students of the medical faculty. The amount of educational hours as well as an exact content was constantly adjusted accordingly to the official requirements as well as experience of faculty teachers. Since 2021 it has been taught to the 1st year students under the title “Medical Informatics and ” and includes 14 hours of lectures, 32 hours of practical classes and about 60 hours assigned to self-guided work as before. It is important to mention that the MI course has been designed as a “blended” course since LMS Moodle inception at TNMU (https://moodle.tdmu.edu.ua/course/view.php?id=403). Some experience of teaching of the MI course in both “blended” and fully distance modes as well as important course details has been presented already [3-4, 11].

It is important to admit that TNMU uses a common Ukrainian academic grading system with 12 levels of students’ achievements, where “4” is a minimal positive grade. According to TNMU’s rules, each student must be graded for each practical class. In case of absence of an exam – an average for all grades has been calculated and used as a final grade for course.

4. An analysis of foreign students’ performance in MIB course studding

The analysis of results of teaching the Medical Informatics and Biostatistics course to foreign students is used to asses a possible difference practical outcomes of migrating from the blended education model to full scale DE workflow under the following circumstances:

- enforcing of the national lockdown caused by COVID-19 pandemic since March 20, of 2020 which mostly affects students of 2019/20 academic year;
- introduction of martial law caused by the military aggression of the Russian Federation since February 24th, 2022 which affects all students since 2021/22 academic year.

The beginning of the military aggression by the Russia on February 24th, 2022, the direct conduct of hostilities, induced the introduction of martial law and the temporary suspension of tuition at all levels of education. After a two-week break, starting from March 14th, the training has continued in a DE format. Although previous experience of DE during SARS-CoV-2 pandemic, teaching in war conditions revealed its own features. Despite the provisions of the Geneva Convention, healthcare as well as educational facilities remain a separate military target, which causes casualties among staff [12]. Such as the safety of students is the top priority, most foreign students in Ukraine had returned to their home countries and continued studding in online mode.

4.1. Collected data

During the 2019/20 academic year 184 foreign students in 14 groups were taught of MI course. The average scores achieved by students during the blended part (topics 1 to 10)

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of the MIB course is shown on Fig. 1. Fig. 2 presents the average scores for the full scale DE part of MIB course during March / May of 2020 (6 topics). Finally (Fig. 3) - the total MIB course average scores is shown.

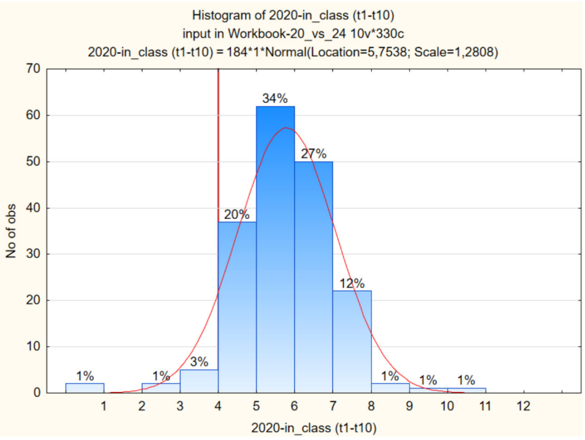

Figure 1. Students' average score for the blended part of the MIB 2019/20 course (topics 1-10)

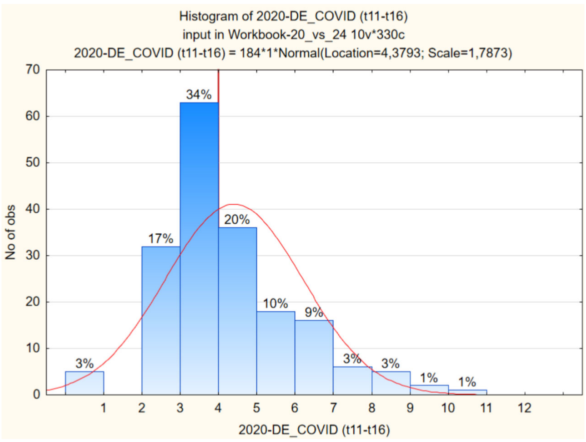

Figure 2. Students' average score for the DE part of the MIB 2019/20 course (topics 11-16)

During the 2021/22 academic year 330 foreign students in 26 groups were taught to MI course by the authors. By the date of starting of military invasion most of students have completed 8 topics of the MIB course. Therefore, the following charts (Fig. 4 - Fig. 6) presents average scores achieved by students during the blended and full DE parts of the MIB course as well as the course total average scores respectively.

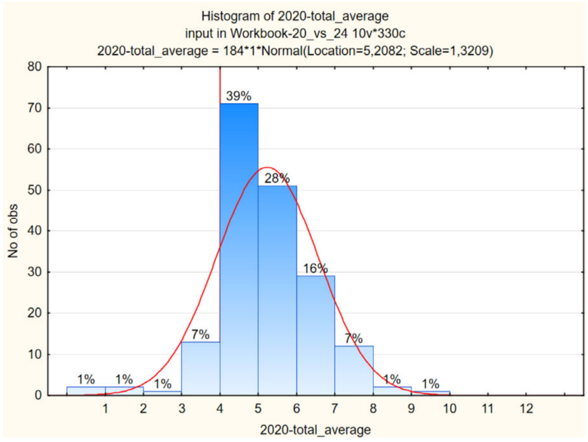

Figure 3. Students' total average score for the total MIB 2019/20 course (adjusted)

4.2. Comparative analysis

Initial assessment of the above charts shows a significant difference in students' performance after transition to the full DE mode, especially for 2019/20 academic year case. To visualize this assumption more clearly, tree combined distribution plots were built (Fig. 7-Fig. 9).

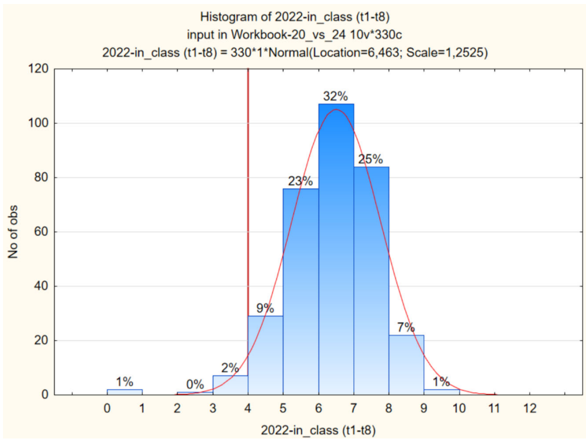

Figure 4. Students' average score for the blended part of the MIB 2021/22 course (topics 1-8)

All distribution plots confirms difference in students' average scores with most notable positive skew in the students' performance in 2021/22 academic year during DE part leaning (Fig. 8). Statistical hypothesis testing was employed to prove that observed differences are significant. Non-parametric statistic methods were used because samples' composed by grade scores represents an ordinal variable type. Authors decided to use both Mann-Whitney U Test (Table 1) and Wald-Wolfowitz

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Runs Test (Table 2) at the same time expecting more reliable result.

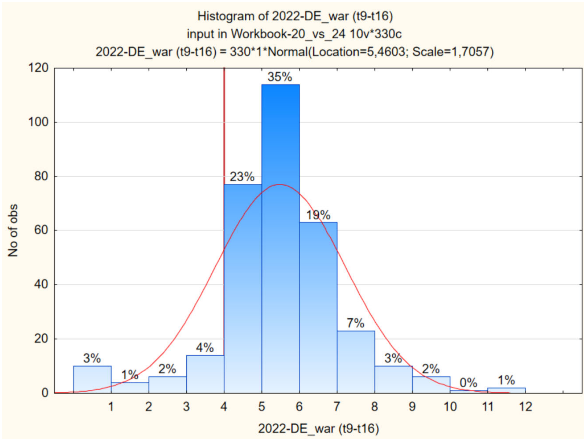

Figure 5. Students' average score for the DE part of the MIB 2021/22 course (topics 9-16)

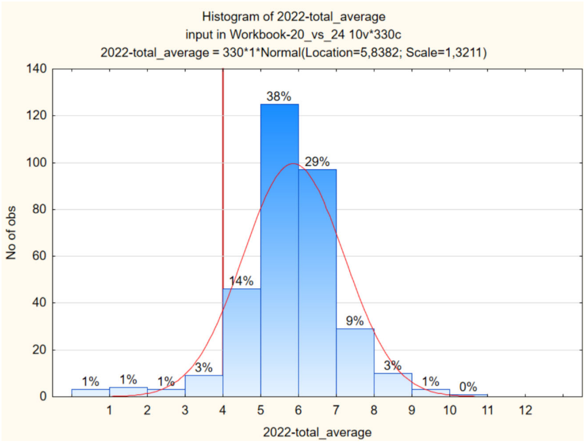

Figure 6. Students' total average score for the entire MIB 2021/22 course

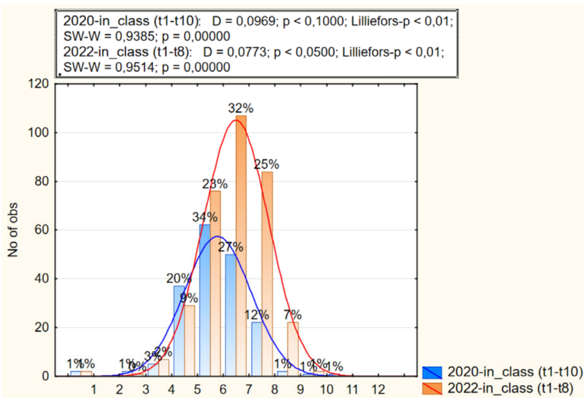

Figure 7. Comparing of distributions of students' scores for the blended part of the MIB course during 2019/20 and 2021/22 academic years

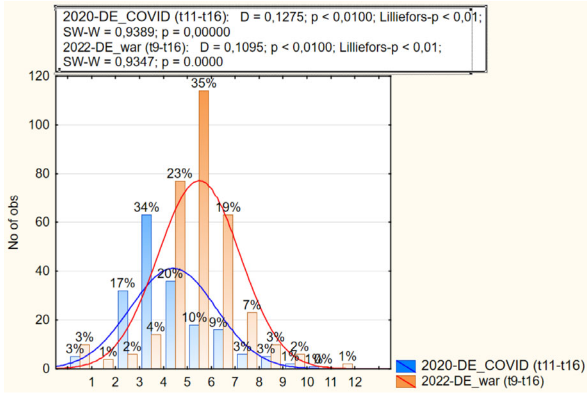

Figure 8. Comparing of distributions of students' scores for the DE part of the MIB course during 2019/20 and 2021/22 academic years

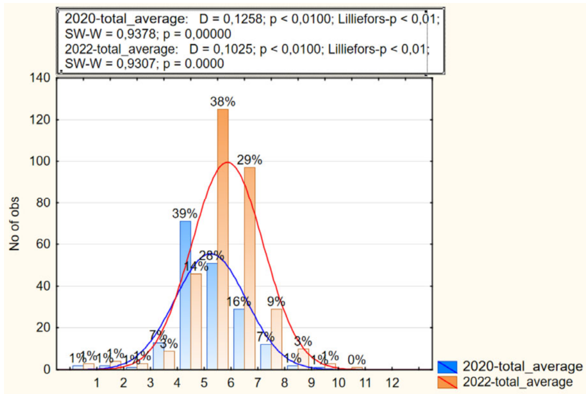

Figure 9. Comparing of distributions of students' total average scores on the MIB course during 2019/20 and 2021/22 academic years

Table 1. The results of the Mann-Whitney U test for statistical hypothesis

Variable	DE
Rank Sum (Group 1)	33853,50
Rank Sum (Group 2)	98501,50
U	16833,50
Z	-8,37897
p-value	0,000000
Z (adjusted)	-8,38152
p-value	0,000000
Valid N (Group 1)	184
Valid N (Group 2)	330

The values of Z-scores from both tests were used to make a conclusion. Obtained values are less than critical (Zc = 1,65) for both methods, so H0 (states of no difference between samples' means) has to be rejected in favor of H1 which indicates presence of significant differences in samples' means. All tests proven to be significant with p well below 0,05.

Table 2. The results of the Wald-Wolfowitz Runs test for statistical hypothesis

Variable	DE
Valid N (Group 1)	184
Valid N (Group 2)	330
Mean (Group 1)	4,3793
Mean (Group 2)	5,46030
Z	-7,71090
p-value	0,000000
Z adjstd	7,662866
p-value	0,000000
No. of (Runs)	157
No. of (ties)	117

4.3. Discussion

The following main outcomes are found after the source data and the corresponded charts (Fig. 2-Fig. 9) and results of statistical hypothesis testing have been studied:

- migration from the blended mode to the full-scale DE workflow in 2019/20 academic year was a very difficult process: grades fell down for all students significantly (Fig. 1, Fig. 2). About half of students (85 of 184 or 48%) failed to earn even a minimal positive average grade (“4”) for topics were taught during DE part of course;
- consequently, general performance of students in the MIB course was quite low in 2019/20 (42% of them barely managed to earn credits with grades just above a minimal positive);
- by contrast, migration the full-scale DE workflow in 2021/22 academic year looks better. Day-to-day students’ performance (Fig. 4, Fig. 5) becomes closer to values were recorded in the past during blended mode (Fig. 2);
- general performance of students in the MIB course was better in 2021/22 as well. Only 14% Number of those who earned credits with grades just above a minimal positive dropped to only 14% (compare to 39% in 2019/20);
- finally, number of successful students (with average grade above “8”) grown significantly form 2% in 2019/20 to 4% in 2021/22.

It is important to admit, that detailed analysis of students’ performance in the MIB course under COVID-19 lockdown measures was conducted by authors and published [3-4].

Obtained outcomes with better performance of international students in 2021/22 academic year compare to those in under COVID-19 lockdown in 2019/20 are considered as correct and had been expected by authors. There are few factors, which contribute to it:

- although war conditions are extremely devastating for Ukrainians, international students in 2021/22 academic year were given comfortable DE environment upon returning to their home countries or being evacuated to safe locations in EU countries. Factor of safety played a key role in success of DE part on learning process;
- introduction of regular online videoconferences as mandatory component of process of DE in TNMU since 2020/21 academic year boost educational outcomes significantly for such mostly theoretical disciplines like Medical Informatics and Biostatistics;
- finally, continuous usage of DE components in educational process since 2020 stimulates students to develop and improve necessary self-education, computer and communication skills to be able to deal with online educational environment.

5. Conclusion

The importance of readiness for comprehensive distance learning processes in high medical education is admitted. This is illustrated by the current challenges to the system of medical education in Ukraine are noted. The process of development and deploying of distance learning components in educational process at the I. Horbachevsky National Medical University in Ternopil (TNMU) is shown. The key elements of implementation of full-scale distance education workflow at TNMU during the COVID-19 lockdown as well as since 2022 full-scale military invasion in Ukraine are presented. The distance education features of teaching of Medical Informatics and Biostatistics course at TNMU are noted. The experience gained during both latest implementation of full-scale distance education at TNMU is presented. The analysis of students’ performance in studding of Medical Informatics and Biostatistics course during latest fully

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distance educational period caused by war threats in compare to previous one induced by COVID-19 pandemic are presented. Contributions of real-time online communication together with safe environment in better students' learning results under distance education mode are shown.

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Touching the Sky. Tactile and Interactive Astronomy

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Abstract. In this article, we present the production of tactile models of the solar system by the Tocando o Céu project, a project that aims to make astronomy education accessible to blind and visually impaired people, democratizing access to knowledge and science. The immersive experience of working with tactile materials sharpens scientific knowledge, allows blind and visually impaired people to have notions of proportion, scale and even the luminosity of astronomical objects, and has the potential to be used as support material in schools and scientific events.

Keywords. Accessible Astronomy, Astronomy Teaching, Scientific Divulgation, Tactile Astronomy.

1. Introduction

Astronomy is a natural science that studies celestial bodies, such as planets, asteroids, comets, stars and galaxies, and the phenomena that occur in space. It also studies the origin and formation of celestial bodies, and what exists between them, that is, the universe. Astronomy is one of the oldest areas of knowledge of humanity, having originated thousands of years ago based on the observation of the behaviour of celestial bodies and stars in the sky.

With its many subareas - Astrobiology, Astrophysics, Planetary Astronomy, Astronomy is fundamental to our understanding of everything that surrounds us, and to the development of science, technology, telecommunications, environmental and military monitoring.

As a fundamental and highly relevant science, it is necessary and fair that we make its knowledge accessible to everyone. For this to be possible, tools must be made available to facilitate physical and intellectual accessibility. This is the case of the tactile models that we produced in our project.

Our models allow, through textures, reliefs, and other tactile resources, in a completely immersive experience and with information available in Braille, that blind and visually impaired people can finally experience and understand a little more about our universe, including concepts such as distance, size, scale, and even the luminosity of astronomical objects, which would be extremely difficult to understand using only oral explanations.

2. Methods

To produce the tactile models we used 3D printers, CNC laser cutting and engraving machines. All the equipment was provided by LabCEFET Maker, at CEFET-MG.

As a starting point for the project, we produced two tactile models based on objects from the Solar System. The first model represents the Solar System in scale, with the Sun as reference, as seen in Fig. 1. It was built by fusing plastic bags, which were transformed into a type of fabric. In the defined scale, the Sun is 1.15 meters in diameter, and the other planets are proportional to it. For the planets, hemispheres were printed on 3D printers and fixed to MDF boards. Each board contains the name and a brief description of the corresponding planet. All engravings were made using traditional spelling and in Braille.

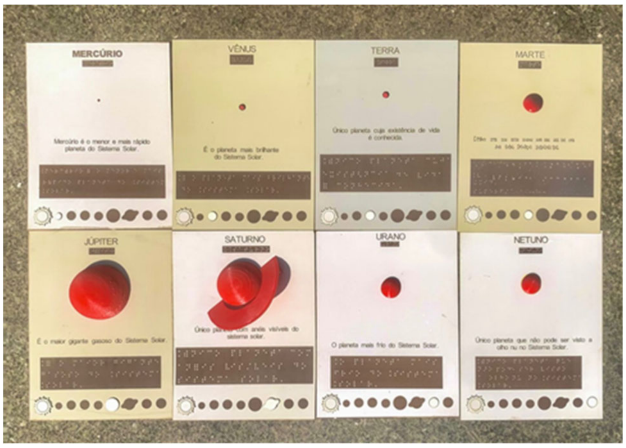

Figure 1. Tactile scale model of the solar system

The second model represents the Earth-Moon system in scale and distance, as shown in Fig. 2. The Earth and Moon were printed in PLA using a 3D printer. To illustrate the distance, a string was used. When stretched, it showed the proportion of the distance within the scale used.

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These models were developed with the aim of providing a sensory experience to the visually impaired and expanding their knowledge about the Solar System and can also be used as educational tools for sighted students of all ages.

Figure 2. The Earth-Moon system with a 14cm Earth and Moom at scale

3. Results and discussion

The models produced were used in presentations at public schools in Belo Horizonte, for children, teenagers and teaching and technical staff, with great acceptance and engagement, as shown in Fig. 3 and Fig. 4.

Figure 3. Young students show interest during an interactive tactile astronomy activity

Figure 4. Interaction of students with our Solar System Tactile Model

The engagement provided by the tactile materials and the possibility of interaction, of being able to touch the materials produced, particularly instigated the children, who showed even more interest and curiosity in the subject. The models produced were also presented to the visually impaired public for testing, with positive feedback both in relation to the quality of the models - the Braille printing and finishes, and the initiative to include blind and visually impaired people in science promotion events.

4. Conclusion

The tactile models produced make it possible to introduce notions of proportions and scales of astronomical objects, stimulating interest in astronomy and allowing learning to be interactive and inclusive for people who are blind or have low vision. The models can be used in classrooms, science centers, museums and academic events, or any other space with people with physical disabilities, making the teaching and learning of astronomy more democratic and accessible.

More research and technical development will be sought so that we can produce increasingly more precise and improved models,

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reducing costs and allowing production on a larger scale, to expand the scope of the project and be present in more schools, events and spaces that promote science in Belo Horizonte and everywhere else.

5. Acknowledgements

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Development of a Virtual Learning Object for Teaching Oxygenated Organic Functions

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Abstract. High school students often struggle to differentiate between oxygenated organic functions. Virtual Learning Objects (VLOs) offer a promising tool for enhancing chemistry teaching by increasing classroom motivation and attention. This research aimed to construct a VLO on oxygenated organic functions, using a qualitative approach grounded in Instructional Design. The VLO was developed in three blocks: Introduction, Contextualization, and Learning Assessment. Results showed that the tool was easily accessible via computers and smartphones and can be used to modify the traditional chemistry classes.

Keywords. Chemistry Teaching, Information and Communication Technologies, Organic Oxygenated Functions, Virtual Learning Object.

1. Introduction

In the subject of Organic Chemistry offered at high school, it is common for students to experience difficulties in distinguishing oxygenated functional groups and understanding the related physicochemical properties of them [1-3].

In this context, the use of Information and Communication Technologies (ICT) can be potentially valuable for the teaching context, considering that it allows students to enhance their learning process by accessing information in ways and exchange of information and knowledge [4-5].

Various studies in the literature [6-7] have highlighted the importance of using technological tools in chemistry education as a didactic resource capable of promoting greater student motivation in the learning process and enabling personalized and active teaching.

Among the various forms of ICT, Virtual Learning Objects (VLO) have emerged as a valuable pedagogical resource for teachers in the classroom context of chemistry teaching [8-9]. These digital resources are defined by Wiley [10] like a are multimedia blocks containing information in the form of videos, texts, images, and sounds, which can be organized and reorganized. This flexibility allows educators to tailor the content to meet specific learning objectives and adapt to diverse student needs.

The important advantage of VLOs is that they can be developed on readily accessible platforms such as *PowerPoint*, facilitating their easy sharing and access through mobile devices and other computers. Considering that in Brazil, digital inclusion is a challenge, this kind of resource can help bridge the gap by providing students with equitable access to high-quality educational materials, regardless of their technological resources or geographical location [11-12].

Thus, in this study, we aimed the development of a VLO on the topic of oxygenated organic functions, with the potential to be applied to high school students in public schools. We emphasize that this proposal arose from the need to teach organic chemistry content in a more interactive and engaging manner, using a tool that students can easily access and that allows for autonomous navigation using mobile phones or computers.

We highlight that this research was conducted during the Institutional Scientific Initiation Scholarship Program, PIBID [13], a program by the Coordination for the Improvement of Higher Education Personnel (CAPES) in Brazil, which aims to support institutional projects of pedagogical residency implemented by higher education institutions. The program contributes to the enhancement of initial teacher training for basic education in undergraduate teaching courses.

2. Methodology

The present study is classified as a methodological development research with a qualitative approach [14] based on the Instructional Design (ID) [15] as a facilitating didactic framework.

This method allows the researcher to develop reliable tools that can be replicated in other contexts, encompassing the development, validation, and analysis of the VLO.

The ID is a structured teaching approach that focuses on creating training strategies based on the analysis of problems or gaps in a specific area, as the teaching of oxygenated organic functions. It follows the ADDIE model, an acronym that represents the phases of the process: Analysis, Design, Development, Implementation and Evaluation [15-16].

These stages are summarized in the image below and described in more detail afterward.

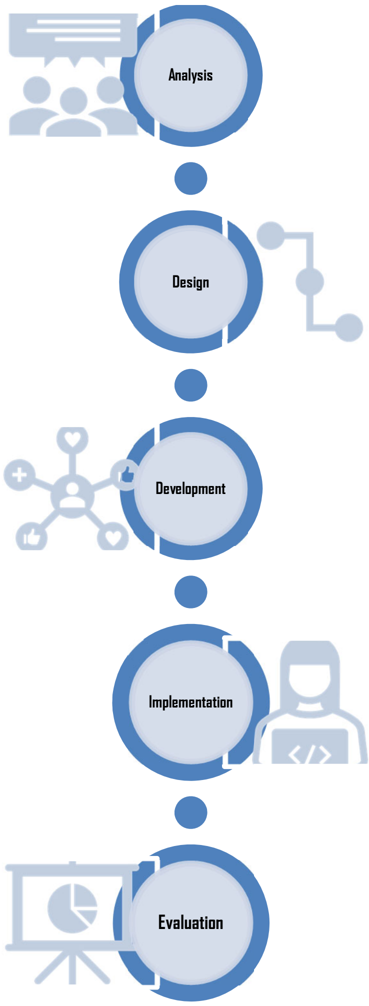

Figure 1. Summarized stages of the Virtual Object Learning development

2.1. Analysis

The first phase of ADDIE involves mapping the current situation to identify performance gaps that may require a training intervention. Thus, the methodology encompassed the investigation of the difficulties faced by high school students in understanding oxygenated organic functions and their physicochemical properties.

In response to this, a bibliographic review was conducted, focusing on publications in the field of chemistry education, which revealed challenges related to memorizing functional groups, nomenclature rules, and distinguishing between organic functions with the carbonyl group, such as aldehydes and ketones.

2.2. Design

In the second phase, the learning objectives, the content to be addressed, and its logical sequence content were determined by the participants meetings. Key aspects of this stage included the setting the learning objectives; defining content that aligns with the desired outcomes; identifying prerequisites for learning; and organizing the sequence blocks of instruction.

2.3. Development

In the third phase, the learning strategies to represent the oxygenated organic functions were defined, and the appropriate media were selected, including videos, texts, characters, books, and images.

Three blocks were created: the first block covering introductory concepts of organic chemistry; the second block presenting organic functions, their physicochemical properties and nomenclature rules; and the third block containing a Quiz for assessing learning.

2.4. Implementation

The fourth stage involved evaluating the functionality of the created interactive resources (animations, text, concepts, images) and the alignment of the content with the students' learning objectives. It is important to note that this stage was carried out by students from the Chemistry teaching program of PIBID.

2.5. Evaluation

The final phase involved applying the VLO to the third-year high school students at the Federal Institute of Goiás. Before the application, the students answered a questionnaire with questions about organic compounds that aimed at evaluating their prior knowledge. After using the VLO, the students were asked to respond to new questions involving situations that required them to identify functional groups, provide nomenclature for compounds, and evaluate the educational object.

In this study, we will focus specifically on discussing the development phase of the virtual learning object.

3. Results and discussion

The Virtual Learning Objects (VLOs) are defined as digital resources that present information in various forms, including images, sounds and graphics that aim to achieve specific educational objectives [17].

The term "learning object" describes the use of teaching materials that are built and designed in small blocks, with the aim of optimizing learning situations that favor interaction, autonomy and memorization [18].

The main characteristics of VLOs according to Benite [8] and Rocha *et al*. [19] are:

- Granularity: The content is presented in separate units, enabling it to be integrated into other resources and more complex materials as a fundamental, indivisible component.
- Reusability: To ensure that a VLO can be reused in different learning contexts, it needs to be accurately cataloged within a repository.
- Adaptability: Attributes that demonstrate the VLO capability to adjust to the needs and preferences of users and the educational environment, including personalization and contextual fit.
- Accessibility: The VLO can be accessed from different platforms like as celular phone.
- Durability: The capacity to remain functional without requiring rejection or recoding, even as the underlying technology evolves.
- Interoperability: The ability to function across various hardware platforms, operating systems, and browsers, facilitating effective communication between different systems.

Considering these characteristics, the VLO was constructed in three main blocks of information: an introductory section presented by a black female scientist character; a second block which was presented the oxygenated organic functions through an interactive diagram; and the third block containing a Quiz compound with questions and answers for self-evaluation. The Fig. 2 shows the presentation screen of VLO.

Figure 2. Presentation Screen of Virtual Object Learning

Upon opening the initial screen of the VLO, the student has access to an introductory animation presenting the topic covered. After the animation is completed, the following screens can be accessed by clicking on specific buttons (arrows). These buttons allowed the student to guide how to access the screens, advance or return to the original frame.

The first block, following the introduction screen, is guided by a Black scientist character showed in the Fig. 3.

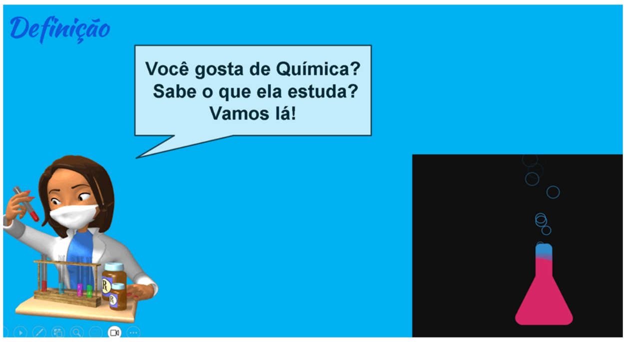

Figure 3. Black scientist character

The choice of a black female scientist was to challenge the traditional view of scientists based on male, european and white standards. One of the major challenges for Basic Education in 21st-century Brazil is the implementation of Laws 10.639/03 [20] and 11.645/08 [21], which mandate the inclusion of Afro-Brazilian and Indigenous history and culture in the country's school curricular. We understand that the character alone is not sufficient for the

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implementation of an anti-racist approach. However, it is important to ensure that students feel represented in these spaces.

In this segment, the character discusses with students what organic chemistry is and contextualizes its different branches. In the sequence, students can access the main table showing the different functional groups. This screen is showed by Fig. 4.

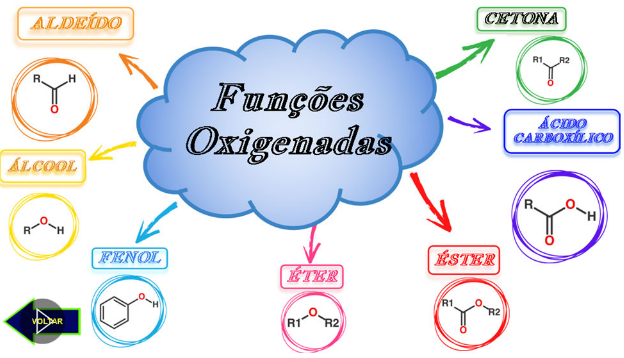

Figure 4. The main groups of oxygenated organic functions

The main screen presents the oxygenated organic functions organized in different colors and allows students to access them according to their preference, making teaching personalized and offering a certain degree of freedom to understand the content.

When accessing some of the functional groups, students are guided by their characteristics, nomenclature, physicochemical properties and can receive information about where these compounds are found in everyday life.

The Figs. 5 and 6 shows an example of this frames. After the student accesses all organic functions, a screen with a Quiz opens allowing the student to answer questions and obtain immediate feedback. The Fig. 7 show an example of question.

A pertinent concern in this regard was not only informing students whether their answer would be wrong or correct, but also in the case of an error, returning to the content on which the error occurred.

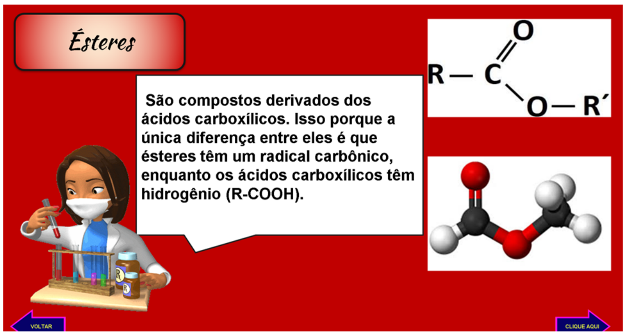

Figure 5. Characterization of the organic ester function

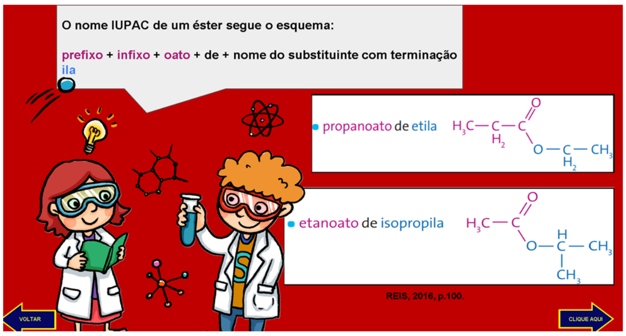

Figure 6. Nomenclature of the organic ester function

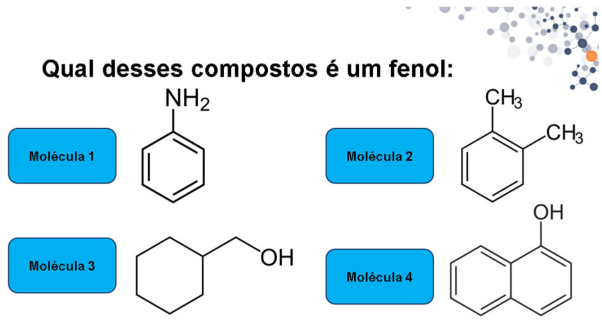

Figure 7. The main groups of oxygenated organic functions

4. Conclusions

The construction of the OVA using the *PowerPoint* platform met the accessibility requirements for broad use in the school context, functioning well on both computers and mobile phones used by students. The development of animated tools, incorporating texts, images with contrasting colors, GIFs, and videos, proved to be a strategy that captures students' attention and can provide greater motivation when used as a complement to traditional chemistry classes. The next stage of the research is the use of this tool on the high school classes.

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Sexuality: Negative Factors that Influence the Development of Sexual Education in the Context of the Federal Institute of Education, Science and Technology of ACRE - IFAC

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Abstract: This article had the general objective of investigating the conceptions about sexuality of students and teachers at the Federal Institute of Education, Science and Technology of Acre, Rio Branco campus. This work we will highlight UT4, which corresponds to the negative factors that hinder the discussion of sexuality in educational practice. The study highlighted the taboo, shame and resistance, absence or deficiency in the initial and continuing training of teachers, lack of commitment to discussing the topic and prejudice against minorities. Therefore, one of the strategies found in the study is discussions within school institutions.

Keywords. Sexuality, Emancipatory. Education.

1. Introduction

According to [1], sexuality consists of a human dimension and, therefore, will be present in all phases of life, demonstrating its own forms of meaning, manifestation and personal experience. In this sense, sexuality involves not only sex, love and reproduction, but is also composed of sexual roles and orientation, eroticism, pleasure and emotional involvement. In this way, it comprises the physical, social and psychological aspects and is also formed by customs, histories, religion and culture [2].

Despite this, in some studies sexuality is confused with sex and the sexual act, with few educators considering it from a more generalized perspective that includes affective, cultural issues, personal and social values [3-4]. In this sense, sexual education practices carried out in schools have predominantly promoted the biological and preventive dimension of sexuality, focusing on aspects such as sexually transmitted infections (STIs), unwanted pregnancies, contraceptive methods and, in addition, prejudice against people who differ from the model heteronormative [5].

However, some studies prove that sexual education with an approach only aimed at the biological issue that involves only risk and specific actions on STIs and pregnancy prevention, are not enough to encourage critical reflection in adolescents so that they can develop conscious attitudes and responsible practices regarding the development of sexuality [5-6].

Therefore, sexual education becomes a process of pedagogical intervention whose development must occur continuously in the school context [7]. And this offer can significantly contribute to reducing the rates of violence motivated by issues related to gender and sexuality. However, this Sexual Education must address other themes that must go beyond biological issues, such as the body, consent, violence and other issues involving gender, sexuality and diversity [8].

In this sense, school Sexual Education:

> It is the way in which the school provides students, in an intentional and systematic way, with information and reflections on a wide range of topics necessary for their health, well-being and integral and emancipatory education, so that they can better understand yourself and others, as well as making decisions about your sexual life [8].

However, although Sexual Education is provided for in the Law, there are several discontinuities in the history of public policies supporting the topic. Furthermore, in recent years we have seen a setback in relation to the development of sexual education in schools. The approval of the National Common Curricular Base (BNCC) and other movements such as Escola sem Partido[a] and the propagation of the "gender ideology" fallacy resulted in a process of silencing and even violence in relation to gender and diversity issues [8].

> However, despite the context being set back, the research demonstrated that there is space, ways and legal and official support for the inclusion of Sexual

> Education, as well as discussions about gender and sexuality, in schools. Furthermore, the history of advances and setbacks in relation to the topic can, in some way, serve as hope that a new, better moment is on the way to being built [8].

In this way, it is clear that school is important in the process of enlightenment for young people and that the teacher has a preponderant role in approaching these issues with teenagers, who are responsible for searching for different strategies that can be transmitted more easily, the content to students. Therefore, as [10] point out, it is necessary for school institutions to provide opportunities for dialogue and involvement of managers in projects aimed at emancipatory sexual education.

2. Methodological Path

The research carried out is qualitative in nature and is classified as descriptive and exploratory. It was held at the Federal Institute of Education, Science and Technology of Acre - IFAC, *campus* Rio Branco, located in the capital of Acre. And the research participants consisted of teachers who worked in integrated high school courses and students in the 4th year of the Computer Science Course in the Technical Integrated to High School modality. To carry out the research, authorization was requested from the IFAC Education Directorate for the study to be carried out.

Data collection was based on a semi-structured interview with all research participants. This type of interview consists of a script of questions, which are not predetermined, so the interviewer has the freedom to ask other questions to obtain more information about the desired topics [11]. Immediately after signing the Terms of Consent (TCLE), the interviews were recorded for later transcription and analysis.

The interviews were carried out in two moments: for the students they took place individually and in person in a reserved room at the school, in the months of October and November 2019. For teachers, the interviews were carried out individually in the months of June to August 2020, so *online* through the platform *Google Meet* due to the corona virus pandemic.

After data collection, the interviews were recorded and transcribed, then transferred to the *software* of qualitative data processing NVivo Pro®11, version 11.4 to be organized. Soon after, the interviews were analyzed according to the Thematic Content Analysis method proposed by [12], which began with a floating reading of the collected material and then with the exploration of the material in order to find the center of understanding of the text. This process is called categorization, and is a procedure that reduces data into meaningful words and expressions [12]. Therefore, at this stage, Thematic Units (TU) and Meaning Units (US) were created as needed.

3. Results and discussion

The research subjects totaled twenty-four people, 9 (nine) students and 15 (fifteen) teachers. Among the students, ages range between 18 and 20 years old, and have Catholic (02), evangelical (04) and none (03) religions. As for the teachers, we noticed that their ages varied between 31 and 54 years old and that the majority of their religions were Catholic (04) or Evangelical (04). Students were identified by the letter “E” followed by a number and teachers by the letter “D” followed by a number to guarantee the anonymity of the research.

Regarding basic training, the majority of teachers, a total of five, have a degree in Biological Sciences, three in Literature, with the remaining seven distributed in different areas of training, namely: Systems Analysis, Computer Science, Physical Education, Electrical Engineering, Philosophy, Physics and Geography. Among the teachers, 03 have a doctorate degree, 05 a master's degree, 04 a specialization degree and 03 only a bachelor's degree.

Regarding the implementation and participation of training courses in the area of sexuality, all teachers stated that they did not participate in any course in this regard, which highlights the need for initial and continuing training courses in higher education courses and in institution as a means of promoting discussions involving sexuality and its themes.

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Thus, the Thematic Units and their Meaning Units that emerged after data analysis were the following:

- **Thematic Unit 1 (UT1)** – Multifaceted approach and conception of teachers in relation to sexuality:
  - Meaning Unit 1 (US1) – Conceptions of sexuality among teachers and students.
  - Unit of Meaning 2 (US2) – Dichotomy between the emancipatory approach and the biological and preventive approach.
- **Thematic Unit 2 (UT2)** – The transversality of teaching practice on sexuality in the context of teaching:
  - Unit of Meaning 1 (US1) – Sexuality approached in a transversal way. **–** Meaning Unit 2 (US2) – Sexuality worked through specific disciplines.
- **Thematic Unit 3 (UT3)** – Dialogic education in the concreteness of educational practices on sexuality.
- **Thematic Unit 4 (UT4)** – Negative factors that make it difficult to discuss sexuality in educational practice.
- **Thematic Unit 5 (UT5)** – Positive factors that favor the discussion of sexuality in educational practice.

Therefore, in this work we will specifically address Thematic Unit 4, which corresponds to the negative points that affect sexual education in the school environment, highlighting how the family, school and politics greatly interfere with the healthy development of sexuality in children. students.

In UT 4 we highlight the negative factors that end up influencing educational practices in sexual education in the school environment, whether directly or indirectly. Thus, we find the following categories: (a) taboos[b], shame and resistance, (b) lack of training of teachers to work on this topic, (c) little importance given to the topic and teachers not committed to this subject, (d) prejudice.

Taboos, shame and resistance were found in some of the participants' statements, revealing an impregnation with moral, ethical and religious values that can result in difficulties in approaching the topic. This leads to a lack of dialogue at school and in the family, resistance from parents and teachers to debating issues of sexuality and distorted views of what sexuality is. As we can check below.

> Interview D01: "*It's a taboo to talk about sex and sexuality with teenagers because the parents themselves don't talk, they haven't given guidance to their children and this becomes a taboo, because they usually take it the other way.*"

> Interview E22: "*It's very difficult to have this approach at school because most parents don't agree with this type of approach, because they think that talking about sexuality is talking about the person as if I were, "oh! I'm going to talk here about sexuality and I'm going to make, I don't know, my son become gay or my daughter become a lesbian.*"

We realized through the testimonies that addressing content involving sexuality, both at school and in the family environment, is considered a delicate subject and full of prejudices and can end up compromising the approach to the subject in the classroom [14-15]. This difficulty in working with sexual education is related to the historical constitution of sexuality, which was marked in its beginnings by hygienist practices and the repression of freedom of sexual expression. In which patriarchy, the view of sexuality as taboo and heterosexual relationships were valued [16-18]. Thus, associations of sex as something sinful and dirty still persist:

> We end up carrying with us a range of taboos, prejudices and feelings, often negative, in relation to sex, which accentuates our difficulty in talking openly about it [17, p.142].

Another negative factor identified in the interviews is the poor training of teachers to work with issues involving sexuality, both in undergraduate courses and in continuing education courses. In this sense, teachers report unpreparedness, lack of training and insecurity to address issues related to the topic:

Interview D02: "*I don't consider myself prepared to discuss this with students*".

Interview D06: "*I also miss training for our technicians.*"

The data is in line with other research in which teachers recognize the difficulty in talking about some subjects, such as masturbation, sexual abuse and difficulties with the sexual education they received. Furthermore, they feel unable to link their discipline to the topic of sexual education [14-15,18-20].

Furthermore, it was concluded that they do not consider the involvement of all professionals in the actions to be developed in schools, such as training and continuing education, to be important.

Interview D11: "*No, I wouldn't participate, because I believe that this sexual topic should be introduced in the family. From a school point of view, Science and Biology should be taught. Behavioral questions about sexuality should be more of a family task than a school one.*"

Thus, we noticed that some participants consider that sexual education should be discussed at school only from a biological perspective, thus considering the psychological and social dimensions as the responsibility of the family. In this sense, the study by [15] points out the transfer of responsibility to other actors, such as science and biology teachers, who believe they are competent for this discussion, due to the lack of awareness and preparation of some professionals. This refusal to discuss this topic may be related to a lack of understanding of the meaning of transversality in teaching, which reflects a lack of pedagogical planning in relation to sexual education [20].

In addition to the points presented above, we noticed that participants reported consequences involving issues related to prejudice, homophobia, machismo and the lack of effective sexual education in the school environment. As we can see in the transcriptions below:

Interview D06: "*I have had several experiences of male students who understand themselves, see themselves as homosexuals and because they hide it from their family, they end up developing anxiety, depression and it was something that took a huge toll. That's why it's so important to practice this content within the school.*"

Interview E22: "*Yes, teenagers end up not knowing what they want and then when they know what they want, they suffer prejudice from their parents, their family and then it is something very complicated, because they think that their choice is something wrong. And then you end up not having the support and it can even cause psychological problems.*"

Interview D07: "*... For example, due to the lack of men discussing sexuality, we observe that men still see women as property. We have alarming rates of domestic violence, even now during the pandemic.*"

Interview E22: "*The issue of violence within the home and rape by family members who end up raping the student. The question is, there are so many cases, so many cases, that's why it's very important to work, you know? Because, often, it is, whether the student is a student, they suffer this at home, but because they don't know, because they don't know that it's wrong, whether it's their father or their cousin touching parts, they end up abusing it. They end up thinking it's normal, you know? Then they end up not even realizing that they are being abused at home.*"

In view of the reports above, we observed that mainly young people are victims of homophobia and violence in the school environment. This could lead to abandonment of school life and psychological problems, leading to a greater propensity to commit suicide [21-22]. Therefore, it is necessary to build an intense dialogue between the subjects of the school, whether students, teachers, technicians, directors and management team so that they can deal with differences and diversities [23].

Furthermore, issues such as an increase in feminicides, sexual abuse and violence against women are highlighted, corroborated by research carried out by the Institute of Applied Economic Research in which, each year, around 1.3 million women are assaulted in Brazil [24]. Therefore, other policies that improve the Maria da Penha Law and actions in the educational

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field should be encouraged, aiming to respect and raise awareness of gender differences [24].

4. Final Considerations

Through research, we have highlighted several negative factors that interfere with the development of sexual education based on a broad view of sexuality that involves biological, emotional, social, historical and cultural aspects. They are: taboos, shame and resistance, lack of training and little interest given to the topic by teachers and all the factors that are linked to prejudice and the distorted view of what sexuality is.

Therefore, we understand that the topic of sexuality is important and discussions within school institutions should be encouraged, based on respect and critical reflection and seeking the emancipation of individuals. Therefore, we highlight how one of the strategies for enabling sexual education in schools efficiently will be the inclusion of the topic in the curriculum for teacher training, in addition to specializations, continuing education courses and postgraduate research.

Furthermore, we also encourage extension and teaching projects that must be carried out in basic education schools so that both students and school staff can understand sexuality in a broad way and thus seek strategies to reduce gender inequalities, prejudice, homophobia and sexual violence in the lives of individuals seeking the development of a healthy and emancipatory sexuality.

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Notes

[a] The so-called Movimento Escola Sem Partido (MESP) is, in fact, a group of *lobb*y that orbits around the lawyer Miguel Nagib, founder of the group, and several other activists. The movement began in 2004, but only after about a decade, this aspect gained visibility in the public debate by incorporating and emphasizing another conservative agenda: opposition to policies promoting gender equality and respect for sexual diversity, generating several actions of political agents of the Brazilian extreme right [9].

[b] Taboo: masculine noun: 1. [Religion] Prohibition of a certain action, of approaching or contacting something or someone that is considered sacred, 2. [Religion] Place, animal, object, thing or action prohibited for fear of divine or supernatural punishment, 3. Fear or prohibition of religious, social or cultural origin, 4. Subject that cannot or should not be talked about, adjective of two genders:1. Which is prohibited. = INTERDICTED, 2. That one cannot or should not utter or that one cannot or should not speak about [13].

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Scientific Method for Children

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Abstract. Advances and progress in chemistry are based on the scientific method. This consists of systematic observation, asking questions, make hypotheses, seeking answers through experiments and testing the hypotheses.

Explaining the scientific method has always been difficult, especially at the most elementary levels, in primary and secondary school. Ussually, children can feel pressure with new and only theoretical knowledge.

For this reason, the Official College of Catalan Chemists (COQC, acronyms in Catalan) started a project focused on teaching the “scientific method” at elementary and primary schools, specifically in the classrooms with students under 11 years old. The goal is to bring chemistry and science closer to young students lives by working the scientific method.

Keywords. Chemistry, Education, Crystals, Chromatography, Science Diffusion.

1. Introduction

Chemistry is part of us and our lives. All you can hear, see, smell, taste, and touch involves chemistry and intricate series of chemical reactions and interactions in your body and in the world around us [1]. Chemistry is an experimental science in which laboratory work usually involves “hands-on” experimental work which leads to the collection of primary data.

1.1. Chemistry and COQC

Advances and progress in chemistry are based on the scientific method. This consists of systematic observation, asking questions, make hypotheses, seeking answers through experiments, testing the hypotheses, formulate conclusions and communicate results.

Explaining the scientific method has always been difficult, especially at the most elementary levels, in primary and secondary school. Usually, children can stress with new and only theoretical chemical knowledge. The Official College of Catalan Chemists (Il·lustre *Col·legi Oficial de Químics de Catalunya*, COQC, acronyms in Catalan) [2] is working in chemistry education [3] because is a fundamental tool for the achievement of a sustainable future at the molecular level. COQC started a new project focused on teaching scientific method at elementary and primary schools, specifically in the classrooms with students under 11 years old.

The goal is to bring chemistry and science closer to our lives by using the scientific method. Children do it without realizing it, without memorizing abstract words and science concepts. At this point, the teaching staff cooperation is particularly necessary.

1.2. Stages of cognitive development

Jean W. F. Piaget (Neuchâtel 1896 - Ginebra 1980), a Swiss phychologist [4-5]. Piaget's theory of cognitive development suggests that children progress through a series of four different stages:

- Stage 1, during the first two years of live, children belong to the sensorimotor stage. Children’s abilities, sight, hearing, smell, taste, and touch, allow them to interact with the world without mental representation or language. Children discover more about the world around them by trial and error as our ancestors.
- Stage 2, children age two to seven belong to the preoperational stage. The major hallmarks are the emergence of language and symbolic representation, and tend to be egocentric.
- Stage 3, children age seven to eleven belong to the concrete operational stage. Children also become less egocentric and begin to think about how other people might think and feel. They become much more logical during the concrete operational state.
- Stage 4, children age twelve and up belong to the formal operational stage. Children begin to think abstractly, using deductive logic and think more about moral, philosophy and moral. They manipulate abstract ideas or concepts;

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make hypotheses of their own thinking and to the others.

Piaget said "*Learning is a process of assimilation in which only part of the information is assimilated, the part understood or interpreted, while experiences modify this knowledge.*" We agree with this statement.

1.3. The Scientific Method

Sir Francis Bacon (London 1561 – London 1626) [6] was an English lawyer, philosopher, and "the father of scientific method". He said scientists should use their eyes and ears to observe the world around them and to learn more by doing fun experiments. He proposed a re-structuration of traditional learning, a new system based on empirical and inductive principles and the active development of new arts and inventions. Therefore, the production of practical knowledge will be for the use and benefit of the human condition [7].

What is the scientific method?

The scientific method is mathematical and experimental technique employed in the sciences [8]. It is a process or series of steps that scientists use to discover and learn how things work. It consists of various steps.

Step one, ASK A QUESTION. When people is forming a question they must think about something they are interested in learning or maybe something they are curious about, the phenomenon.

Step two, OBSERVATION - RESEARCH. When people make an observation, they have to look at and gather information. One way is using your five senses, sight, smell, taste, hearing, and feeling. To gather information, you can research on the internet or ask an expert.

Step three, HYPOTHESIS. When scientists or people like you make a hypothesis, they develop a hypothesis or prediction about what they think will happen during the observed phenomenon. Often, scientists don't accurately predict hypothesis.

Step four, EXPERIMENTATION. Scientists tested their hypothesis with an experiment. They need to make a plan on how they will do the experiment and the materials they will need.

Step five, ANALYZE AND RECORD THE RESULTS. Scientists record what happened during the experiment (data). They write down exactly, step by step, what they are doing for their experiment.

Step six, CONCLUSION. Scientists review the data and check to see if their hypothesis was correct. It is not bad if the hypothesis was wrong. In this case it is necessary to make a new hypothesis and repeat the process, they can try again.

Step seven, COMMUNICATE RESULTS. Scientists communicate their work within our society and the scientific community by writing and publishing research articles and presenting posters and oral communications at scientific conferences.

In addition, scientists have to communicate science in forums for everyone, scientists and non-scientists. They must improve it; basic sciece knowledge must arrive to our society.

SCIENTIFIC METHOD

ASK A QUESTION
OBSERVATION-RESEARCH
HYPOTHESIS
EXPERIMENTATION

ANALYZE AND RECORD THE RESULTS
CONCLUSION
COMMUNICATE RESULTS

At the beginning of the human age, the artisans started to use the "trial and error" method to solve a daily problem or a natural phenomenon. If their action worked they could continue to do it but if it did not work they sought a new approach.

They did not care about the how or why the phenomenon occurs, in contrast with the scientific method.

First scientists observe and then they make a hypothesis which will be proved or rejected by an experiment. If the hypothesis is confirmed they can formulate a theory.

2. Children and Scientífic Method

Authors and Leopoldo de Meis [9] accept the idea that “every child is a potential scientist” and the possibility that “the scientific method is indeed natural”, and consequently every human being is sure to use it unconsciously in everyday situations.

Leopoldo was a brilliant biochemist and also an excellent and innovative teacher. He has written two popular comic books both on thermodynamics and the scientific method [10] in order to foster the curiosity and interest in science in both students and teachers.

The COQC venture, presented here, is focused on teaching and working the scientific method at elementary and primary schools. At these educational levels, children have an excellent curiosity on Nature. Usually, children stay curious and never stop learning.

Our project for primary school students presents two different and complementary activities:

- Making geodes and crystals. The scientists in association with school teachers proposed to start an experiment in the whole class which could finishes in 1-2 weeks. Children find to grow salt crystals, any type of salt, inside a nutshell or around a thread of clothing or wool. They have to work and feel the scientific method while the experiment is going on. The experiment was posed and explained by COQC scientists.
- Solving a question, A group class from a Primary school level searched a question related to a natural phenomenon. Children work on the scientific method at school with the help of the COQC scientists. Young students have to search information about the phenomenon and make a hypothesis. Afterwards and with the collaboration of teachers and scientists, they all prepare an experiment together. Then, they do the exoerimental part, obtain results and discuss them, and validate or not their hypothesis.

Finally, children have to present their scientific work in a meeting, outside of school and, only because of their level,.

Children learn chemistry and science at school, following the scientific method steps. They work in it every day without stress. They made geodes and crystals [11].

3. Making geodes and crystals

Geodes are natural rock formations with little crystals, minerals, inside. The minerals crystallized in the cavity, into the stone. In nature some of the minerals are in the liquid of rivers, just water coming down and it can penetrate in the cracks of the rock and then over thousands of years it crystallizes.

Natural mineral crystals grow in different environments; from vapors, from hydrothermal solutions, from magmas or in the course of metamorphic reactions.

Natural geodes and mineral crystals take thousands and milions of years. We have to keep them. In Fig. 1, you can see some examples.

Figure 1. White glass geode (left) and Quartz, fluorite and aguamarine crystals (right) (Source: https://www.etsy.com)

3.1. Preparing and making Geodes

Primary school students age eight and nine developed an experiment in their classroom or at home. The experiment is easy to do and to understand for them, making crystals of salt [12]. It takes more than one week to finish it. Children have to catch pictures of experiment development until its end as a proof of their participation.

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3.1.1. Material

Participants in this experiment were divided in groups of three or four students. Every group and their teachers need: two nutshells, some hot water, very careful, some salt (NaCl, sodium chloride), 2 to 4 beakers or transparent containers, some food coloring, 2 spoons to mix, plastic Pasteur pipettes, containers to store each experiment, gloves, safety glasses and lab coat, paper hand towels, and any safety material deemed necessary.

3.1.2. Method and results

Children, in groups of three or four students have to take nuts and break the shell in two halves and wash them in hot water and dry them out really well. On the day of the experiment they have it ready, clean and tidy.

Figure 2. Zoe is making a saturated solution A→B→C→D. Pictures from Josep Fernández

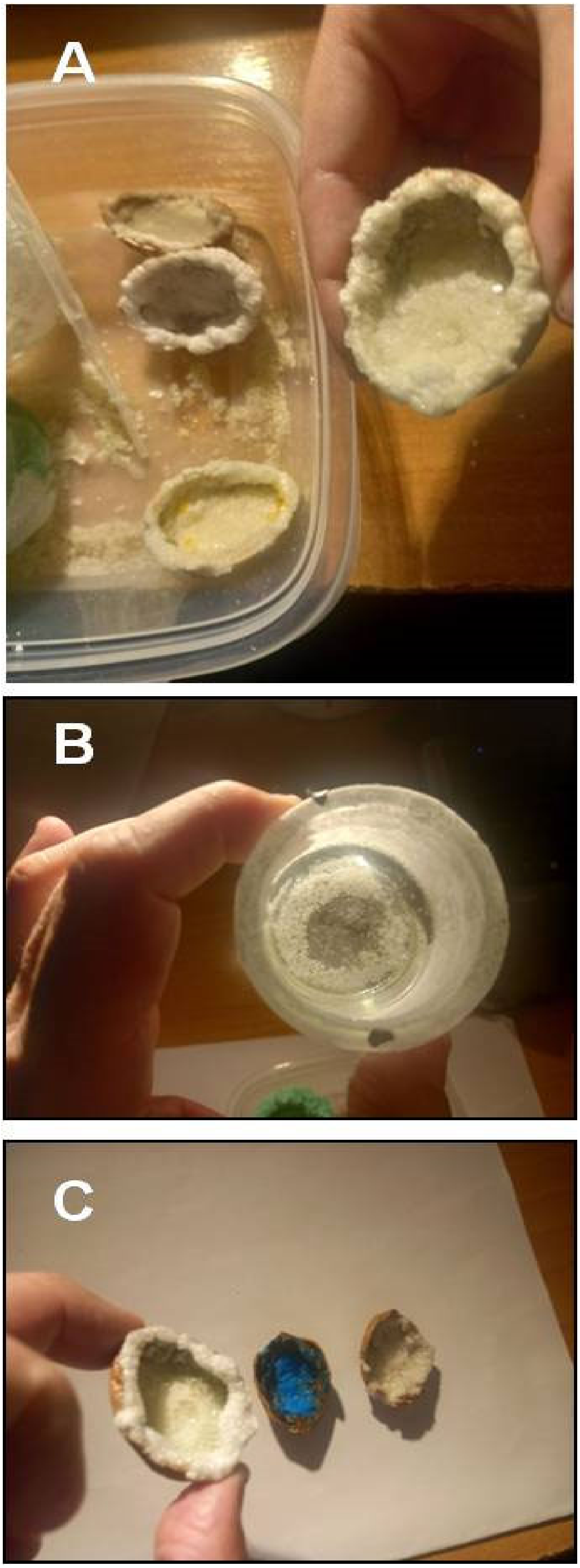

Figure 3. Obtention some geodes (A and C) and salt (NaCl) evaporation (B) Pictures from Zoe and Josep Fernández

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The next step is put a little glue inside the half shell and then use a little brush to spread it all out. Then fix some salt (NaCl, sodium chloride) in there first just to give that extra bit of crystal to start growing properly and then you need to remove the excess salt that will be used to make the saturated salt solution. Next, with boiling or very hot water, each beaker is filled to half, more or less. Then, young students are going to make a saturated solution (in a later section it will be explained what a solution is) by adding a lot of salt, a couple of spoonfuls, into the hot water (Fig. 2A, 2B), stir until all the salt disappear, water is moving really fast (Fig. 2C). Repeat until salt sediment, children can see some crystals at the bottom in the water; they have made saturated solutions (Fig. 2D).

The next thing to do is add color on the crystals. Each group of students can put, in one of their saturated salt solutions, food coloring, blue, red, yellow, etc., 10 to 20 drops will be enough. They will obtain a white or transparent geode and other colored one. Finally, children must fill, with some plastic Pasteur pipette, each half nutshell, previously treated, with a saturated solution (Fig. 3A). This experiment will take quite a bit of time; children and teachers put it in a nice warm place for the sediment to evaporate properly (Fig. 3B).

Children observe how it evolves every day, note the changes and take photos to record them. After 7-10 days they will be able to see their own geode (Fig. 3C).

3.2. Preparing and making crystals

Most crystals are formed through evaporation. For example, when water from saltwater evaporates (or is dried up into the air) salt crystals will be formed. You can see these crystals in Fig. 3B.

3.2.1. Material

Participants in this experiment were divided in groups of two students. Every child and their teachers need: some hot water, very careful, some salt (NaCl, sodium chloride),2 beakers or glasses, 2 paper clip for each experiment, some food coloring, 2 spoons to mix, cotton string, containers to store each experiment, gloves, safety glasses and lab coat, paper hand towels, and any safety material deemed necessary.

3.2.2. Method and results

This experiment was prepared at school and developed at home. Firstly, at school, the COQC scientists (always a woman and a man) both explain how to do the experiment and fill all students' glasses/beakers with warm water.

Figure 4. The process of crystallisation has occurred. Salt crystals are growing at home. 3 days (A), 6 days (B) and 10 days (C). Pictures from Zoe and Josep Fernández

Next, children add several spoons of salt

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(NaCl) to the water and stir until all the salt has dissolved and repeat this until no more salt will dissolve (saturated solution).

A paper clip is then tied to each end of a piece of wool string or cotton string which is placed either end in the glasses and a small plate underneath to collect any water.

Then children bring the experiment at home for a week and they have to observe the crystals grow. In addition, children take pictures about growing crystals and explain it in the middle of the classroom.

The crystals grow on the wool as the water evaporates off. In Fig. 4 you can observe some pictures at different times 3 days (Fig. 4A) or 6 days (Fig. 4B) and 10 days (Fig. 4C). Children sent us their pictures about their experiments.

3.3. Solute, solvent and solution

Since young students, in all primary schools that participated, asked us what they were doing? What a solution is made of? it becomes necessary to address these questions.

A solution is a specific type of mixture where one substance is dissolved into another. A solution is a homogeneous mixture like salt in water; sugar in water or water in alcohol. Their characteristics don't change over time.

In these experiments children have prepared different solutions, they mixed salt (NaCl) and water until to prepare a saturated solution.

There are two components of a solution: The solute is the substance which is being dissolved by another substance, in our experiments the salt is the solute. The solvent is the substance that dissolves the other substance, in our experiments water is the solvent.

Solubility is a measurement of how much solute can be dissolved into a liter of solvent, When a solution reaches the point where it cannot dissolve any more solute it is considered saturated.

The concentration of a solution is the proportion of the solute to solvent if there is a lot of solute in a solution then it is concentrated if there is a low amount of solute then the solution is said to be diluted.

4. Solving a question

Another approach to the scientific method for young and future scientists is to develop this methodology in class and at home in a relaxed but quite interesting way for their science learning.

Classmates at primary school searched for a question to solve by scientific method, question chosen by the whole classe and their teacher. Then, al least two COQC scientists help them to do the scientific method.

4.1. Methodology

Children work on chemistry and science at school for one to four weeks. During this time, children have to do:

- Search for a question from the observation of a phenomenon.
- Make a hypothesis.
- Meeting at school with COQC scientists. Young students ask to the scientists about their question and their hypothesis. Then, students, teachers and scientists discuss what to do? Finally, an experiment is proposed.
- Do the experimental part in the school laboratory and they explain it at home.
- Observe the experiment progress (one–two weeks). If problems arise in the laboratory experiments, the scientists are available to find an explanation from reasoning with children and teachers by chat or video meeting.
- See and record the results.
- Meeting at school with COQC scientists to analyze data, discuss results and validate or no their hypothesis. Usually, scientists propose to carry out a new experiment to expand knowledge or to explain any doubt of the whole class about research.
- Communicate their experience and results. Finally, children have to do a public presentation of their scientific work in front relatives and other children from Catalan primary schools. These “mini congresses” are always developed in a surprising place for children as universities or research centers with the COQC collaboration.

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So, children follow and working in scientific method at school and then they bring science at home and relatives.

4.2. Results

Three experiments made by young students from Catalan primary school during the last (23-24) course are presented here.

Figure 5. Climate change. Warming of the Sea

4.2.1. Climate change. Sea Warming

Some of the climate change effects favor the life cycle of jellyfish in the Mediterranean Sea. Children want to know: what is a jellyfish? Are they dangerous? How and where do they live?

School name: Escola La Pau

Student level: 3rd (8-9 years)

Question: What is the Mediterranean Sea water composition?

Experiment: Prepare different solutions of water (H_2O) and salt (NaCl, sodium chloride)

Presentation: April 9, 2024 at the Barcelona Biomedical Research Park, PRBB.

In Fig. 6 you can observe, in the upper part a presentation slide made by children and, in the lower part a picture with the young scientists.

4.2.2. Sea salt and food conservation

Uses of sea salt (sodium chloride, NaCl). Sea salt is a traditional, natural and sustainable option for conserving food. Students want to know where we could find it by analyzing “Fresh water bottle labels” and “Canning labels”

School name: IE Sicília

Student level: 1st (6-7 years) i 6th (13 years)

Question: How does sea salt affect food preservation?

Experiment: Action of salt on different foods.

Presentation: April 9, 2024 at the Barcelona Biomedical Research Park, PRBB [13].

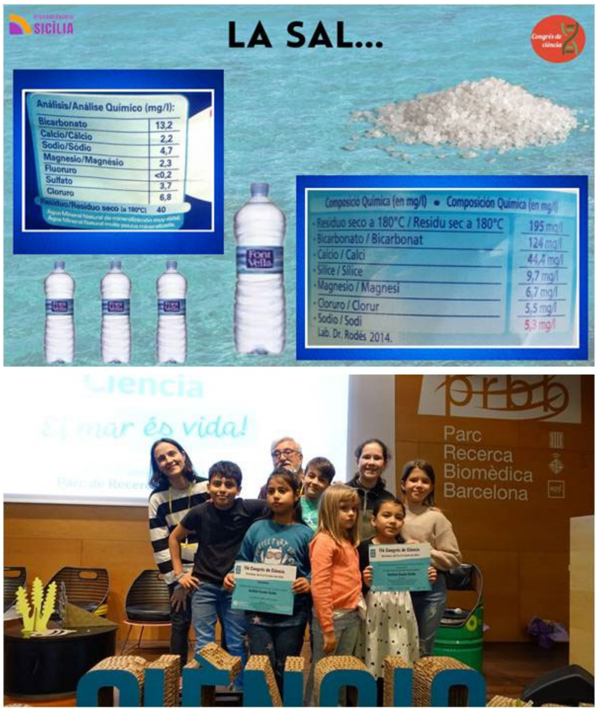

Figure 6. Sea salt and food conservation

Students aged 13 helped the youngest by acting as tutors. Children have used table salt (NaCl, sodium chloride) with some food [14] and they have learned that salt dehydrates the food and, this does not allow the bacteria that rot the food to act. These bacteria cannot grow because they need moisture to live.

Fig. 6 shows us, in the upper part a presentation slide made by children and, in the lower part a picture with the young scientists.

4.2.3. Composition and soil permeability

The soil closed to School permeability was studied. In addition want to know if the human action could change the river water pollution.

School name: Escola Madorell

Student level: 3rd (8-9 years)

Question: Why does not river water go underground?

Experiment: Water filtration through gravel (1), sand (2) or clay (3)

Presentation: April 29, 2024 at the Social hub of Barcelona, in the "research goes to school" activity [15].

Fig. 7 shows us, in the upper part a picture with participants and, in the lower part the young scientists explaining their work.

5. Secondary school students

In addition, this project has also been done for students under 14 years old in the first cycle of Catalan secondary education level.

The objective is the same as for primary school students, but the experiments and explanations are a little more elaborate. Next year, if all goes well, we will explain these results to you.

However, three small summaries of these experiments will be presented.

1. "How to make geodes and crystals?" Growing crystals is also a good experiment for students aged 12-14. Crystals of potassium nitrate (KNO_3) and copper sulfate ($CuSO_4$) are the novelty. And, he concept of oxidation observed in paper clips within the salt solution can be deepened.
2. "The separation of a dye ink pen on paper chromatography" The chromate-graphic technique is applied to separate dyes or pigments present in an ink pen or vegetable pigments from leaves. One can argue about color theory.
3. "Dirty water and river pollution" These students wanted to study how to purify water by filtration, boiling it or adding a little bleach, a bactericide. At the same time, they worked on Water River to fight against their village river pollution.

Figure 7. Pictures from de presentation day

6. Conclusions

The authors do not wish to begin the conclusions without reflecting the importance of the involvement and confidence that emerged between COQC scientists and primary and secondary science teachers.

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At this point, the teaching staff cooperation is essential. A small example: On the first day in a primary school class, the teacher told her students "*You like look at the world through a lens of enormous curiosity. And today you're going to be a scientist*". Beautiful words dedicated to the youngest scientists.

The feedback that primary and secondary school students and their science teachers sent us has been very positive:

- Children said that laboratory experiments and working in them was amazing and have modified their initial bad opinion about chemistry, science and scientists (Why?).
- And primary and secondary school science teachers' point of view about this experience indicated us its importance. They want to repeat it next year.

Scientists kept in mind that laboratory work must be safe and sustainable.

In this project, students quickly understood and directly participated in accomplish laboratory safety rules. They have to wear a white coat and sometimes theyare wearing hands gloves or protection glasses. More rules: don't run, don't drink or don't eat inside the laboratory.

The sustainability is also important in our lives, so when they put some salt into the geodes, the leftover salt was used to prepare the saturated solutions, it cannot be thrown away. In addition, they paid attention that any products used in science experiments cannot be thrown down the sink.

Public presentations, despite the obvious nerves, are a turning point for young scientists, young students have to present their experiments and practice the presentation, first, at school. It's a big challenge for them.

Children, better in science than in social (Oral explanation) explained a scientific work performed with the help of some classmates, better in social than in science. It has been demonstrated that the mix scientific and humanistic interest obtain good academic results [16]

Young students become the protagonists of experimental activities. These projects lead a favorable environment to discover knowledge from free exploration and experimentation.

Group work with classmates is necessary to understand the experiment and ask the right questions [17]. The result is that students develop a sincere attention and curiosity in science.

Children work on the scientific method at school and at home because the experiment is developed in both places. Furthermore, they bring chemistry and science at home and this could increase family members' interest in science.

Our future young scientists spread science in our society. And, as a result, our society will have a more positive view of science and less distorted from the danger of pseudosciences. Fighting against pseudosciences is a difficult task [18] that worries all science school teachers and scientists.

Finally, chemistry and science have come closer to children's lives.

7. Acknowledgements

We thank students and teaching staff of Catalan primary schools who participated in this educational approach. We also thank Zoe and Josep Fernández for giving us the pictures of their experiments. These activities were supported by the Official College of Catalan Chemists, COQC.

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Educational and Sustainable Robotics in the Manga Indigenous Village

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Abstract. The project described here has been named "Robô Karipuna," as it is developed in the Manga Indigenous Village in the City of Oiapoque, Amapá, where the predominant indigenous ethnicity is the Karipuna. The central idea of the project is to propose workshops in educational robotics using LEGO and Arduino materials. The primary objective of this initiative is to build a teaching and learning network in educational robotics within the Indigenous Village, supporting the professionalization and social development of the indigenous children involved. The project is an innovative action within the village, as no indigenous person has had prior contact with educational robotics. The entire learning process in robotics, as outlined in this project, was proposed using qualitative methods, as it aims to work constructively, valuing dialogue, difficulties, and individual learning styles. This entire process was divided into three stages: the first, conducting workshops in Robotics learning; the second, participating in scientific exhibitions with all students; and the final stage will consist of participating in tournaments throughout the year. To meet the goals, weekly meetings are held. This project has been contributing to the educational development of twenty-five students, aged between 10 and 17 years, serving as an essential resource in the development of skills related to technology, as well as providing opportunities for experiences that the village previously did not have with educational robotics.

Keywords. Educational Robotics, Indigenous Empowerment, Skills.

1. Introduction

Manga Village, located 24 km from the municipality of Oiapoque, is situated on the banks of the Curipi River in the Uaçá Indigenous Land, where most of the indigenous population belonging to the Karipuna ethnicity resides. The village has 24-hour electricity, internet access, and a public school structure, the Jorge Laparra Indigenous State School (Cardoso, 2019; Santos, 2019).

According to Cardoso (2019), Manga Village has undergone various transformations that have affected the population's way of life due to its proximity to Oiapoque. With the arrival of electricity in the year 2000, the population gained access to various technological resources, such as television, computers, cell phones, among others. In some ways, this led to changes in the habits of the village's inhabitants.

Regarding technological resources, the village school has internet access and some deactivated and unusable computers due to time-related factors and the lack of a professional to operate them. The students frequently use their cell phones in their social context; however, they have never had opportunities to work with activities involving Educational Robotics, making this their first experience.

The work with robotics has contributed to the development of various skills and competencies, not only those related to building and programming robots but also in conjunction with the technological resources necessary to facilitate this learning.

Sousa (2019) implemented a project with educational robotics in an indigenous school in Boa Vista – Roraima, and according to one of the school teachers, robotics can contribute to teaching and learning by putting all the theory built in the classroom into interdisciplinary practice. It also greatly motivated teamwork among the students, making a difference in their progress.

Similarly, Plácido Segundo *et al*. (2019) highlight in their experience with robotics in an indigenous community in the city of Grajaú in Maranhão that the project can provide students with the development of skills in flow control, actions, variables, logical and numerical operators. Additionally, they affirm that there was no dropout during the project implementation.

Thus, the purpose of this project is to carry out activities involving Educational Robotics practices within Manga Indigenous Village, aiming to build a teaching and learning network with educational robotics that cooperates with the professionalization and social development of the indigenous children involved.

2. Educacional Robotics ans Skills

Robotics is a branch of technology studies that primarily encompasses the fields of mechanics, electronics, and computing, consisting of machines or mechanical parts controlled by circuits, making a motorized mechanical system controlled by electrical mechanisms. Robots, although some models are humanoid, are merely machines; they have no life, feelings, bodily reactions, or any other type of human response (Martins, 1993).

More precisely, robotics is the set of studies and techniques aimed at designing systems capable of replacing humans in their motor, sensory, and intellectual functions (Martins, 1993). This definition clearly conveys the idea that robotics was created to replace human labor with machines, making tasks more practical and increasing production capacity.

In the current generation, people are increasingly seeking to use robots. In practice, a robot is an automatic device adaptable to a complex environment, replacing or extending one or more human functions and capable of acting upon its environment (Martins, 1993, p.13). Robotics emerged as an auxiliary tool to facilitate human life and is currently found in various sectors of society, especially in schools.

Within school spaces, professionals work with their students using Educational Robotics, a term used to characterize learning environments that bring together scrap materials or assembly kits composed of various parts, motors, and sensors controllable by computer and software, allowing some form of programming for model operation. Campos (2005) describes educational robotics as a tool designed to

> [...] designate learning environments (from Early Childhood Education to High School), that make use of assembly kits composed of parts such as motors, pulleys, sensors, gears, axles, building blocks or bricks, scrap materials like metals, plastics, wood, as well as a microcomputer and an interface, thus allowing the assembly of objects that can be controlled and operated by a programming language (pp. 28-29).

Working with robotics can help awaken certain skills and competencies. Zilli highlights some of them:

> Logical reasoning; manual and aesthetic skills; interpersonal and intrapersonal relationships; use of concepts learned in various fields of knowledge for project development; investigation and understanding; representation and communication; research work; problem-solving through trial and error; application of theories to concrete activities; creativity in different situations; critical thinking (Zilli, 2002, p. 40).

When working with educational robotics, students are invited to internally develop respect, creativity, information exchange, empathy, social interaction, among other similar qualities. Therefore, it is necessary to develop actions that seek the inclusion and development of skills and competencies.

3. Methodology

According to the project's objectives, qualitative aspects prevail over quantitative ones in all execution phases. Thus, the focus is always on quality learning, aiming at personal, intellectual, and professional development.

The project is centered on developing robotics training activities for children and adolescents in Manga Village. This experience involves 25 students from elementary and secondary education, aged between 10 and 17 years. In this way, observing ethical principles, identities have been preserved.

It is noteworthy that this project develops a participatory work methodology based on the use of flexible and dialogic communication techniques that stimulate the exchange of ideas and opinions.

The activities are conducted in person, occurring weekly with 4-hour meetings. This project is divided into three stages:

Introductory Training in Educational Robotics: Offering robotics workshops aimed at introducing students to the functionalities of

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each robot part and how to program using LEGO and Arduino materials.

Preparation and Training for Participation in Robotics Events: Preparing to participate in various annual robotics events. This stage aims to develop writing of papers and assembly of robots for competitions.

Participation in Events: Taking part in events such as the Brazilian Robotics Olympiad, Brazil Robotics Tournament, National Robotics Exhibition, Amapá IFTech, Amapá Science and Engineering Fair, or similar ones.

The evaluative monitoring of this extension project is based on the theoretical foundations and the extension policies regulated by IFAP, aiming to address five axes present in all such actions: impact and transformation, dialogic interaction, interdisciplinarity, inseparability between teaching, research-innovation, and extension, and formative evaluation.

For better evaluation, it was necessary to formulate and analyze student testimonials, produce images and videos about the project, gather information on student participation and dropout rates, and conduct interviews with the school team of the village regarding the development of activities at the school.

4. The Experience

The workshops, currently ongoing, are held weekly within Manga Indigenous Village, at the Jorge Laparra Indigenous State School.

Figure 1. Location of the Village

This project has been innovative within the village, as the residents and students had never been exposed to robotics before. Initially, the school coordinator reported that there was little interest in the project, but demand increased as the workshops progressed.

The central idea is to offer workshops with Arduino materials and gradually delve into their concepts. The classes so far have been divided as follows: Introduction to the equipment; assembling an LED; programming an LED; creating circuits with multiple LEDs; block programming; Arduino programming.

Figure 2. Location of the project development in the village

In the first workshop, the main information was presented to the students. At this time, some robots were brought in to stimulate and encourage participation in the project. There was some initial resistance from a few students, but gradually, they progressed during the workshops and increasingly engaged in the assemblies.

Figure 3. Moments of robot assembly

When the assembly with LEDs began, the students were divided into groups and started building the prototype. Some results were satisfactory, while others were not. However, there was nothing that discouraged the students; they were always interested in correcting the assembly errors. It is worth noting that, to date, there has been no dropout from the project.

In another class, a challenge was proposed for the students to build a prototype with multiple LEDs and light them all up. Initially, the idea was to create a robot with two LEDs, but the students built several prototypes with multiple LEDs lit, without assistance from the project members. What was interesting that day was that the students became the teachers, and they helped their peers who were having difficulties assembling their projects.

Figure 4. Moments of robot assembly

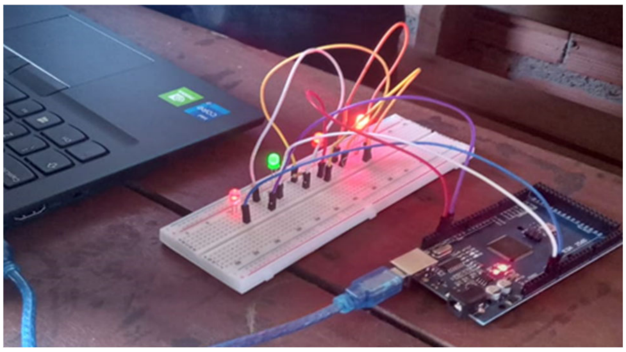

Figure 5. Robot assembled by the students

There were two phases for working with programming. The first was with the Arduino software itself, and the second was with block programming. When working with Arduino, students faced some difficulty following the programming due to it being in English. The students, who are from the Karipuna ethnic group, have Galibi-Marworno as their native language and Portuguese as an additional language. Some still struggle with speaking Portuguese, although they understand it well. It is believed that the Arduino software was not well received by them due to the unfamiliar language, so they adapted quickly to block programming.

Another basic point to mention during the workshops was the moments of socialization. As students spend the entire morning on the project and there is no funding for the activities, project members organize to provide snacks for the students.

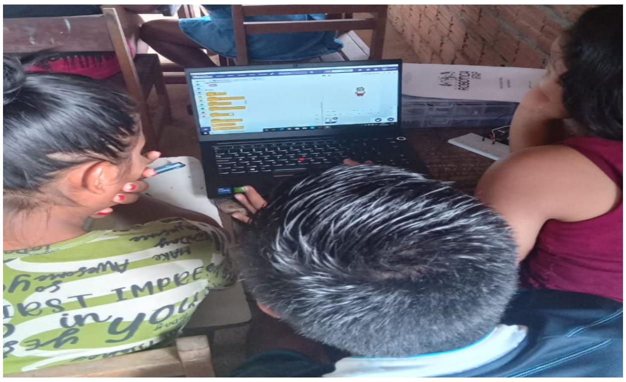

Figure 6. Students programming their robots

These moments allow teachers and students to get to know each other better, exchange experiences, and, most importantly, share a bit of indigenous culture with everyone on the team.

The initial practices of this project also brought about a cultural transformation for the members involved. Reflections on pedagogical practices and the realities experienced were the greatest learnings gained during this knowledge-building phase.

We have observed that the students are eager to learn more about robotics concepts and are attentive to every explanation. The satisfaction and enthusiasm to participate in the workshops are notable.

5. Final Considerations

The development of this project aims to contribute to social transformation, professional development, and civic education for the children residing in Manga Village. In line with the initial objectives, the involved members have been developing their cognitive and psychomotor aspects, as well as enhancing

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existing skills and competencies, while creating new ones.

Upon completion of this project, it is expected that some outcomes will emerge, such as: a network for educational robotics learning in Manga Village; cognitive and psychomotor development through innovative interdisciplinary approaches in robotics workshops; development of logical reasoning and programming logic; professionalization of students in the field of robotics and programming, as well as proposing pathways for continued careers in science and technology; empowerment of indigenous children in social, professional, and emotional aspects.

As there has been no dropout to date, it is noticeable that the students enjoy the sessions. There is evident empathy and respect among them, with teamwork and mutual assistance prevailing throughout the workshops. So far, it can be observed that in a short time they have developed emotional skills, teamwork, assembly, and basic block programming logic.

Although this project sets some goals and results from the execution of activities, it is expected that new benefits will arise from this social formation process.

6. Acknowledgements

We thank the Federal Institute of Amapá (IFAP) and the Manga Indigenous Village for all their support.

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Development of Classes by Chemistry Undergraduates on the Topic of Laboratory Waste

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Abstract. This work aims to report the planning and development of two classes developed as part of a training activity for the discipline of Epistemology for Training Chemical Educators (EFEQ). The study is an experience report of an activity carried out in the first semester of 2024 by two undergraduate students in Chemistry with a class of an integrated technical course and was carried out in two stages: planning (lesson plans and meetings with supervisors) and development (theoretical class and laboratory waste characterization activity). The study was beneficial because it allowed future teachers to have direct experiences with the classroom environment, in addition to creating an activity that promoted interaction and could enhance student participation and interest.

Keywords. Teacher Training, Chemical, Technical Secondary Education.

1. Introduction

Teacher training has been widely debated in the last two decades, especially due to the reformulations of the Curricular Guidelines for Teacher Training Courses, as well as the initiative to overcome the so-called 3 + 1 courses. In this sense, Tardif (2004) technical rationality is not capable of overcoming the diverse and complex situations that occur during professional practice.

Other authors with Schön (1992) emphasizes that professional training should not be limited to the acquisition of content for the development of teaching work. It should also be capable of integrating theoretical and pedagogical knowledge with empirical knowledge and professional practice. Schön (1992) proposes professional training based on the epistemology of practice, where learning and doing are intertwined, allowing future teachers to develop a deeper and more reflective understanding of teaching through direct experience and critical reflection on their practice.

Practical knowledge is that which's acquired through direct experience and reflection on action, is as important as theoretical knowledge. But this approach is essential to prepare teachers capable of dealing with the complexities and uncertainties of the school environment, as it promotes training that is at the same time reflective.

According to García (1999), there is a consensus that initial training should enable future teachers to develop practical, rational and well-founded know-how to face complex teaching situations. Thus, the knowledge base for teaching should be built from lived experiences and critical analysis of concrete practices, in order to overcome a pragmatic approach and achieve a critical-reflective approach.

Teacher training based on practical rationality was implemented in Brazil in 2002, with the publication of Resolutions CNE/CP nº 1 and 2/2002, based on Opinion CNE/CP nº 9/2001 (Brazil, 2001a, 2002a and 2002b). These documents demonstrate the influence of practical rationality and the epistemology of practice as pillars in teacher training for basic education. Nevertheless, discussions based on documents such as CNE/CP 2/2015 advance towards the perspective of critical rationality.

In the meantime, the discipline of Epistemology for the Training of Chemical Educators proposed by the Pedagogical Project of the Chemistry Degree course of a Federal Institute has as its principle critical formation, going through problematizations of how Science and Scientific Knowledge are constructed. With this discipline it is possible to study some theories of renowned authors on this subject, Gaston Bachelard, Thomas Kuhn, Ludwik Fleck. Given that the aforementioned discipline makes up the core of Practice as a Curricular Component, in which undergraduate students develop activities with Basic Education students, this work aims to report the planning and development of two classes developed as part of a formative activity of the discipline Epistemology for Chemical Educator Training (EFET).

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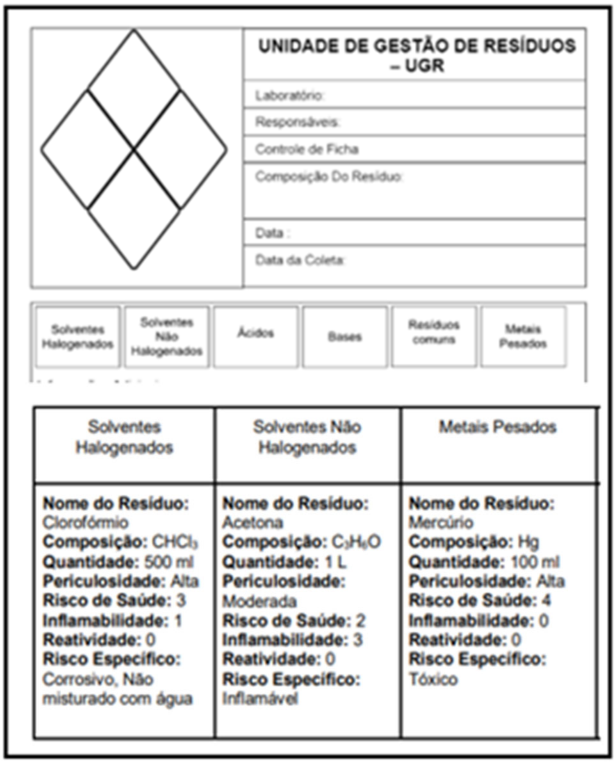
2. Methodology

To conduct this study, a qualitative approach was used, whose focus is on the description of phenomena and is of the experience report type of an activity carried out in the first semester of 2024 by two undergraduate students in Chemistry.

The experience reported was developed with students in the first year of the Chemistry Technician course integrated into high school at a Federal Institution, supervised by the teacher (PS1) of the Laboratory Waste Management discipline and by the teacher (PS2) of the EFEQ discipline. It was carried out in two stages: planning and development. Initially, PS1 presented the topic of the class available for the proposal, which was "Laboratory Waste". Later, the first stage consisted of planning the classes, carried out together with the supervising teachers PS1 and PS2. At this time, the topics that should be addressed were defined collaboratively, considering which contents would be most relevant and which activities would be most coherent for the students.


UNIDADE DE GESTÃO DE RESÍDUOS – UGR

Laboratório:
Responsáveis:
Controle de Ficha
Composição Do Resíduo:
Data :
Data da Coleta:

Solventes Halogenados	Solventes Não Halogenados	Ácidos	Bases	Resíduos comuns	Metais Pesados

Solventes Halogenados	Solventes Não Halogenados	Metais Pesados
Nome do Resíduo: Clorofórmio **Composição:** $CHCl_3$ **Quantidade:** 500 ml **Periculosidade:** Alta **Risco de Saúde:** 3 **Inflamabilidade:** 1 **Reatividade:** 0 **Risco Especifico:** Corrosivo, Não misturado com água	**Nome do Resíduo:** Acetona **Composição:** C_3H_6O **Quantidade:** 1 L **Periculosidade:** Moderada **Risco de Saúde:** 2 **Inflamabilidade:** 3 **Reatividade:** 0 **Risco Especifico:** Inflamável	**Nome do Resíduo:** Mercúrio **Composição:** Hg **Quantidade:** 100 ml **Periculosidade:** Alta **Risco de Saúde:** 4 **Inflamabilidade:** 0 **Reatividade:** 0 **Risco Especifico:** Tóxico

Figure 1. Label and card sheet (Source: The authors, 2024)

The development stage was developed in two classes, one theoretical, using slides and a projector to present the concepts related to the management of laboratory waste. In the second class, the objective was to develop a more dynamic activity, in addition to providing students with an interactive experience on the correct management of this waste.

For the activity, the students were divided into five groups. Each group received an ice cream tub and a labeling card, as shown in Fig. 1, to fill out and attach to the tubs, identifying them as containers for the disposal of different types of waste: halogenated solvents, non-halogenated solvents, heavy metals, acids, and bases. In addition, each group received 6 cards with the names of compounds with these classifications. After all groups had filled out the labeling cards, the tubs were placed on a desk at the front of the room, so that the cards with the names of the compounds could be added to them according to the labels made. After the students had segregated the waste, they filled out the characterization card.


FICHA DE CARACTERIZAÇÃO DE RESÍDUOS

Departamento/Unidade:__________
Laboratório/Setor:__________
Professor(es) Responsável(eis):__________
Técnicos Responsáveis pelo preenchimento:__________

Data da solicitação:__/__/__
Data da Coleta: __/__/__

PREENCHIMENTO OBRIGATÓRIO: Assinalar com um X as características do Resíduo Químico

	Solvente Não halogenado		Fenol		Acetonitrila
	Solvente Halogenado		Ácido		Presença de enxofre ou substâncias sulfuradas
	Pesticida e herbicida		Base		Oxidante
	metal pesado		Amina		Resíduos Biológicos
	Solução contaminada com solvente orgânico		Óleos especiais (de equipamentos e que estejam contaminados)		misturas
	Peróxido orgânico		Outros (tintas, vernizes, resinas) não contaminantes		Gerador de cianetos

Composição Do Resíduo	Quantidade (L ou KG)	Observações Dos Resíduos

Figure 2. Waste characterization form (Source: The authors, 2024)

3. Results and discussions

Planning was very important, as it made it possible to choose a dynamic that was aligned with the lesson proposal. In addition, it helped in choosing the materials, making it possible to reflect and outline how the lesson could be developed. According to Campos *et al*. (2019), it is essential to promote a comprehensive reflection on the use and development of new methodologies and tools in teaching chemistry. The diversification of teaching resources can be used to stimulate students' interest and encourage them to learn.

During the planning phase, a lesson plan was developed for two 55-minute classes. The first class was theoretical in nature, using slides and a projector to present concepts related to the management of laboratory waste. During the class, the undergraduates encouraged student participation by asking questions such as: "What is laboratory waste?", "Why is it important to study this subject?" and "What are halogenated solvents?".

As this was a first-year class, the students had not yet studied the periodic table and therefore had no knowledge about halogens and metals. In this way, the undergraduates prepared themselves to explain these concepts, since this situation was expected. Despite this, the students demonstrated some prior knowledge on the subject. It is important to always seek to connect new ideas and content with prior knowledge in order to facilitate understanding of the subject.

With each new topic, students were asked about their prior knowledge of the subject being discussed. In addition, students asked questions related to the disposal of hazardous equipment, such as batteries, demonstrating interest and engagement with the content presented.

The second class, which was practical in nature, was attended by 36 students. At the beginning of the class, some concepts that the students still had doubts about were reviewed, which were essential for carrying out the dynamic. Among these concepts were halogenated compounds, for which a periodic table was used to show the location of the halogens, in addition to explanations on how to identify acidic and basic substances.

For this class, labeling cards were developed that included the name of a fictitious laboratory, the diagram of Hommel, and the specification of the type of waste being given to the groups. The intention of this dynamic was to simulate how a waste form is made in a chemistry laboratory. This part will be very important for students who, in addition to high school, are taking a technical course in chemistry, as they are future laboratory technicians and will have to make these forms in the future, which was in line with what Tardif (2004) comments, that learning cannot be based only on theoretical content because is not able to overcome different situations in professional practice.

In addition, 30 cards were created with detailed information about the waste, such as name, composition, quantity, hazardousness, and other relevant characteristics. Each group received six cards, which had to be discarded into the ice cream containers with the labels. Waste characterization cards were also prepared, with additional information, to show students how to identify and document the specific characteristics of chemical waste generated in a laboratory or teaching unit.

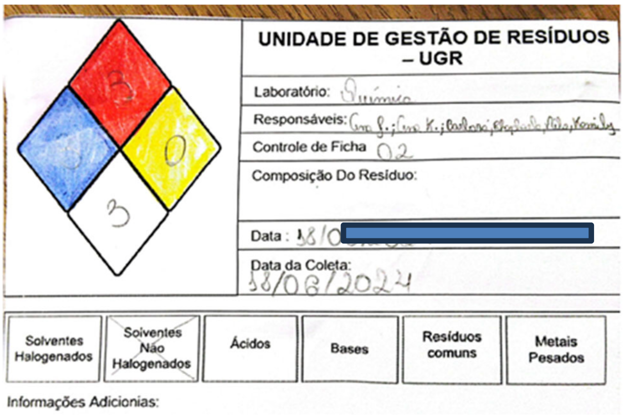


Figure 3. Label form filled out by a group of students (Source: The authors, 2024)

In this part the students started to talk to their peers in the group to decide which category each waste would fit into, whether it could be halogenated solvents, non-halogenated solvents, heavy metals, acids, bases or common waste. This showed an interaction between them, in which it was possible to notice exchanges of knowledge. According to Vigotsky (2009), social interaction and mediation are fundamental in the educational process. The author highlights that these two elements are deeply interconnected in the development and formation of individuals. After discussing, the

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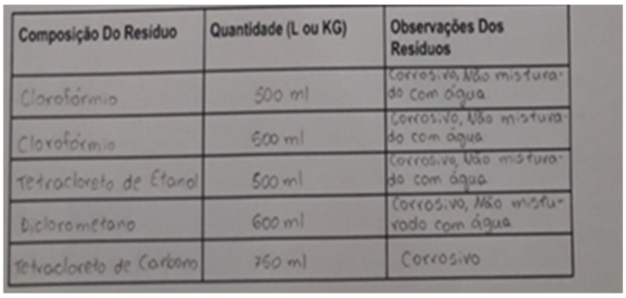
students placed the cards in the corresponding jars.

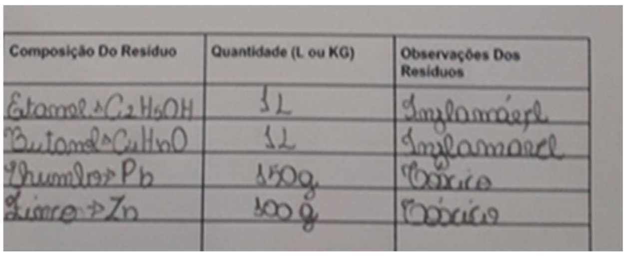
During the activity, students frequently had questions related to the identification and categorization of compounds. Although many demonstrated a solid understanding of the basic concepts, they struggled with more complex concepts, such as differentiating between specific types of residues such as halogenated and non-halogenated solvents, acids and bases. On these occasions, questions were clarified and concepts were reviewed on the board, especially regarding acids, bases and halogenated and non-halogenated solvents. The hands-on activity was essential to clarify these questions and reinforce learning.

The students showed good participation in the proposed activities. During the dynamic, they discussed among themselves to categorize the waste correctly and filled out the labeling and characterization forms. Analysis of the forms revealed that most groups were able to identify and categorize the waste correctly. However, some errors were observed, especially in the identification of certain waste and in the association with the appropriate categories.



Composição Do Resíduo	Quantidade (L ou KG)	Observações Dos Resíduos
Clorofórmio	500 ml	Corrosivo, Não misturado com água
Clorofórmio	500 ml	Corrosivo, Não misturado com água
Tetracloreto de Etanol	500 ml	Corrosivo, Não misturado com água
Diclorometano	600 ml	Corrosivo, Não misturado com água
Tetracloreto de Carbono	750 ml	Corrosivo

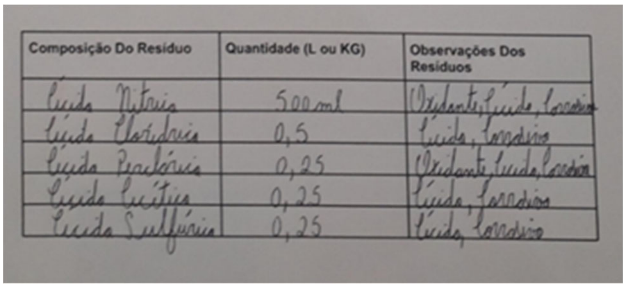
Figure 4. Halogenated waste characterization sheets filled out by students (Source: The authors, 2024)



Composição Do Resíduo	Quantidade (L ou KG)	Observações Dos Resíduos
Etanol → C_2H_5OH	1L	Inflamável
Butanol → $C_4H_{10}O$	1L	Inflamável
Chumbo → Pb	150g	Tóxico
Zinco → Zn	100 g	Tóxico

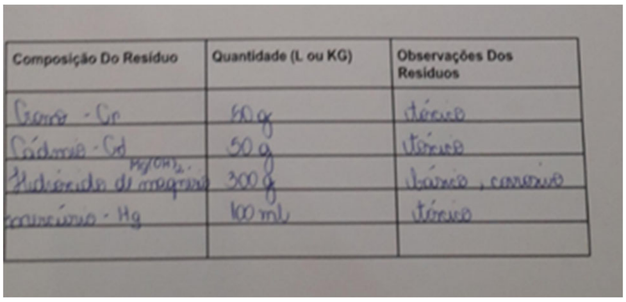
Figure 5. Characterization sheets of non-halogenated waste filled out by students (Source: The authors, 2024)

As shown in Figs. 4-7, it was observed that two groups correctly filled out the Characterization sheets, while the other two groups made some mistakes in identifying compounds. These errors occurred mainly during waste segregation, in which there was confusion between the types of compounds, especially in relation to bases, metals and non-halogenated solvents. For Varga *et al.* (2009), errors are seen as a starting point for the development of critical awareness. By identifying gaps in their knowledge, students have the chance to build new cognitive bases and improve their intervention skills. Despite these difficulties, the dynamic was valid, as it provided students with a practical understanding of waste management in a laboratory. Even with the errors observed, the number was small, indicating that most students assimilated the concepts presented well.



Composição Do Resíduo	Quantidade (L ou KG)	Observações Dos Resíduos
Ácido Nítrico	500 ml	Oxidante, Ácido, Corrosivo
Ácido Clorídrico	0,5	Ácido, Corrosivo
Ácido Perclórico	0,25	Oxidante, Ácido, Corrosivo
Ácido Acético	0,25	Ácido, Corrosivo
Ácido Sulfúrico	0,25	Ácido, Corrosivo

Figure 6: Acid waste characterization sheets filled out by students (Source: The authors, 2024)



Composição Do Resíduo	Quantidade (L ou KG)	Observações Dos Resíduos
Cromo - Cr	60 g	tóxico
Cádmio - Cd	50 g	tóxico
Hidróxido de magnésio $Mg(OH)_2$	300 g	básico, corrosivo
Mercúrio - Hg	100 ml	tóxico

Figure 7: Heavy metal characterization sheets filled out by students (Source: The authors, 2024)

4. Conclusion

This paper aims to report the planning and development of two classes taught by undergraduate Chemistry students to a first-year class of an integrated technical course. The study was beneficial because it allowed future teachers to have direct experience with the classroom environment, in addition to creating an activity that promoted interaction and could enhance student participation and interest. The

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entire planning and development stage was supervised by two teachers in order to promote dialogue and reflection on their own practice, overcoming a technical training.

Furthermore, the proposed activities allowed high school students to work collectively and face challenges that they will face in their professional practice. Based on the students' comments and participation, it can be inferred that the proposed dynamic was positive, enabling the appropriation of knowledge and the development of activities inherent to future professional performance.

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Science in Elementary School: The Playful Experience of Effervescent Colors

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Abstract. This article reports a practical experience carried out with 3rd year elementary school students in Brazil at the Research Laboratory for School Science and Geoscience Teaching (LabPECGeo) at the Federal University of Jataí. The activity, called "Effervescent Colors," used baking soda (NaHCO□), vinegar and dyes to demonstrate a simple chemical reaction, presenting scientific concepts in a playful and interactive way. The drawings produced by the students highlighted their perceptions about the practice carried out.

Keywords. Elementary School, Experiments, Pedagogical Practices, Scientific Education.

1. Introduction

Scientific education in basic education is essential for understanding phenomena and for the formation of scientific concepts, which are often abstract and complex. In this context, practical activities facilitate learning in a visual and engaging way.

This report describes the "Effervescent Colors" experience, conducted with 3rd year elementary school students who carried out a pedagogical visit to the Research Laboratory for School Science and Geosciences Teaching (LabPECGeo) at the Federal University of Jataí, Brazil. The objective of the activity was to explore concepts of substance transformation and effervescence through a simple and visually stimulating chemical reaction.

As highlighted by Cavalcanti (2005, p. 194), "the development of conceptual thinking, understanding that it allows a change in man's cognitive relationship with the world, is a function of the school and contributes to the student's reflective consciousness." The "Effervescent Colors" activity exemplifies this approach by promoting a practical and theoretical understanding of scientific concepts, enriching students' educational experience.

2. Development

The students participated in a practical activity in the laboratory, initially observing the mixture of baking soda, vinegar and dyes in small containers. When vinegar was added to baking soda, a chemical reaction occurred that released carbon dioxide, creating a fizz. During the activity, it was discussed with the students that, when chemical substances are combined, reactions can occur that result in visible changes, such as changes in color, texture, and the release of bubbles, among other effects.

Choosing materials such as baking soda and vinegar, which are safe, affordable and biodegradable, demonstrated how scientific experiments can be carried out in a sustainable way, avoiding the use of harmful or difficult-to-dispose chemicals. This approach encouraged students to reflect on the environmental impact of the substances they use, promoting a more conscious mindset about the use of resources.

The activity was led by the laboratory monitor, allowing students to first observe the experiment, discuss their impressions as a group and then carry out the experiment on their own. They recorded their observations through drawings, which helped to consolidate their learning. Furthermore, hands-on activities like "Effervescent Colors" not only develop fundamental scientific skills such as observation, experimentation and communication, but are also essential for understanding complex environmental issues and proposing sustainable solutions.

The observed chemical reaction can be related to natural processes. By discussing these connections, we expand students' understanding of the impact of human actions on the environment.

3. Results

Assis Barros and Santos Silva (2023) emphasize the importance of integrating theory and practice in scientific education. The "Effervescent Colors" activity exemplifies how this integration can occur. Instead of just hearing about theoretical concepts like chemical reactions and the formation of substances, students have the chance to see and experience these concepts in practice.

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In the activity, students closely observed a chemical reaction, which is a change that happens when certain substances mix. We use baking soda and vinegar. When combining them, an effervescence occurred, that is, many bubbles began to appear. After observing the reaction, the children made drawings to represent what they saw. These drawings reflect their interpretations of the phenomenon, such as the emergence of bubbles. With this activity, they learned, in a fun and practical way, how some substances can transform when mixed, connecting theory with practice in a meaningful way.

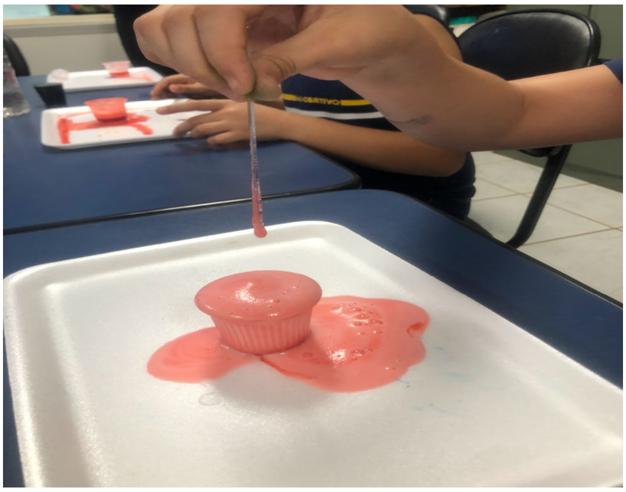

Figure 1. Practical experiment

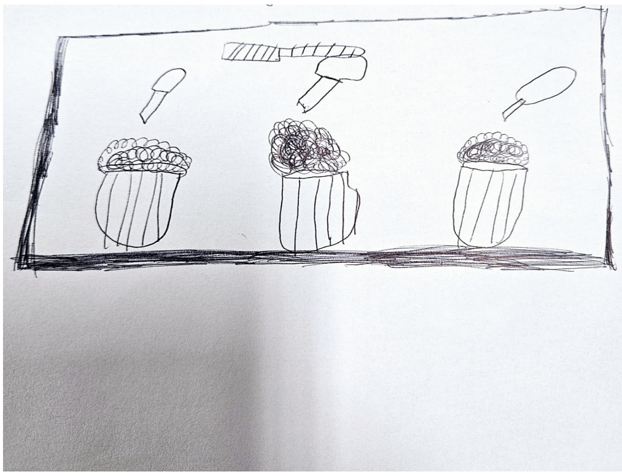

Figure 2. Participant registration A

Some drawings highlighted the formation of bubbles, elements that students associated with the idea of transformation. In addition to reinforcing the theoretical content covered in the classroom, the activity stimulated students' interest and curiosity in science.

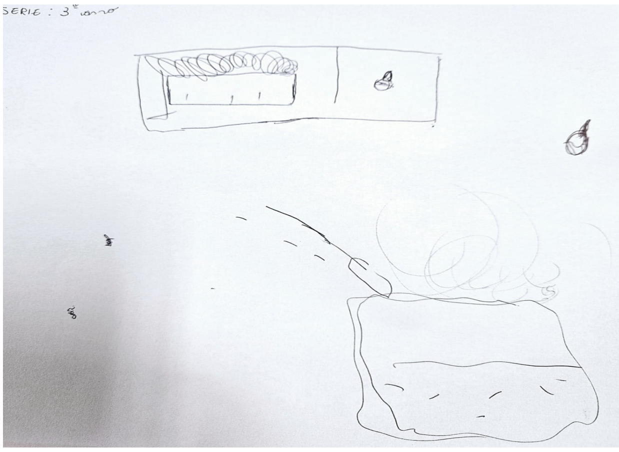

Figure 3. Participant registration B

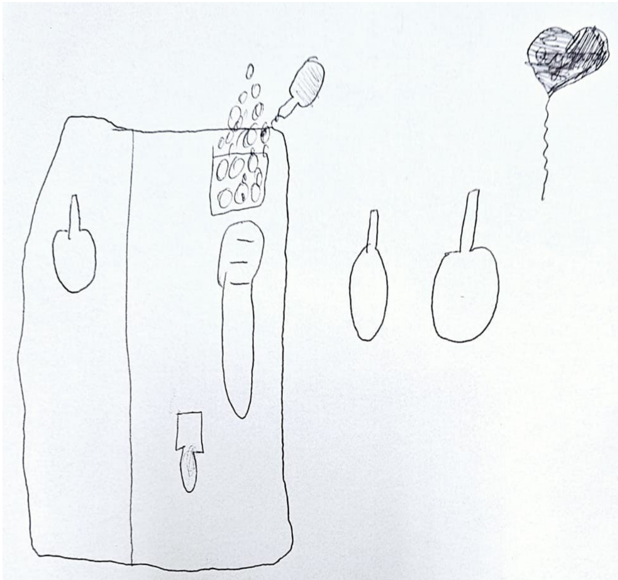

Figure 4. Participant registration C

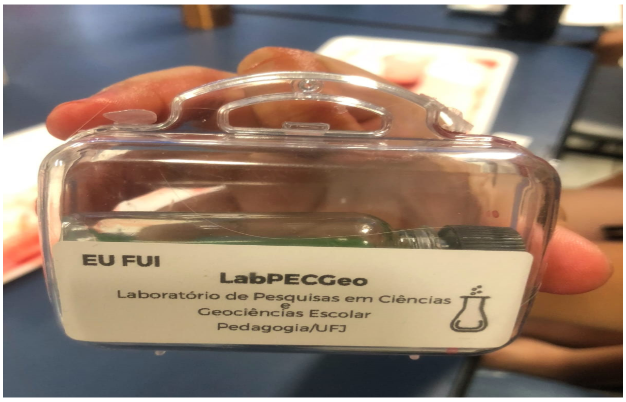

Figure 5. Souvenir containing biodegradable pipette and edible dyes for experimenting with color mixtures

By connecting practical experience with scientific concepts, students were able to construct meaning and develop essential

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investigative skills such as observation, description, and communication of results.

4. Conclusion

Hands-on experiments like "Effervescent Colors" are effective tools in teaching science, especially for students in the early grades. They offer an interactive approach that facilitates the understanding of complex scientific concepts in a playful and visual way and unites theory and execution.

Experience has demonstrated that practical activities in the laboratory can enrich learning, promoting not only the acquisition of knowledge, but also the development of investigative skills and the active engagement of students in the scientific learning process.

Finally, by incorporating sustainable practices into scientific activities, teaching such as waste reduction, the use of reusable materials and encouraging critical thinking about environmental impacts, students begin to internalize these values from an early age, developing a solid ecological awareness.

5. Acknowledgements

We would like to thank the Laboratory for Research in Teaching Science and School Geosciences (LabPECGeo) at the Federal University of Jataí, Brazil for the infrastructure and support in carrying out the activity.

The translation of the text with the original Portuguese title "Ciência no Ensino Fundamental: A Experiência Lúdica das Cores Efervescentes" was carried out by Iago Berttone Silva for the HSci2024 conference, on September 2, 2024.

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Affordable Sensors for Ozone Detection under Science-Technology-Society Study

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Abstract. We explored air quality study in the Cerrado using a Science/Technology/Society (STS) approach to create a more humanized professional education that addresses environmental and social demands. We guided nine second-year students from the Technical Course in Networks Integrated with High School, organized into four groups, in studies on air pollution. The focus was on key gases and particulates affecting the Cerrado Biome, their properties, toxicity, sources, and mitigation strategies. Our project included guided itineraries, lectures, classes on electronics, programming, Tinkercad simulators, and portfolio evaluations. Our Integrated Professional Practice (IPP) proposal has progressed towards developing a project that integrates research knowledge into professional training, fostering student autonomy in decision-making and environmental commitment. We will present partial results from one group's work from May to July 2024, focusing on an ozone detection sensor, its link to atmospheric pollution, and air quality. Additionally, we will share real measurements from Uberlândia city, MG. Also this, how these results have contributed interdisciplinary chemistry teaching, supporting a more autonomous and social responsabilite for professional training.

Keywords. Atmospheric Pollution, Ozone Gas, STS Education.

1. Contextualization of the proposal and interrelations

We began our proposal for integrative practices in March 2024, with 33 students from the technical course in computer networks integrated into high school. The project started with a thematic presentation focused on planning and developing research on air-polluting gases that could affect the air quality of the Cerrado region. This research will be conducted throughout 2024 and 2025 as part of the students' professional training, rooted in Integrative Professional Practices (IPP) and emphasizing a Science-Technology-Society (STS) approach to promote student autonomy [1].

In this work, we will present the partial results of activities developed with a subgroup of 9 students who were tasked with studying and researching atmospheric pollution, focusing on gases such as ozone, carbon monoxide and dioxide, volatile organic compounds, and suspended particulate matter. Our primary focus will be on atmospheric ozone pollution and the results of experiments conducted in Uberlândia, MG.

Based on the studies of gases and polutions and the knowedge of sensors we planned to use in thematic approaches, we engaged in reviwer of text and papers, programming learn, preliminary testing, and obtaining measurements for analysis and comparison with conventional equipment. Four teams were organized: one trio and three pairs, each tasked with themes related to the study of low-cost sensors, programming, and interdisciplinary studies in collaboration with teachers from chemistry, biology, physics, and computer science. In weekly meetings, students were expected to study their assigned themes, conduct research on reliable platforms—such as those from universities, SciELO, and journals from the Coordination for the Improvement of Higher Education Personnel (CAPES).

The Group 1, consisting of three students, is focusing on ozone gas, its importance in the stratosphere, and the environmental problems it can cause in the atmosphere. They are currently in the bibliographic research phase, selecting the equipment and software they are learning to use for taking initial measurements, scheduled for early 2025 on campus.

The Group 2, made up of two students, is studying carbon monoxide and carbon dioxide, their possible sources, the environmental problems these oxides cause, and their impact on air quality in the Cerrado. They are also exploring the broader impacts on climate

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change and the greenhouse effect, particularly focusing on carbon dioxide as a primary pollutant from anthropogenic sources, and examining strategies for mitigating its effects on the environment and society. So the Group 3, also consisting of two students, is studying volatile organic compounds (VOCs), including their toxicity limits and the environmental issues that affect health and quality of life. They are researching the physical and chemical properties of VOCs, their sources, and the causes of their propagation in the environment.

Finally, Group 4 was selected to work on the determination of suspended particulate matter and smoke, focusing on their health impacts and monitoring these particles using sensors and programming. They are studying electronics and particle patterns typically measured to assess pollution levels from these particulates. Ozone gas (O_3) is currently one of the key air quality indicators recognized in national legislation. So we had got a foccus in this part of our IPP, cause we have more details of this and because is so important know about this in societe. Prolonged exposure to high concentrations of ozone can pose serious health risks, underscoring the importance of continuous air quality monitoring for public health and environmental protection. This highlights the need for accessible and effective solutions. In this context, we present results from measurements taken with a low-cost, portable sensor prototype for ozone detection, which integrates technology through the use of Arduino and various sensors.

Components used include ozone meters (MQ-131), display monitors, storage modules, and temperature and humidity sensors (DHT22). The integration of these elements has enabled the creation of a functional prototype capable of autonomously collecting and storing O_3 data, showing a good correlation when compared with conventional measurements. The results of same measurement take demonstrate the effectiveness of the prototype, which successfully monitored ozone concentration. A comparative analysis between the prototype's sensors and commercial equipment, such as the Aeroqual 200, highlights the quality of the developed sensor, with an R^2 of 0.8 for some calibration equations. Another notable point is the average cost of the prototype, which is approximately 12 times lower than that of equivalent commercial equipment.

These data and graphics were presented to students participating in the Integrative Professional Practices (IPP) at Ipamer/IFGoiano Campus. The students discussed the findings, conducted simulations, and collaborated with other classes to create reports. These reports were then compiled into a portfolio to share and socialize their research findings.

2. Materials and equipment

Prototyping Equipment:

- Hardware and software integration with
- Arduino.
- Components Used:
- Aeroqual 200 O3 Meter.
- Four Arduino UNO for component integration.
- Four MQ-131 ozone-sensitive modules.
- Four OLED display monitors for real-time viewing.
- Four SD shield modules for local data storage.
- Four DHT-22 temperature and humidity meter modules.
- Stata, R, Jamov and/or Excel software for data analysis and adjustment.

The Fig. 1 showed a fluxograme of sensors and test that we had use.

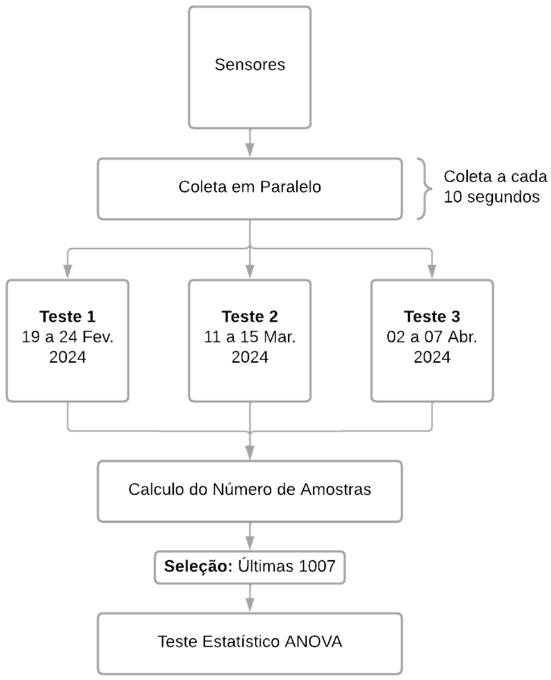

Figure 1. Test flowchart between sensors

All results were comparated with a convencional measument that we had

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presented in Fig. 2.

Figure 2. Aeroqual 200 meter a conventional meter for ozone content

3. Methods

Integration Base:

- Use of Arduino UNO to integrate data collection, visualization and storage components.
- Components and Functionalities:
- MQ-131 ozone gas sensor for data collection.
- OLED display monitor for real-time visualization.
- SD shield module for local data storage.
- DHT-22 temperature and humidity sensor for environmental conditions.
- PLA printed box to accommodate the components.

The procedures, collected data, and analyses were used to introduce the theoretical foundations for similar projects at the Ipameri Campus in an interdisciplinary and cooperative manner. To facilitate this, we organized a seminar in June, where researchers presented their work for students. So them can interact and make questions for undertands what they must to do at our campus after, in second semester 2024.

4. Some pedagogical results from interactions among students and researchers

Engaging with the planning, data collection, and challenges faced by the researchers served as a contextualized learning experience for the students. This is evident in the reflections shared by the participants. For this analysis, we will refer to the students as S1, S2 and S3/ozone group. Their insights will be explored as part of their portfolio presentation, where they took on the responsibility of evaluating ozone and its impact on air quality in the Cerrado.

We will first present some considerations from regarding the importance of chemical knowledge about ozone gas and its effects on health, followed by the difficulties the researchers encountered in taking measurements and the limitations of the equipment they were using.

The students of ozone group wrote in them portfolio, thinking about the theoretical aspects he had learned from the lecture given by the researchers to th IPP students at the beginning of June 2024.

> Excessive levels of these gases can lead to various health issues, including respiratory diseases and skin cancer. To address this, One of the search launched a project to set up a greenhouse gas measurement station focusing on ozone. Measurements were conducted at three distinct locations: a farm, a city center terminal, and an industrial area, with the latter showing the highest ozone levels. (ozone group had written in them portfole).

This could be meet at literature that talk about ozone pollution in megacities like 'São Paulo' and they had reletated this trouble in peoples [5]. It was possible too understand that these students did not know the differences between greenhouse gas and ozone pollution despite we had talked about this in class, so we must review these terms to give a more adequate idea of this for them. We also realized that the students did not fully understand the differences between greenhouse gases and ozone pollution, despite discussing these topics in class. This highlighted the need to review these terms to provide a clearer understanding. It was important for us to continually assess their learning, and communicating with them is crucial to identify areas for improvement and correct any misconceptions.

The same students also addressed aspects related to the technical course in computer networks. They presented ideas on assembling sensors for measurements at the Ipameri campus, focusing on the technical and logistical considerations necessary for effective setup and operation. This approach could integrate both general and professional training for these students, similar to the proposal in the IPP.

However, during the presentation of searchs data collection and analysis process, the students thouth that the reaserch had noted several limits and they coud writte this in them portfole, about the data Processing Limitations and measurement logistics that could had a high costs, these were significant factors. And so they had reflected about the importance of experimental methods and they affirm that:" […] the importance of not only collecting data but also addressing the logistical and technological challenges involved in analyzing environmental data."(Ozone's group).

Another aspect that we had noticed was that based on the presentation of the research developed by the researchers from Uberlândia, our partners in the application of the PPI proposal in the evaluation of air quality in the cerrado, there was a comparison that them worked among differents sensors to assess possible problems and the reproducibility of the experimental datas collected. We believe that this procedure was quite illustrative for our students, as we can use it to help them understand the need to validate equipment and procedures in order to achieve results closer to empirical reality and eliminate possible errors in obtaining scientifiques datas.

We consider it important to discuss this with our students in intregated cours of technal an high school, so that they can have an idea of the nature of science and scientific research, since as human constructions they are subject to technical limitations and adopted methodologies. The activities developed during our orientation meetings are important for us to reflect on this with our students.

In this way, we will be able to move away from a positivist model of science and consider the relativity and validity of scientific knowledge and its limitations. Another very important aspect to break with the supposed infallibility of scientific knowledge, this aspect should be worked on even more in the second semester, since students can delve deeper into this issue

Thus, we will move away from a positivist science model and address the relativity and limitations of scientific knowledge, including its technical and procedural constraints in same epocs or places. It is also crucial to challenge the notion of scientific infallibility. This aspect should be explored further in the second semester, as students will have the opportunity to delve deeper into these issues.

Others researchers were working with the STS approach at a school in the metropolitan region of Curitiba, PR, implemented a project with 14 classes that analyzed indoor air quality through the study of gases and chemical kinetics. Similarly, we have too observed an increase in students' interest and motivation to study chemistry.

5. Last considerations

We believe that our proposal could improve professional education and enhance students' decision-making skills. We hope that integrating a social, technological, and scientific approach will contribute to their education and foster greater civic and social participation. To improve this we must envolved and motiveted this students with dialoge and refleting about we could be better if we could help our society know and participate more of decisions that can help life quality of people.

The studies conducted by the other three groups and their thematic approaches within the STS framework could also provide valuable insights. These studies have the potential to offer a more comprehensive and interdisciplinary view of the world, better preparing students for the workforce and contributing to Brazilian society.

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Production of Nutritional Labels of Artisanal Products from Family Farming

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Abstract. COOPERSAFRA is a cooperative with 10 families, who produce organic food in the rural settlements in the city of Uberlândia-MG. Vegetables and some processed products are produced and sold at a charity fair. The fair aims to provide workers with the opportunity to occupy market spaces without intermediaries, improving their income. The products were commercialized without any nutritional labeling and are offered to the consumers only with an indicative label. Thus, the objective of the work was to assist the producers in the preparation and production of the right nutritional labeling of products meeting the demands of ANVISA, improving the quality of the products offered and increasing consumer safety.

Keywords. Family Farming, Organic Food, Quality Control, Social Movements.

1. Introduction

Nutritional labeling is a fundamental tool to inform consumers about the nutritional properties of food products, helping them choose suitable foods and ensuring sanitary control and public health protection, in addition to complementing health policies and strategies for the benefit of individual health. [1-2]. The National Health Surveillance Agency (ANVISA) in Brazil is responsible for regulating nutritional labeling. The Agency sets mandatory standards on what information must be included on packaged food labels. These labels contain information about several nutrients, including calories, macronutrients (such as proteins, fats and carbohydrates) and micronutrients (such as vitamins and minerals). They also show the presence of certain ingredients, such as sugars and fibers. The adoption of clear and standardized nutritional labeling systems aims to improve public health, prevent non-communicable chronic diseases and meet consumer demands for clearer food information. Yet, there are still obstacles, such as understanding the information.

Besides providing data on food composition, the nutritional table is important to identify the products, providing information such as product characteristics, manufacturer data, expiration date and batch number, which facilitates traceability. The nutritional label, which appears on the packaging, provides crucial information about the compostition of the food, such as the amount of saturated fats and whether or not there are trans fats. This information is essential for people who want to consume food which contains specific nutrients or to whom is allergic or intolerant to one or more ingredients of the product [3]. The list of ingredients is also important and mentions any additives that were used in the preparation, such as flavorings, sweeteners, preservatives and other substances that can be used to change the chemical, physical, biological or sensory properties of the food. The warnings, which are also mandatory, help the consumer recognize ingredients as eggs, gluten, soy and lactose, which can harm their diets or negatively affect people who have some kind of dietary restriction, whether due to intolerances, allergies or diseases such as diabetes [1].

Brazilian food legislation has evolved throughout history. Food labels are important because they provide relevant and fundamental information for a suitable food choice. Without this information, the label would not be useful for the nutritional consumption of food. As a result of food safety and nutrition raised by many Brazilians, food safety and nutrition regulations have become necessary. Initially, only informative materials about the subject were distributed to the Brazilian public to raise awareness about healthy eating habits [4].

Below there is a brief history of nutritional labeling in Brazil and around the world:

- <u>Before the 1970s</u>**:** Early regulations focused on ingredient lists to ensure food safety and combat fraud,
- <u>1980s</u>: The US FDA has regulated labeling for fortified foods. Health awareness has increased the demand for detailed information,
- <u>1990s</u>: The U.S. Nutritional Labeling and Education Act (NLEA) made labeling mandatory, standardizing

information. Other countries followed with similar regulations,

- 2000s: Inclusion of information about trans fats and added sugars. Emergence of simplified labeling systems, such as the nutritional traffic light,
- 2010s: Adoption of front-of-pack labeling and new emerging technologies such as label scanning apps,
- 2020s and beyond: Focus on public health and Sustainability, with increase of digital labeling and QR codes.

Considering that nutritional labeling of food products, even artisanal ones, increases consumer safety and the income standard of producers through product appreciation, the objective of this work was to develop nutritional labels for food products processed artisanally by family farmers in the city of Uberlândia - MG, Brazil.

2. Discussion

The nutritional labels were developed for the products sold at "Feirinha Solidária" at the Federal University of Uberlândia. "Feirinha Solidária" is an extension program that has existed since 2015, developed by the Pro-rectory of Extension and Culture of the Fedeal University of Uberlândia (UFU) through the Center of Incubation of Popular Solidarity Enterprises (Cieps). Cieps is an incubator that aims to advise groups of workers who are willing to organize productive initiatives based on the principles of the Popular Solidarity Economy. This is understood as an approach that is above all political, which questions the capitalist mode of production, its results on the well-being of workers and its impacts on human development as a whole and aims to build an economic alternative in which workers have decision-making power over the production and distribution of the value generated by collective work [5].

Through Cieps, groups of workers are advised, mainly when it comes to selective collection, popular art and culture and farmers in agroecological transition. UFU Solidarity Fair is a program that aims to develop knowledge, skills and attitudes that allow workers involved in Solidarity Productive Organizations (OPS) of farmers to occupy market spaces without intermediaries, overcoming exploitation by middlemen and improving the income of these workers. The products offered in the fair come from agroecological production and only a small part of them undergo some processing, so that processed products with an artisanal character are offered. The products have always been offered without labeling, without a manufacturing or expiration date and without containing the ingredients. Often, only a label with the product identification (Fig. 1).

Figure 1. Processed products sold at the fair

The Project involved teachers from different areas (administration, communication, computing and engineering) and technical and higher education students. The work was developed through a diagnostic assessment of the enterprise and the exchange of experiences with rural producers. The fair takes place in person on Saturday mornings, with a circulation of about 100 and 150 people. In addition to the natural products, processed products of different types are sold: bakery, jams, preserves, dairy products and sauces. All of these products require identification and, in order to increase

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the food and nutritional security of consumers, correct labeling was proposed.

Some visits were made to the settlements, in order to assess the production techniques, train rural producers in terms of hygiene and good handling practices and, mainly, evaluate the product made in terms of each input in order to prepare its nutritional table.

In order to boost label production, a Nutritional Label Management System for Artisanal Products from Family Farming was created (Fig. 2), developed using the Java Web 19.0.1 (Java Server Pages) programming language and is running on a local Apache Tomcat 2.4.47 server. The data inserted into the system is stored in a MySQL 10.4.19 database.

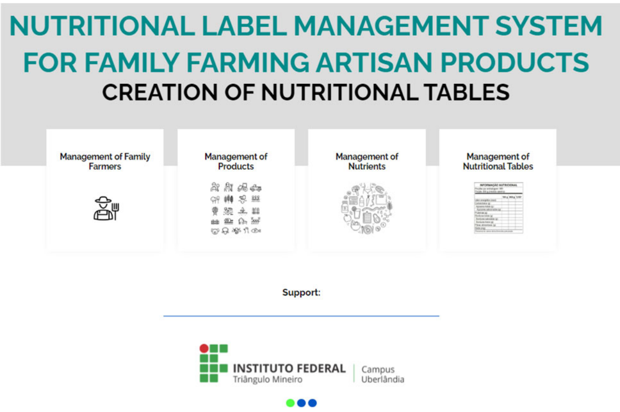

Figure 2. Nutritional Label Management System for Family Farming Artisan Products

According to the requirements survey carried out, the system allows users to insert new data, change registered data, remove registered data and perform various types of queries for decision-making.

The system administrator is allowed to: (i) register and manage a new unit of measurement of nutrients (proteins, fibers, fats, vitamins, among others), (ii) register and manage a new cooperative, and (iii) register and manage a new family farmer (Fig. 3).

The system allows Family farmers to: (i) register and manage their respective products, and (ii) register, manage and print nutritional tables for their respective products.

In a practical way, the system allows each family farmer to insert a new nutritional table, change the data in the registered nutritional table (in the case of replacing ingredients) and, if necessary, remove a registered nutritional table. Finally, it is possible to print the nutritional tables stored in the database (Fig. 4).

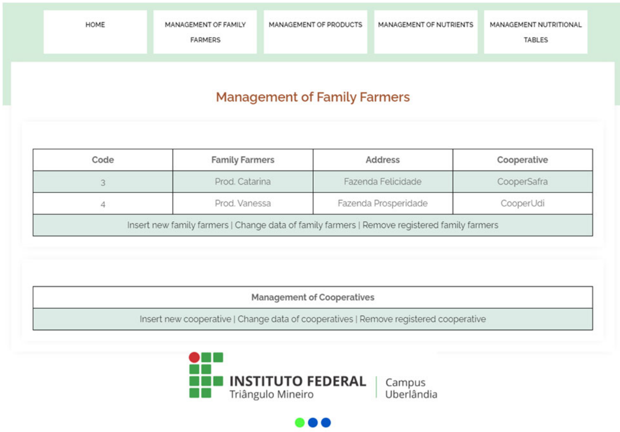

Figure 3. Management of Family Farmers

Figure 4. Print the nutritional tables of a certain family farmer

3. Results

One of the objectives of the extension project was to visit communities and exchange experiences in the area of food handling. Food processing with the application of good manufacturing practices allows longer food preservation, increasing the shelf life of products and offering consumers safe, ready-to-eat food. Fig. 5 shows one of the visits that took place.

Without intending to completely change the producers' work routine, some details were inserted in the handling, in order to improve the quality of the final product and increase the safety of the food offered. Disposable caps were offered to be used in all handling. Training on glass sterilization was also provided to producers, to ensure complete sanitation before receiving the preserves. A handout from the

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Ministry of Health was distributed with all the rules of Good Manufacturing Practices (GMPs) for food. The production of preserves was based on an exchange of experiences, in which the knowledge of rural producers was passed on to students, characterizing the moment of information exchange. At the end, there was training on how to pasteurize the finished product, in order to ensure the elimination of any microorganisms remaining in the process. After the training phase in good manufacturing practices, all recipes for the products sold were compiled in order to produce product labels in accordance with current legislation [6]. Twelve recipes were obtained from different rural producers and all of them were standardized in terms of portions and weight. Seveal products were labeled (Table 1).

Figure 5. Production of preserved vegetables

Table 1. Standardized and labelled products

Item	Product
01	Chili pepper sauce
02	Biquinho pepper sauce
03	Jurubeba preserve
04	Mini cucumber pickle
05	Hibiscus jam
06	Pineapple and pepper jam
07	Milk cream
08	Baked tapioca flour biscuit
09	Corn cake
10	Cornmeal cake
11	Lemongrass lemon cake
12	Carrot cake with chocolate

Fig. 6 shows the nutritional table of the product “Hot pepper sauce” registered in the system by the product’s family farmer.

Besides the table shown in Fig. 6, the list of ingredients and a space for inserting variable information, such as the date of manufacture and expiration date of the product, are made available to the consumer. All tables were printed on adhesive paper and distributed to rural producers. Fig. 7 shows a nutritional label made.

The work leaves us with a necessary and constant thought on the world we live in and what we want to build. The motto of CIEPS is "Solidarity happens in Practice", that is, actions that reflect in the practice of all involved. The project provided a path for the establishment of partnerships of permanent technical collaboration between the Institute and the University, publicizing to the external community the potential of both institutions to offer the public an environment of continuous improvement for the generation of jobs and improvement of the income standard of workers, highlighting solidarity production and local development.

Molho de pimenta
Prod. Catarina
NUTRITION FACTS

Serving per container: 15.0
Serving sizes: 10.0 g (1 colher de sopa)

	100.0 g	10.0 g	%VD*
Calories (kcal)	50.0	5.0	2.0
Carbohydrates(g)	10.0	2.0	2.0
Total Sugar (g)	0.7	0.1	
Added Sugar (g)	0.0	0.0	0.0
Protein (g)	1.0	0.1	0.0
Total Fat (g)	0.0	0.0	0.0
Saturated Fat (g)	0.0	0.0	0.0
Trans Fat (g)	0.0	0.0	0.0
Diatary Fiber (g)	0.8	0.1	0.0
Sodium (mg)	1000.0	100.0	4.0

* Percentage of daily values provided by the serving sizes

Figure 6. Nutritional table for pepper sauce

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Figure 7. Nutritional label for pepper sauce

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A Study on Sustainable Alternatives through Investigative Experimentation Based on the Synthesis of Bioplastics

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Abstract. This study presents the integration of chemistry education and environmental awareness through the synthesis of bioplastics as a teaching strategy. The general objective is to explore and produce sustainable alternatives with the aim of raising awareness among elementary school students about reducing the use of conventional plastics. In the work methodology, we adopted the three pedagogical moments. In the research methodology, we used a written questionnaire as a data collection tool. The results indicate that experimental practice facilitates students' understanding of sustainable alternatives to conventional plastic, although there are challenges in teaching chemistry. We conclude that the practical approach, combined with contextualized issues, promotes environmental awareness among students.

Keywords. Experimentation, Bioplastic, Sustainability, Contextualization.

1. Introduction

Understanding visual representations is considered essential in chemistry education, as the abstract nature of this science is a characteristic challenge for students. Some literature identifies categories of problems to address them systematically [6]. In the environmental field, one of the main issues is the use and disposal of plastics, which are produced from petroleum, a non-renewable resource, and result in persistent environmental waste.

A promising alternative is the development of bioplastics, which can decompose into carbon dioxide, water, and biomass through the action of organisms such as fungi, bacteria, and algae [2]. In light of these educational and environmental challenges, it is suggested to implement a project that integrates theory and practice. To address our concerns, we have the following research problem: How can the production and analysis of bioplastics influence the process of critical thinking about sustainability? Our objective is to explore and produce sustainable alternatives with the aim of raising awareness among elementary school students about reducing the use of conventional plastics.

2. Methodology

The work was carried out by two interns from the Chemistry Teaching Degree program at the State University of Goiás (UEG), and involved 42 students from the 7th, 8th, and 9th grades of elementary school. The intervention lasted for two classes, a total of 1 hour and 40 minutes.

In the methodology of the work, we adopted the three pedagogical moments, an approach based on the principles of the dialogical-problematizing perspective, as described by Crestani *et al.* (2017) [1]. This model, proposed by Delizoicov, Angotti, and Pernambuco (2002) [3], is structured in three moments: initial problematization, organization of knowledge, and application of knowledge. In the initial problematization, which occurs at the beginning of the lesson, we raise questions about the content to be addressed. This stage aimed to engage the students, stimulate curiosity about the lesson topic, and gain insight into the students' prior knowledge. The organization of knowledge was carried out through the practical production of bioplastic. During this phase, students were able to solidify and assimilate the concepts discussed earlier in the initial problematization. The application of knowledge is a phase that has not yet been developed, as it is an ongoing project.

In the research methodology, we used a written questionnaire as a data collection tool. According to Oliveira *et al.* (2020) [4], a questionnaire consists of a series of questions that must be answered in writing. The questionnaire was completed by each of the six participating groups. Due to time constraints, we chose to include only two questions, which focused on obtaining concise and direct feedback on the students' learning experience.

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3. Results and Discussion

In the initial problematization, the following questions were posed to the students: 'What solution would you propose for the amount of waste in the environment?' and 'What measures would you take to balance the use of plastics with the health of the environment?' With these questions, they were able to reflect and share their opinions on the topic and understand the proposed theme of the lesson. In the application of knowledge, the students produced a bioplastic. For this production, the class was divided into six groups, each with approximately seven students. After organizing the room, we handed out the instructions, explained the experiment, and the students began the production of the bioplastic, as shown in Fig. 1.

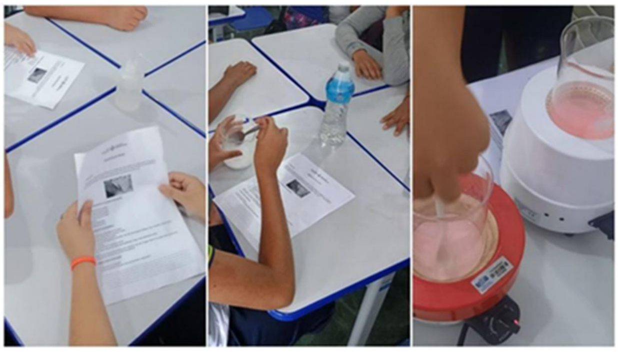

Figure 1. Bioplastic production

For the experiment, the synthesis method employed by De Almeida in 2018 [2] was used, which involved the following reagents and equipment: tapioca, water, glycerin, vinegar, beaker, spatula, heating mantle, and a tray, as shown in Fig. 2. The procedure is simple and uses materials commonly found in everyday life.

Figure 2. Materials and reagents used in the experiment

Finally, the students were able to recognize the importance of the bioplastic they produced, shown in Fig. 3, and understand that with simple reagents, we can conduct experiments.

Figure 3. Bioplastic

At the end of the class, the students answered the questions that were at the end of the experimental procedure. The questions are shown below in Table 1.

Table 1. Questions related to the experiment

1. What would a bioplastic be?
2. What are the main conclusions you drew from the experiment?

All six groups answered these two questions at the end of the experiment. In analyzing the first question, it is evident that the students managed to carry out the experiment and achieve the environmental awareness we aimed for from the beginning of this project: 'It is a sustainable plastic.' However, in the second question, it was observed that the students, being younger and with limited exposure to chemistry, had difficulty formulating a response to the question: 'The experiment is quite interesting and fun to do.' In light of this, it is important to highlight that teaching chemistry faces significant challenges due to the complexity of some of the concepts involved and the need to integrate different levels of understanding, such as macroscopic, submicroscopic, and symbolic models [5]. These difficulties are directly related to students' limitations in learning abstract chemistry concepts. Therefore, the work procedures applied in this project were of great importance and very suitable for helping to simplify some chemistry concepts for students who have not yet had any exposure to this field.

4. Considerations

During the development of the project, it became clear that the students have difficulty understanding chemistry concepts, as they had not been exposed to the content until then. However, this obstacle has helped us develop more contextualized problematizing questions related to their reality. Thus, this work has highlighted the importance of bridging the gap between theoretical knowledge and the students' everyday experiences, as this approach makes learning more practical and easier for them.

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Training of Research Teachers: Innovation and Teaching of Science through Research

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Abstract. This text is the result of ongoing research, aiming to contribute to the training of teachers as researchers for innovation in Science teaching. It is being developed in collaboration with teachers from basic education schools in the state network of Goiás, as well as undergraduate students in Chemistry, Biological Sciences, and postgraduate courses. The data collection procedures used were questionnaires and oral and written narratives. The initial results indicate that the development of projects in Science teaching has the potential to engage undergraduate students as protagonists in the production of knowledge, fostering their ability to seek innovative and collaborative alternatives, while positioning basic education students as protagonists in their own learning.

Keywords. Science Teaching through Research, Education for Science, Research on Pedagogical Praxis.

1. Introduction

The materiality of research on pedagogical praxis and teaching through inquiry is a problem that needs to be investigated and offered possibilities for actions to alleviate the problems, as well as to enhance existing initiatives, such as those we are developing, Paniago et al [1-3]. After all, initial training is not enough to adequately prepare undergraduates to exercise research as pedagogical praxis and as an educational principle. As well Sedano and Carvallho [4] e Nóvoa [5] state that teacher training has been based on the transmission of scientific knowledge and skills, therefore proving to be inefficient in training students and teachers themselves with investigative capacity.

This perspective of education encourages the undergraduate student, a future teacher, to reproduce models and ready-made knowledge, and to adapt to the themes prescribed in textbooks, without a questioning and investigative stance that would enable them to develop their own ideas. Now, if teachers do not develop research into their practice in the classroom with a view to mobilizing different actions for teaching and learning Science, in order to contribute to the construction of new knowledge, how will they work on teaching Science through research? How will they popularize science in basic education?

This justifies the importance of this research, which is currently underway and has as one of its principles the “demystification” of science, overcoming the view of science restricted to academia and towards a view of science for everyone, with the lively, concrete and complete insertion of scientific education focused on research with the teachers and undergraduate students involved in the project, so that they are also, in addition to consumers, producers of knowledge and mobilize it in their pedagogical practice.

In this way, they encourage the development of the critical and investigative spirit of the student so that he or she is able to reflect critically on the impacts of scientific and technological advances. In this sense, it is essential to popularize science, not only in the sense of showing its wonders, as the media in general do, but also to enable people to participate in decision-making. If science and scientific problems originate in real, disturbing situations, linked to people's lives, then why don't schools discuss these issues? Why does science have to be reserved for thinking minds, for powerful scientists? Why does science education develop in a way that is disconnected from students' lives?

2. Methodology

In this qualitative research, we used Alarcão [6] as a basis for defending collective work and a reflective school as a learning community and a place where knowledge about education and teaching is produced collaboratively; and Sedano and Carvalho [7] as they emphasize the importance of collaborative activities between teachers and students in order to work with research and solve problems.

The data collection procedure used was a questionnaire and oral and written narratives with the participants, basic education teachers, internship supervisors; and students of the Chemistry and Biological Sciences Degrees. Melo, Murphy and Clandinin [8] contribute by elucidating that "narrative research is the study of experience understood narratively". Thus, for the authors, the main characteristic of narrative research is that it defines the study of experience, how it is lived and told; However, it is something more than telling and living stories, because narrative research elucidates the experience told in a (re)signified way, after all, whoever tells a story, filters it, highlights what was significant to it. The methodological process of the proposal is carried out according to Fig.1.

Figure 1. Research organization chart

The actions were organized in the form of a cyclical flowchart, since the idea is for the project to be perennial in the teaching practice of the proponents and protagonist participants, enabling the participation of other collaborators to be expanded in a continuous process of generating and transferring innovative educational products/technologies. To this end, a diagnosis was initially made via a Google Forms questionnaire to identify the needs arising from the work of the teachers, and then produce materials; study groups and the production of teaching materials are being developed simultaneously. In addition, we are producing innovative teaching materials collaboratively, using our Labmaker artifacts for modeling the materials, such as (Tinkercad and Blender, both free) and "slicers", applications that promote commands on the 3D printer to produce teaching materials from the 3D model. The labmaker station at Campus Rio Verde, created in 2020, after approval called SETEC, Notice 35/2020, phase I, has several pieces of equipment, such as: 3D pen 3D printer, Notebooks, Smart TV, Tool Kit, Screwdriver/Drill, Jigsaw, Orbital Sander, Arduino/Robotic Kit, Lego Robotic Kit, Multimedia Projector and 3D Scanner.

3. Results and discussion

The results indicate that our objectives are being met, since a diagnosis has already been made via Google Forms questionnaire and we have identified the following difficulties: themes linked to the following axes: Life, Environment, Universe and Technology.

Thus, as a team, simultaneously with the studies of the theoretical and practical elements, guidelines are being organized for the development of investigative action projects in schools focusing on the teaching of Science through investigation, aimed at the 6th to 9th grades, having as a guideline everyday situations based on the aforementioned thematic axes and socio-environmental aspects linked to the Sustainable Development Goals (SDGs).

Several types of materials were produced, such as prototypes of plant and animal cells, prokaryotic cells, atoms, DNA, materials, which were used in real classroom situations by interns under the guidance of teachers from the IES and the basic education school, after, of course, the survey of the school's needs in terms of teaching and learning Science.

Figure 2. Teaching materials produced in LabMaker under our coordination

Thus, we are developing a training itinerary based on a dialectical relationship between the actors, so that everyone is encouraged to be protagonists in the development of actions, systematization and publication of results, a

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perspective that is close to what Zeichner [9] proposes about the idea of the third space in teacher training, "[...] which concerns the creation of hybrid spaces in pre-service teacher training programs that bring together school- and university-based teacher trainers and practical and academic knowledge in new ways to enhance the learning of future teachers".

We are certainly contributing to the initial teacher training process at IF Goiano and to ongoing training in the basic education network of the state of Goiás. In addition to involving basic education teachers, graduate students, and undergraduate students as protagonists, the various learning experiences of teaching, seen in the use of research as a pedagogical practice, are contributing to the improvement of the teaching practices of the teachers involved, and, therefore, directly impacting the improvement of the quality of the teaching-learning process of Science in basic education. Furthermore, it is important to highlight that the research is promoting a dialogue between initial training and teaching work, valuing basic education teachers as co-trainers and as producers of knowledge based on their pedagogical practices, and will contribute to the theory-practice relationship in the training process of undergraduate courses at IF Goiano. We also mention the creation of a MOOC Course – Maker Education and Innovation, developed based on the team's studies over several months [10]. Finally, we hope that with the continuity of the research, as results, we will produce: 1) Didactic sequence for teaching Science through investigation; 2) Interdisciplinary Science Pedagogical Kits with innovative teaching materials using the 3D printer and the assumptions of Maker culture, also containing guidance on working with projects, playful games about the themes worked on in the projects, experiments, interactive models; 3) Extension courses (in-person and MOOC); 4) Book or e-book

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More Science! Considerations on Scientific Literacy in a Public School in Central Brazil

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Abstract. Scientific literacy is a dimension of education that enables individuals to understand scientific knowledge and relate it to reality, using it to make decisions in their daily lives. Due to its relevance, this work aims to characterize the development and organization of the Projeto de Alfabetização Científica (Scientific Literacy Project), promoted by a public school in a Brazilian municipality; present and analyze the results already obtained; and reflect on the impacts of this project on learning and school education. After almost three years of implementation, the results achieved show that the project is viable.

Keywords. Learning, Education, Training.

1. Introduction

Scientific literacy (SL) can be considered as one of the dimensions of the educational process committed to promoting the integral formation of individuals, considering the approach of scientific knowledge integrated with the reality of each generation [1-4]. In this sense, promoting scientific literacy also means providing people with greater cognitive capacity to observe and understand reality based on evidence, demystifying and reinterpreting common sense knowledge [5-7]. In this way, by critically appropriating scientific knowledge, individuals can change their conceptions and daily habits, as well as influencing other people to do the same, including fighting for socio-political changes in their community, region or country [8-11].

It is in primary education that scientific instruction can reach the majority of the Brazilian population, since this level of education is the most consolidated and widespread in the country [12]. In this environment, it is possible to propose and develop pedagogical initiatives that converge to popularize access, understanding, application and transformation of scientific knowledge. Many of them are already widespread and, depending on their planning and development, provide promising results, such as: science fairs or science shows [13-16], practical lessons [4, 17-18], field lessons [19-20] and the use of play [21].

However, there are still factors that make further progress in this schooling process difficult and unfeasible, such as deficiencies in teacher training, a lack of technological resources and laboratories, a shortage of contextualized teaching materials, the dismantling of public educational policies for science teaching, student disinterest and indiscipline [11, 22-25]. In view of this, it is necessary to intensify changes in public policies and the involvement of society, with regard to the process of strengthening and expanding improvements in the teaching and learning process committed to scientific literacy.

To this end, there are initiatives within the school environment that aim to overcome existing difficulties so that scientific literacy proposals become viable and successful. This paper therefore aims to characterize the development and organization of the Scientific Literacy Project promoted by a public school in a municipality in the state of Goiás; to present and analyse the results already obtained; and to reflect on the impact of this project on learning and training in ST.

2. Development

The case study took place at the Cristiano Carlos Friaça Municipal School, a public institution in the municipal education network in the municipality of São Luís de Montes Belos, state of Goiás, in the Midwest region of Brazil. This institution operates in the morning and afternoon with classes from sixth to ninth grade. Located on the urban outskirts, it caters for students aged between 11 and 15 years old, most of whom have unfavorable socio-economic conditions, with low affective and cognitive

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development, which has been aggravated by the occurrence of the coronavirus pandemic.

We chose as our methodology the experience report of the actions carried out within the institution and the analysis of official public documents: the Pedagogical Political Project (PPP) - for the years 2022 and 2024; and financial reports from the public administration of the municipality of São Luís de Montes Belos - for the years 2023 and 2024. The experience report is a methodological approach that allows us to report on experiences other than academic research, such as projects carried out in the school environment [26]. However, its writing has a theoretical basis and critical-reflective elements that make it possible to produce and disseminate new knowledge [26-27].

Documentary research, in turn, makes it possible to revisit data and extract the information needed to broaden our understanding of realities in their historical and social contexts [28]. Considering the objectives of this study, documentary analysis provides a framework for reflecting on decision-making and its impact in the field of education [29].

The Scientific Literacy Project (PAC) was designed taking into account the learning gaps measured in the initial weeks of the 2022 school year, the first post-pandemic to take place with 100% face-to-face classes. The diagnosis was made through oral questions, reading and interpreting information, producing texts and illustrations in science classes. The school's physical structure was also observed, which revealed a lack of specific teaching resources to promote science teaching in a meaningful way, such as zoological and botanical samples, equipment and a laboratory.

Given this reality, the PAC was set up as a pilot initiative for the school unit to be carried out with the aim of overcoming gaps in the teaching and learning process in relation to science teaching, making it possible to build and strengthen a systematic and effective scientific literacy process. All the planned actions took place in stages (Fig. 1), according to budgetary possibilities and student involvement, being revised and adjusted to meet existing demands and those that have arisen to date.

Initially, there were changes to the science lesson plans, mainly in terms of methodology. The approach to the content became quite diversified, using audiovisual resources, field lessons, scientific illustrations, experiments, concrete materials, games and specimens of organisms. These strategies became frequent, raising the students' expectations and interest in taking part in the lessons, especially the experimental ones, where they would play a more leading role, sometimes individually and sometimes in groups.

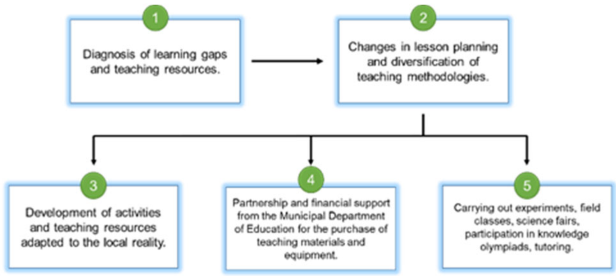

Figure 1. Flowchart of the organization and development of the Scientific Literacy Project, period 2022-2024

In order to ensure the continuity of this stage, it was necessary to develop activities adapted to meet the specific needs, such as case studies, assembling three-dimensional structures, practical lesson plans suitable for the age group of the students, informative texts and flowcharts on biodiversity and local socio-environmental aspects. By reusing plastic and glass containers, it was possible to start assembling zoological collections made up of the corpses of animals found in the region. Models, games and prototypes representing the human body, microorganisms and matter were made using recyclable and low-cost materials.

As of 2023, the purchase of equipment and books to set up a science laboratory began. Even though there is no suitable room to install the items purchased, most of them are used in class, such as microscopes, stereomicroscopes, replicas of organs and glassware. The proper assembly, organization, handling and maintenance of these new resources relied on the collaboration of a school employee with technical knowledge.

The continuous development of the above steps made it possible to organize the institution's first Science Fair, whose works were proposed and carried out by the students, involving the entire school community. In the first semester of 2024, the Science subject also began to include the training of student monitors, who were selected to take part in theoretical and practical training meetings inherent in experimental classes, the organization of zoological and botanical collections, as well as scientific exhibitions.

The progress of the PAC actions was monitored and evaluated by means of photographic records of the students' performance in carrying out the science and text production activities.

3. Results and discussion

The PAC actions developed during the period under analysis covered 292 students in 2022, 303 in 2023 and 360 students in the first semester of 2024, totaling 955 students from the São Luís de Montes Belos municipal public school system.

Gradually, everyday school life began to have specific and holistic activities based on academic knowledge adapted to the context of the final years of elementary school. As a result, many students have developed the ability to relate abstract concepts to real events and to construct and present arguments that are more grounded in the knowledge they have studied. This level of CA is made possible when science teaching starts using challenging and diversified methodologies that encourage student engagement and protagonism [17, 21, 30-32]. In this way, students take on the role of active subjects and participants in the educational process [2, 5].

As an example of the youthful protagonism stimulated by the actions presented, a student from the rural school built a three-dimensional prototype representing the element oxygen to help understand the basic structure of atoms (Fig. 2). Made from cardboard, plastic and recyclable metals, the prototype can be used in class or at science fairs to observe the location and arrangement of the main components of an atom (nucleus and electrosphere), with some structures moving using a system of pulleys and gears. This student work will make it easier to approach abstract concepts in chemistry, physics and biology that many students find difficult to understand through lectures [33-34].

Considering that student experiences consist of preparatory rehearsals for entering the world of work and university, proposals such as PAC can contribute to the formation of subjects with greater criticality, autonomy and engagement to make decisions or act responsibly in society individually and collectively [35-37]. Achieving this ideal is becoming increasingly urgent if contemporary problems are to be tackled with greater seriousness and commitment, such as the climate emergency and social inequalities.

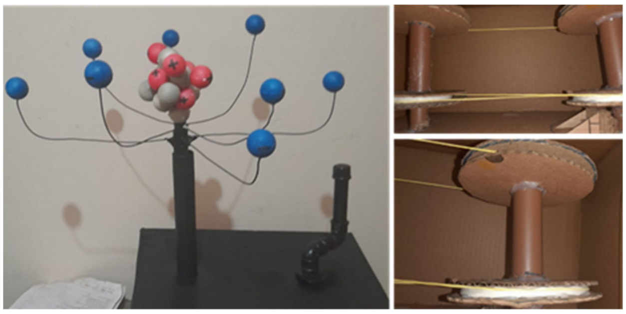

Figure 2. Atomic model made with recyclable materials by a student of the Municipal School Cristiano Carlos Friaça, São Luís de Montes Belos, Brazil

Although no official external proficiency exam focusing on the subject of science has been carried out, improvements in the learning process can be seen in the quality of the technical productions (scientific illustrations, crafts, inventions, science fair); in the performance of the students at the 7th National Science Olympiad [38], who won two gold medals and three silver medals; and at the 27th Brazilian Astronomy and Astronautics Olympiad [39], with two silver medalists) and pre-selected to represent Brazil at the XVIII International Olympiad of Astronomy and Astrophysics and XVII Latin American Astronomy and Astronautics Olympiad in 2025. In all these cases, the students had to understand and relate phenomena and data from different contexts [40-41], a condition that would be difficult to achieve without scientific literacy.

Although these results are modest, they highlight the relevance and need to design and develop integrated and long-lasting actions to promote CA in schools, as significant and wide-ranging transformations are achieved in the medium and long term. It is through these experiences that students will be able to expand and exercise their ability to investigate, analyze, observe, reflect, argue, create and socialize [36, 41-43]. However, this reality cannot materialize

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without improvements in the school structure and teacher training.

The implementation of the PAC is also due to the collaborative effort between the school management and the Municipal Department of Education (SME), which made possible the estimated financial contribution of $ 4255.00 for the purchase of laboratory equipment and various teaching resources. In addition, the SME has continually offered meetings and continuing education courses for the school's teachers to update and improve their teaching practices. The investment and support given to the field school reflects the intention of the local public administration to comply with the public educational policies in force in the country that deal with improvements in teaching and learning conditions, such as the Education Guidelines and Bases Law [44] and the National Education Plan 2014-2024 [45]. This action also contributes to fulfilling the United Nations' fourth sustainable development goal [46]: "Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all."

It is worth highlighting the pioneering nature of the development and implementation of the PAC, which was set up entirely on the initiative of the school unit and later supported and strengthened by the partnership with the SME. Generally, projects and proposals focused on scientific literacy in basic education are planned at universities and implemented in schools [19-20, 47]. In this way, this work highlights the potential that the school community has to build systematized and academic projects with autonomy, polishing its own scientific culture [37]. However, engagement, persistence, ongoing training, commitment and collaborative work between teachers, students, pedagogical coordination, management and public authorities, represented here by the SME, are necessary.

Despite the progress made, investments in the physical structure, acquisition of teaching materials and equipment need to be stepped up. Although it has been designed, the science laboratory has not yet been built and many methodologies have not been put into practice due to the scarcity of items, especially to cater for students with special educational needs. The infrequency and resistance of some students to participate actively in the proposed activities are challenges that still persist and require complex actions, as they are imbricated with the socio-economic and family context. Effective responses will require integrated efforts from various public policies, not just educational ones.

4. Final considerations

The Scientific Literacy Project was structured to meet the specific needs of a Brazilian public school located in an urban periphery, whose students are very heterogeneous and have learning disabilities that were aggravated by two years of school confinement caused by the Covid-19 pandemic. However, its structure and methodologies form a flexible and replicable educational project model, as long as the school community acts in a persistent and articulated manner, supported by an adequate scientific basis and effective public policies.

The holistic and problematizing nature of the methodologies used, coupled with the commitment to transform teaching and learning conditions in Science, shows that a public school can offer the community a quality and meaningful education. Although the results presented in this study refer to the PAC, the progress made in the pedagogical and educational fields of the students transcends all the areas of knowledge covered in the school environment.

It's worth noting that the PAC is still in development. Its actions are periodically reviewed and restructured to meet the demands and challenges that emerge each school year or semester. Robust investments in the physical structure of the rural school are still needed, especially to build and equip the science and computer labs. This will depend fundamentally on state action.

It is hoped that PAC's actions will continue over the next few years, regardless of administrative changes at the rural school and in the political and socio-economic context of the community. Solid transformations in the scientific culture of a population require the implementation of systematized and lasting actions [37, 48], otherwise they become fallacious, obsolete and ineffective.

Initiatives like PAC need to be encouraged, supported and valued. They are becoming increasingly essential, especially in communities

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located in countries where the majority of the population is negatively affected by inequalities, environmental degradation, discrimination and misinformation, as is the case in Brazil.

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The Three Levels of Knowledge and Types of Experimentation: A Thematic Project Based on the Anime "Dr. Stone"

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Abstract. The aim of the research was to identify how experimentation can contribute to primary school students' understanding of the three levels of knowledge. We used three experiments from the Dr. Stone anime theme project to analyze their contribution to students' understanding of the three levels of knowledge. At the end of the analysis, we confirmed that each experiment played its part in showing the levels of chemical knowledge: macroscopic, submicroscopic and representative.

Keywords. Dr. Stone, Experimentation, Three Levels of Knowledge.

1. Introduction

Experimentation plays an important role in the teaching-learning process and can provide students with the opportunity to explore scientific concepts in a practical and engaging way. For this to happen, teachers need to be attentive to the type of experimentation that best favors their class so that it can involve students as a strategy that contextualizes real problems and also creates questions and investigation (Guimarães, 2009).

In order to diversify and carry out more dynamic activities in science teaching, we can use different teaching strategies that enable students to understand the three levels of chemical knowledge (macroscopic, submicroscopic and representative). Brazil advocates the use of contemporary media in order to provide critical analysis. Thus, we used the anime Dr. Stone to carry out a thematic project. This anime tells the story of a world where humanity is petrified and then awakens thousands of years in the future. Through the adventures of the characters, various scientific concepts are presented in an accessible and exciting way.

The three levels of knowledge are: *1) macroscopic*, interpreted by experiences, *2) submicroscopic* abstract concepts that use an intrinsic language and *3) representational*, in which we use formulas and numbers (Melo et. al, 2019). Their use in the classroom promotes an improvement in teaching and learning in science teaching for students, as they acquire a broad visualization of the theory and what happens in the experiment.

In pursuing this theme, our research problem is "How can experimentation contribute to understanding the three levels of knowledge based on studies in a Thematic Project on the anime Dr. Stone?". Therefore, the aim of this research is: To analyze how experimentation can contribute to the understanding of the three levels of knowledge based on studies in a Thematic Project on the anime Dr. Stone carried out with high school students.

2. Methodology

We carried out the thematic project Aniquímica: Dr. Stone in an elective course, held in stage III, with the participation of two students from stage I of a Chemistry degree course at the State University of Goiás (UEG). The class participating in the project consisted of 11 students from the 1st to 3rd year of high school. Although the project was initially planned for 15 meetings, we chose to focus our analysis on three meetings that represent different types of experimentation.

The work methodology was organized in meetings based on the three pedagogical moments, structured as follows by the authors Delizoicov, Angotti and Pernambuco (2002): *Initial problematization*, *Organization of knowledge and Application of knowledge*. Initial problematization presents real issues questioned in a reflective way, Organization of knowledge the problematization is organized by the teacher's guidance and Application of knowledge, here we interpret the initial ideas and others that can be explained by the same knowledge (Muenchen et. al, 2012). We also aim to address Johnstone's (1982) three levels of knowledge, phenomenological, theoretical and representational. There is a variety of nomenclature for the levels of knowledge (Soares, 2019).

In the research methodology, each experiment was carried out in a different way with variations in its approach and set-up - problematizing, investigative and predictive experimentation, observation and explanation. We used different types of experimentation approaches in order to explore different aspects of the teaching-learning process, from the initial problematization to the application of the knowledge acquired. By adopting this diversified approach, we aim to stimulate students' critical and investigative thinking.

3. Results and discussion

Following the chronology of the anime Dr. Stone (first season), we set up the meetings to present scientific concepts in an explanatory way, differentiating fantasy from reality.

3.1. Extraction of cabbage and lemon leaves

In one lesson, we worked on episodes 1 and 2 of the first season. The students carried out simple extractions, macerating and then heating on a hot plate, in order to obtain green pigment from the cabbage and essence from the lemon. Divided into two groups and without a pre-defined script, they were guided by the trainees to carry out the extraction procedure, resulting in dynamic and participatory learning.

Figure1. Experiment carried out; lemon and cabbage leaf extraction

Illustrative experimentation is one of the most widely used in schools, as it consists of reinforcing the theory that was seen in class with the aim of integrating theory with practice (Taha, Marli Spat et. al, 2016) in a way that makes it better to visualize levels of knowledge. In this lesson, experiment "A" was carried out after the explanation of extraction, and the students used the method closest to what was done in the anime. They therefore reinforced what they had seen in the explanation and in the anime in a macroscopic way.

3.2. Soap bubbles

For this meeting, we used an excerpt from episode 7, where the protagonist solves "spells" with science. This episode shows experiments such as a flame test, a static generator with a sulphur ball and the simplest, soap bubbles. We decided to use the soap bubble experiment to start the lesson.

We demonstrated the process to the students in a transparent basin, encouraging them to understand the principles behind the formation of bubbles, stimulating reflection, questioning and curiosity.

According to Freire (2005), problematization aims to stimulate students' critical and reflective thinking, encouraging them to question and seek solutions to the problems presented. In experiment "B", the students were encouraged to reflect on the process of forming soap bubbles and discuss the best approach to obtain the desired result. This type of experiment promoted the active participation of the students, in order to stimulate the development of their critical sense and scientific curiosity.

3.3. The alchemists' dream: The bronze coin that becomes gold

In this meeting we used excerpts from episodes 7, 8 and 9, in which we dealt with the theme of metals. We emphasized the scene in episode 7 when the protagonist turns a stone spear into "gold". We carried out the experiment "The alchemists' dream", in which a 5 cent coin was transformed into "gold" in a demonstrative way. The students recorded their predictions and observations during the experiment and were encouraged to reflect on the process and its scientific explanation using a method known as prediction, observation and explanation (POE).

According to Taha, Marli et. al (2016), investigative experimentation is similar to scientific research, which involves developing hypotheses, carrying out experiments and drawing conclusions based on the results obtained. In experiment "C", the students were challenged to predict the outcome of the experiment before carrying it out. Out of 10

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students, 6 said that the coin would be clean, 3 that it would change color and 1 that the metals would melt. During the experiment, we kept asking them questions so that they would observe carefully and be able to understand and explain what happened at the end of the experiment. This method allowed the students to understand the process presented in the anime at a submicroscopic level, promoting a deeper understanding of the concepts covered.

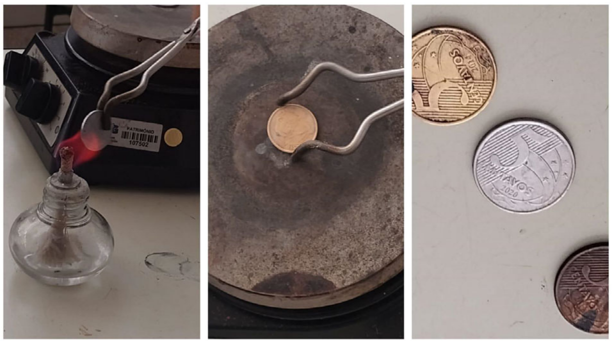

Figure 2. Alchemists' dream experiment

4. Considerations

From the brief analysis carried out, we understand that each type of experiment chosen and carried out had its contributions to the teaching-learning process. Therefore, the teacher can choose the one that best fits and enhances their class, so that they can encompass the three levels of knowledge in the lesson. Another important point is how we can use the media to make lessons dynamic and bring scientific subjects from the classroom to discuss a real problem that makes sense to the students.

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Color Chemistry: Experimentation and Integration of the Three Levels of Knowledge in Basic Education

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Abstract. The main objective of this research is to understand how experimentation, through the three levels of knowledge, can influence the learning process of students in Basic Education, using a thematic project within an elective course. The methodology of this study utilizes the three levels of chemical knowledge: a) phenomenological; b) theoretical; c) representational. As part of the research methodology, participants answered a questionnaire consisting of two open-ended questions and one closed-ended question. This allowed us to highlight some student perceptions regarding the integration of theoretical and experimental content.

Keywords. Colors, Dyes, Experiments, Three Levels of Knowledge.

1. Introduction

Experimentation in Chemistry teaching is a dynamic strategy that generates questioning and discussions in the search for explanations for observed phenomena [7]. According to Silva, Machado, and Tunes [8], experimentation in teaching is an important activity for connecting phenomena and theories. While it does not concretize the theory, it promotes the development of thinking and the formation of hypotheses. However, Galiazzi and Gonçalves [2], emphasize that experimentation should not be just a mechanical technical procedure, but rather an investigative approach that contributes to the construction of scientific knowledge by students. In this way, educators seek to avoid decontextualized approaches to content [2].

In this context, the theme of colors, as highlighted by Kraisig [4], is relevant in education since colors are present in many everyday objects, influenced by dyes found in foods, objects, and fabrics. Therefore, a project on colors not only enriches student learning but also promotes experimental activities that encourage active participation and the understanding of contextualized scientific content. Thus, the following research question arises: "How can experimentation and the integration of the three levels of knowledge influence the learning process of Basic Education students through the chemistry theme of colors?"

The use of experiments on the chemistry theme of colors can be an excellent approach for Basic Education. Students can extract natural dyes, understand the additive concepts of colors, explore the electromagnetic spectrum, and understand the principles of color theory and Newton's Disc. Therefore, the objective of this research is to understand how experimentation, through the three levels of knowledge, can influence the learning process of students in Basic Education through a thematic project within an elective course.

2. Work procedures

This project was developed during the Supervised Internship III by two student teachers from the UEG Chemistry Licensure course. It was carried out within the elective course "Chemistry of Colors," with 10 high school students from a public school in Anápolis, Goiás. Originally planned for 15 sessions, this excerpt covers the first six sessions, following the methodology of the three levels of chemical knowledge by Johnstone [3]: phenomenological, theoretical, and representational. This approach allowed exploration from a macroscopic understanding of matter to the use of symbolic representations such as formulas and equations, to integrate different forms of learning in Chemistry [5].

The proposed project covered three main topics: Pigments, the History and Curiosities of the Chemistry of Colors, and Color Theory and Newton's Disc. We addressed the phenomenological aspects by introducing contextualized questions related to the proposed theme, to encourage students to observe in detail the macroscopic aspects of matter. In the second level, we used slides and videos to present the theory and submicroscopic aspects of matter. Finally, in the representational level, we conducted experiments and practical activities that

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represented the concepts discussed in previous classes.

In the research methodology, participants answered a questionnaire consisting of two open-ended questions and one closed-ended question. The analysis of this data seeks to investigate the approach used in the Chemistry of Colors project. The responses were analyzed qualitatively, aiming to identify patterns that highlight the effectiveness of the teaching methodology, the challenges faced, and suggestions for improving experimental practices.

3. Results and Discussion

The following topics were addressed at different levels of knowledge: phenomenological, theoretical, and representational.

3.1. Pigments

This content was divided into two sessions. In the first session, we began with an initial problematization using a fruit basket and problem-posing questions such as, "Do you believe that the colors present could influence the nutritional properties of these foods?" Additionally, the students cut these fruits and added them to a beaker with different solvents to observe the dyes present.

This activity explored the phenomenological level of knowledge. At the theoretical level, we used slides to highlight pigments such as chlorophyll, anthocyanins, and carotenoids, relating them to submicroscopic aspects of knowledge. In the second session, the students extracted chlorophyll pigments from kale and performed paper chromatography (Fig. 1), an activity that falls under the representational level of knowledge.

Figure 1. Chlorophyll extraction and paper chromatography

3.2. History and Curiosities about the Chemistry of Colors

This lesson was divided into two sessions. In the first session, we used questions about natural phenomena such as "Why is the sky blue?" and "Why do leaves change color in the fall?" to introduce the macroscopic level. Then, we used visual resources like slides and videos to discuss primary, secondary, and tertiary colors, the additive mixing of colors, and the cones present in the human retina, addressing submicroscopic aspects of knowledge. To reinforce learning, we used a digital activity on Kahoot. In the second session, the students created flashcards about color wheels (Fig. 2), which stimulates the representational level of knowledge.

Figure 2. Color wheels

3.3. Newton's Disc

We began the lesson with questions about the rainbow, such as "What is a rainbow?" and "How is it formed?" to connect with the macroscopic level of knowledge. Next, we presented information about Newton and his contributions to science, including his theory of colors and the introduction of Newton's disc, to address the submicroscopic level. To conclude, the students engaged in a hands-on activity by creating Newton's disc (Fig. 3), reinforcing the representational aspect of learning.

Figure 3. Newton's Disc

To assess student satisfaction with the teaching methodologies used, a questionnaire was conducted. This aimed to provide insight into the students' learning experience. The data obtained consists of the following questions presented in (Table 1).

Question 1 aimed to evaluate the students' perception of the effectiveness of the approach used in the project by integrating theoretical and experimental content. Analyzing the students' responses: E1: "Very good, as I acquired a lot of knowledge regarding colors and the chemistry involved in them in this project." E2: "Very good, the explanations were very specific, and I was able to understand the concepts in more detail."

Table 1 - Questionnaire

1. How do you evaluate the approach in the "Chemistry of Colors" project regarding the integration of theoretical and practical content? **2.** What were the most significant aspects of your learning during the project sessions? Please explain. **3.** What was the main challenge you faced while participating in the project? **A.** Understanding theoretical concepts **B.** Performing practical activities **C.** Relating theory to practice **D.** Other (please specify)

The responses from students E1 and E2 support Silva, Machado, and Tunes [8] proposal that the ability of theories to generalize and predict gives experimentation an investigative character. Additionally, it suggests a positive connection with Galiazzi and Gonçalves [2] approach, which emphasizes the importance of an investigative approach in the construction of scientific knowledge by students.

Question 2 aimed to identify the most significant aspects of the students' learning during the project sessions. Among the responses obtained, the following stand out: E3: "The practical classes, as we were able to apply the concepts from the theoretical classes." E4: "Through both theoretical and practical classes, as everything addressed in theory was confirmed in practice."

The responses from students E3 and E4 highlight the importance of both practical and theoretical classes in learning during the project sessions. Silva and Machado [7], Silva, Machado, and Tunes [8], and Galiazzi and Gonçalves [2] emphasize that through experimental classes, students can not only understand concepts abstractly but also in real situations.

Question 3 aimed to analyze areas that may require more attention in the project. Four out of the five students who answered the questionnaire selected option A) relating theory to practice, and one student chose option D) other, without specifying. These results suggest that students still face difficulties transitioning between different levels of chemical knowledge, highlighting the need for future research with a more integrated approach focused on the connection between theory and practice. As emphasized by Melo [6], although chemical language may seem simple and easy for educators, students still face difficulties transitioning between levels of knowledge due to its complexity. Therefore, it is necessary to continue promoting discussions of the three levels of chemical knowledge and use appropriate demonstrative and investigative strategies within the context.

4. Considerations

The activities planned in the project provide Basic Education students with opportunities to learn through experimentation and contextualization. However, students face challenges when transitioning from the phenomenological level to the theoretical level. The ongoing work addressing this perspective indicates recognition of the importance of overcoming students' difficulties in understanding the submicroscopic nature. This demonstrates a commitment to improving teaching and providing more effective learning by integrating pedagogical strategies that help students understand scientific concepts.

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Exploring The Cerrado Biome: The Inverted Forest

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Summary. This paper reports on the experience of applying the Investigative Teaching Sequence, Cerrado: “The Inverted Forest”. The aim was to promote meaningful learning about the Cerrado through an investigative methodology. Applied to 28 students from the 6th to 9th grades of elementary school in Anápolis-GO, the methodology included carrying out a variety of activities, resulting in active engagement by the students, who were interested and curious. The students took a leading role in planning actions, such as presentations and the creation of a themed room on the Cerrado, as well as distributing native tree seedlings, highlighting the importance of the Inverted Forest.

Keywords. Teaching, Investigative Approach, Meaningful Learning, Cerrado.

1. Introduction

The theme of the Cerrado is extremely important in the educational context, as it gives students closer contact with the biodiversity and sustainability of this Brazilian biome. However, the subject appears very superficially in textbooks. When analyzing the textbooks in Natural Sciences and their Technologies of the National Textbook Program in 2021, it was shown that there was a reduction in content about the Cerrado biome [1]. As such, this teaching resource does not fully cover the skills proposed in the Curriculum Document for Goiás (DCGO) for the final years of elementary school.

In the curriculum practiced in the state of Goiás, in the final years of primary school, in the are a of Natural Sciences, the topic is worked on in the Science curriculum component, in the 7th grade. This curriculum document establishes that at the end of primary school, students should identify the characteristics of the Cerrado, highlighting its predominance in Goiás, understand the Cerrado's water potential, analyse the importance of the Cerrado for the local ecosystem, recognize the biodiversity present in the Cerrado, relate the characteristics of the Cerrado to its conservation, understand the importance of preserving the Cerrado for the environment and society, identify the main threats to the Cerrado and possible conservation measures, apply concepts of sustainability in relation to the Cerrado and develop skills in observing, analyzing and interpreting natural phenomena related to the Cerrado.

In this context, after analyzing the students' previous knowledge on the subject, an Investigative Teaching Sequence (SEI) was created with the aim of being a potentially significant material for primary school students to facilitate learning about the Cerrado.

Different teaching resources were used in the SEI, highlighting the importance of acquiring knowledge through reading the textbook: Cerrado, the Inverted Forest; the use of digital tools and technologies in the classroom; the importance of presenting students with visual and concrete information through an interpretive trail on the Cerrado; experimental activities to verify the veracity of the theories studied and the construction of knowledge; and finally, the presentation of a thematic exhibition on the Cerrado in which students presented the learning acquired in the context of the elective subject: The Cerrado.

Thus, this work aimed to report on the development, application and evaluation of an Investigative Teaching Sequence (SEI), from the perspective of meaningful learning, impacting the teaching and learning of Science with a focus on the Cerrado and using different educational resources.

2. Teaching Resources and the Teaching - Learning Process

In order for the teaching-learning process to take place, teachers look for different teaching resources to help them in the arduous task of making sure that knowledge reaches the student. A teaching resource can be defined as any material, equipment or educational technology used to help the teacher, with intentionality and planning [2]. It is therefore a means of facilitating the teaching-learning process. They can be classified, according to the author, as natural, pedagogical, technological and cultural, examples being: the blackboard, chalk or paintbrush, the textbook, the paradidactic book, natural elements, scientific experiments, engravings, murals, library, museums, internet, television, computers etc.

The use of a variety of teaching resources is an important strategy for facilitating learning and overcoming the gaps left by traditional teaching, which is often based on a single resource, usually the textbook [3].

It is important to emphasize that the almost exclusive use of textbooks plus blackboards and chalk/paintbrushes makes the teaching-learning process demotivating [4]. On the contrary, the use of different resources makes lessons more engaging and dynamic, contributing to students' interest in the content and potentially promoting meaningful learning.

3. Teaching Science by Inquiry and Meaningful Learning

Inquiry-based science teaching is a didactic approach that values the active action of students in the learning process and allows them to develop argumentation and knowledge-building skills [5].

In this way, instead of passively receiving information, students are motivated to investigate, question and discuss the content presented. In this way, the investigative methodology allows students greater autonomy and responsibility for their own learning, stimulating critical thinking and problem-solving skills.

For this didactic approach to be effective, it is essential that teachers create an environment conducive to learning, favoring dialogue, questioning and teaching resources that facilitate learning, contributing to the formation of students who are protagonists of their learning, and that this is meaningful for the student.

Learning can be considered meaningful when students are faced with new concepts and are able to understand them, explain them in their own words and solve related problems [6]. Significant learning is characterized by the interaction between new knowledge and that considered relevant, which is already structured in the learner's mind. There is a need to have a pre-disposition to learning and to have potentially significant educational materials for such learning to take place.

4. Methodological Procedures

The research methodology adopted is qualitative, with the aim of gaining an in-depth understanding of a phenomenon by exploring different perspectives and the meanings that participants attribute to their experiences [7]. The research is classified as applied and explanatory, aiming to identify the factors that influence the occurrence of phenomena. Field research was used to collect data from 28 students in the 6^{th} to 9^{th} grades of elementary school at a full-time education center in the city of Anápolis, Goiás.

The research was carried out according to the stages and descriptions of the actions taken, as shown in Table 1.

Table 1. Summary of the actions carried out in the SEI stages: Cerrado, the Inverted Forest

Steps	Actions taken
Problematization	A round of discussions with the students, encouraging them to put forward their hypotheses and assumptions in response to the question “Why is the Cerrado the most threatened biome in Brazil?”
Building and expanding knowledge.	Reading the text: “Cerrado: THE INVERTED FOREST”, Visit to the Tatu Trail, a Cerrado Ecological Reserve located on the campus of the State University of Goiás, in order to experience the Cerrado.
Synthesis, communication of results and evaluation	Creating videos with photos and data collected on the Tatu Trail. Making posters and ipês trees (yellow and pink). Collecting elements representative of the Cerrado, such as fruit, seeds, flowers and animals (images, sculptures, etc.).

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	Textual productions on the theme Rehearsal by a group of six students for a dance performance to the tune of the song “Frutos da Terra” by Marcelo Barra. Setting up a Cerrado-themed room. Presentation of the knowledge acquired to the community to raise awareness about the preservation of the Cerrado. Distribution of native Cerrado tree seedlings to the community.

5. Experience report

The problematization provided an active approach, encouraging the students to formulate hypotheses and explore relevant questions on the subject of the Cerrado.

The students were initially shy, but after the teacher's questions, they expressed various opinions on the reasons why the Cerrado is Brazil's most threatened biome. This initial interaction served to mobilize the students' prior knowledge and encourage them to express themselves, promoting a joint construction of learning.

In order to build and expand the students' knowledge of the Cerrado, the students were asked to read the text, Cerrado: The Inverted Forest, a teaching resource that is part of the dissertation “Cerrado: The Inverted Forest - Investigative Methodologies for Promoting Meaningful Learning about the Cerrado”, from the Postgraduate Program in Science Teaching at UEG. The text aims to integrate reading with the digital environment, encouraging students to explore the theme of the Cerrado, carry out investigations and use digital resources to collect and analyze data. The reading was conducted in the classroom, with the intention of promoting meaningful learning, allowing students to incorporate new knowledge about the Cerrado into their cognitive structure.

The teaching resource presents information in a logical and coherent way, helping students to understand the characteristics of the Cerrado, its phytophysiognomies and the importance of biodiversity, as well as the role of students in preserving this biome.

The proposed activities included the use of digital technology, favoring interaction with the theme, evidenced by discursive activities, conversation circles and poster productions that highlighted the importance of the Cerrado's biodiversity. After studying the textual material, the students carried out activities on the Tatu Trail, a Cerrado Ecological Reserve at UEG.

When they arrived at UEG, they were greeted by monitors and divided into six teams, each with the name of a Cerrado animal. On the trail, they observed the vegetation, soil and characteristics of the environment. At strategic stops, such as the viewpoint and the Dry Forest, they discussed the characteristics of the Cerrado and the importance of fires.

In the Gallery Forest, they noticed differences in temperature and humidity. When they reached the stream, they identified pollution and reflected on its causes. After the trail, they carried out activities in laboratories, exploring the soil and analyzing collected samples. The students reported on soil characteristics and created plant exsiccates, relating their practical observations to the theoretical content they had learned, as illustrated in Fig. 1.

Figure 1. Activities carried out in the biodiversity laboratory - UEG

The field and laboratory activities were essential for meaningful learning, allowing the students to take greater ownership of their knowledge about the Cerrado.

At the stage of summarizing and communicating the results, the students, in collaboration with the management team, developed a plan of activities to share their learning about the Cerrado with the school community. Among the proposals were the creation of a learning video and a physical exhibition about the biome, including materials produced, representative elements and even the distribution of native tree seedlings.

The Cerrado Exhibition included artistic presentations and the dissemination of information about the importance of trees for preserving the environment.

During the presentation, the students demonstrated a deep understanding of the Cerrado, mentioning its biodiversity and the relationship between trees and the hydrological cycle. The students' speeches reflected confidence and interest, showing how they had appropriated the knowledge acquired during the project. The experience was aligned with Ausubel's Significant Learning theory, which emphasizes the connection between new knowledge and previous experiences [8]. Thus, the sequence of activities had a significant impact on the students' learning, as they showed themselves to be protagonists in their educational process.

6. Considerations

During the implementation of SEI: Cerrado a Floresta Invertida, a positive impact on student learning was observed. The methodology proposed investigative activities that provided a theoretical and practical insight into the Cerrado, including a visit to the A Trilha do Tatu ecological reserve. This approach, which moves away from the traditional teacher-centered view, fostered student autonomy, allowing them to actively participate in their science learning.

The students carried out research, teamwork, reflections, hypothesizing and presentations, emphasizing the importance of preserving the Cerrado. The activities, which included discussions, creating posters and distributing native seedlings, helped raise awareness among the school community about the threats to the biome and its conservation.

SEI was an enriching experience that promoted significant knowledge and environmental awareness. Combining prior knowledge with practice proved to be essential for successful teaching and learning, resulting in deeper learning, where students not only assimilate information, but also apply it in real contexts.

It is hoped that the reflections arising from this experience will be disseminated, contributing to the appreciation and protection of the Cerrado.

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3D Printing in Science Education: A State of Knowledge Survey

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Abstract. This work was based on a state of knowledge survey, which is a study that addresses a sector of publications on a topic studied, the research was carried out in Dissertations and Theses on the website of the Coordination for the Improvement of Higher Education Personnel. The present research is qualitative and quantitative**.** This article, in addition to providing an overview of 3D printing in Education, also aims to provide bases for future research on the subject, thus contributing to national education and research for future editions of this event on this technology that has increased in dissertations in our country.

Keywords. 3D, CAPES, Science Teaching, Printing.

1. Introduction

3D printing corresponds to a technology that can be used to manufacture a wide variety of structures from three-dimensional models [1]. The use of this technological equipment consists of printing layers of different materials such as filament or resin, one on top of the other, successively, having three dimensions being height, length and width. It has been used in medicine, engineering, exact and earth sciences, health sciences and many other fields of knowledge as found in the Catalog of the Coordination for the Improvement of Higher Education Personnel - CAPES.

The use of this technology in higher education is also not new, in medicine for prototyping [2], in civil construction [3] and in bioengineering [4], education we find in Biological Sciences courses the construction of didactic models in the 3D printer: a significant approach to the teaching of embryology [5]; the use of 3D models in the teaching of human embryology [6]; and the importance of using 3D printed didactic resources in the teaching and learning process of zoology [7] also in Chemistry [8-10], Physics and in Natural Sciences in Middle School.

We also noticed the use of this technology in Basic Education, which is recent, however 3D anatomical models in the teaching-learning process in Middle School have already been used to introduce the concept of Sexuality Education [11] and the use in a degree course in Physics thinking about future use in the classroom in High School in am process to use 3D printing technology in the construction of didactic instruments for science teaching [12].

For Carvalho *et al.* [13], the benefits of using 3D printed models in the approach to education content are several, such as the possibility of quickly producing several copies of the model of interest, helping in spatial education and tactility, since the student can touch and move the model in all its dimensions [14], stimulate exploration, collaborative work and dialogue [15], although when used excessively 3d models can cause frustration, physical fatigue, exhaustion, boredom and occupational panic [16].

For Pires and Júnior [17], 3D technology has been gaining a growing space in education, driven by several factors, such as the wide dissemination in the media, the emergence of new techniques and materials, as well as the development of low-cost technologies and the availability of open source software on the market. At the same time, the distribution of 3D printers to some basic education schools and the growing interest around the competencies and skills needed to operate these tools have contributed to their popularization [18].

In addition, there has been a significant incentive for teachers to take improvement courses, aiming at the use of this technology for the classroom. This technology also has potential in promoting accessibility for students, expanding the possibilities of educational inclusion [19].

Intending to research the use of 3D printed materials in teaching in *Strictu sensu* Graduate works at the gate of the Coordination for the Improvement of Higher Education Personnel - CAPES, which is one of the main search sites as a catalog of Theses and Dissertations institutionalized in Brazil of academic

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production, being, therefore, also one of the national search engines.

In this context, the objective of the work described in this article was to analyze the state of knowledge of theses and dissertations on the CAPES website. Seeking to know the following questions: What are the titles found after refining the search? Which disciplines are most recurrent? In what years did they appear the most? Thus seeking to know more about the theme for the production of more materials and articles.

2. Methodology

This work was based on a state of knowledge survey, which is a study that addresses only one sector of publications on a studied theme [20], the research was carried out in Dissertations and Theses on the website of the Coordination for the Improvement of Higher Education Personnel - CAPES. The present research of the work described in this text is of a qualitative and quantitative nature, as the quantitative information is relevant to the results of the research to be intertwined. Regarding the qualitative research, we will do a documentary analysis. According to Rosa [21], when there is a large number of articles to carry out analysis, this type of investigation is more advantageous, mainly because we aim to highlight the production of the theme in Dissertations and Theses.

3. Results

We performed the search for the keyword 3D on the CAPES *Thesis and Dissertation Catalog* [22] website in which we found a total of 4,475 works, 2820 dissertations and 1288 theses, we continued to refine the results by selecting specific fields of interest for this search. We marked in the Large Knowledge Area the Multidisciplinary field that consisted of 284 works, followed by the Area

Knowledge in which we selected the Teaching of Science and Mathematics with 47, in the Evaluation Area the field of Teaching remained at 47, in the Area of Concentration the fields Science, Technology and Educational Environment, Science and Mathematics Teaching, Science Teaching, Science Teaching and Mathematics Education, Science and Mathematics Teaching, Teaching and Learning of Natural Sciences and Mathematics, Science Teaching, Mathematics Education and Engineering Education with 24 works. Finally, the Program Name field. After selecting all fields, we found 21 (twenty-one) dissertations, 17 (seventeen) in Professional Master's Degree and 4 (four) in Academic Master's Degree, no theses were found. Table 1 shows the quantities found in the selected Areas and fields, the works are repeated in more than one field.

Table 1. Area, selected fields and number of dissertations

Area	Selected field	Nº
Large Area Knowledge	Multidisciplinary	284
Knowledge Area	Science and Mathematics Teaching	47
Evaluation Area	Teaching	47
Area of Concentration	Science, Technology and Educational Environment	1
	Science Teaching	4
	Teaching Science and Mathematics Education	1
	Teaching Science and Mathematics	16
	Teaching and Learning Natural Sciences and Mathematics	1
	Science Teaching, Mathematics Education and Engineering Education	1
Program Name	Science and Mathematics Teaching	10
	Science Teaching	4
	Scienceand Mathematics Education	1
	Andeducation for Science	1
	Science Teaching	1
	Teaching Science and Mathematics Education	1
	Teaching of Natural Sciences and Mathematics	1
	Teachertraining for Sciences,Technologies, Engineeringand Thematic	1
	Scientific, Educational and Technological Training	1

In this research we can perceive an increase in interest in Science Teaching on the theme in dissertations, we found publications starting in 2014. It follows "Graphic1. Quantity of

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dissertations by year of publication" with the quantity by year.

In this research we are only interested in the works in the area of Sciences that used 3D technology in the form of a printed model, some dissertations brought the use of the expression 3D as a three-dimensional figure, but in a virtual way, as a virtual game, or educational software, or interactive animation or manually produced, after separating all the works We checked the titles, year of publication and the institution. In a sample of 9 papers, four (4) focus on Biology, three (3) on Chemistry, one (1) on Physics and one (1) on Natural Sciences in Middle School. This is how the dissertations found in "Table 2. Dissertations developed, year, program and institution."

Graph 1. Quartet of dissertations by year of publication

Table 2. Developed dissertations, year, program and institution

Title	Program	Instition
Models made with a 3d printer for teaching molecular geometry in Chemistry [8]	Professional Master's Degree in Science and Mathematics Teaching	Federal University of Acre- UFAC
The construction of didactic models in the 3D printer: a significant approach to the teaching of embryology [5]	Professional Master's Degree in Natural Sciences and Mathematics Teaching	CState University EEnters This
The use of 3d models in the teaching of human embryology [6]	Professional Master's Degree in Science and Mathematics Teaching	Federal University of Acre- UFAC
Sexuality education through workshops and 3d anatomical models, in the teaching-learning process in Basic Education [11]	Professional Master's Degree in Science and Mathematics Teaching	Federal University of Acre- UFAC
Importance of the use of 3D printed didactic resources in the teaching and learning process of zoology [7]	Professional Master's Degree in Science and Mathematics Teaching	Federal University of Acre- UFAC
Design and construction of flexible and modular molecular models for 3D printing [9]	Professional Master's Degree in Science Teaching	Fundation Federal Pampa University
A process to use 3D printing technology in the construction of didactic tools for science teaching [12]	Master of Science in Education	- State University - UNESP
The use of 3D technology in the construction of pedagogical models as a facilitating instrument in the identification of venomous and non-venomous snakes [23]	Professional Master's Degree in Science and Mathematics Teaching	Federal University of Acre- UFAC
The updating of didactic models, in the form of analogies, in		Federal University of Pernambuco

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the teaching of 3d isomerism: an investigation of teaching knowledge with Chemistry teachers [10]	Master's Degree in Science	

In the research produced, the first category analyzed was the title based on the search for the expression 3D in the Quantitative Information Panel of theses and dissertations, we bring for better visualization of the most frequent words in the titles a cloud of words. Silva and Jorge [24] explain that word clouds are graphic resources that represent the frequency of words used in a text.

In the case of this work, the cloud was built for the words present in the titles of the articles. Through ready-made algorithms, it is possible to construct images made up of dozens of words whose dimensions indicate their frequency or thematic relevance. They are usually used as mere illustrations, although here we are interested in the perception of the most central issues of 3D research in Science Teaching in the dissertations found.

Thus, in Fig. 1 word cloud built from the titles of the dissertations", in relation to the titles, the word cloud highlights, mainly, the term 3D, then teaching, followed by the words: models, didactics, construction, process, among others, considering that these words were the most recurrent in the titles.

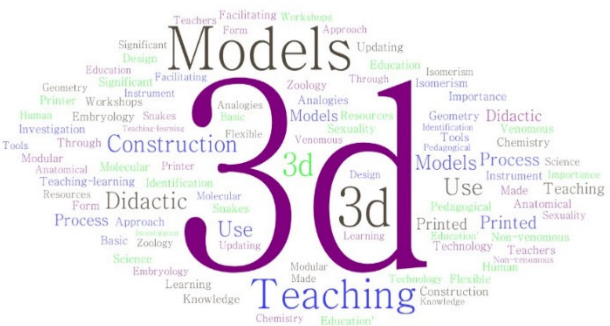

Figure 1. Word cloud built from dissertation titles

4. Final considerations

The theme of this article is 3D research in the area of Knowledge of Science Teaching. The objective, as seen, is to explain the panorama of educational research aimed at the use of 3D printing as a didactic resource, as well as its trends, thus providing bases for future research that addresses the same theme. A table of the area of Knowledge, area of Concentration and names of Graduate programs was produced the importance of the theme in recent years, observing a greater production with emphasis on the Higher Level. We also present a graph with the number of these dissertations per year, a word cloud based on the titles.

This article, in addition to providing an overview of 3D printing in Education, also aims to provide bases for future research on the subject, thus contributing to national education and research for future editions of this event on this technology that has increased in dissertations in our country.

5. Acknowledgment

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The Importance of Teaching Relativity in High School: Relationship with Technologies and the Popularization of Science

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Abstract. This article discusses the importance of teaching the Theory of Relativity (TR) in high school by exploring how digital native students use technologies to search for information on topics related to TR. The research involved applying a questionnaire to 92 first-year high school students, analyzing their interactions with different sources of information and their understanding of advanced physics concepts such as relativity and black holes. The data were analyzed quantitatively and qualitatively using multiple regression analysis to correlate student performance with the sources of information used. The results revealed significant variations in understanding concepts, highlighting the influence of search engines and social media on students' learning. From this, the need for pedagogical and scientific dissemination strategies that promote a deeper and more critical understanding of science is discussed.

Keywords. Relativity, High School, Scientific Dissemination, Science Popularization, Digital Natives, Black Holes.

1. Introduction

The teaching of physics in high school is one of the main ways to provide scientific training for young people, preparing them to face a society increasingly permeated by technological advances and scientific challenges. Among the advanced concepts discussed in the school curriculum, the Theory of Relativity (TR) formulated by Albert Einstein emerges as one of the most significant. This theory, which revolutionized the understanding of space, time, and gravity, has direct applications in technologies that students use daily, such as the Global Positioning System (GPS). Despite its importance, relativity is often considered a difficult topic for students to grasp, partly due to its abstract complexity.

This research was motivated by the need to understand how students, characterized as digital natives, use information technologies to learn complex scientific concepts such as relativity. These young people, who have grown up in an environment immersed in digital technologies, have a unique relationship with learning, where the internet and social media play central roles in the search for information. However, the abundance of information available in the digital age brings with it challenges, such as the dissemination of low-quality or incorrect content.

Moreover, scientific dissemination and the popularization of science play crucial roles in the formation of a critical and informed society. In this context, this study seeks not only to evaluate students' performance in issues of relativity and gravity but also to explore how different sources of information influence this performance. In the end, the importance of teaching strategies and scientific dissemination that promote a deeper and more critical understanding of science is discussed.

2. Literature Review

2.1. Theory of Relativity in High School and the Role of Scientific Dissemination

The Theory of Relativity, both the special and general theories, is fundamental for understanding various physical phenomena such as time dilation and the curvature of space-time. Recent studies show that although it is a challenging topic, its introduction in high school can stimulate critical thinking and increase students' interest in science (Silva, 2020; Almeida, 2018).

With the advancement of space exploration technologies, scientists have had access to new data and discoveries about the universe, and TR has increasingly proven to be a robust theory. However, society generally does not well understand the concepts involved in TR due to its physical-mathematical complexity, partly due to the new concepts that escape common sense

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and everyday experiences, such as time dilation or space contraction.

In this scenario, we have students who come to school with many hours of exposure to television, screens, and the internet, yet without a deeper understanding of such topics. Today's high school students are known as digital natives, a term coined by Prensky (2001) to describe those who grew up in an environment immersed in digital technology. These students have access to a wide range of technological resources that can facilitate learning, but they can also present challenges, such as the spread of incorrect or superficial information (Ferreira, Costa, 2019).

Social media has democratized access to information and knowledge, but it is necessary for people to be able to judge whether that information is truly accurate or not. In this sense, scientific dissemination on social media plays a fundamental role because it allows people to access scientific knowledge, creating communication channels with society and enabling ordinary people to dialogue with scientists, specialists, and scholars.

Scientific dissemination is essential for building an informed and critical society. It allows complex concepts such as relativity to be understood by a broader audience, helping to form citizens capable of making informed decisions (Santos, 2017). The popularization of science, in turn, is crucial for promoting science as an integral part of culture (Mendonça, 2015).

3. Methodology

This study used a combination of quantitative and qualitative analyses to examine the understanding of first-year high school students from a public school about relativity and gravity, as well as their interactions with different sources of information. A questionnaire (Appendix) was applied to 92 first-year high school students, addressing advanced physics concepts and the sources of information used by students to learn about these concepts. The first-year high school students were chosen because they are entering high school, the stage where they begin to study physics as a regular subject. The analyses included the correlation between performance on the questions and the preferred source of information, as well as the comparison between groups of students with similar response patterns.

4. Results and Discussion

4.1. Student Performance and Sources of Information

The results revealed that questions about relativity and gravity showed significant variations in student performance, particularly regarding the understanding of GPS functionality and time dilation.

To facilitate reading, all questions will be denoted by the uppercase letter Q and their corresponding number. Since questions Q1 and Q2 were open-ended questions related to students' understanding of black holes and gravitational waves, the analyses performed were qualitative and will be discussed in the results and discussions section. Based on the students' responses to questions Q3 to Q9, which were objective questions, the Pearson Correlation Coefficient statistical method (Pagano, Gauvreau, 2018) was used to analyze the relationships between the responses to the different questions in the questionnaire, seeking to identify patterns of association between students' understanding of concepts related to relativity and their attitudes toward science.

4.2. Analysis of Questions Q1 and Q2

- **Q1 - In your own words, how would you explain what a black hole is?**

About 30% of students describe the black hole as an entity that "sucks" or "attracts" matter, light, and other elements around it. Approximately 20% of respondents related the black hole to the collapse or death of a supermassive star. Another 15% mentioned more advanced concepts such as space-time distortion and singularities, although many of these explanations are confusing or inaccurate. About 10% of students admitted not knowing what a black hole is, and a similar number provided vague or incorrect descriptions.

- **Q2 – What do you think gravitational waves are?**

Of the 92 participants, a significant portion (about 30%) admitted not knowing what gravitational waves are or left their answers

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blank. About 20% of students associated gravitational waves with gravity concepts, often vaguely or inaccurately, such as "waves present in gravity" or "waves that promote gravity." Another 15% of responses mentioned the collision of celestial bodies like planets or stars as the cause of these waves. Approximately 10% understood that gravitational waves involve oscillations or disturbances in space-time.

Although some students presented notions close to the scientific definition, such as "ripples in the curvature of space-time," most responses lacked precision or a deep understanding, indicating that the concept of gravitational waves is still poorly understood among the participants. Question 2, which asked about gravitational waves, revealed a wide range of responses and varied understanding among students. About 30% of the participants admitted they did not know what gravitational waves are or left the question blank. Around 20% associated gravitational waves with gravity concepts, often vaguely or imprecisely, such as "waves present in gravity" or "waves that promote gravity." Another 15% mentioned the collision of celestial bodies, such as planets or stars, as the cause of these waves, while approximately 10% understood that gravitational waves involve oscillations or disturbances in space-time. Although some students provided definitions close to the scientific one, like "ripples in the curvature of space-time," most responses lacked precision or deep understanding, indicating that the concept of gravitational waves is still poorly grasped among the participants.

4.3. Analysis of Questions Q3 to Q9

The chart below provides an overview of the questionnaire, considering questions Q3 to Q7, which were objective and related to gravity and the theory of relativity. Questions Q8 and Q9 were related to verifying information and the main means by which they seek scientific information.

The chart clearly shows significant variations in the understanding of the different concepts addressed in the questionnaire. Some questions, like Q6, show greater difficulty among students, indicating the need to reinforce these topics in education. Other questions, such as Q4, demonstrate a good level of understanding, but there is still room for improvement in several areas.

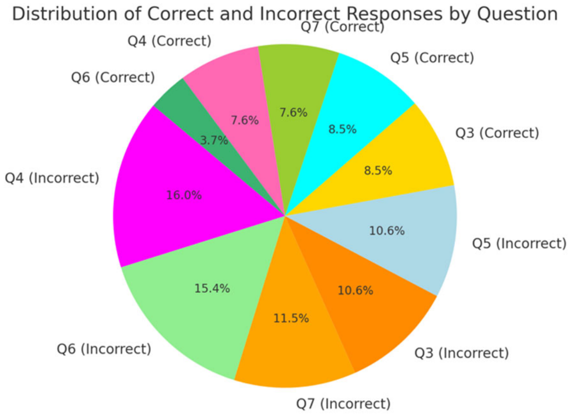

Figure 1. Overview of the Questionnaire on Questions 3, 4, 5, 6 and 7

4.4. Analyzing Each Question Separately

- **Q3 (Table 1):** It is noted that most students correctly identified the definition of gravity according to General Relativity Theory (letter B). However, a significant number of students still hold traditional or incorrect concepts about gravity.

Table 1. Responses on the Description of Gravity According to the Theory of Relativity

Option	Percentage
None	7%
Option A	23%
Option A	45%
Option A	23%
Option A	3%

- **Q4**: Which related the accuracy of GPS due to the improvement obtained by applying the Theory of Relativity, only 16% of students correctly identified this. Many students associate GPS with more intuitive areas such as Dynamics and Electromagnetism, showing a lack of understanding of the practical application of Relativity.

- **Q5**: Which dealt with the understanding of time relativity, most students (55%) understand that time can be relative as described by the Theory of Relativity. However, 45% of them still hold the conception that time is absolute, reflecting an incomplete understanding of time likely anchored in Newtonian determinism. This misconception about time was also observed in question Q6, which argued about the influence of the black hole on the passage of time. Most students (63%) have the incorrect understanding that time would pass faster near a black hole. Only 20% of students correctly understood that time would pass slower due to gravitational time dilation.

- **Q7**: On the other hand, when asked about the influence of the black hole on light (Q7), most students (40%) correctly understand that a black hole deflects the path of light. This is a concept related to the curvature of space-time. However, 35% of students believe that the black hole causes light to disappear, showing a simplified and incomplete understanding of the phenomenon.

From these questions, it was possible to obtain general information about how students perceive time, gravity, relativity, and their effects. However, in addition to these concepts, they were asked about how they deal with scientific news (Q8) and what their main research sources are (Q9). Since questions 8 and 9 are correlated, the analyses will be conducted based on this correlation divided into subtopics.

4.4.1. Verification and Dependence on Social Networks

Most students occasionally verify the truthfulness of scientific information (64%). This correlates with the high dependence on quick and popular sources such as search engines (72%) and Instagram (64%). The use of these platforms, which offer a large amount of information quickly, can lead students to check the truthfulness of news only "sometimes" instead of "always."

4.4.2. Influence of Search Engines

Search engines are the most used source (72%), and this suggests that students widely trust these platforms to access scientific information. However, this trust may be superficial since only 17% of students always verify the information, suggesting that quick searches may not be accompanied by a deep critical analysis.

4.4.3. Instagram and YouTube as Main Sources

Instagram (64%) and YouTube (58%) are visual and interactive sources that attract a young audience, but the dependence on these platforms may result in less rigorous verification of the truthfulness of information. These channels, often focused on visual content, may prioritize attracting attention over accuracy, which could explain why most students check the information only occasionally.

4.4.4. Limited Use of Books and Artificial Intelligence (AI)

Only 25% of students mentioned books as one of their sources, and 21% mentioned AI. These relatively low numbers may suggest that more traditional or data-based sources (such as books) and more advanced verification tools (such as AI) are not the preferred ones. This may contribute to less frequent verification as these methods require more time and effort than quick online searches or social media consumption.

4.5. Analyzing the Correlation Using the Pearson Correlation Coefficient Method

4.5.1. Correlation between Question 5 (Time and Motion) and Question 6 (Time Near a Black Hole)

The correlation between these two questions is strongly negative (-1.0), indicating that students who answered "Yes" in question 5 tend not to get question 6 right, and vice versa. This may suggest that there is confusion among these concepts among students.

4.5.2. Correlation between Question 6 (Time Near a Black Hole) and Question 7 (Effect on Light)

The correlation between these two questions is strongly positive (1.0), suggesting that students who get question 6 right also tend to get question 7 right. This may indicate that students who understand the effect of a black hole on time also understand its effect on light.

4.5.3. Correlation between Question 7 (Effect on Light) and Question 8 (Verification of Scientific News)

The correlation is strongly negative (-1.0), indicating that students who get question 7 right tend not to verify scientific news, or that those who verify scientific news have difficulty with question 7.

4.5.4. Correlation between Question 5 (Time and Motion) and Question 8 (Verification of Scientific News)

The correlation is strongly positive (1.0), suggesting that students who understand that time does not pass the same way for everyone tend to verify scientific news more frequently.

5. Final Considerations

The questionnaire reveals that although many students have correct basic notions about some modern physics concepts such as relativity, there is a fragmented understanding and, in some cases, significant misconceptions, especially related to concepts such as time dilation and the effect of black holes on light. On the other hand, since these are students who are at the beginning of high school and will still have contact with modern physics, it is expected that by the end of high school, they will better understand these concepts. Future research could verify this development.

The data also suggest that although students have access to a variety of sources of information, most do not consistently verify the truthfulness of the scientific information they encounter. The strong dependence on search engines and social media platforms such as Instagram and YouTube, combined with occasional verification, may indicate a risk of exposure to inaccurate or unchecked information. This opens the possibility of discussing with students the importance of always verifying the truthfulness of information, especially when it comes from quick and popular sources. The difficulty in understanding concepts such as the Theory of Relativity highlights the need for greater emphasis on scientific dissemination and the popularization of science. In one of the analyses that crossed performance data with information sources, it became evident the importance of scientific dissemination being accessible and based on reliable sources. Students, as digital natives, have access to a wide range of information, but they often lack critical discernment to evaluate the quality of that information. In this sense, the guidance of a teacher during this process of concept construction is very important and necessary.

6. Suggestions for the Classroom

As a practical suggestion for addressing the Theory of Relativity in the classroom, I propose using a didactic model known as a gravitational well. This model can be built using a hula hoop and a stretched lycra fabric over it. Heavy and massive spheres are placed on the fabric, representing massive bodies such as planets or stars. Then, marbles are launched near these spheres, demonstrating how gravity distorts space-time around these bodies. This experiment allows for a simple and didactic visualization of the curvature of space-time proposed by Einstein. From this, students can directly observe how the trajectories of the marbles are altered when passing near the spheres, analogous to how gravity influences the movement of objects and light in space. From this model, other activities can be developed, such as discussing the orbit of planets or the influence of gravity in different astrophysical contexts.

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Appendix 1
Questionnaire Applied to Students

1. In your own words, how would you explain what a black hole is?

2. What do you think gravitational waves are?

3. Which of the following statements best describes gravity according to General Relativity Theory?

   a) Gravity is a force caused by the interaction between masses as described by Isaac Newton.
   b) Gravity is the curvature of space-time caused by the presence of mass as proposed by Albert Einstein.
   c) Gravity is a force that attracts all objects to the center of the Earth.
   d) Gravity is an energy that makes objects fall.

4. When we use GPS in the car or even on the phone, which part of Physics do you think contributed to making it more accurate?

   a) Dynamics
   b) Thermodynamics
   c) Electromagnetism
   d) Relativity

5. Do you believe that time passes the same way for everyone, regardless of the speed at which they are moving?

   a) Yes
   b) No

6. If you were near a black hole, how do you think time would be affected compared to a person on Earth?

   a) Time would pass faster.
   b) Time would pass slower.
   c) Time would not be affected.

7. How do you think a black hole affects light that passes near it?

   a) It does not affect light.
   b) It deflects the path of light.
   c) It makes light accelerate.
   d) It makes light disappear.

8. When you read a scientific news story on social media, do you check if it is true?

   a) Always
   b) Sometimes
   c) Never

9. What is your main source of information? (You can select more than one)

   a) TV
   b) Search engines (Google, Microsoft Edge, Bing, etc.)
   c) AI
   d) Book
   e) Instagram
   f) Facebook
   g) X (Twitter)
   h) YouTube

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Inventive Training of Mathematics Teachers. Challenging the Method of Representation

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Abstract. This paper is part of an excerpt from the first author's dissertation and aims to discuss the training of Mathematics teachers from the perspective of invention, that is, to reflect on the training that is limited to symbolic representation and problem-solving. To this end, we discuss inventive learning, inventive teacher training, and Inventive Mathematics Education. Finally, we offer a brief reflection on this theme.

Keywords. Inventive Learning, Educational Technology, Inventive Mathematics Education.

1. Introduction

This paper discusses the training of Mathematics teachers with regard to what we understand as mathematical knowledge. That is, the issue with teacher training that resides solely in symbolic representation and problem-solving. This work is part of a segment of a dissertation by the first author, which invites us to have a different notion of teacher training, one that involves knowledge through problematization, thereby challenging the training itself.

With this in mind, I first address the issue of learning in cyberculture as presented by Pierre Lévy. Subsequently, I articulate the policy of invention, which encompasses "a experiência de problematização e a invenção de problemas" [1]. Finally, the paper presents reflections on the training of Mathematics teachers.

2. Learning in Cyberculture

In relating intellectual technologies, Lévy (1993, p. 75) presents three stages, which he refers to as "the three times of the spirit": the oral stage, the written stage, and the digital stage. We acquire the knowledge we use in our daily lives orally, that is, mostly in the form of narratives: stories from family members, friends, or even companies (Lévy, 1993, p. 84).

Lévy asserts that our skills are acquired “by observing, imitating, doing, and not by studying theories in school or principles in books”; that is, writing allows us to transcend the limits of memory, as writing something means we are “recording” that information in the mind, which justifies writing’s efficiency as an intellectual technology.

When analyzing the works of Deleuze and Lévy, we can observe a convergence between them, as the latter theorist addresses the issue of thought in his work “The Technologies of Intelligence: The Future of Thought in the Age of Informatics.” In this context, two questions arise: a) the genesis of thought and its future; b) the issue of learning, that is, analyzing the image of thought through two metaphors: the rhizome and hypertext.

When reflecting on thought, it is natural to imagine the tree of knowledge. This metaphor refers to the idea that knowledge starts from the roots that support the trunk, that is, from the very knowledge itself. In this sense, the trunk must be solid, as it is from this trunk that all premises seen as true are raised, and later, they branch out forming various areas of knowledge, the “branches.”

Gallo raises an issue with this metaphor, presenting the arborescent process of knowledge, that is, as one moves from the roots to the branches, specific sciences of knowledge emerge.

However, the rhizome opposes the tree of knowledge's premise, as Gallo believes that other connections can exist that do not go through the center. For the author, associations occur only through the trunk. This conception assumes that hierarchies exist, leading the author to believe that knowledge is only acquired if it passes through previous stages.

In this sense, the tree's logic refers to the logic of sameness, because “All tree logic is a logic of copying and reproduction. [...] The tree articulates and hierarchizes copies, the copies are like the leaves of the tree” [3]. According to this tree of knowledge thinking, it is believed that

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there must always be a superior unity that determines the connections, which are established in advance, and seeks to provide meaning. On the other hand, the rhizome can be interrupted "at any point, and also resumes according to another of its lines and other lines" [3].

Deleuze and Guattari present some principles of the rhizome: 1st and 2nd - Connection and Heterogeneity; 3rd - Multiplicity; 4th - A-signifying rupture; and 5th and 6th - Cartography and Decalcomania.

1st and 2nd - Connection and Heterogeneity: the rhizome grows by decentering, making heterogeneous connections, for example: cyberspace. A hypertext can link to an image, a sound, a digital platform, without needing to follow any hierarchy.

3rd - Multiplicity: the rhizome is multiplicity dealt with as a subject that traverses objects, modifying them. For example: in RPGs, the narrative is guided by a player called the "master," who dictates the plot, presents the scenarios, among other things. The other players move and make decisions freely.

4th - Rupture: the rhizome can be disconnected at any point without being destroyed; on the contrary, it opens possibilities for multiple paths from its ruptures. For example: "É impossível exterminar as formigas, porque elas formam um rizoma animal do qual a maior parte pode ser destruída sem que ele deixe de se reconstruir" [3].

5th and 6th - Cartography and Decalcomania: the rhizome is the principle of cartography because it cannot be copied, that is, represented by a forgery. For example: a map of a city has multiple entrances and exits to a given park, thus remaining open to various uses according to the subject's need.

The rhizome differs from the tree because there are no hierarchies, as it does not involve any prior significance or is reduced to a single unit. The rhizome multiplies and operates in relation to other rhizomes, which can be accessed from different locations, that is, from infinite points, according to its cartography. In other words, the rhizome "is an anti-genealogy" [3].

Given the above, the rhizome is a becoming, as it "has neither beginning nor end, but always a middle through which it grows and overflows" [3].

3. Scientific Knowledge and Teacher Education

Varela (1994) problematizes the notion that knowing is related to the elaboration of information, that is, cognition "[…] é precisamente a sua capacidade para exprimir o significado e as regularidades; a informação deve aparecer não como uma ordem intrínseca, mas como uma ordem que emerge das próprias atividades cognitivas […]" [4].

This author emphasizes that cognitive sciences are a blend of artificial intelligence, neuroscience, psychology, linguistics, epistemology, among others; they process information and concern themselves with human consciousness and its knowledge. In this context, Varela (1994) warns us about two types of representations: the first defined by representation through interpretation and the second by epistemological and ontological involvement, which emerges from a pre-defined world and its properties established prior to cognitive activity.

Thus, in the following section, we will address the epistemology of inventive learning.

3.1. Inventive Learning

Thinking about inventive learning brings to light what Bergson understands by invention, which in its strong sense is the act of inventing problems rather than merely inventing their solutions. For this to occur, it is important to ground ourselves in the works of Deleuze and Guattari.

Another important aspect to mention is that invention is not viewed by us as something rare and exceptional, that is, something that occurs only with artists and scientists. Instead, we should consider that invention permeates our daily lives and is part of the experience of ordinary people.

Given this, in the following section, we present the epistemology of Inventive Mathematics Education.

3.2. Inventive Mathematics Education

Inventive Mathematics Education (IME) aims to challenge crystallized and reproductive practices present in the educational field, which limit Mathematics to mere memorization of formulas and reproduction of exercises. However, IME proposes conceptions that diverge from this teaching model, as it recognizes that both the learner and the objects of learning are the result of actions and practices of knowledge that go beyond mere adaptation to the world.

IME does not restrict the learning of Mathematics solely to problem-solving but encourages the shift of mathematical knowledge towards the invention of problems and the creation of worlds. This inventive process emerges from the subjects themselves, who self-produce and reinvent themselves when confronted with experiences of estrangement that provoke unpredictable shifts from crystallized reproduction practices.

Based on IME's conceptions, mathematical knowledge, when combined with the use of Digital Information and Communication Technologies, is approached from the perspective of problem invention, self-invention, and world invention, as presented by Silva & Souza Júnior (2020a) in the following image:

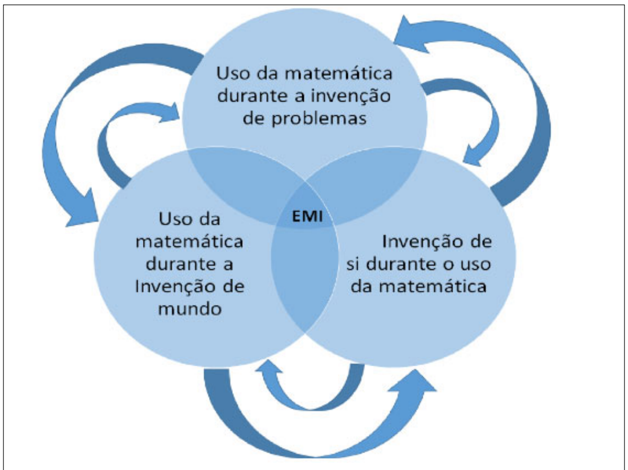

Figure 1. Inventive Mathematical Education (IME)

The Inventive Mathematical Education (IME) materializes when the individual reinvents themselves as an educator, moving away from the model of representation and using Mathematics for world invention, problem creation, and exploration of different contexts. The term "inventive world" is used by Silva (2020) to refer to the scenarios and/or models created by the subjects of his research (mathematics education students). Such a scenario is initially conceived through imagination and then constructed using concrete objects. In this process, they can (re)invent themselves.

In this context, IME is conceived from the perspective that the individual has and the knowledge they bring with them, as the individual is shaped by (trans)formative processes, regardless of their awareness of these processes [7].

4. Some Reflections

Therefore, it is essential that we explore a cognition of problematization, which seeks to shift the focus from outcome-oriented training to experiences of learning governed by problem invention. This approach highlights pathways that move away from the deterministic and limiting logic of thinking in teacher education.

Kastrup (2007a) uses Lévy's (1999) ideas to describe the computer as a technological resource capable of producing subjectivities and cognition. In this aspect, by using these resources, we can transcend world representation, problem-solving, and the transmission of content easily found in cyberspace [7].

In this context, we can explore computers as machines capable of enhancing our "human cognitive and operational power—in other words, using computers and computer networks to increase our productivity, inventiveness, and creativity" [6].

Thus, our challenge is to problematize knowledge through problem invention, thereby enabling the unpredictability of inventions in teacher education.

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Liquids: A Paradidactic Book for Teaching Chemistry and Scientific Literacy

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Abstract. The text provided is a report on an experience involving an intervention at a public school in Goiás with first-year high school students. The intervention used a paradidactic book as a resource for teaching Chemistry to promote Scientific Literacy. A didactic sequence was involved, including preparation, presenting the proposal to the students, reading a chapter from the book, holding a debate, and creating an advertising poster about one of the subjects read about. The students' profile was assessed through a questionnaire, and the process of Scientific Literacy was identified through emergent indicators in the debate, chapter summaries, and the posters produced. The act of synthesizing the reading into a short piece of information through an advertising poster allowed for the development of the ability to organize and classify information using logical and proportional reasoning, seeking to explain and justify scientific phenomena.

Keywords. Scientific Literacy, Chemistry Education, Paradidactic Book.

1. Introduction

This text is the result of an intervention project proposed in the course on Analysis and Development of Methodologies and Didactic Resources for the Teaching of Science and Mathematics within the Postgraduate Program in Education for Science and Mathematics (PPGECM) at the Federal Institute of Education, Science, and Technology of Goiás (IFG) - Jataí Campus. The project aimed to investigate the use of paradidactic books (PD) as a didactic resource for the Teaching of Chemistry and to promote Scientific Literacy (SL).

We began the discussion of this experience report by seeking to answer fundamental questions that will justify the path taken in the intervention project. Why teach Science? [1] states that "our greatest responsibility in teaching Science is to strive for our students to transform themselves, with the teaching we do, into more critical men and women... agents of transformation of the world in which we live."

What to teach in science and/or how to teach Science so that students become critical? For Sasseron (2017), we should teach scientific concepts and ideas in an unveiled manner, pointing out historical and philosophical aspects of science, scientific practices, connected to the reality of the students, not privileging only the products brought by the scientific community, but also the processes by which such products were constituted. One of the purposes of the school is to build bridges between science in the way of scientists with the world and the experiences of the students. We should teach Science as part of the student's reality, enabling them to develop a critical rationality of science that allows students to participate in discussions concerning problems in their surroundings, capable of becoming agents of transformation of their reality.

2. Scientific Literacy

[1] upholds the concept of Scientific Literacy as the set of knowledge that enables men and women to understand the world they live in. It's not just about understanding the world, but also recognizing the need to change it for the better. [2] refers to Scientific Literacy when the teaching of science aims to prepare individuals to solve everyday problems by considering knowledge and methodologies from the scientific field, which in turn leads to making decisions about situations around them that will influence their lives and futures.

The grim futility of science education lies in training students for entrance exams and external assessments, or even in increasing students' lack of critical thinking. Historically defined scientific content for an antiseptic and hermetic science, which confines the understanding of science to a scientific community. The reality of the school presented here demands that teachers take on the role of educators, not just informers. It is necessary for us, as teachers, to move from esotericism to exotericism. Educators are tasked with providing this scientific education that promotes scientific literacy [1].

From this perspective, the teaching of Chemistry must be surrounded by reality, which doesn't mean reducing it to everyday chemistry, making it merely utilitarian, but teaching Chemistry within a conception that highlights its social role through contextualization [1].

[3] identifies three foundational axes in the planning of science classes aiming for Scientific Literacy (SL). They are: 1) Understanding of terms, concepts, and fundamental scientific knowledge, 2) Understanding the nature of sciences and the ethical and political factors surrounding their practice, and 3) Understanding the relationships between Science, Technology, Society, and Environment. These axes serve as guidelines for the development of science classes. For an analysis of actions in classroom work, [3] proposes indicators to diagnose whether SL is in the process of development among students.

3. Reading and the Paradidactic Book

Facing research, there is a significant challenge in proposing the teaching of science using the reading of paradidactic books as part of the teaching-learning process. But after all, what are paradidactic books (LP)? The prefix "para" means "beyond" or "forward." The proposal is that these are books that go beyond traditional textbooks. They are alternative texts with cross-cutting themes and more accessible language, which serve to introduce the student to the universe of reading and prepare them for more complex works [4].

Paradidactic books (LPs) are developed with the aim of providing access to the scientific universe and the knowledge necessary for life in society, through reading that is contextualized with reality, without neglecting historical facts and the way in which scientific knowledge was produced [5].

We conducted a search for works and articles that used paradidactic books (LP) in the Teaching of Chemistry to serve as a starting point for the development of our proposal for intervention. We highlighted the article by [6] titled "Paradidactic Chemistry Books: Analysis of the Topic of Radioactivity." The authors analyze how paradidactic chemistry books approach radioactivity, highlighting how LP authors explore cross-cutting themes according to the PNLD 2018 (National Textbook Program). Zapateiro *et al*. (2020) perform an analysis of LPs based on the criteria of 1) Compliance with Legislation, 2) Chemical Knowledge in the Work, 3) Theoretical-M methodological Assumptions, and 4) Graphic Design of the Work.

It is observed that the works aim to use LP to ensure that the Chemistry taught in school makes sense outside of it, reaching the social, political, and economic dimensions that permeate citizenship. School content is increasingly detached from the students' life reality, making the school an environment of alienation and misinformation. Considering the study of sciences, specifically Chemistry, the result is scientific illiteracy. The following problem arises: How can Scientific Literacy be promoted using a Paradidactic Book as a teaching resource for Chemistry education? Seeking to answer this question, we developed a proposal for intervention following the methodological processes described below.

4. Methodology

The objective of this intervention was to investigate how it is possible to associate theoretical school Chemistry with the practical Chemistry of everyday life with the purpose of promoting Scientific Literacy, using a Paradidactic Book as a resource. We chose as the LP the work "Liquid: The Enchanting and Dangerous Substances That Permeate Our Lives" by [7].

The intervention was carried out at a state school in Goiás. The target audience of the research were nine (09) classes of 1figu Year High School students, in the afternoon shift between September and October 2023. Each class had an average of 40 students. Therefore, approximately 360 students participated in the research.

To achieve the objectives of the research-intervention, some actions were initially listed as part of the intervention:

1) Raise awareness among students about the importance of reading and scientific knowledge,
2) Conduct reading of the paradidactic book (only 01 chapter per group),
3) Facilitate a debate on the book's reading in order to investigate their learning and the Scientific Literacy (SL) in process,
4) Create an artistic exhibition work based on the reading, promoting scientific dissemination.

The intervention was carried out in 5 stages:

1) Preparation/Application of the Reader's Form: A slide presentation was prepared indicating research and data regarding readers in Brazil and the advantages of using printed books for in-depth reading. An overview of the book that would be part of the intervention and the product that would be developed was presented, as well as the presentation of all the stages that would be included in the intervention. Printed material by chapters was prepared for the students to read. The chapters were also prepared in digital PDF format to share in the class's social media groups so that all students had access to the text.

   Still in the preparation stage, questionnaires for student evaluation were developed. The first, called the "Reader's Form" (which will be presented in Table 01 of results), aimed to quantitatively and qualitatively analyze the reading students who participated in the research. The work carried out by [8] was used as a reference for the construction and analysis of the readers' profile. The form was built on the Google Forms platform with 25 closed questions and 2 open questions, divided into three sections: 1) reading habits, 2) living in literate environments, and 3) interest and reading about scientific subjects.

   The second evaluation questionnaire was developed in the form of a Book/Chapter Assessment Sheet (Attachment 02) that was provided to each group of 6 to 7 students. This sheet consisted of open-ended questions seeking to evaluate the work from the participants' perspective, as well as the indicators of scientific literacy pointed out by [3] To conclude the first stage (Preparation), the regular teacher presented the intentions of the current research to the classes and provided the link to the Reader Profile Form for them to respond using their cell phones.

2) Presentation: This took place in a 50-minute class. The prepared slides were presented to the students to raise awareness about the importance of reading. The stages of the work were presented. Groups were formed with 6 or 7 students each. Each group chose a chapter of the book and received a copy of the chosen chapter.

3) Reading: This took place in the classroom in a single 50-minute class and not in the reading corner as planned. The students formed circles, adopting different forms of reading. Some students had already read the text at home, and others did not read at home or even in class.

4) Debate: This also took place in the classroom in one or two 50-minute classes. A total of 45 groups were formed (4 to 6 groups per class). In this stage, the teacher interviewed the groups, recording the audio, seeking to identify the indicators of SL (Scientific Literacy) in the students' explanations and interpretations of the topic discussed. At the same time, they answered the Book/Chapter Assessment Sheet. The questions addressed in the book's sheet aimed to identify the understanding of the text, whether they had indeed understood it. Some groups were still reading, and other students who were absent in the previous stages formed groups to start reading. For this reason, not all groups were able to conduct interviews. The questions in the interview were like the questions present in the book assessment sheet. In this stage, students were instructed on the advertising poster they should develop.

5) Exhibition: This took place in the classroom with the display of the advertising poster created by each group, and in the schoolyard where the posters resulting from the reading were fixed. The posters should address some scientific fact, historical event, or curiosities read in the chapter. With the intention that we could verify the indicators of SL. The exhibition of the posters was recorded in photography. We present the results obtained in the intervention below, as well as the discussions relevant to the results.

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5. Results and discussion

The first data collected in the intervention pertains to the reading habits of the students. It was estimated to collect 360 responses for analysis, since there were 40 students enrolled in each of the 09 participating classes, however, only 210 responses were recorded for the reader's form. All classes received the same instructions regarding access to the link to fill out the form. They could use their own cell phone, a classmate's phone, the teacher's phone, or even fill out the form at home. When asked about not completing the form, some students said they had forgotten, others had difficulties accessing it because they did not have an email, and others reported a lack of internet access.

Through this form, it was possible to analyze the profile of the students participating in the intervention. In the quantitative approach evaluation, no distinction was made between data, so the data presented refers to the 210 responses to the form. Participating students were aged 16 (34.9%) and 17 (44.5%).

We observed in the first section of questions that few students enjoy reading (less than 30%) despite the encouragement to read (41%). They claim not to have difficulties in writing, but sometimes starting to write (49%) and arguing (50%) is not easy. More than half of the students rarely read or have not read a book. Consequently, the weekly reading time for 49% of the students is less than 1 hour. They usually read at home on digital platforms. Less than 7% have the habit of reading newspapers or magazines. Their reading habits focus on websites, emails, and social networks.

In the second section of the questionnaire, we observed that the frequency of these students visiting libraries and theaters is very low. The frequency of going to the cinema is higher, being an environment related to literacy that has been popularized and associated with leisure and entertainment. 45% of the respondents read movie or book synopses before accessing the work. Regarding advertising and propaganda, many of them read it. More than 70% answered yes or sometimes regarding the attention that advertisements attract. This data becomes relevant for the research proposal because the groups developed advertising posters to promote science at school. Therefore, the posters can arouse curiosity and interest in scientific subjects.

In the third section of the reader's form questionnaire, we observed a significant number of respondents who enjoy science, or specific subjects within science, corresponding to more than 50%. Regarding the reading of scientific magazines or books, we noticed a relevant number of readings (around 30%), considering that these materials are not easily accessible or popularized. Concerning difficulties in school subjects, the data is high. More than 50% have difficulties in Chemistry, and 66% have difficulties in Physics.

6. Final considerations

There were many challenges during the execution of the intervention project. We can list the difficulty in answering the online questionnaire due to the lack of a cell phone, unfamiliarity with the platform, lack of internet, etc., the distribution of the textbook as printed material, an appropriate space for reading, the amount of data generated, which would allow for countless discussions, in addition to the processes of recognizing the indicators of SL (Scientific Literacy).

We believe we have promoted processes of Scientific Literacy among the students participating in the research by using a Paradidactic Book as a didactic resource. Despite the lack of a reading habit, infrequent visits to literate environments, and the difficulty presented in Science subjects, a portion of the students became interested in reading and were surprised by the existence of the type of text they accessed.

We believe that further research can be conducted based on this work, with themes related to the teaching of Sciences through the STS (Science, Technology, and Society) approach using paradidactic books, interdisciplinarity in the teaching of Sciences, or even how paradidactic books can be part of the annual planning of a Science component, making reading a habit and a continuous process. We know that for many students, the only opportunity they will have to access this type of material and knowledge is at school [9].

7. Acknowledgements

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A Brief Study on The Cerrado Theme and its Developments in Science Education

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Abstract. The aim of this brief bibliographical survey is to get to know the panorama of research on the cerrado and its aspects in Science Teaching and to identify gaps in order to direct future research and thematic projects on the cerrado biome, using the theoretical-methodological assumptions of Science, Technology, Society and Environment Education (CTSA). This research is a bibliographic selection from the years 2013 to 2023, based on the periodical annals of ENPEC (National Meeting for Research in Science Education). With the keyword "Cerrado". The research revealed gaps in educational approaches to teaching about the Cerrado, as there is still a need for practical and experimental activities to improve students' understanding. Integrating CTSA education would be beneficial in broadening educational strategies. Therefore, a more complete project, which includes field visits and varied practical activities, such as local food production and environmental data analysis, is needed.

Keywords. Bibliographic Analysis, Cerrado, CTSA Education.

1. Introduction

Educational projects should prioritize problematic issues in CSTA relations, in which reflection and action arise in the face of local and global challenges [1].

According to Lacerda *et al*. [7] scientific and technological advancement redefines society, which requires an adaptive educational approach that affects social interactions and generates consequences for life in society. Santos and Mortimer [6] point out that STEM education promotes scientific and technological literacy, preparing students to make decisions with critical capacity in relation to scientific issues and to take action in the face of everyday challenges.

Authors such as Santos and Mortimer [6], Auler [1] and Lacerda *et al*. [7] emphasize the importance of STEM education in training critical citizens in scientific, technological, social and environmental issues. On the other hand, traditional teaching, cited by Oliveira [8], faces difficulties in addressing these essential aspects in the critical education of students.

The cerrado, recognized for its biodiversity, plays a fundamental role in sustainability, as highlighted by Costa and Silva [5]. In addition to its biological richness, this region presents challenges and opportunities for interdisciplinary understanding. Thus, investigating the teaching of the cerrado from the perspective of CTSA Education not only enriches our understanding of this biome, but also expands the possibilities of promoting a more integrated and critical education in relation to the complexities of the contemporary world.

With this in mind, the following research problem arises (How to identify gaps to direct future research and thematic projects on the cerrado biome, through the theoretical-methodological assumptions of CTSA Education?), in view of this, the objective of this research is to know the panorama of research on the cerrado and its aspects in Science Teaching and to identify gaps to direct future research and thematic projects on the cerrado biome, through the theoretical-methodological assumptions of CTSA Education.

2. Methodological Path

Brito *et al*. [3] highlight the importance of bibliographic research as an essential approach to accessing and synthesizing existing knowledge on a topic. This type of research involves analyzing theoretical works that have already been published, with the aim of obtaining relevant information to answer the study questions.

In this study, we carried out a bibliographical survey of published articles on the teaching of chemistry and science, with a specific focus on the cerrado biome. This investigation is a bibliographic cross-section from 2013 to 2023, based on the periodical annals of ENPEC (National Meeting for Research in Science Education). Using the keyword "Cerrado", 10 articles were initially found, as can be seen in Table 1.

Table 1. Number of papers published in the last ten years at ENPEC (Source: Authors, 2024)

Yrs	N° of works
2013	1
2015	-
2017	2
2021	2
2023	5

After identifying the papers and their years of publication, the articles were subjected to a qualitative analysis. This analysis involved interpreting the data presented in each article. So we carried out an initial reading followed by the preparation of reading sheets, in which we highlighted the target audience, objective, methodology and main results of each work, but for our purposes we will analyze three articles. This initial analysis allowed us to understand the results, as will be presented in the course of this work.

3. Results and Discussions

Using the reading sheets, we analyzed the data from the articles. During this analysis, 10 articles and 3 essential categories were identified, as shown in Table 2.

Table 2. Number of works by category (Source: Authors, 2024)

Category	N° of works
Analysis of textbooks and materials	3
Analysis of educators' knowledge	2
Teaching strategies that discuss the cerrado.	5

However, after reading the article and finding that only the category “teaching strategies that discuss the cerrado” involved teaching methodologies, we will analyze only three of the articles whose titles can be seen in Table 3 in order to identify their methodologies and objectives and identify the gaps in this research.

The aim of article A was “To investigate the use of an ecological trail as an instrument for promoting a dialogic-problematizing education.” The authors use the lessons as the main source of data and the researcher as the central instrument. The data is descriptive, recorded by means of class recordings. According to the authors, the analysis of the interactions between students and teachers reveals significant student participation with dialogues between students and teachers that show a dynamic and participatory interaction, which results in engaging and dialogued lessons. In view of this, the authors emphasize that the development of complementary activities provided a differentiated approach to the content on ecological interactions, which promoted discussions, problematizations and mediation by the teacher, which influenced the learning process and the appropriation of knowledge by the students. Through the activity on the trail, the students were encouraged to explore, formulate hypotheses and learn actively in order to develop skills of evaluation and appreciation of the importance of these areas for the environment in which they live.

Table 3. Articles selected for analysis (Source: Authors, 2024)

Article	Article title	Yrs
A	The construction of knowledge about ecological interactions through dialogic - problematizing education along a trail in the cerrado [2]	2017
B	Field class in the cerrado and science learning: a study with 9th grade students [9]	2023
C	Knowing the Cerrado” quiz: a contribution to teaching ecology in elementary school [4]	2023

Later, when we analyzed article B, the aim was to “raise students' awareness so that they are able to exercise their roles as citizens in decision-making, in order to achieve the collective good and environmental preservation of the cerrado”. In order to achieve its objective, the work carried out a field trip to PESCAN with students from the 9th grade of elementary school to relate the concepts discussed in class with the observation of fauna in the park. This experience facilitated a more critical and reflective approach to the environment, going beyond the BNCC guidelines by encouraging students' active participation in understanding and carefully intervening in their surroundings. According to the authors, the field lessons worked as an effective methodology for connecting theoretical knowledge to practice, which prepares students to make conscious and innovative decisions in search of a sustainable future.

The aim of article C was to “develop and analyze a computer game centered on the Cerrado, designed to teach ecology concepts to elementary school students”. An intervention was conducted with 21 5th grade students at a school in Orizona, Goiás, in 2019. The game, presented in the form of a Quiz, was used as a tool to explore themes related to the Cerrado and facilitate discussions about its environmental and social importance, and follow an active learning approach. According to the author, the game stimulated students' interest due to its attractive interface and the competitive style used in the classroom. The students' evaluation of the game was positive. Therefore, the game proved to be an effective educational tool, as it provided a playful approach that captivated the students and stimulated their interest in learning.

In studies A, B and C we noticed gaps in the educational approaches presented, although the contextualized and discursive interactions were valuable, the absence of theoretical and experiential activities can limit in-depth understanding of the topic. We therefore recommend the implementation of a more complete project, integrating visits and the inclusion of a variety of practical activities that enable a better understanding of the cerrado biome.

These practical activities could involve food production for local gastronomy, products with medicinal potential, as well as environmental awareness, and experiments such as acidity and basicity in relation to the PH of the region's soil, analysis of field data and other forms of direct interaction with the environment, which broadens the students' experience and the importance of this ecosystem.

In addition, it is noteworthy that articles A, B and C did not research CSTA education in depth. However, integrating this approach into future research could further enrich students' understanding of the relationship between science, technology, society and the environment, with the cerrado theme.

4. Considerations

The research revealed gaps in educational approaches to teaching about the cerrado, as there is still a need for practical and experimental activities to improve students' understanding. Integrating CTSA education would be beneficial in broadening educational strategies. Therefore a more complete project, which includes field trips and varied practical activities, such as local food production and environmental data analysis. These measures not only enriched learning about the cerrado biome, but also prepared the students to face contemporary challenges critically and consciously.

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From Historical Context to Educational and Governmental Action: The Urgency of Environmental Education for the Preservation of the Natural Tesources of The Cerrado

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Abstract. This work highlights the importance of Environmental Education (EE) in the preservation of natural resources, with a focus on the Cerrado biome. It emphasizes that EE is essential for developing conscious and sustainable citizens, especially in the face of environmental degradation and the undervaluation of the Cerrado. The review reveals the need to integrate EE more systematically into the school curriculum, recommending its implementation as a mandatory subject. Addressing challenges such as insufficient teacher training and the lack of effective public policies is crucial to strengthen EE and ensure the preservation of the Cerrado and other biomes.

Keywords. Environmental Education; Cerrado Biome, Preservation of Natural Resources, Sustainability.

1. Introduction

Reflecting on the importance of water and soil in the educational context leads us to question the relevance of the environmental problems we face today. Since the Industrial Revolution, which began in the 1760s, the extraction of natural resources has increased rapidly. The migration of rural populations to large urban centers, combined with population growth, has driven unbridled development that has worsened environmental degradation and profoundly transformed the relationship between humans and nature.

The evolution of steam engines for large-scale production has consolidated the culture of consumerism driven by capitalism, which has compromised the conservation of ecological resources, since ecosystem services come from the environment. In this context, it is essential to highlight Environmental Education (EE) as an essential element for raising awareness, preserving, and valuing the environment. Environmental conservation plays a crucial role in shaping values that encourage and shape behaviors aimed at environmental conservation and improvement, acting as a key driver for the maintenance of natural resources and offering an educational approach to addressing environmental issues [5].

Soil and water are essential resources that need to be used and preserved responsibly [5]. Soil not only provides space for human activities but also sustains natural cycles, maintains the balance of habitats, and acts as a water reservoir.

Water, in turn, is indispensable, being vital for the functioning of biogeochemical cycles, production, and economic development. Water scarcity can generate serious consequences for both humans and ecosystems, as can soil degradation, which also causes serious environmental imbalances. In the state of Goiás, part of the Cerrado biome, intensive use and inadequate soil management face major challenges due to the gradual replacement of native vegetation by agricultural expansion, which directly impacts local biodiversity [13]. Although it is a global biodiversity hotspot, the Cerrado remains undervalued in terms of conservation, especially because it is a non-forest biome and remains threatened by ongoing deforestation in the region [1].

The Cerrado is a vital center for the cultivation of essential foods in addition to being home to indigenous peoples and traditional communities that depend on the sustainable use of the region's natural resources. However, deforestation and conversion of native vegetation threaten local biodiversity, with projections indicating the possible extinction of around 480 endemic species by 2050 [1]. These activities also compromise carbon stocks, freshwater supplies, and the livelihoods of local populations.

Given this scenario, it is urgent to implement conservation policies that prioritize environmental education, based on guidelines such as Law No. 9,795/1999 [4], the Stockholm Declaration [9] and Agenda 21 [8]. Although the National Curricular Parameters (PCNs) propose a cross-cutting approach to Environmental

Education (EE), this integration can result in superficial teaching. Making EE a mandatory subject would ensure greater depth, offering a more structured and effective education, with specialized teachers. Thus, the appreciation of natural resources and the preservation of the Cerrado depend on a systemic change in education and in the relationship with the environment.

This study aims to conduct a systematic qualitative review to deepen the understanding of Environmental Education (EE) and its importance in the preservation of natural resources, with a focus on the Cerrado biome. The aim is to identify effective strategies for integrating environmental awareness into the educational process and overcoming challenges such as teacher training and institutional resistance. The review also aims to provide support for public policies that promote more structured education, aiming at sustainable development and the preservation of vulnerable ecosystems, such as the Cerrado.

2. The Cerrado biome, its wealth and anthropic exploration

The Cerrado Biome, the second largest in Brazil, occupies 21% of the country's territory and is home to a vast ecological diversity. In addition to its unique natural characteristics, this biome has gained prominence as an important global agricultural frontier driven by rapid advances in recent decades [3]. Brazil, which contains approximately 10% of the planet's living species [7], stands out for its immense biodiversity, of which the Cerrado is an essential part. For this reason, the Cerrado deserves due respect and recognition for its environmental and economic importance.

However, the Cerrado Biome has been facing intense degradation for decades, caused by predatory exploitation in several areas, aggravated by national policies of occupation and territorial development. Although it is an important agricultural frontier driven by the increasing use of technology by large landowners, the application of biotechnologies to increase production without expanding cultivated areas is still limited. The unbridled search for higher yields within a predatory and exploitative system often disregards the need for more rational and sustainable exploitation of areas that are already arable.

Due to its appearance and popular perception, the Brazilian Cerrado is often considered a poor biome of little relevance [2]. This distorted view may explain the limited notoriety of the Cerrado in comparison to other national biomes as well as the lack of protection it receives, especially in relation to regions such as the Amazon. While the Amazon is widely recognized both nationally and internationally for its biodiversity and ecological importance, the Cerrado often remains on the sidelines of conservation discussions.

According to Sorretoni, this lack of notoriety is reflected in the insufficient implementation of environmental protection policies aimed at the Cerrado, which ends up aggravating unbridled exploitation and deforestation in the region [15]. Without a change in public perception and recognition of its ecological and economic relevance, the Cerrado will continue to be vulnerable to degradation even though it is essential for Brazil's biodiversity and ecological cycles.

3. Environmental challenges faced by the Cerrado

The Cerrado has faced major and intensified challenges since the 1960s to the present day. Although the biome had already suffered from human actions before this period, it was in the 1920s with the expansion of coffee production in São Paulo that the first areas of exploitation appeared in the southwest of the Cerrado. Over time, these areas intensified and spread to the central region and other areas. The part of the Cerrado that remained preserved for the longest time was the upper central and northern regions. Currently, the advance of a new agricultural frontier is observed in the area known as MATOPIBA, which includes the states of Maranhão, Tocantins, Piauí, and Bahia [15].

The relationship between man and nature in the Cerrado is disharmonious and benefits only one side. Environmental degradation is evident and manifests itself in alarming situations and disasters all over the planet. Deforestation for various human uses affects this biome largely due to its vast territorial area and its presence in several Brazilian states, including regions that

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are already densely populated. The construction of roads facilitates movement and development but has a high cost: death of species, extinction, drought, and desertification. In 2007, data indicated that 47% of the Cerrado area had been lost due to human occupation and economic use [14].

The Cerrado is widely known for its rich availability of water, housing an immense aquifer, and being the site of the outcrop of three large Brazilian river basins [15]. Due to this characteristic, it is often called the "cradle of waters" in reference to its crucial role in the hydrological cycle essential for life. As Da Paz points out, “Man has been modifying the environment in which he lives in order to adapt it to his needs, which has had an impact on significant changes in the hydrological cycle” [10].

The climate of the Cerrado is characterized by two well-defined seasons: the dry season, which occurs during the winter, and the rainy season, which occurs during the summer [12]. In addition, the climate of the Cerrado is influenced by the effects of other biomes, since all ecological systems are interconnected. Intensive exploitation of the region has generated several negative impacts, such as prolonged droughts, unregulated rainy periods, and rising temperatures. These climate changes directly affect the local economy, resulting in significant losses in the production of several economic activities.

4. Man-nature relationship and environmenttal education: historical and current challenges

Given the various reasons presented in the previous topics, it is pertinent to consciously disseminate scientific knowledge in favor of Environmental Education. It is essential that students, already citizens in training, learn to exercise their citizenship by understanding the causes and consequences of their actions in relation to the environment. According to Reigota, the concept of environment is defined as “a determined and/or perceived place where natural and social aspects are in dynamic and constant interaction” [11]. These relationships lead to processes of cultural and technological creation, as well as historical and political processes that transform nature itself and society.

Understanding this concept is essential for the basis of the study of Environmental Education, aiming at the protection and preservation of our environment in addition to better understanding the relationship between production and consumption patterns and environmental degradation. With the exploratory advancement of society under a capitalist system, Marx and Engels state that the relationship between man and nature is established through the production of goods and the transformation of natural resources for the benefit and identity of historical civilization. Man appropriates the natural environment not only as an inhabitant of this planet but also to meet his own needs and interests.

Environmental Education must be contextualized in a global environment that is overexploited and poorly preserved. Raising awareness and disseminating this knowledge is crucial to preserving and recovering nature and its resources, which are indispensable for life on Earth.

In the school environment, it is essential that the Environmental Education approach be integrated with the concepts necessary for students' daily lives and with production and consumption patterns. Without practical communication between the concepts taught and the students' daily experiences, the teaching of Environmental Education will be ineffective and disregarded. Students need to appropriate knowledge in a didactic way to think critically and act in relation to the environment. As highlighted by Davidov, “The essence of theoretical thinking consists in the fact that it is a special procedure with which man focuses on understanding things and events through the analysis of the conditions of their origin and development” [6].

Learning must be meaningful, critical, and above all based on the scientific concepts of what is intended to be taught in order to lead students to think more deeply and form their own conclusions based on their experiences and reflections.

Therefore, it is essential that teachers are prepared and qualified to integrate Environmental Education into their respective disciplines. Thus, ongoing teacher training and the encouragement of public policies aimed at the practice of Environmental Education in schools are fundamental. Currently, it is observed that Environmental Education is a latent topic in universities but little explored in the school environment of basic education in terms of greater interdisciplinary curricular incentive and greater government importance for the real implementation of Environmental Education in school practice.

The Cerrado and other biomes are deteriorating before our eyes. The strength of the people, especially scientists, activists and universities, must be greater to demonstrate to the Government in the most diverse spheres, and to the Parliamentarians who serve on the Education and Environment Committees at the Federal level, the real needs for greater implementation of Environmental Education practices in the basic school environment. EE needs to be implemented as a mandatory subject in basic education and, in addition, undergraduate courses must be prepared to train teachers and several other professionals who are aware of knowledge, good practices and environmental preservation and who are prepared to act in the protection and conservation of the environment, as citizens aware of their duties and rights.

5. Results and discussion

The systematic qualitative review revealed that Environmental Education (EE) is crucial for the development of citizens committed to preserving natural resources, especially in the Cerrado biome. EE plays an essential role in promoting awareness of the importance of environmental conservation and shaping sustainable behaviors. However, the current approach to EE in the Brazilian school curriculum, which is often superficial, needs to be more structured and in-depth, and its inclusion as a mandatory subject is recommended.

Significant challenges were identified in the implementation of EE, such as inadequate teacher training, the scarcity of specific teaching materials, and the lack of effective public policies. The erroneous perception of the Cerrado as a biome of low relevance also hinders the adoption of EE practices that emphasize the ecological importance of the region.

Proposals for strengthening EE include teacher training, the development of contextualized teaching materials, and the formulation of supporting public policies. These initiatives aim to ensure that EE is taught in a structured and continuous manner, adapted to local realities and different levels of education, promoting an education that goes beyond and truly changes students’ perception and knowledge.

The relationship between man and nature in the Cerrado, marked by intensive exploitation and environmental degradation, reinforces the need for a paradigm shift, where EE must promote sustainability and raise awareness among future generations about the importance of conservation. Soil degradation, water scarcity and biodiversity loss are problems aggravated by the lack of protection policies and the undervaluation of the Cerrado.

Finally, a more holistic and integrated approach to EE in Brazil is urgently needed, with joint efforts between educators, managers and society to strengthen EE and promote environmental conservation. Future research and initiatives should continue to explore ways to value and protect the Cerrado and other biomes, ensuring a more sustainable and balanced future for the country and the planet.

6. Conclusion

The conclusion of this work highlights the vital importance of Environmental Education (EE) in promoting awareness and preservation of natural resources, with special emphasis on the Cerrado biome. The systematic qualitative review demonstrated that EE is an essential component for developing citizens committed to sustainability, and highlighted the urgent need to strengthen its presence in the Brazilian school curriculum, preferably as a mandatory subject. This would allow for a more in-depth and structured approach, training teachers and developing teaching materials that reflect regional and environmental specificities.

The Cerrado, often undervalued, faces significant challenges due to intensive exploitation and the lack of effective conservation policies. Environmental education, therefore, should be seen as a crucial

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instrument for transforming this reality, promoting changes in students' perception and care for the environment. By addressing issues such as soil degradation, water scarcity and biodiversity loss, EE can foster a new generation of citizens who are aware of and committed to protecting the environment.

Given the challenges identified, such as inadequate teacher training and the absence of effective public policies, it is necessary to adopt measures that ensure the effective implementation of environmental education in schools. Proposals such as teacher training, the development of contextualized teaching materials and government support are essential to ensure that environmental education is continuous and effective.

Finally, the preservation of the Cerrado and other Brazilian biomes depends on collective action involving educators, public administrators, communities and society in general. By encouraging sustainable behaviors and valuing the environment, environmental education emerges as a fundamental tool to ensure a sustainable and balanced future for future generations, consolidating itself as a central element in the fight against environmental degradation and in promoting truly sustainable development.

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Epistemological, Pedagogical and Methodological Assumptions of Historical-Critical Pedagogy (PCH)

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Abstract. The article explores Historical-Critical Pedagogy (PHC) in the educational sphere, starting with a historical contextualization of the theory. It, then, examines the epistemological assumptions that underpin PHC, highlighting the connection between Historical-Dialectical Materialism (MHD) and pedagogy. Finally, it presents the methodological assumptions of PHC. The research is based on a bibliographic survey, with emphasis on the works of Dermeval Saviani, who defends an emancipatory education, forming critical individuals who are aware of their social reality.

Keywords. Historical-Critical Pedagogy (PHC), Critical Theory, Historical-Dialectical Materialism (MHD).

1. Introduction

Historical-Critical Pedagogy (PHC) has its bases supported by several contributions of Historical-Dialectical Materialism and incorporates influences from the thoughts of Marx and Engels. According to Triviños [1], historical materialism is the philosophical science of Marxism that studies the sociological laws that characterize the life of society, its historical evolution and the social practice of men, in the development of humanity. In this sense, PHC seeks to understand the objectification of education throughout its historical process, conceiving individuals as beings in constant formation through work, which, according to Marx [2], is not synonymous with employment, but a starting point for the humanization of the social being. As stated by Marx [3], work is, therefore, a condition of man's existence, independent of all social forms, an eternal natural need for mediation of the metabolism between man and nature and, therefore, of human life". Corroborating this perspective, Lukács [4] emphasizes the double transformation that occurs through work, where the individual not only modifies the environment around him, but also alters his own nature. Thus, PHC is opposed to the traditional pedagogical approach, which is characterized by the unilateral transmission of knowledge and does not stimulate students' critical reflection. PHC's proposal is to form critical and conscious citizens, overcoming the dichotomy between theory and practice, understanding that critical reflection on reality is fundamental to guide educational action [5].

2. Historical contextualization of PHC

Historical-Critical Pedagogy (PHC) emerges as a critical response to the traditional pedagogical approaches that predominated in the Brazilian educational scenario, especially from the nineteenth century onwards. According to Saviani [5], traditional pedagogy is characterized by the unilateral transmission of knowledge, where the teacher is seen as the holder of knowledge, while students are mere passive receivers of information. This verticalized approach disregards the students' ability to build their own knowledge, resulting in a hierarchical relationship that limits students' autonomy and creativity. Pedagogical practice, in this context, does not stimulate critical reflection or the resolution of everyday problems, perpetuating an education that reproduces existing social inequalities.

On the other hand, the PHC, proposed by Dermeval Saviani in 1979, arises in the context of the redemocratization of Brazil, after a long period of military dictatorship. Saviani [6] clarifies that the expression "Historical-Critical Pedagogy" reflects the effort to understand the educational issue from an objective historical development. PHC positions itself as an alternative to the authoritarian and technocratic pedagogies that prevailed during the military regime, proposing an education that values critical training and the active participation of students.

The metaphor of the curvature of the stick, used by Saviani [7], illustrates the search for a point of balance between theory and practice in the educational context. Just as a fishing rod bends under the pressure of a fish, educational practice must be shaped by the educational theories adopted. PHC seeks to find this balance, based on historical-dialectical materialism and understanding the social and educational reality in a critical way. PHC's pedagogical proposal is not limited to the transmission of knowledge, but aims to stimulate critical thinking and transformative action of students in relation to the reality in which they are inserted.

From 1979 onwards, PHC began to structure itself in an organized manner, gaining momentum in pedagogical discussions and influencing educational practices and public policies. Saviani [5] points out that, around 1983, PHC dominated pedagogical discussions, gradually replacing reproductionist thinking and promoting the valorization of the school as an essential tool for the less favored groups. During this period, voices emerged that defended the widespread adoption of PHC, aiming to directly influence the practices of teachers in their classrooms.

An important milestone in the consolidation of PHC was the National Congress of Sociology, promoted by the Brazilian Society of Sociology in 1979, where topics related to history, politics and culture were discussed, deepening the debates on the historical-critical approach. These events and publications contributed to a greater diffusion and consolidation of the historical-critical perspective in the field of social sciences and humanities. From then on, PHC began to influence historical, sociological, and geographical studies more profoundly, providing a clearer understanding of the relationships between society, history, and space.

Among the fundamental works that consolidated PHC, "School and Democracy" and "Historical-Critical Pedagogy: first approximations" stand out, which publications date from 1983 and 1991, respectively. These works by Saviani are essential to understand the theoretical and methodological aspects that underlie PHC, which seeks to promote an emancipatory education, capable of forming critical individuals who are aware of their social reality. Thus, PHC is established as a pedagogical proposal that aims not only at the transmission of knowledge, but at the transformation of society through education.

3. Epistemological assumptions of PHC

The epistemological assumptions of Historical-Critical Pedagogy (PHC) are fundamental for the understanding of its educational approach and for the pedagogical practice it proposes. These assumptions are based on a critical view of education, which seeks not only the transmission of knowledge, but the formation of critical individuals who are aware of their social reality. Next, we present the main epistemological assumptions of PHC, as discussed by Saviani [7], [5], [8] and other authors.

In this sense, dialectical relationship between theory and practice is one of the pillars of PHC. It is the understanding of the dialectical relationship between theory and practice. This relationship is understood as inseparable, where theory is not seen as a set of abstract knowledge, but as an instrument that enables the understanding of reality and the orientation of educational practice. Practice, in turn, is the moment when theory is applied, tested, and improved. This feedback between theory and practice is essential, as educational practice must be informed by a solid theoretical foundation, while theory must be constantly reviewed and adjusted in the light of practical experiences. Thus, PHC promotes an approach that values praxis, understood as reflective and conscious action that seeks to transform social reality [7].

Besides, education is considered as a social and historical process. This way, PHC considers education not only as an individual act, but as a social and historical process. This means that education must take into account the social, political, and economic relations that permeate the educational environment. The historical perspective is crucial to understand that education is a phenomenon in constant transformation, influenced by the cultural and social contexts in which it is inserted. Therefore, PHC seeks to understand education as a reflection of social dynamics and as a means to promote changes in these dynamics [5].

In addition, for PHC education implies social transformation, that is, PHC emphasizes the importance of education as an instrument of social transformation. For advocates of this approach, education should not be seen only as a means of transmitting knowledge, but as a social practice that has the potential to question and transform unjust and unequal social structures. PHC seeks to promote an emancipatory education, which enables the formation of critical individuals who are aware of their social reality. This implies valuing dialogue and the active participation of students, encouraging reflection, questioning and the development of critical thinking [5].

Following this way, PHC's epistemological assumptions are deeply rooted in the critique of the inequalities and injustices of capitalist society. PHC shares with Marxist theory a critical view of the social structures that perpetuate oppression and alienation. Education, in this context, is seen as a tool not only to understand these structures, but also to empower students to act consciously and transformatively in relation to them. PHC seeks, therefore, to train critical citizens who can question and challenge the social norms that sustain inequalities [9].

For this, PHC values a dialectical approach to education. This way, PHC adopts it to emphasize the interaction between opposites and constant transformation. This means that the educational process is seen as dynamic and evolving, where students are not mere passive recipients of knowledge, but active agents in their learning. This dialectical approach is also reflected in the way educational content is presented, always seeking to connect theory and practice, and promoting a critical and contextualized understanding of knowledge [5].

Another assumption of the PHC is the importance of valuing history and social practice. In this sense, PHC recognizes the importance of history in the formation of knowledge and in the construction of the identity of individuals. Education must therefore be contextualized, taking into account the experiences and realities lived by students. This valorization of history is linked to the idea that social practice is the starting and ending point of education, and that the contents should be worked on in order to reflect the social realities of the learners [10].

In this context, these epistemological assumptions of Historical-Critical Pedagogy not only underpin its educational approach, but also guide pedagogical practice, seeking to promote an education that is critical, reflective, and committed to social transformation. PHC, therefore, presents itself as a proposal that aims not only at academic training, but at the formation of conscious citizens engaged in the struggle for a more just and egalitarian society.

4. Pedagogical assumptions of PHC

The pedagogical assumptions of Historical-Critical Pedagogy are foundational for developing educational practices that transcend mere knowledge transmission. They emphasize the formation of critical individuals who are cognizant of their social realities. Below, we explore these assumptions further, drawing upon the works of Saviani [5], [11], [8] and other relevant authors.

First of all, PHC asserts that educational work should stem from the interconnectedness of theory and practice. This means that knowledge must be approached by considering students' experiences and needs. This relationship is termed praxis [5], which implies that theory is not an isolated entity; rather, it is shaped by the social practices that give it meaning. Consequently, educational practice transcends the simple delivery of content, engaging in a reflective process aimed at understanding and transforming social reality. Praxis is thus viewed as a conscious, critical action that strives to reshape the world by harmonizing thought and action.

Moreover, recognizes education as a social and historical process. It posits that education cannot be viewed merely as an individual act; it is deeply embedded in collective dimensions informed by social, political, and economic relationships prevalent within the educational environment. Saviani [5] highlights that educational practices are influenced by diverse historical and cultural contexts, underscoring the necessity to adapt pedagogical approaches to students' social realities. This continuous historical perspective is vital to grasp the evolving nature of education.

One of the central tenets of PHC is the belief in education as an instrument for social transformation. Proponents argue that education must extend beyond the mere conveyance of knowledge, striving instead to cultivate critical individuals who can interrogate and reshape unjust and inequitable social structures. Saviani [11] asserts that education is a political practice, focused on raising students' awareness of their realities and motivating them towards actions that contribute to a more just and equitable society. Consequently, PHC promotes dialogue and encourages student participation, fostering critical thinking and reflective questioning.

PHC is also grounded in a robust critique of the inequalities and injustices endemic to capitalist societies. This aligns with Marxist theory, which provides a potent critique of social structures that uphold oppression and alienation. In this context, education emerges as a powerful tool for understanding these structures and empowering students to act with awareness and intention. HCP thus aims to cultivate critical citizens who can challenge societal norms sustaining inequalities, fostering an educational framework that is both informative and transformative [9].

In addition, PHC embraces a dialectical approach to education, emphasizing the interplay between opposing forces and ongoing transformation. This perspective highlights that the educational process is dynamic and ever-evolving, wherein students are not passive recipients of knowledge but active participants in their learning journey. Saviani [5] indicates that this dialectical approach is mirrored in the presentation of educational content, which seeks to connect theory with practice and promote a critical, contextual understanding of knowledge. Education, therefore, becomes a fluid process where critical reflection and transformative action are essential.

Furthermore, PHC places significant value on history and social practice in knowledge formation and personal identity construction. Education must be contextualized to resonate with students' lived experiences. Lombardi and Colares [10] emphasize that this appreciation of history is linked to the notion that social practice serves as both the starting and ending point of education. Educational content should reflect students' social realities, fostering a deeper and more meaningful connection between theory and practice.

Another core concept within PHC is pedagogical mediation, where the teacher's role is to act as an intermediary between knowledge and students. Saviani [8] advocates that the teaching-learning process unfolds through mediations, wherein the teacher facilitates comprehension of content while helping students relate that knowledge to their social reality. This mediation is crucial for nurturing critical and reflective thinking, allowing students to integrate what they learn into their daily lives.

Lastly, PHC champions the training of autonomous and emancipated subjects who are equipped to question and transform their social circumstances. This approach aims to foster critical awareness and empower students as agents of change. Saviani (11) posits that education should encourage students' autonomy, enabling them to take ownership of their learning journey and actively engage with their social realities.

In summary, the foundational principles of Historical-Critical Pedagogy support its educational philosophy and inform its practical teaching approaches. This framework aims to cultivate an education that is both critical and reflective, with a strong focus on social transformation. In addition, PHC positions itself as a model that strives for not just academic excellence, but also the cultivation of aware citizens dedicated to achieving a fairer and more equitable society.

5. Considerations about PHC

Historical-Critical Pedagogy stands out as an educational proposal that aims not only at academic training, but also at the formation of critical citizens engaged in the struggle for a more just and egalitarian society. This educational approach seeks to promote a critical and contextualized understanding of knowledge, emphasizing the importance of critical reflection and transformative action in the educational process. For Saviani [5], PHC proposes that educational work is based on the inseparable relationship between theory and practice, where the objects of knowledge are worked on considering the experiences and needs of students. Thus, education should be seen as a process in constant movement, where social practice is the starting and ending point, allowing students to relate the knowledge acquired to their life experiences, making learning more relevant and meaningful [10].

A central concept in PHC is pedagogical mediation, where the teacher acts as a mediator between knowledge and the student. Saviani [8] argues that the teaching-learning process occurs through mediations, involving the teacher's action in facilitating the understanding

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of the contents and the relationship of students with social reality. This mediation is essential for students to develop critical and reflective thinking, integrating the knowledge acquired in their daily lives. The role of the teacher, therefore, is of utmost importance, as he must be able to adapt his educational approach to the specific needs of each student, promoting a learning environment that encourages active participation and questioning.

In addition, PHC values the formation of autonomous and emancipated subjects, capable of questioning and transforming the social reality in which they are inserted. Saviani [11] argues that education should promote the autonomy of students, allowing them to become protagonists of their own education and their social reality. The formation of critical and engaged citizens is, therefore, a central objective of PHC, which aims to contribute to the construction of a fairier and egalitarian society.

However, despite its robust theoretical foundations and innovative pedagogical proposal, PHC faces several challenges and limitations that hinder its implementation and dissemination. Saviani [5] points out that the lack of a National Education System (SNE), the discontinuity of government policies and the precariousness of teachers' working conditions are some of the obstacles that need to be overcome. The absence of a cohesive and structured educational system prevents the implementation of pedagogical practices that promote a truly emancipatory education. In addition, resistance to changes in traditional educational practices and the lack of continuing education for educators also represent significant barriers to the adoption of PHC in schools.

In short, Historical-Critical Pedagogy presents itself as an educational proposal that seeks to promote a critical, reflective education committed to social transformation. For this proposal to materialize, it is essential to face the challenges and limitations that still persist in the Brazilian educational scenario, always seeking to build a fairer and more inclusive educational system.

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Chemistry of Colors: Teaching Strategies in Inclusive Education

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Abstract. The objective of this work is to investigate the impacts of the teaching strategies used in the thematic project on the Chemistry of Colors and their relations with experimentation, through the three levels of chemical knowledge that affect the teaching-learning process of students in Specialized Educational Assistance (AEE). In the methodology, we employed the three levels of chemical knowledge—phenomenological, theoretical, and representational—along with the three pedagogical moments: initial problematization, organization of knowledge, and application of knowledge. Participants responded to a questionnaire consisting of 6 closed-ended questions, the analysis of which aims to investigate the approach used. Based on the responses, it is important to highlight the value of adopting diverse and interactive teaching approaches to promote meaningful learning and student engagement with the presented content.

Keywords. Colors, Dyes, Science Education, Experiments, Inclusive Education.

1. Introduction

The study of the history of inclusion reveals that groups considered "other" have faced discrimination and dehumanization for centuries. By the late 20th century, a broader discussion on social inclusion emerged. Although many individuals with special needs overcome these barriers, they still encounter prejudice and exclusion in various areas [1, 10].

According to the Law of Guidelines and Bases of National Education (LDB 9.394/96), special education is established as an integral modality at all levels and types of education. In 2023, the federal government launched a Plan for the Affirmation and Strengthening of the National Policy on Special Education in the Perspective of Inclusive Education (PNEEPEI) [4]. Inclusive education (EI) promotes equality for all, as evidenced in official documents such as the Brazilian Federal Constitution and the Salamanca Statement of 1994 [3].

In the context of science/chemistry teaching, EI promotes a comprehensive understanding of essential scientific concepts for students in Specialized Educational Assistance (AEE) [2, 4]. It is essential to consider the diversity of students and adopt a flexible and collaborative approach [10].

This study investigates the integration of AEE students in experimentation through the three levels of chemical knowledge and focuses primarily on the development of students regarding scientific concepts in an elective course. It examines how the teaching strategies used in the thematic project on "Chemistry of Colors" and their relation to the three pedagogical moments can impact the teaching-learning process for AEE students.

The objective of this work is to investigate the impacts of the teaching strategies used in the thematic project on the Chemistry of Colors and their relations with experimentation through the three levels of chemical knowledge that affect the teaching-learning process of AEE students.

2. Work procedures

The "Chemistry of Colors" project was developed by two students from the Chemistry Licensure program at UEG – CET Campus, and was carried out in the first semester of 2024 with a group of students from the 1st to 3rd year of high school. Originally planned for 15 sessions, the project included the participation of three students with special needs. The successful implementation of the project was made possible thanks to the collaboration of teachers, students, and academics from the Chemistry Licensure program at UEG.

We employed the methodology proposed by Delizoicov, Angotti, and Pernambuco (2002) [5], which consists of three pedagogical moments: "Initial Problematization," "Organization of Knowledge," and "Application of Knowledge." This approach connects academic knowledge with real-life situations for a deeper understanding of the topics [6].

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Additionally, we incorporated the three levels of chemical knowledge outlined by Johnstone [7], which address phenomenological, theoretical, and representational aspects of chemical knowledge [8].

The research methodology adopted in this study was Action Research, a participatory approach involving direct intervention in the social reality. By nature, it is interventionist, aiming not only to understand but also to actively influence the studied context. Furthermore, an exploratory survey was conducted, typical of areas with little systematic knowledge. Due to its exploratory nature, it does not assume hypotheses, which may emerge during or at the end of the research [9].

The results will present the four sessions conducted with a class from CEPI school in Anápolis, GO. The activities were carried out with students with special needs who are part of the Specialized Educational Assistance (AEE) at the school. It is important to note that each student has specific needs: Student E1 has cerebral palsy with hemiplegia, while Students E2 and E3 have Intellectual Disabilities (ID).

In the research methodology, participants were given a questionnaire with 6 closed-ended questions. The analysis of these data aims to investigate the approach used in the "Chemistry of Colors" project. The responses were examined qualitatively to identify patterns that highlight the effectiveness of the teaching methodology, as well as challenges faced and suggestions for improving experimental practices.

3. Results and Discussion

In this section, the results will be presented chronologically, covering four sessions with the participation of three students with special needs.

3.1. Initial Problematization with a Basket of Fruits

In the first session, we began with an "initial and phenomenological problematization" using questions such as: “Are there any similarities between the fruits?” “Do you believe that the colors present might influence the nutritional properties of these foods?” Based on the responses, we moved to the second moment, "organization of knowledge and theoretical." A theoretical presentation using slides was employed to relate the content to the students' everyday experiences. In the third moment, "application of knowledge and representational," students were able to connect theoretical concepts with practice and visually understand what chlorophyll, carotenoids, and other pigments are.

3.2. History and Curiosities about the Chemistry of Colors

This activity was conducted over two sessions. In the second session, we started with an "initial and phenomenological problematization" using slides and questions such as: “Why does the sky turn orange at sunset?” “Why does it have these characteristics?” “What influences the color change of leaves in autumn?” Based on the students' responses, we organized the knowledge and presented theoretical content, including videos on the concept of color and the history of "chemistry of colors." We conducted a digital game activity to reinforce the content. In the third session, students participated in creating color wheels of primary, secondary, and tertiary colors. The AEE students recreated the wheel of primary colors.

3.3. Isaac Newton

In the fourth session, we provided an explanation and discussion about the renowned scientist Isaac Newton, accompanied by "initial and phenomenological problematization" questions such as: “What were his contributions to the modern world?” “What is a rainbow?” We then proceeded to the "organization of knowledge and theoretical" phase with a slide presentation on Newton’s life and contributions. In the "application of knowledge and representational" stage, the Newton’s disk was created. We also conducted the "color phenomenon" experiment using a prism.

The analysis of the four sessions reveals significant progress in the involvement and understanding of the students with special needs. Active interaction during the initial problematization laid a solid foundation, boosting engagement. Practical application of concepts, such as the pigment extraction test, allowed for tangible understanding. In subsequent sessions, students actively participated in discussions and games, demonstrating their interest. The final session, which included the explanation of Isaac Newton and the creation of Newton's disk, enhanced comprehension, while the color phenomenon analysis with the prism provided a concrete experience. The enthusiasm and motivation of the students demonstrate the effectiveness of practical learning.

To assess student satisfaction with the teaching methodologies adopted, we conducted a questionnaire, with questions detailed in Table 1.

Table 1 - Questionnaire

1. During the practical activities of the project, did you feel:
2. What part of the project did you like the most?
3. How did you feel participating in the digital dynamics, such as Kahoot, during the project?
4. Did you prefer the practical activities or the theoretical activities during the project?
5. What was the most interesting thing you learned about colors during the project?
6. What was the most difficult part of the project for you?

To assess student satisfaction with the adopted methodologies, we conducted a questionnaire with six questions categorized into three groups.

In the category "Experience and Feelings During the Project," questions 1, 3, and 6, participants expressed a predominantly positive experience, demonstrating interest and engagement in the activities. In the category "Preferences and Opinions about the Project," questions 2 and 4 showed a variety of perspectives, highlighting the importance of offering diverse approaches to meet different student preferences. In the category "Learning and Interest in Colors," question 5 revealed that students reported an in-depth understanding and growing interest in the topic, indicating the positive impact of the adopted pedagogical strategies.

However, it is important to emphasize the necessity of adopting diverse and interactive approaches in teaching to promote meaningful learning and student engagement with the presented content. As Schinato and Strieder [10] highlight, inclusive education aims to provide common education for all, which requires constant adaptations and improvements in pedagogical practice to ensure the development of all students. In this line of thought, the relevance of didactic resources in the context of inclusive education becomes evident, as they play a crucial role in the teaching and learning process, assisting in student comprehension and engagement.

4. Conclusions

The activities of this project aim to provide students with special needs opportunities for learning through experimentation and contextualization. The continuation of these initiatives reflects a commitment to overcoming difficulties in understanding the submicroscopic nature and promoting inclusive and effective education. In the context of inclusion, it is essential for teachers to consider diversity and adapt their pedagogical practices, using a variety of didactic resources to meet the individual needs of students, thereby creating an inclusive and meaningful educational environment.

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Strategic Implementation in Decision-Making in Microenterprises: A Literature Review

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Abstract. This study examines the significance of strategic management in decision-making within microenterprises, emphasizing the challenges associated with implementing strategic management and practices such as strategic planning, knowledge management, and efficient administrative processes. The research suggests that the lack of strategic planning, business knowledge, and the inability to adapt to market changes negatively impact decision-making. To enhance the performance and competitiveness of microenterprises, the development of managerial skills, integration of strategic management practices, and improvement of administrative processes are crucial.

Keywords. Challenges, Decision Making, Microenterprises, Strategic Management.

1. Introduction

Microenterprises, despite representing a crucial engine for the Brazilian economy, face significant challenges in achieving success and longevity. Among these challenges, the difficulty in implementing effective strategic management stands out, capable of guiding decision-making and ensuring competitiveness in a dynamic and competitive business environment. This paper presents the results of a literature review that explored the relationship between strategic management, the administrative process, and decision-making in microenterprises.

2. Methodology

This study is grounded in a systematic review of academic literature related to strategic management, the administrative process, decision-making, and the microenterprise environment. Articles, books, and other relevant sources were analyzed with the aim of understanding the impact of strategic management on decision-making in microenterprises, as well as identifying the main challenges and opportunities associated with this context.

3. Results and Discussion

The literature review highlighted the crucial role of strategic management and administrative processes in the success of microenterprises. The research revealed that the lack of strategic planning [1-3] and a deficiency in business knowledge [4-6] negatively impact decision-making.

Furthermore, environmental analysis [7-8], optimization of administrative processes [5, 9], and the ability to adapt to market changes [10], [11-12] are crucial factors for the longevity of microenterprises.

Key finds:

- Strategic Planning: Establishing clear goals and objectives to guide actions [1].
- Knowledge Management: Developing managerial skills and accessing information for effective decision-making [4-6].
- Efficient Administrative Processes: Ensuring the effectiveness of operations and resource management [5, 9].
- Adaptation and Proactivity: Responding to market changes and seeking continuous learning [10-12].

3.1. Discussion

The findings highlight the significant gap between the importance of strategic management and its actual implementation within microenterprises. The lack of planning, limited knowledge, and inefficient processes create a vicious cycle of poor decision-making and limited growth.

3.2. Implications

- Policymakers: The study emphasizes the need for targeted initiatives to promote strategic planning and business knowledge within the microenterprise sector.
- Microentrepreneurs: The research provides a roadmap for microenterprises

to prioritize strategic planning, knowledge acquisition, process optimization, and continuous adaptation.

3.3. Limitations

This study is limited by its reliance on secondary data. Further research involving primary data collection through surveys or case studies could provide deeper insights into the specific challenges and opportunities faced by microenterprises in different sectors.

Overall, this research underscores the urgent need for microenterprises in Brazil to embrace strategic management principles and adopt robust administrative processes to achieve sustainable growth and success.

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With Art and Educational Games in High School, Students Take the Lead in their Learning about Protein Synthesis

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Abstract. In 2003, on the 50th anniversary of the discovery of DNA, I had a great idea that was very well received by the undergraduate students and interns in Biology at the Federal University of Uberlândia-MG: the creation and production of teaching materials, followed by a dramatized presentation. After the planning and preparation phase, the didactic transposition was implemented for first-year high school students studying the chemical composition of cells, specifically nucleic acids. In the traditional teaching model, this topic often seemed uninteresting or meaningless, but our approach aimed to make it engaging and meaningful. Firstly, the preservice teachers, among other suggestions, chose the Integrated Panel to teach about the biological content in question, as a way to avoid simply reading the textbook. They proposed hands-on activities to create teaching materials that would engage more the students. We had prepared for creation of the narrative text to guide the actors during the dramatization. For several years, this experience, adapted to the reality of each school, was implemented in other schools by interns teaching as we suggested at the university. In 2015, as a Biology teacher at the Instituto Federal Goiano-Morrinhos-GO and advisor to a student scholarship holder of the Institutional Program for Scientific Initiation (PIBIC) at high school, this methodological approach, which already had teaching materials developed, was adapted for reapplication. This approach continued to evolve in its objectives, now more aligned with playful elements and technology, including the use of digital platforms. The project, titled 'Playful Elements in Presence and Virtual Reality: Dramatization and Games, was carried out by the scholarship holder. This methodological approach continues to have open spaces for further improvement. We considere that integration of interactive and engaging elements for students such as dramatization and games has could be a valuable strategy in enhancing educational experiences and fostering a deeper connection with the contents'school. This proposal remains an interesting and current topic for implementation as an active methodology in both basic education and in the continuing professional development for teachers

Keywords. High School, Preservice Teacher Education, Playful Activities, Protein Synthesis.

1. Introdution

Teaching and learning abstract topics in Biology, such as protein synthesis involving nucleic acids, DNA, and RNA, require teachers to implement strategies currently understood as active methodologies. This is especially important with the immersion of information and communication technologies (ICTs), using images and playful elements in hybrid teaching-learning environments.

Our pedagogical approach prioritizes to give at students a leading role in their own knowledge acquisition by having them represent characters in the dramatization of the protein synthesis process. Additionally, with teacher guidance, students will also explore the same process through educational games, leveraging technology in education and professional development. Furthermore, we aim to share the didactic experience researched through playfulness to enhance and explore the possibilities of technology in education for teacher training.

In this sense, we have always been committed to methodological guidelines for teaching and research at both high school and university levels to cultivate critical biology educators. These guidelines include investigating, creating, socializing, and developing various forms of oral and written communication, as well as other essential skills necessary for mastering the competencies of knowing, doing, and being, which are crucial in contemporary times.

Dramatization, as a different way of teaching and learning, has a place in the classroom, both in person and virtually, and can be incorporated into educational games. Despite external and

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institutional limitations and the disinterest of some students, it can be motivated by the pedagogical intentionality of science teachers. It fosters dialogue among participants and provides them with the opportunity to learn how to learn together, with ethics and citizenship.

This approach could replace traditional directive teaching models for active methodologies. It could also stimulate students to discover their individual competencies and encourage teachers to act as mediators in the teaching-learning process. This idea emerged from the following need of the teacher, herself and was posed as a problem situation with this question: How could it be more interesting and easier for students to learn about the functioning of cells if they could understand what happens inside them in a more representational way?

We get some contexts and experiences in Science teach and learn in high school and with protagonism students, In 2015, as a Biology teacher at Instituto Federal Goiano-Morrinhos-Go and advisor to a scholarship student from the Institutional Program for Scientific Initiation in high shcool (PIBIC/EM), a methodological proposal that already had developed teaching materials was adapted for reapplication. The approach evolved to align more closely with playful elements and gamification technology, incorporating digital platforms.

The project, titled 'Playful Elements in Presence and Virtual Reality: Dramatization and Games,' resulted in immense benefits for learning and social engagement, re-signifying knowledge through the pleasure of learning and involving students in investigation. Therefore, this article shares the journey of teaching and research, first describing the teacher's experience leading up to dramatization and then detailing the research trajectory of the technical high school scholarship student leading to the gamified material.

This includes: (i) Creation of teaching materials: description of characters and materials to be used; images for setting up the dramatization scenario; (ii) Script for the dramatization narrator; (iii) Suggestions for diagnostic and formative assessment of high school students and teaching interns; (iv) Images produced through playful games and relevant considerations about our activities in protein synthesis.

2. Development and contextualization for understanding

Undergraduate biology students, during their university classes in the practical teaching discipline, prepared for the supervised internship to be developed in the 1st year of high school at a state public school. In response to the treiner teacher’s suggestions, they agreed to first engage with an integrated panel for reading and familiarizing themselves with the content that after would be theaching.

This approach positioned them as future teachers rather than merely students preparing for exams. They then worked on a script for dramatization and, in the second phase, focused on producing teaching materials and preparing to interpret situations related to protein synthesis. The dramatization was presented with students taking on the roles of characters, authors, and actors, thus becoming the protagonists of the educational experience.

In this article, we first present the results of this formative experience at the university, aimed at preparing and planning for undergraduate students' teaching internships over several years. We then describe the experience developed in the classroom during the teaching internship:

(i) In the integrated panel, each group prepared to represent one of the components of protein synthesis. Subsequently, new groups were formed, each including a character from the previous groups to discuss their function in the cell. Finally, the original groups prepared the script for the dramatization;

(ii) The dramatization preparation involved thirty undergraduates as actors, with the sequential development of the protein synthesis process being enacted. In our view, there was a lot of positive anticipation and confidence from the undergraduates that the adaptation of the dramatization for the school students—using the school's gymnasium—would be very interesting.

(iii) In fact, what happened during the

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internship exceeded expectations, as it surprised everyone, even those who chose to be spectators at that moment. We respect this choice, understanding that within a class group, it is important to acknowledge and respect individual differences.

This experience has shown over many years that teaching becomes easier and more interesting when students, driven by a need and motivation, discover the motivation that drives their journey. We are referring here to our efforts as teacher trainers to stimulate student engagement in the face of a problem situation involving learning.

From the students' perspective, the dramatization, as a mobilizing strategy, is very engaging. It is a didactic approach that helps transform the meaning of teaching, assessment, and teaching materials. To the surprise of some interns, four students even composed a song about ribosomes. Each student, regardless of their age, presents a challenge to the teacher's competence, as their interest is directly linked to the existence of a personal need that drives the necessary actions to satisfy that need—learning.

Even though the initial goal of the proposal, first by the teacher and then by the undergraduates, was not achieved by some students who showed disinterest in the dramatization, it was extremely relevant for others—the majority. In this context, dramatization has increasingly occupied curricular and disciplinary space in the teacher's trajectory as a trainer of biology teachers, as it challenges teaching practices and stimulates the interest of high school students. This methodological proposal continues to have opportunities for improvement.

In general, student teachers in internship situations often think or say, "Where do I start the lesson? It could be simple: start by telling a story, asking some students what they know or have heard about nucleic acids, presenting a problem situation or a concept map, or even asking a straightforward question like, 'What is your need to learn about the role of nucleic acids—DNA and RNA—in cells.

A long time ago, in the 1990s, when I felt the need to understand whether constructivist teaching could be a reality in my teaching practice, I asked my daughter, who was completing the final year of elementary school. By then, she had already studied this content in the chapter of her textbook on the chemical composition of cells, which was presented in a basic and simple manner according to the pedagogical experts of that time.

3. Some dialogues from a mother who is a biology teacher and teacher trainer at a federal public university to understand how teaching and learning occurred at a basic school

- I started by asking her: 'Have you ever heard of genetic material? Where is this genetic material, DNA and RNA, located in your body? What is its purpose?' The response was quick:

- 'Yes, at school in science classes. This genetic material is found in the gametes.' After a few seconds of silence, I managed to ask her:

- 'Why do you think this material is only in the gametes, in your opinion?' She answered,

- 'Because of heredity, to pass from parents to children.' Without showing any sign of discomfort in her speech or gestures, I continued:

- 'You must have learned that cells have a nucleus and that it provides all the commands for the cell to function. If this material is in the nucleus of gametes, how would other cells in the body receive commands to function? She answered me calmly,

- 'It seems complicated, so I need to study more; it was very quick, and I’m realizing that I have a lot to learn.' I replied,

- 'True, we can talk a bit more so you can understand what really happens in gametes and other cells in the body.' And with that, the 'interview' ended.

A simple conversation between mother and daughter helped us realize the importance of dialogue, questioning, and listening. This

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enables us to organize the knowledge to be taught, revisit the process, and review our pedagogical practice, with the goal of encouraging students to reflect on their own learning. We hope that the presentation of this dialogue will better illustrate our thoughts on the use of games and the intersubjective processes that such activities can promote in the elaboration of spontaneous scientific concepts and how the teacher's social mediation is necessary for the development of student learning [1].

Regarding this, Duarte affirms that "The teaching of scientific concepts is not a process of physically removing everyday concepts and replacing them with scientific ones [2].

Another question we frequently raise in university teaching to address issues related to protein topics is: When we say that the cells in our body synthesize proteins, produce enzymes that participate in digestion, and carry out metabolism, we might ask: Why do they need to do this if the foods we ingest already contain a variety of proteins? If that were the case, all cells in our body would be identical and perform the same functions, which is not true, as we have different cells performing distinct functions. On the other hand, would the proteins, as large molecules, pass through the cell membrane to enter the cells that make up our body, starting with the mucosa lining the intestines?

The breakdown of food into smaller molecules begins in the mouth and continues in the stomach, with the digestion of proteins occurring in the stomach. Smaller molecules, such as amino acids, then cross the mucosa and enter the bloodstream. But how are the proteins in our body, within our cells, synthesized? How does this process occur using the amino acids resulting from the digestion of proteins in the foods we consume? What is the purpose of this material? Have you ever heard of genetic material—ADN and ARN? Where is this material located within the cell? Does this happen in other living organisms as well? Certainly, some questions were posed to arrive at a problem situation that guides teaching through investigation, starting from the contextualization of the lesson's theme, helping students recognize their need to learn.

It is important to highlight contributions from Rubem Alves in his text *The Art of Producing Hunger*, where he quotes Adélia Prado: 'I don’t want the knife or the cheese; I want hunger.' 'Eating doesn’t start with the cheese. Eating starts with the hunger to eat cheese. If I’m not hungry, having cheese is useless. But if I’m hungry for cheese and don’t have any, I’ll find a way to get some cheese...'

4. Sequence of activities for the dramatization of the protein synthesis model

4.1. Creation of teaching materials: description of characters and materials to be used

- DNA: 10 students wearing white robes, carrying signs with DNA nucleotide triplets.
- mRNA: 5 students wearing blue robes, carrying signs with nucleotide triplets complementary to the DNA strand.
- tRNA: 5 students wearing blue robes, carrying signs with corresponding nucleotide triplets, and with faces painted to represent the color of the amino acid they will transport (each face should be painted according to the colors of the geometric shapes of the amino acids involved in the synthesis).
- Enzyme: 1 student wearing a red robe with a pair of scissors.
- Amino Acids: 8 students wearing green robes.
- Ribosome: 1 student wearing a lilac robe

Suggestion: The robes can be designed as sleeveless vests worn over the school's T-shirt, made from Non-Woven Fabric (TNT). The nucleotide triplet signs can be made from thin PVC, foam board, or cardboard, measuring 38 cm x 28 cm. The amino acids, in different geometric shapes, can be made using the same materials.

4.2. Images for setting up the dramatization scene

The plasma and nuclear membranes can be represented by ropes or marked on the floor with chalk, leaving the pores of both membranes free for the passage of substances involved in the synthesis process. The dramatization is carried out in three scenes:

To start the dramatization, all characters

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should be positioned semi-kneeling and distributed in the cell according to Fig. 1, which depicts the cell before protein synthesis as follows: four amino acids inside the cell and four outside. DNA and Ribosome are located, respectively, inside the nucleus and in the cytoplasm. RNA nucleotide triplets (codons) are located inside the nucleus, while tRNA anticodons are in the cytoplasm. The enzyme is positioned in the nucleus.

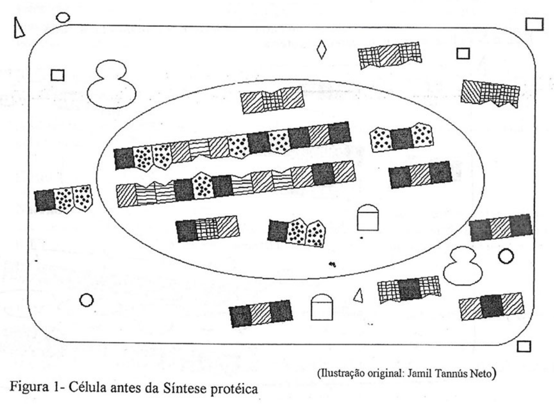

Figure 1. Some cells before protein synthesis

Fig. 2, illustrates the beginning of protein synthesis.

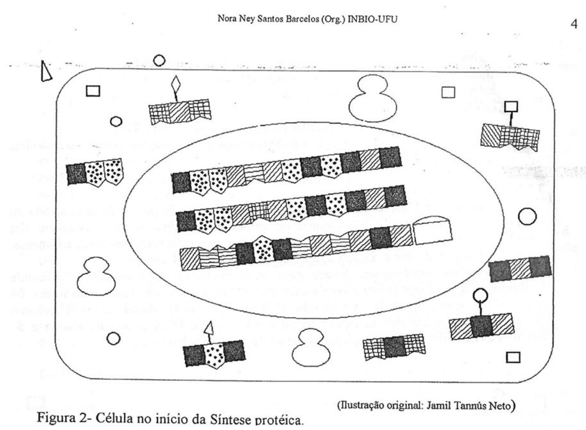

Figure 2. Some cells at the beginning of protein synthesis

Now we could seem the protein formed before some process in Fig. 3.

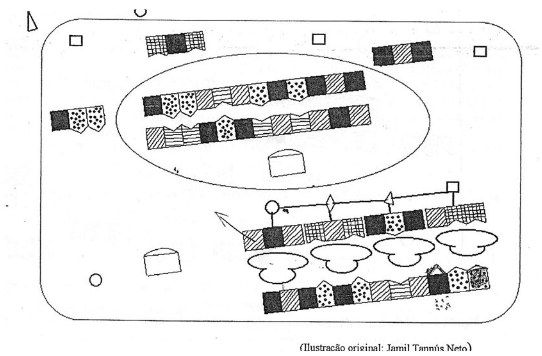

Figure 3. Representation of the peptide synthesis process

4.3. Script for the Narrator of the Dramatization

- Narrator: Good morning, afternoon, or evening, dear audience! I am one of the cells in your body and I'm delighted that you are here. Today, you will see how I produce proteins essential for the life of my body. As you know, there are many types of proteins that perform a wide range of functions. For example, they participate in the transport of respiratory gases, muscle contraction, defense of our organism through antibodies, and digestion of food through enzymes. Protein synthesis is a dynamic process involving many cellular components. For this reason, we will show you only the production of a protein fragment, but remember that I can produce countless proteins. Before we start, you need to get to know my cellular components.

- All: Hi, we are here! (All characters move and then kneel again. The amino acids outside the cell stand up, and one of them speaks.)

- Amino Acid 1: We are essential amino acids, produced by cells of other living organisms (mostly from plant sources and some from animals). We are present in the foods consumed by animals and humans. After digestion, we reach the blood, which transported us to this cell.

(The amino acids return to their initial positions. The amino acids inside the cell stand up, and one of them speaks.)

- Amino Acid 2: We are also amino acids, but we were produced inside this cell and in smaller quantities. (These amino acids return to their initial positions.)

- Narrator: As a cell, I have an information center called the nucleus. This is where the protein synthesis process begins, starting with DNA. Despite its vast size and function, here we will present only a small fragment.

(The DNA stands up, and one of the DNA nucleotide triplets speaks):

- DNA: We represent DNA. I am composed of two strands that combine with each other through nucleotides.

(After the DNA's speech, all the DNA nucleotide triplets move. Next, the transfer RNA (tRNA) nucleotide triplets stand up, and one of them speaks):

- tRNA Triplet 1: We are tRNA nucleotides, part of the tRNA molecule. We were produced by the DNA, which is why some of our nucleotides are also present in it. Our strand consists of several triplets, but it is folded. Therefore, only one of the triplets from the strand will be involved in the synthesis of this protein, meaning three interconnected nucleotides.

- tRNA Triplet 2: We are the tRNA nucleotides. We were also produced by the DNA and share some of its nucleotides. We play a crucial role in forming a specific protein. We are the messengers of DNA, which is why we are known as messenger RNA (mRNA). We have two states: free when we are not actively working, and associated as a single strand when we need to help the cell produce exactly the protein it needs. It’s a serious task. While we are working, our nucleotides must remain linked until the protein is formed. We appear as a strand only when we are at work, representing the sequence of multiple nucleotides.

(The precursor mRNA nucleotides return to their places. The Ribosome stands up and speaks):

- Ribosome: I am the Ribosome, and I was also formed from DNA. However, in addition to RNA nucleotides, I also contain proteins. I am known as ribosomal RNA (rRNA).

(The Ribosome returns to its original position).

- Narrator: After the formation of rRNA in the nucleus from DNA, it combines with proteins in the nucleus to form the Ribosome. Finally, it’s time to introduce the last component of the synthesis. Important! This component will start our work for the day—the process of protein synthesis. Let’s go, Enzyme! It’s your turn now.

- Enzyme: Hello everyone! Hello, audience! Nice to meet you all. Welcome to the world of the cell. I am the Enzyme. What do I do? Follow my work. It’s important, and I really enjoy what I do. And you, do you like learning?

(The Enzyme approaches one of the DNA strands. At this moment, the cell begins to work as the narrator speaks).

- Narrator: The enzyme has attached itself to one of the strands of the DNA, causing the strands to separate. Between the two strands of DNA, triplets of mRNA precursor nucleotides are arriving. Only a few triplets of the DNA combine with the incoming ones. The arriving triplets have arranged themselves in a sequence on a strand that science has named mRNA. Watch now! mRNA is detaching from the DNA and exiting the cell nucleus toward the cytoplasm. Pay close attention to what happens with the DNA strands. When the enzyme detached from the DNA strand, the two strands of DNA came back together. This is how DNA works in protein synthesis. But the cell's work continues, just in a different location. Let's go to the cytoplasm! Notice the triplets of nucleotides of the tRNA. They are approaching the amino acids, which became very excited with the arrival of the mRNA. tRNA nucleotides harmonize with specific amino acids.

- Where is the ribosome? What is it doing? The mRNA has arrived in the cytoplasm and is being inspected by the ribosome.

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Look! It is reading the first triplet of the mRNA. Meanwhile, the tRNA triplets are approaching the ribosome, which is already bound to the mRNA. Each tRNA triplet carries a specific type of amino acid. With the help of the ribosome, the first tRNA triplet pairs with the first mRNA triplet. The next step: the ribosome moves to the second triplet of the mRNA, and a second tRNA triplet arrives with another amino acid. At this moment, the first amino acid bonds with the second amino acid. As a result, the first tRNA triplet detaches from the process, becoming free to pair with other amino acids of the same type. When the third tRNA triplet pairs with the mRNA, the second triplet detaches from the mRNA. And so on. The amino acids bond through what is called a peptide bond, forming a specific type of protein that is unique to that type of cell, which, as determined by the DNA—the controlling genetic material—was produced in that cell according to that sequence of amino acids.

- What a beautiful cooperative work takes place within cells. It is very similar to what happens among us, in our families, schools, workplaces, and society. For today, we'll stop here, but the cell's work continues; it never stops. Thank you for your attention.

5. Suggestion for Individual Assessment for Diagnostic and Formative Purposes

We can begin the assessment throughout the entire process of developing the activities by observing and noting the most relevant information in a field journal. Considering assessment as a process for reflection and replanning of activities to support the learning of high school students and biology interns who were beginning their experiences, planning, developing educational materials, and participating as mediators in teaching this important topic in science/biology education. Thus, we present suggestions for possible questions to stimulate the desire to learn and motivate high school students. Initially, we conducted a survey of the students' prior knowledge through diagnostic assessment, followed by formative assessments of a qualitative nature in the next we present our proposal for processual evaluation:

5.1. Diagnostic Assessment

What other words does the term "genetic material" remind you of? Did you ingest DNA today? Justify your answer. Why do you need to learn about genetic material? How do you find out about scientific discoveries? DNA alone cannot carry out the protein synthesis that the cell needs. So, who are its helpers? Playful activities are alternatives, dynamic and interactive ways to enhance teaching and learning. For example, dramatizations, games, etc. Have you ever participated in a playful activity? If yes, tell us a bit about it, describing what you liked most. If could you justify why?

Some evaluations that we suggest to understand how our students and biology interns learned from our protein synthesis dramatization experience, all individual and qualitative assessments.

5.2. Formative Assessment - Individual

a) After the dramatization, at the students' home time: Production of a text by the students, after the dramatization, with the help of the textbook. Students should use the terms "codons" and "anticodons" to enhance their learning.

b) Production of a text by the students, after the dramatization, with the help of the textbook. Students should use the terms "codons" and "anticodons" to enhance their learning.

c) How was it to accept or not the dramatization, both for you and your peers? What caught your attention the most at the beginning of the dramatization? When did the dramatization become more interesting, and why? During the dramatization, were you able to relate the content to the image produced? Discuss yourself before, during, and after the dramatization, both as a student and as a person. What difference does it make to learn about protein synthesis using dramatization in addition to the textbook? What could be improved in the

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teaching project of protein synthesis using dramatization? Should the dramatization take place before students encounter the theory in the textbook, at the same time as it happened, or after they have learned the content in the textbook? Justify your answer. On a scale from zero to ten, how would you rate this teaching and learning experience?

d) Formative-qualitative group assessment. Someone of group could evaluate how the interaction, participation, and division of tasks occurred within the group, both among the 1st year students who carried out the activity and the biology interns who were part of the mediation process. Thus, we propose some questions for reflection and self-assessment of learning How was my interaction within class? How proactive everybody was in the class? Were the tasks completed equitably? How was the interaction between the leaders and the other collaborators in classroom? How was the communication and participation among the group members? Was there collaboration between the participants and mediators? Did I learn more on my own or through interaction with colleagues and mediators/teachers? What was better learned through group interaction? What was better learned individually? What hypothesis would you propose to justify your best performance in relation to the group that participated in the theater activity?

This evaluation in class can be conducted through a discussion circle where everyone can participate, engage in dialogue, and reach a consensus on the positive and negative aspects of the process during the development of the proposed dramatization.

Fig. 4 that we presentes in next was criate for ou PIBICEM, after the dramatization in Campus Morrinhos in 2015. This game could help students if they had some instrutions for simulations and texts for avaliation theyself lern and create others games about this subject.

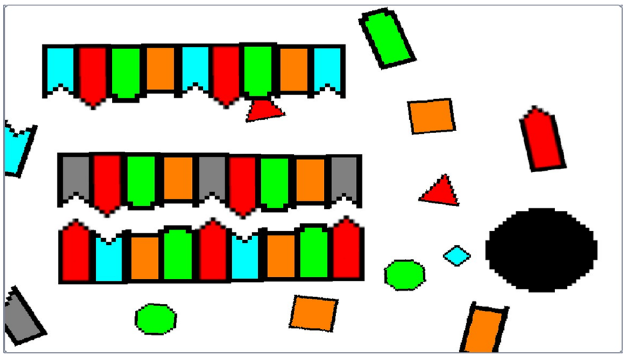

Figure 4. Images of part of the digital game created by the PIBIC/EM student

It was important for them to test their own knowledge and hypotheses, as this process allowed them to mobilize their internal language to develop scientific concepts and abstract thinking [5].

6. Final Considerations

In our view, dramatization serves a playful, formative/educational, and social function by providing an environment conducive to symbolic and imaginative representation, relaxation, creativity, and pleasure; formative/educational/research by enabling the search, thinking, and construction of scientific knowledge; and social by stimulating interaction, dialogue, criticism, speaking, and attentive listening—important aspects for ethical formation in interpersonal relationships, improving self-esteem, as well as developing reflective and responsible decision-making at all levels of education.

It is necessarily a significant scientific-cultural, psychopedagogical, and social activity because performing in public through dramatization requires diverse knowledge, sensitivity, balance, and oratory skills, in short, the exploration of all individual and group competencies. In dramatization, students aim to develop reasoning, communication, and logical thinking, while the teacher makes the class more enjoyable. Additionally, students feel motivated to seek answers to the teacher's questions and their own emerging questions throughout the process, with peers, in textbooks, and on the internet.

What gives learning the character of knowledge construction is the context created and the reflective experience. According to high school students who participated in this didactic

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experience, dramatization is very engaging and educational. The students' interest has become the driving force behind the teaching and learning process.

Adélia Prado’s "The Hunger to Eat Cheese" corresponds to the elements of Leontiev's [3] Activity Theory, specifically to the element of Need. Davidov [4] cites Rubinstein and Leontiev for the importance of the contribution of the individual subject to collective realization. “The individual subject, through appropriation, reproduces in themselves the historically-social forms of activity. The initially generic type of appropriation is the individual's participation in socially significant collective realization. An important particularity of activity, which constituted Leontiev's major discovery in the field of human activity as a complex structure, are its elements: need and motive, which are in a state of constant interrelation and transformation

Two fundamental ideas for Soviet psychopedagogy are: the social aspect, which constitutes the source of conceptual development and characterizes the organization of the student’s activity and learning, and Leontiev’s structure of activity, which emerges after the manifestation of a need. Thirst is a need that manifests until the appropriate object for its satisfaction, water, becomes available so that the activity of drinking can occur.

Similarly, Leontiev situates cognitive need as a need that manifests until an appropriate object is available for the learning activity to be carried out. Davidov [4] developed the theoretical analysis that better characterizes the learning activity in school. “For an action to arise, it is necessary for its object (its immediate end) to be conscious in relation to the motive of the activity in which this action is embedded.” Learning situations, from the perspective of Soviet researchers, aim primarily at the grasping of concepts through theoretical reflection, which is based on the analysis and planning of actions in problem-solving.

In this learning model, the key concept is that of the structuring conflict as a source of change in the individual, which is only possible through social interactions. The role of socio-cognitive conflict in individual cognitive construction has been highlighted by the work of genetic social psychology, contributing to the understanding of social variables within cognitive development. [...] From this reexamination of learning, the authors emphasize the dynamics of socio-cognitive interactions: ‘Learning is characterized by the subjective reconstruction of social models and meanings, through the negotiation of meaning in social interaction’” [5].

Our understanding of the elements of Leontiev's [3] Activity Theory and the ideal image of the object according to Galperin as described by Davidov [4] includes:

(i) Subject’s need—what provokes the search. A lack of something. Hunger;

(ii) Ideal image of the object of the need is the personal projection of an object. The scene involving the consumption of an appropriate prey;

(iii) Motive of the subject in relation to the need—what stimulates the subject, making it possible to satisfy the need. The capture of the prey.

(iv) Object of the need—What the entire process is directed towards. The realization of the motive. A prey that satisfies hunger;

(v) Motive—What incites the subject to act, facing difficulties and making the elaboration of the motive possible. Something that suggests the possibility of capturing the prey;

(vi) Object of Activity represents the possibility realized in the psychological and social action of the activity. The possession of the prey.

The subject’s activity is always linked to a specific need, being an expression of the lack of something that the subject experiences. When combined with a motive, it triggers the subject's tendency to search, in which the plasticity of the activity is manifested. Therefore, in Activity Theory [3], the objectification of the need occurs, that is, the conversion of the need's object into a concrete motive for the activity. In a subsequent phase, another property of the activity is observed, related to the construction of the image of the activity's object.

Thus, there is a growing demand for group dynamics and active methodologies, as these approaches stimulate students to become protagonists in their own learning, which implies greater competence from teachers as mediators of the process. In a different way, cells function; in addition to this function, cells produce identical cells with the same number of chromosomes through mitosis, and when followed by meiosis, they produce cells with half the number of chromosomes, known as gametes, which participate in heredity.

We emphasize the importance for educators and interns teachers to understand some principles inherent to the use of educational games in teaching, in order to engage in research through playfulness intentionalaty and recognition of the pedagogical potential of games and play aligned with teaching and learning theories. Thus, we believe that dramatization, as suggested, can enable various levels of interaction in intra- and intersubjective processes that help students organize their thoughts and develop hypotheses to aid in the formation of abstract concepts in process [6].

Educational games and dramatization that encourage reflection on one's educational practice and support the development of activities that meet the formative needs of students are valuable [7]. Such educational actions have the potential to mobilize and develop activities that, when critically reflected upon and analyzed, can be validated both within the academic community and in basic schools.

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Mobile Exhibitions and Biology Literacy: Formative Experiences in Scientific Education

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Abstract. In Brazil, educational initiatives in informal spaces, such as museums, science centers, and mobile science projects, have grown significantly. The Baú da Ciência project, through its itinerant exhibitions, has been instrumental in promoting scientific education in the state of Goiás. This study analyzes the activities carried out, with a focus on the Biology stand, which enhance the understanding of biological sciences and improve the biology literacy of visitors. The activities include interactive demonstrations and practical experiments, stimulating engagement and the development of critical and analytical skills, facilitating the application of knowledge in everyday contexts.

Keywords. Biology, Science Communication, Traveling Exhibitions.

1. Introduction

Educational activities conducted in non-formal spaces have played a crucial role in integrating with school curriculum themes and enhancing scientific education. According to Marandino [1], the expansion of scientific education initiatives in recent years is evidenced by the increasing number of science centers, museums, and mobile science projects.

In this context, the Instituto Federal Goiano - Campus Ceres, located in Goiás, Brazil, recognizing its role as a key generator and disseminator of knowledge, has actively promoted scientific outreach through the extension project “Baú da Ciência”, which has been operational since 2022 following its approval through a public call. “Baú da Ciência” operates itinerantly, bringing scientific activities to various cities within the state of Goiás, with a diverse collection of interactive experiences in the fields of Physics, Chemistry, Biology, and Information Technology.

The project team consists of faculty members from IF Goiano – Campus Ceres, affiliated with the relevant areas, as well as extension scholarship holders and volunteer monitors. The project functions as an interactive science center, providing various learning modalities and serving the general public, including both adults and children, in both educational and non-educational settings.

The main objective of the project is to promote the dissemination of scientific knowledge in the fields of Physics, Chemistry, Biology, and Computer Science through simplified and technological experiments and equipment. Operating itinerantly, the project aims to bring these activities to various locations, providing practical and interactive experiences that enhance the understanding of scientific concepts. The itinerant approach allows the project to reach a broad audience, including schools and communities, fostering learning and interest in science across different contexts and adapting to the specific needs of each location.

Scientific dissemination involves a range of methodologies and actions aimed at communicating scientific advancements to the public in a clear and accessible manner. This process fosters closer connections between the fields of science, research, and researchers with society, facilitating a more dynamic dialogue between science and the public as communication methods evolve [2]. The role of scientific dissemination has developed over time, increasingly highlighting the importance of popularizing science.

In this context, our goal was to highlight the actions involving the approach to biological sciences in the itinerant exhibitions of the Baú da Ciência, emphasizing how these activities contribute to enhancing the biology literacy of the visitors. Biology literacy, defined as the ability to understand and apply biological knowledge in everyday life, is crucial for the development of well-informed and critical citizens. By offering activities ranging from direct observation to simple experiments and clear explanations of biological phenomena, the Baú da Ciência encourages the application of biological concepts in diverse contexts, contributing to a more effective and meaningful scientific education.

2. Methodology

This is a descriptive and qualitative study that examines the activities related to Biology conducted in various municipalities across the state of Goiás through the extension project titled "Baú da Ciência" from the Campus Ceres of IF Goiano. The study provides a comprehensive view of the project's effectiveness in promoting biology literacy and engaging the public with scientific concepts.

In 2021, Campus Ceres received a donated truck with a trailer from the Federal Revenue Service to set up four science laboratories: one in Physics, one in Chemistry, one in Biology, and one in Information Technology (Fig. 1). Since then, the project has conducted periodic visits to cities in the Vale do São Patrício region and other areas in the state of Goiás. With simple equipment and experiments, the project aims to promote and stimulate interest in science among people of all ages.

Figure 1. View of the truck and trailer donated by the Federal Revenue Service, with the extension project design already applied

The project, submitted in May and approved in June 2022, establishes the field of Biology as a means of scientific dissemination, integrating theory and practice. Its goal is to promote the spread of scientific knowledge, enabling participants to explain and connect various biological phenomena with their own experiences.

The exhibitions are held in various locations, including schools, gyms, and public squares, and cover scientific events, technical-scientific fairs, and community activities. These exhibitions aim to reach a broad and diverse audience, promoting science and education in different contexts and adapting to the specific needs and interests of each location.

In the approach to biological sciences, the booth offers interactive practices ranging from demonstrations to hands-on experiments. Initially, the goal is to capture the visitors attention, followed by interaction and explanation of the phenomena. The focus is on contextualizing the experiences by linking them to everyday situations of the visitors, using common or popular knowledge. This aims to engage them in the scientific explanation of the surrounding phenomena, fostering active interaction with the team of monitors.

According to Padró [3], active visits facilitate the development of metacognition and allow visitors to deepen their interpretations. This type of visit requires dynamic engagement from the audience, encouraging reflection on their learning strategies and understanding of the content presented. To achieve this, innovative activities are created and implemented, promoting continuous visitor participation and the expression of their own ideas.

3. Results and Discussion

According to Marandino *et al*. [4], the evolution of scientific knowledge dissemination processes goes beyond mere simplifications. It requires ongoing debates and controversies among scientists and science communicators. The author's perspective is grounded in didactic transposition, which emphasizes the need to prevent errors, speculation, and positive but decontextualized representations of scientific knowledge.

Considering the contextualized approach to biological sciences, visitors exhibit a high level of empathy and engagement. All project demonstrations are generally conducted according to a schedule, consistently aiming to present simple yet attention-grabbing practices for each covered area. Thus, the Biology stand offers a wide variety of practices, covering various aspects, as detailed in Table 1.

In the field of Cell Biology, both animal and plant cells are demonstrated, with the option to

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prepare slides on-site during the exhibition. This practice includes observing epithelial cells from the oral mucosa and cells from the aquatic plant *Elodea* sp., allowing for the visualization of the cell wall, chloroplasts, and other cellular structures. Three-dimensional cell models are presented to facilitate the understanding of the structures being observed under the microscope (Fig. 2). These didactic models provide a clearer analysis of cellular components, complementing microscopic observation with a tangible and detailed representation of the organelles and other internal structures.

Table 1. Branchs and activities developed at the Biology booth

Branch	Activity conducted
Cell Biology	Observation of animal and plant cell structures under a light microscope; exhibition of educational models
Botany	Preparation of slides and observation of plant anatomical structures under an light microscope; observation of algae under an light microscope
Microbiology	Observation of protozoa under an light microscope; display of educational models of viruses and bacteria
Histology	Visualization of animal/human tissues under a light microscope
Parasitology	Discussion of the stages of *Aedes aegypti*; observation under the light microscope
Zoology	Observation of insect diversity in entomological boxes

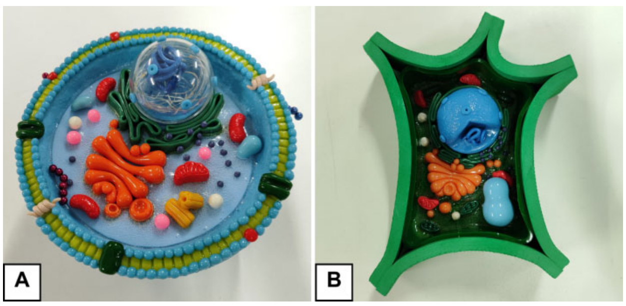

Figure 2. Cell models displayed during the Biology exhibits at the Baú da Ciência stand. In A, an animal cell model; in B, a plant cell model

In the Botany area, slides containing samples of plant anatomical structures, including roots, stems, and leaves from various plant groups such as gymnosperms and angiosperms, are displayed. These samples allow for detailed observation of the morphological and anatomical characteristics specific to each type of plant, aiding in the understanding of the adaptations and functions of these structures. Furthermore, this practice provides a comprehensive view of the differences and similarities between these plant groups, enriching the knowledge of plant diversity and complexity.

Additionally, various algae samples are presented, typically collected on the day of the exhibition to ensure the freshness of the specimens (Fig. 3). The public is given the opportunity to prepare their own slides, with guidance from teachers and monitors, and observe them under the microscope. During the activity, a detailed explanation is provided about the vast diversity of algae and their ecological significance in ecosystems.

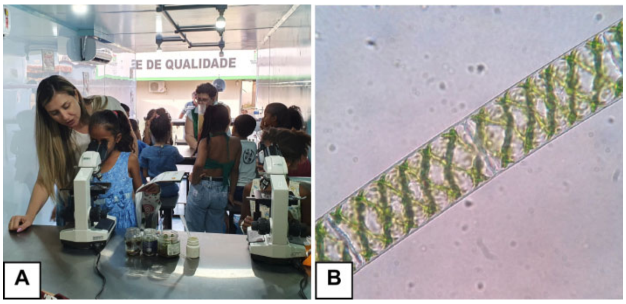

Figure 3. In A, students observing algae samples under the microscope under the guidance of a professor from the field; in B, a sample of the algae *Spyrogira* sp. observed under the optical microscope

All these practices were carefully selected to ensure they can be effectively carried out within the constraints of space and resources, while still providing meaningful and interactive educational experiences. The simplicity of the activities allows for their adaptation and implementation in various contexts, maximizing educational impact and facilitating visitor engagement. Initially, detailed scripts for prompting and explanation are developed for topics related to the field of biology. These scripts include instructions on the preparation of slides using various materials and the proper handling of microscopes, ensuring both the

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accuracy of procedures and the preservation of equipment. Additionally, the scripts are designed to spark the interest and curiosity of participants, thereby facilitating the understanding of the concepts being presented.

It is frequently observed that many participants have limited knowledge about these organisms and their true significance. In this context, the project is seen as a facilitator in conveying knowledge on topics that are generally underexplored, either due to a lack of access to specialized information or the absence of educational approaches that address these subjects in an accessible and engaging manner.

In the field of Microbiology, slides containing samples of protozoa are presented, accompanied by an explanation of the importance of proper water treatment (Fig. 4). During the activity, participants are informed about the risks associated with the presence of pathogenic protozoa in untreated water, emphasizing the potentially severe impacts on public health. Additionally, recommended methods and practices for ensuring water potability and preventing contamination by these microorganisms are discussed.

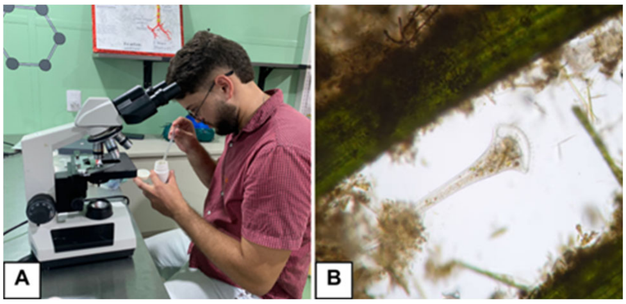

Figure 4. In A, sample collection for slide preparation; in B, Stentor sp. protozoan observed under an optical microscope

Educational models, developed by students from the Biological Sciences teaching program at the institution, are also displayed to facilitate visitors understanding of scientific concepts. In this context, structural models of viruses are presented, detailing their main components such as the capsid and genetic material, as well as bacterial models illustrating structures like the cell wall, flagella, and pili. These visual representations aid in the understanding of the characteristics and functions of these microorganisms, providing a clearer and more accessible view of their biological and structural aspects.

In the field of Histology, permanent slides from the institution's histological slide collection are displayed, featuring a variety of animal and human tissues (Fig. 5). Among the sampled tissues are blood tissue, epithelial tissue, and muscle tissue. These slides allow for a detailed observation of the structural and functional characteristics of different tissue types, contributing to a deeper understanding of histology and its applications in medical and scientific practice.

The public commonly expresses questions not only about the concepts related to the samples but also about the preparation process of these samples. Therefore, a detailed explanation of the method for preparing histological slides is provided, which differs from common cell preparation.

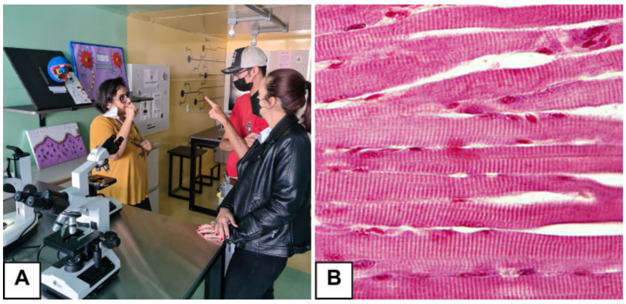

Figure 5. In A, an explanation is provided about what is being observed under the microscope; in B, a slide displaying details of skeletal striated muscle tissue is shown

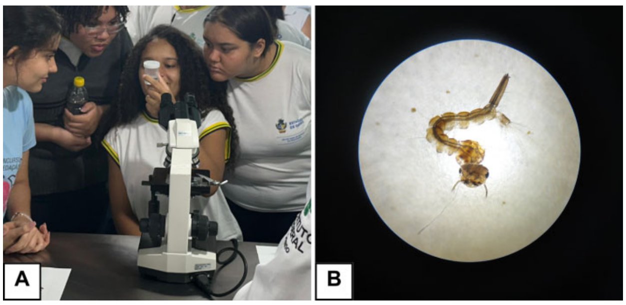

Figure 6. In A, students are observing a sample of the *Aedes aegypti* mosquito in a jar; in B, the observation of its larval stage under the microscope is being conducted

It is explained that histological preparation involves a series of essential technical steps. Initially, the sample is fixed with chemical agents, such as formalin, followed by dehydration with ethanol. Next, clarification is

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performed using a paraffin solvent, such as xylene, and subsequent embedding in paraffin. The next step is microtomy, which provides thin and uniform sections of the sample. After microtomy, the slide is stained with acidic and basic dyes and finally mounted for microscopic observation. This entire process is explained, defining each term and detailing what each step accomplishes in the sample to be observed.

In the field of Parasitology, the life cycle of the *Aedes aegypti* mosquito, a known vector of various tropical diseases, is examined in detail (Fig. 6). The exhibition allows for the visualization of the mosquito's structures at different stages of development, and the discussion extends to include prevention strategies, emphasizing the importance of control measures to reduce mosquito proliferation and minimize the impact of the diseases it transmits.

Finally, in the field of Zoology, a detailed exhibition of an entomological collection is presented, utilizing entomological boxes to showcase the diversity of insects (Fig. 7). This section offers a comprehensive view of the various orders and families of insects, illustrating their range of forms, sizes, and adaptations. The displayed samples include specimens from different habitats and geographic regions, allowing for a comparative analysis of morphological and ecological characteristics. The objective is to highlight the importance of insects in biodiversity and their respective ecosystems, as well as to raise awareness about their crucial role in environmental balance.

Figure 7. In A, a student examines the morphological characteristics of an insect using a magnifying glass; in B, a conceptual explanation of entomological boxes is provided

These traveling exhibitions, with a particular focus on biology, provide visitors with the opportunity to deepen their knowledge and feel empowered to share this information with others. In this way, they promote biology literacy and achieve the primary goal of encouraging scientific outreach, expanding the dissemination of knowledge, and reaching an increasingly broad audience.

According to Meyer [5], informal spaces for scientific outreach, such as museums and exhibitions, play a significant role both socially and culturally within the community. However, when these exhibitions are conducted in an itinerant manner, they achieve the same purpose with the added advantage of reaching people who, for various reasons, do not have the opportunity to visit these spaces [6].

Regarding the teaching of biology, the importance of science centers has significantly increased as transmitters of knowledge [7]. Through exhibitions, interactive activities, and practical demonstrations, they help make learning more accessible and engaging, fostering greater awareness and appreciation of biological sciences among students and the general public.

Biology is the science dedicated to the study of life in its various manifestations, examining aspects such as the functioning of living organisms, their interactions with the environment, and evolutionary processes. It allows for an understanding of the transformations that have occurred over time, how these changes have contributed to the survival of species, and how evolutionary mechanisms continue to influence contemporary life.

Thus, in the context of the Baú da Ciência exhibitions, this understanding is directly reflected in the activities provided. The traveling exhibitions allow the audience, composed of individuals of various ages and educational backgrounds, to access information about the central aspects of Biology in a practical and interactive manner.

Since its implementation, the project has held more than 40 exhibitions. In each of these events, a significant level of interest and curiosity was observed among the visitors. Many of them had never been exposed to much of what was presented. In the case of aquatic microorganisms (such as algae and protozoa),

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for example, it was noted that most people have little knowledge, and when they do, it is often superficial and highly abstract.

Many participants express doubts about what is being exhibited, with several, especially students, noting that they had only encountered such content in textbooks or through media outlets. These interactions highlight the importance of providing a practical and visual experience that goes beyond the theory presented in the classroom. Moreover, the opportunity to observe and directly interact with scientific phenomena not only sparks greater interest but also enhances the understanding of the concepts being addressed, enriching the learning process and making it more engaging and meaningful for the visitors.

During the various exhibitions held, there is a notable enthusiasm for biological topics, as demonstrated by visitors through questions, discussions, reflections, and personal accounts. In similar studies, Bonadiman *et al*. [8] highlighted that the diversity of the visiting audience helps to reinforce the perception that popular cultural common sense is not only varied but also deeply rooted in people's experiences.

These interactions with individuals of various ages, educational levels, and professions represent valuable opportunities for mutual learning. They facilitate the convergence of popular knowledge and scientific understanding, thereby promoting an enriching exchange between different forms of comprehension and language.

4. Conclusion

The dissemination of scientific knowledge through exhibitions or displays is crucial for both the teaching and learning process of those involved and for fostering a critical understanding and active engagement of society with various fields of biological sciences.

In this context, the extension activities offered by this project are grounded in the premise that the university has a social responsibility toward the community, as well as a commitment to implementing actions that effectively promote scientific dissemination. By developing strategies to broaden knowledge and understanding of scientific concepts and processes, we aim to achieve scientific outreach that enhances the spread of scientific knowledge across various social spaces.

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Application of Science Practices for Early Childhood Education

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Abstract. Science education for children is often treated in a simplistic way, not advancing critical thinking and restricting learning. We note the importance of initiating scientific literacy in early childhood education. Thus, we propose a rapprochement between early childhood education and scientific education in order to apply practical science activities to early childhood education. Practical science activities were applied so that children could report and question the experiences they had in practice, giving them scientific meanings, being able to develop the necessary skills to correlate the phenomena observed with the theories learned in the classroom.

Keywords. Scientific dissemination, Scientific literacy, Science teaching.

1. Introduction

Science teaching is often treated in a simplistic way, without advancing the world that surrounds the child, which restricts their learning. Teaching is somewhat limited between mathematics and written language, especially for children aged five and six, as the greatest attention is focused on literacy, sometimes not allowing children to explore the environment, observe the situations around them and get to know the world in their daily lives [1].

We can see the importance of starting scientific literacy in Early Childhood Education, as long as it is carried out in the child's language, through interactions and fun and enjoyable games. Therefore, it is necessary to introduce Science Education in this age group, as well as offering scientific language, since the acceptance and assimilation of the content by students are significant, promoting and reinforcing the notorious criticality during the process through the continuous participation and questioning of these young learners [2].

The law of National Curricular Guidelines for Early Childhood Education [3] determines that pedagogical practices developed in educational institutions must provide children with diverse learning experiences, creating learning situations in which children become the protagonists.

Morin [4] states that one of the roles of education and of extreme importance is to encourage children to engage in investigative practices, enabling the correlation of knowledge, as well as the complexity of life and existing problems, allowing children, through curiosity, to find themselves in the environment in which they are inserted. We observe that Science Education is directly linked to our daily lives, providing experience, investigation, logical development, as well as observation, communication, reflection, questioning, critical thinking, research, values, cooperation and action. Therefore, we can say that science education effectively contributes to the intellectual development of children, preparing them to be critical, active and responsible towards the world [5].

When observing studies of children's cognitive development, it can be noted that they already recognize themselves as “little scientists”, since their innate curiosity and their cognitive functions make it possible to do science, where the child sees himself as a little scientist systematically exploring his surroundings, formulating and proving hypotheses about it and thus building his intuitive scientific knowledge [2].

Scientific dissemination is a set of methodologies and actions in which scientific advances are communicated to the population in a simple and intuitive way. Dissemination leads to greater intimacy between the science-research-researchers axes and the general public, where the dialogue between science and the public has become more dynamic with the evolution of the media [6].

The role of scientific dissemination has evolved over time and increased the importance given to the popularization of science. In this context, we highlight the importance of scientific literacy in early childhood education, since we observe numerous difficulties in teaching science in general and the lack of methodological knowledge in science in the

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training of basic education teachers. Given the points reported, we understand the need to introduce science beyond theoretical and practical learning, the field of experimentation, providing scientific knowledge to children in Early Childhood Education, in a contextualized, interdisciplinary, didactic and playful way.

In this way, our objective was to propose a rapprochement between early childhood education and scientific education, providing conditions and providing means to instruct children to understand science within their possibilities of thinking and acting, sharpening their curiosity about nature in order to enhance their demand for knowledge of the world and their surroundings, aiming at the construction of a critical-reflective view on natural phenomena.

2. Methodology

This is a descriptive, qualitative study in the form of an experience report, based on the implementations carried out in the extension project entitled "Methodologies and Application of Science Practices for Early Childhood Education".

The project was implemented in a municipal early childhood education unit in the city of Rialma-GO, at the Costa e Silva Municipal Early Childhood Education Center (CEMEI). The activities were carried out over a period of 9 months, with an average of 1 to 2 activities per month. The classes to which the practices were applied correspond to the early stages of early childhood education (preschool levels), with children aged between 5 and 6 years.

Our objective was to conduct a series of experiments based on content already covered or included in teaching plans appropriate for the age group, so that children could experience such content in a practical and playful way. To this end, the project's scholarship students would enter the classrooms and begin to discuss the subject to be addressed in practice in order to pique the children's curiosity. Many of the activities were developed using resources such as stories told from literature or educational books, through cartoons, questions, challenges, games, and more.

After the experiments were carried out, the children followed the instructions for each experiment, where a pre-determined script was followed. The instructions contained methodologies applied to each experiment in a different way, which could be oral, flowchart, comic strip, among other methods relevant to the age and science content in question. After each proposed experiment was carried out, an assessment and/or activity was carried out with the purpose of collecting and observing data on the interest, curiosity, understanding and application of the practice developed in the children's understanding. These assessments were applied orally through questions, drawings, collages, reports, among others.

3. Results

Various science teaching activities were implemented in the form of participatory practices. During the application of science teaching practices to children, he is involved all the time, and brings together their daily experiences, relating them to the activities that were applied, showing their initial concepts and then recapping what was learned with what they already knew.

Figure 1. A and B, children's interaction with project members. Medicinal plant practice

Among the applied activities, we can highlight some practices, such as learning about aromatic and medicinal plants (Fig. 1), which included identifying different species, their properties and uses, and conducting small cultivation projects. Practices also included exploring the effects of plants on the environment and creating small gardens. These activities were designed to stimulate children's curiosity and promote an understanding of the importance of plants in our daily lives.

Practical activities focused on laboratory knowledge were conducted with the aim of

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familiarizing children with the scientific environment (Fig. 2), presenting them with the functioning of laboratories, the equipment used, and the activities carried out. These experiences were designed to spark an interest in science, a fundamental aspect for the development of a critical and reflective citizen. The laboratory tours took place at the Instituto Federal Goiano – Campus Ceres, where students had the opportunity to explore the Plant Biology and Zoology laboratories.

In the Zoology laboratory, the children observed stuffed animals, and some venomous animals stored in glass with preservatives (formaldehyde). During the visit to the Plant Biology laboratory, the children saw and handled a microscope with slides containing green algae and learned a little about living microorganisms. The entire time they were sharing their experiences and encouraged to observe and relate what was learned with what they brought from home.

These experiences were designed to spark an interest in science, a fundamental aspect for the development of a critical and reflective citizen.

During the execution of the project, activities were conducted with the children, including an entomology exercise using entomological boxes (Fig. 3), which allowed for detailed observation and understanding of insect diversity, as well as an experiment with psychedelic milk, which illustrated basic chemical concepts such as precipitation reactions and interactions between different substances, providing a practical and engaging approach to chemical phenomena. These activities fully captured the students attention, who exhibited intense curiosity and fascination with what they were observing.

In addition to these activities, the project included other practices such as investigating soil erosion, conducting density experiments, exploring conduction and electricity, observing microorganisms through optical microscopes, botanical painting, and studying development through butterfly metamorphosis. All of these practices were meticulously planned, tested, and implemented with the aim of fostering scientific literacy among the children at the school involved in the project. The goal was to provide them with a renewed perspective on the scientific environment and enable them to understand and interpret the various phenomena occurring around them in their daily lives.

Figure 2. Students from CMEI Costa e Silva visiting the Zoology Laboratory at the Instituto Federal Goiano – Campus Ceres

Figure 3. Practical classroom activity with an insect collection in entomological boxes

4. Discussion

Through the activities conducted with the aim of initiating scientific literacy, the children were able to report and question their practical experiences, assigning scientific meanings to them. This process enabled them to develop the necessary skills to correlate observed phenomena with the theories learned in the classroom, thereby strengthening and creating more solid pathways for understanding the

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connection between theory and practice in subsequent content and grades.

During the periods of conducting the practical activities, the interest and involvement of the children were notable. Their eagerness to be part of the process was very perceptible, as they responded to questions and participated with enthusiasm, making the experience more dynamic and enjoyable. Thus, science teaching practices imply understanding that this task should be implemented from the early years, and that the teacher working at this stage has the important role of creating and facilitating learning situations that open pathways and develop the skills and attitudes necessary for the gradual construction of scientific knowledge [7].

Thus, it is necessary to incorporate scientific practices into the students daily lives in science education, as these practices stimulate thinking, which enhances learning and the critical development of a citizen. With this perspective, the student transitions from being a passive receiver of knowledge to an active builder of knowledge as they investigate various sources and cross-examine theories to either construct new theories or confirm existing ones.

Vygotsky [8] highlights that the construction of scientific concepts requires the promotion of formal teaching and learning processes, where the teacher assumes the role of mediator between the spontaneous concepts already developed by the children and scientific knowledge. In light of this, we recognize the importance of the teacher experimenting and using the students spontaneous concepts as a starting point, as these and the scientific concepts are interconnected, forming part of the same teaching and learning process.

It is necessary to reconsider the pedagogical practices used in science education and propose methodologies that add meaning for the students, as these practices are often applied in a manner that is excessively theoretical and abstract, making it difficult for individuals to understand [9].

Lorenzetti and Delizoicov [10] propose a science education that does not solely focus on the training of future scientists but also provides students with the tools to understand and discuss the meanings of scientific topics and apply them to their understanding of the world. It is essential that work with these skills begins in the early years of elementary education. Thus, in the context of this work, we reflected that an environment open to dialogue, with a contextualized approach and a diversification of teaching strategies, becomes favorable for science education and scientific literacy in the early years of elementary School.

5. Conclusion

We conclude that our project provided preschool students with an experience that connected the content learned to their prior everyday knowledge. The children were able to engage in contextualized and interdisciplinary activities, with proposals linked to science education, contributing to the development of critical and scientific thinking, the construction of their worldview, and encouraging curiosity through experimentation.

It is also worth noting the importance of contextualization in Science Education from early childhood, as the application of these practical activities, no matter how simple, contributes to the students learning process as well as the ongoing professional development of the teacher. These actions need to occur continuously and systematically, providing meaning for the students and offering the teacher opportunities to conduct activities similar to those we have worked on here.

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PET Bottle Rocket as a Tool for Integrated Science Teaching

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Abstract. This paper describes an integrative project carried out at the Federal Institute of Education, Science, and Technology Goiano, Campus Trindade. The project aimed to build and launch PET bottle rockets from a launch pad as far as possible in an integrated manner. This project, which began in 2022, is now in its third edition. In addition to being an integrated and interdisciplinary study, the project also aims to prepare students to participate in scientific olympiads. Since then, the project has evolved, improving the aerodynamics of the rockets and launch pads, and has been successful in scientific competitions. The project highlights the importance of practical and interdisciplinary education, preparing students for academic and professional challenges.

Keywords Science Teaching, PET Bottle Rocket, Scientific Olympiads, Integrative Project.

1. Introduction

In 2018, the Integrated High School Technical Courses at the Federal Institute of Education, Science, and Technology Goiano, Campus Trindade, restructured the Course Pedagogical Projects (PPC).

In this restructuring, integrative projects are present as a mandatory complementary activity. The integrative project is characterized by the articulation between the disciplines of the national common base and the professional base disciplines, aiming to integrate the content of both areas [1]. The integrative project can also be defined as an activity that promotes and develops scientific initiation, aiming to foster interdisciplinarity by establishing the integration of knowledge developed in one discipline in an articulated manner with the others [2].

Regardless of the strategies used in the integration process, the professional profile of the course should be the focus, preferably involving regional and/or local issues [1]. It is an approach that closely aligns with the problems experienced in the world of work in the intended area of training [2].

Integrative Projects enable the experience of interdisciplinarity and the principle of transversality of teaching content through the transversal axis of the curriculum, which aims to promote the articulation between the disciplines in the academic semester, improving the understanding of the content offered to the student by the teacher [3].

Institutions that embrace the interdisciplinary proposal of Integrative Projects tend to favor more contextualized teaching; the proposal is also to deepen and dynamize the curriculum and strengthen the training of their students [4].

Integrative Projects involve group and class activities concerning the different skills and concepts learned throughout the course. Therefore, a path should be chosen through a problem-theme that favors analysis, interpretation, and criticism [2].

According to the Pedagogical Political Project of the Integrated High School Technical Courses of Campus Trindade, the integrative projects aim at a teaching-learning process that prepares the student for the challenges they will face in life and work [...] "It should provide the student with a global situation related to different areas of knowledge, requiring the search for knowledge in various disciplines to be solved" [1].

In this sense, this work aimed to implement didactic and methodological initiatives and experiences that aim to improve the teaching-learning process at IF Goiano – Campus Trindade through integrative activities in the practice of actions involving the construction and launching of homemade PET bottle rockets.

This project is now in its third edition. To participate, students must register, participate in workshops, and carry out the rocket launches. The project also aims to prepare students to participate in national and international scientific olympiads. Since 2023, students have participated in the Brazilian Astronomy and Astronautics Olympiad (OBA) and the Brazilian Rocket Olympiad (OBAFOG), winning several

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medals. Those who excel in these competitions conduct workshops in public schools in Trindade and surrounding areas to promote and popularize science.

2. Evolution and Challenges in PET Bottle Rocket Construction

This project began in the second semester of 2022 and is currently in its third edition. The target audience is students from the integrated high school technical courses at IF Goiano, Campus Trindade.

The first activity of the project consisted of a theoretical interdisciplinary study followed by an integrative lesson with shared teaching between institution professors. This activity aimed to integrate the subjects of the national common base with the areas of technical courses. Fig. 1 shows the first lesson of the first edition of the project in 2022.

Figure 1. Expository lesson with technical area teachers and the national common base in 2022

This activity aimed to integrate areas of knowledge from the National Common Base (Physics, Mathematics, Chemistry, History, Geography) with areas of knowledge from the integrated high school technical courses at IF Goiano, Campus Trindade. The Physics teacher provided an overview of rockets, existing types, and addressed the application of Physics in structural and aerodynamic engineering. The History teacher conducted a study on the space and arms race during the Cold War until the present day. The technical area teacher (Civil and Labor Engineering) discussed the application of mathematics in aerodynamic and structural engineering in the construction of rockets and their launch bases, as well as in the launch of real rockets, relating it to the materials used in the construction of PET bottle rocket bases and rockets. Additionally, she addressed safety precautions during the rocket production and launch process. The Geography teacher worked on geopolitics, addressing the launch bases and their locations on the globe. The Informatics teacher discussed the importance of satellites in communication, technological development, defense, space exploration, and Earth observation for monitoring deforestation and fires.

One of the biggest challenges was the effective integration of the different disciplines of the National Common Base with the technical areas of the courses. This integration required coordination among teachers and adaptation of content to make sense within the project's context.

After the initial classes in the auditorium, students were directed to the Physics laboratory for workshops focused on constructing launch bases and PET bottle rockets. Students were divided into teams of up to five members. Each team built a launch base and two rockets.

The construction of the bases and rockets followed the regulations of the Brazilian Rocket Olympiad (OBAFOG). This scientific olympiad, organized by the State University of Rio de Janeiro (UERJ), is held among students from all years of elementary, middle, and higher education throughout the national territory.

The OBAFOG aims to foster young people's interest in Astronautics, Physics, Astronomy, and Rockets by promoting the dissemination of basic knowledge in a playful and cooperative way, focused on aerospace activities. The OBAFOG is divided into five levels, of which the first three are intended for elementary school students, and levels 4 and 5 are exclusively for high school and/or higher education students:

a) Level 1: for elementary school students regularly enrolled in the 1st to 3rd grades.

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In this level, the rockets are launched obliquely and propelled by simple thrust.

b) Level 2: for elementary school students regularly enrolled in the 4th and 5th grades. In this level, the rockets are launched obliquely and propelled by simple thrust.
c) Level 3: for elementary school students regularly enrolled between the 6th and 9th grades. In this level, the rockets are launched obliquely and propelled by pressure manually applied by the respective participants.
d) Level 4: for students regularly enrolled in any grade/level/period of high school or higher education. In this level, the rockets are launched obliquely and propelled by the pressure generated by the chemical reaction between vinegar and baking soda.
e) Level 5: for students regularly enrolled in any grade/level/period of high school or higher education. In this level, the rockets are launched obliquely and propelled by solid propulsion [5].

This study was limited to working with level 4 rockets. This level is intended for high school or higher education students who launch PET bottle rockets powered by vinegar and sodium bicarbonate.

The rocket's propulsion occurs due to the internal pressure generated from the reaction between vinegar and sodium bicarbonate. Sodium bicarbonate ($NaHCO_3$) is a basic salt commonly used in beverages as a chemical leavening agent, in fire extinguishers, and as an antacid in medicine (effervescent tablet). Acetic acid ($C_2H_4O_2$) is a clear, viscous liquid with a pungent odor, soluble in water, and present in vinegar.

When these two substances come into contact, the acetic acid in the vinegar reacts with sodium bicarbonate, releasing carbon dioxide and forming water and sodium acetate, a colorless crystalline compound with the formula $C_2H_3O_2Na$, also known as anhydrous salt, as shown in the chemical equation in Fig. 2.

$$CH_3COOH_{(l)} + NaHCO_{3(s)} \longrightarrow CH_3COONa_{(aq)} + CO_{2(g)} + H_2O_{(l)}$$

Figure 2. Chemical reaction of acetic acid with sodium bicarbonate

This reaction occurs inside the PET bottle rocket. This reaction releases CO_2 (carbon dioxide), which results in pressure inside the bottle. As the internal pressure progressively increases, when the trigger is activated, the liquid and air are expelled (action) and push the bottle in the opposite direction (reaction), according to Newton's third law, thus performing the oblique launch of the rocket.

In the rocket construction workshop, each component of the rocket (nose cone, rocket body, and fins) and its importance to the rocket's stability were discussed. During this lesson, the shapes of the nose cones and fins were presented, along with material suggestions for their construction. The choice of materials, dimensions, and mass of the rocket are fundamental to the rocket's stability.

The center of mass (CM) and the center of pressure (CP) are two important points for the stability of a PET bottle rocket. The center of mass is the balance point of the gravitational forces acting on the rocket, located on the rocket's central axis and directly related to its mass. A common practice is to position the CM at a distance approximately equal to the diameter of the PET bottle in front of the CP.

The center of pressure is the point where aerodynamic forces act on the rocket during flight. The moving air strikes the tail with greater force than the tip, causing the tail to experience greater "drag" or resistance. Therefore, the CP is located between the CM and the tail of the rocket. The determination of the CP depends on the length of the rocket's tip, the length of the rocket, and the dimensions and shapes of the fins. It is important that the CP is closer to the tail and the CM closer to the nose. If they are in the same place or too close to each other, the rocket will have an unstable flight.

After this study, each team had to build its own rocket. The students needed to choose the model of the PET bottle, define the dimensions, shape, and materials to make the rocket's nose cone and fins. After making these decisions, the students conducted a study on the rocket's stability, determining the exact location of the

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center of mass and the center of pressure of their rocket. Fig. 3 shows photographic records taken during the workshops.

Figure 3. PET bottle rocket and launch base construction workshop in the first stage of the project in 2022

The image above shows the rocket construction during the first edition of this project. Most teams used disposable PET bottles. For the construction of the fins, file folders were used, and for making the nose cone, parts of another PET bottle or juice boxes were utilized. To raise the center of mass closer to the nose cone, the teams used water-filled balloons. Fig. 4 shows the evolution of the rockets from 2022 to 2024.

Figure 4. Evolution of the rockets between 2022 (left) and 2024 (right)

Starting in 2023, the projects evolved to use returnable PET bottles. These bottles have thicker walls, which allow them to withstand higher pressure. The fins were made from 1.0 mm acrylic, a light and resistant material, cut to the shape of the bottle with scissors. We removed the "skirt," which was the part where the fins were attached in the first edition of 2022.

Another innovation was the use of 3D-printed nose cones and counterweights made with epoxy putty. In the 2024 versions, the fins were laser-cut, and we used 1.5 L returnable bottles, further reducing the rockets' mass and improving their performance.

After constructing the rockets, the students studied the chemical reaction between acetic acid present in vinegar ($C_2H_4O_2$) and sodium bicarbonate ($NaHCO_3$). This reaction is crucial as the resulting product is responsible for the rocket's flight. The students researched the best proportion to optimize the rocket's performance.

A study was conducted to build the launch base, which is essential to ensure the rocket is launched as far as possible. The rocket's trajectory is parabolic, typical of an oblique launch, making the choice of the launch angle crucial. Additionally, strong materials were used to prevent the base from breaking during the launch. Each team studied and defined the materials and design of the launch base.

Figure 4. Evolution of the PET bottle rocket launch bases and rockets from (left) and 2024 (right)

The choice of materials for the construction of the base and rockets followed the principle of reuse, using PET bottles, pieces of PVC pipe, and connectors—concepts covered in Biology. The selection of materials also considered strength, malleability, and mass, aligning with the concepts from technical disciplines. The use of measurement tools such as rulers,

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protractors, compasses, and scales was discussed in the disciplines of Chemistry, Applied Mathematics, and Technical Drawing. Fig. 5 shows the evolution of the launch bases over the three editions of this project.

In all projects, we used PVC pipes, a strong and low-cost material compared to alternatives like iron. PVC pipe segments are easily found at construction sites and can be reused in the production of launch bases. In 2022, we used a simple base with sealing done by thread seal tape. Subsequently, we replaced the tape with sealing rings, improving the sealing efficiency. Additionally, we enhanced the trigger to prevent the rocket from leaving the base without being activated, ensuring the rocket was securely fastened and there were no leaks.

To control the pressure inside the rocket, we used a manometer. In the 2022 project, we did not use a manometer, which made it difficult to precisely control the pressure during the launch. Launches were performed based on visualizing the reaction inside the rocket and using a stopwatch. Starting in 2023, we incorporated a manometer for better control. In 2024, in addition to the manometer, we introduced two valves. The upper valve is used to hold the spike, preventing the balloon from bursting prematurely. When the valve is activated, the spike releases the balloon. To improve safety during the launch, we introduced an abort valve in 2024. This valve allows for depressurizing the rocket in case of problems during the launch. This device was not present in previous editions of the project.

The evolution of the rockets and launch bases over the editions (2022-2024) required constant innovations and adaptations. Improvements in rocket design, the choice of new materials, and the development of technologies such as laser cutting and 3D printing were fundamental and challenging. These improvements resulted in better performance, with launches reaching pressures equal to or exceeding 150 PSI. The rocket range, which initially was approximately 150 meters, doubled to over 300 meters. The current national record is 496.15 meters, and the goal for 2025 is to achieve launches of 400 meters or more.

To perform the launch, the team fills the rocket with sodium bicarbonate and then places vinegar (acetic acid) in a balloon or condom inside the rocket. The reaction occurs when the spike is activated, piercing the balloon and allowing the acetic acid to come into contact with the sodium bicarbonate. This reaction releases carbon dioxide, which pressurizes the rocket. Each team determines the best way to fill the rocket for their project. Fig.5 shows the teacher explaining how to fill the rocket.

Figure 5. Filling the PET bottle rocket

The most anticipated moment for the students is the launch when the result of all the study and process is observed. Fig. 6 shows the students gathered in front of the campus, preparing for the rocket launches.

Figure 6. Students gathering for the launch

Figure 7. Launch bays

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For the launch, a flat area in front of the campus was chosen, free of obstacles and without any movement of people and animals. To avoid accidents during the launch, students used Personal Protective Equipment (PPE), and a safety zone was marked where other students could not enter. Fig.7 shows the marking of the launch bays and the isolation of the launch area.

Before the launch, students watched a video about safety during the launches. The choice of location, the use of PPE, and the precautions necessary during the launch to avoid accidents are knowledge acquired in the Work Safety courses.

Figure 8. Teams filling the rocket using PPE

During the launch, students applied all the theory studied in Mechanical Physics, including initial concepts of kinematics and dynamics. The correct proportion of reagents (vinegar and baking soda), concepts covered in Chemistry, was crucial. Mathematical calculations were important to optimize the rocket's horizontal range. Fig. 9 shows a moment after the rocket detaches from the launch base.

Figure 9. Trajectory of a PET bottle rocket during flight

The trajectory of a PET bottle rocket is parabolic, typical of an oblique launch, as studied in Physics classes and described in quadratic equations in Mathematics classes.

Each team conducted a test launch during which several problems arose. Among the main issues with the launch base were broken bases due to incorrect gluing of PVC pipes, leaks that reduced the rocket's pressurization, and improper angles, with some bases having angles greater than 45°, resulting in a higher maximum height but reducing the horizontal range.

The main issues with the rockets were related to the fins, which were glued at incorrect or crooked angles, causing the rocket to spin during flight. Additionally, some rockets had excessive mass or an improper center of gravity, impairing aerodynamics. These initial tests were essential to identify and correct problems, allowing for improvements in rocket performance.

One of the main challenges in executing this work is the cost of resources needed to develop the activities. Despite reusing some materials, the cost of producing the base and rockets is significant, especially for public school students. With each launch, adjustments were necessary, including the replacement of nose cones, fins, and often returnable bottles.

The students had to create a project, manage resources, time, and people, evaluate the product, and correct potential flaws. This entire process involved the application of concepts from technical disciplines such as Entrepreneurship and Planning and Budgeting.

At the end of the work, each team had to write a technical report on their participation in the activity. In this process, the Portuguese Language and Instrumental Portuguese teachers played a fundamental role in drafting the reports.

3. Final Considerations

This work presents a direct application of scientific and technological concepts, providing a learning experience that goes beyond traditional classroom teaching. The construction and launch of PET bottle rockets allow for the integration of knowledge from both the

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propaedeutic and technical areas. Thus, this project provided students with an enriching and interdisciplinary learning experience. Through the construction and launch of PET bottle rockets, it was possible to apply theoretical concepts in a practical context, which not only reinforced the understanding of academic content but also fostered the development of essential skills such as problem-solving, critical thinking, and teamwork. The implementation of integrative projects in the integrated technical courses, articulating different areas of knowledge, stands out as an innovative approach to technical and vocational education.

The adopted methodology, which combines theoretical teaching and practical activities, significantly contributed to student motivation, highlighting the value of contextualized and integrated education. Additionally, participation in competitions such as OBA and OBAFOG not only broadened the students' academic horizons but also provided them with a platform to apply their knowledge in real and competitive scenarios.

The results achieved, such as medals and qualifications for international selections, reflect the success of the project in meeting its educational objectives. More importantly, the impact of this work goes beyond the school environment, as the planned activities to disseminate knowledge in public schools in the region expand the reach of scientific education and contribute to the development of the local community.

Finally, this project reaffirms the potential of integrative projects as an innovative strategy for technical education, demonstrating that practical, contextualized, and interdisciplinary education is essential for preparing citizens for the challenges of the contemporary world. The continuity and expansion of these initiatives can significantly contribute to improving the teaching-learning process at the Federal Institute of Goiano and strengthening scientific education in our society.

4. Acknowledgments

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My Lunchbox, Our Health: Innovative Food and Nutrition Education Practices

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Abstract. This paper presents an experience report on the development of a student extension project focused on the creation of resources for Food and Nutritional Education (FNE), applied to Food and Nutritional Security. The primary goal of the project was to foster the development of artisanal, digital, and communication skills. The project participants were students from technical high school programs integrated with the Brazilian federal education system and members of the external community. To support the learning of new concepts, interdisciplinary workshops were held, focusing on topics like children's communication, the handcrafted creation of educational materials, regional cuisine, and the use of digital information and communication technologies. At each workshop, the participants worked on building new teaching resources. The participants had the opportunity to carry out two FNE actions, in which they applied the skills they had developed.

Keywords. Food and Nutrition Education, Food and Nutrition Security, Healthy Eating, Primary and Secondary Schools.

1. Introduction

In Brazil, Food and Nutritional Education (FNE) is recognized as a strategy for achieving Food and Nutritional Security and ensuring the Human Right to Adequate Food (HRAF) [1]. In this context, FNE is a transdisciplinary and multiprofessional field of action, characterized by continuous practice aimed at promoting healthy eating habits [2].

Among the principles of FNE, the following are particularly noteworthy: education as a continuous, participatory process that fosters autonomy; the diversity of practice settings; the appreciation of local cuisine and the respect for differing opinions and perspectives; the practice of emancipatory cooking; and intersectoral collaboration [3]. Consequently, FNE should be grounded in the principles of dialogical and active education, the horizontal nature of relationships, and the respect and acknowledgment of traditional knowledge [4].

Daycare centers, schools, and universities serve as significant public institutions for the implementation of FNE initiatives [3]. In these settings, the use of engaging and technological resources is essential as tools to stimulate students' curiosity and interest in taking part in FNE activities [5]. Furthermore, according to the National Common Curricular Base (BNCC), it is imperative to prioritize the development of students' abilities to understand, use, and create technologies with ethical considerations and critical thinking, to get and produce information [6].

The aim of this article is to present the implementation and outcomes of interdisciplinary workshops designed to build skills and competencies in the creation of Food and Nutrition Education (FNE) resources. These resources are intended for community outreach efforts, with the goal of promoting Food and Nutrition Security (FNS) in the region.

2. Experience methodology

2.1. Mapping and needs assessment

In Brazil, the Federal Institutes of Education, Science and Technology (IFES) were created within a concept of professional and technological training. Due to their multi-campus structure and defined territoriality, the IFES are committed to promoting interventions in their respective regions, identifying problems, and developing solutions for development and social inclusion [7].

The Goiânia Oeste Campus, located in the municipality of Goiânia (Goiás), operates within the Technological Axis of Environment and Health. This campus offers a technical course in Nutrition and Dietetics, integrated with high school education. Within this program, student involvement in food and nutrition education activities is recognized as a vital part of their professional training.

Thus, to meet the commitment of the IFES and enhance students' practical learning in FNE, a student extension program entitled "Minha

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Marmita, Nossa Saúde" (My Lunchbox, Our Health) was developed. To improve the interventions, especially those aimed at the external community, there was a need to train participants in the development of innovative FNE resources.

2.2. Experience objectives

The main aim of this experience was to train students and the external community to develop FNE resources using new methodologies. To this end, specific goals were set, including that the participants develop artistic, craft, communication, cooking, and computer skills.

2.3. Definition of the workshops

To train the participants, pedagogical workshops were chosen. Pedagogical workshops are conceptualized as a time and space for learning, in which there is a reciprocal transformation between subject and object, through a path with alternatives, which progressively bring us closer to the object to be known [8].

The first workshop offered a sensory experience for the full perception of the act of eating. The second workshop promoted the development of craft and communication skills through the making of puppets and the development of strategies for writing theater scripts for children.

The third workshop prioritized the development of culinary skills. With this in mind, it was decided to value local cuisine, with an emphasis on foods native to the Brazilian Cerrado and on making full use of food. The other workshops included information and communication technology (ICT) tools. Workshops were held to create visual content such as photographs, videos, posters, and podcasts.

2.4. Organization and development of the workshops

2.4.1. Workshop "Sensory experience: a full perception of food"

The starting point was the deconstruction of the "mechanistic food" idea, which consists of reducing food to mere fuel for man, conceived as a machine. This is a narrow and simplistic theory that reduces the human-food relationship to a form of "food behaviorism", where stimulus and response condition the human body to a biologically necessary process, but one that is totally mechanical and absent of any historical or cultural aesthetic reflection [9].

Visual and auditory perceptions were explored using video projections of sequential images, paired with a classical music audio track that had been edited to create a soundtrack intentionally disconnected from the visuals. The perception of aromas was explored using a variety of essential oils. Participants were exposed to a range of scents, including citrus, floral, woody, and spicy.

All sensory perceptions were addressed individually, and then combined with specific foods, including a fruit and nuts cake, apples, nuts, dried fruits, and seeds.

2.4.2. Workshop "Craft skills and communication: puppet making and storytelling"

To develop participants' crafting and communication skills, workshops were conducted where students had the opportunity to create their own puppets and explore various techniques for telling children's stories. The construction of this methodology is significant, considering the potential for EAN activities to be developed with children. For children, playing is the main activity of the day, and in this sense, playfulness favours the exploration and construction of knowledge, allowing them to identify, classify, group, order, symbolize and combine information, while at the same time developing attention and concentration [10-11].

Materials such as coloured felt, hot glue and scissors were used for the puppet-making workshop. The workshop was facilitated by a Campus teacher, a partner in the extension project, who makes felt crafts. The participants were shown how to handle the materials and were given tips on how to structure and make the puppet functional.

The storytelling workshop was mediated by a teacher, coordinator of the extension project's teaching activities, with experience in children's storytelling applied to FNE practice. Participants were instructed to use simple, clear and direct language with children. They were also instructed to use references that were close to the children's reality, to promote greater understanding. After the instructions, everyone was encouraged to construct short plays so that they could practice their writing skills. They were also invited to present them with the help of the puppets produced in the previous workshop, so that they could practice using proper language and voice intonation.

2.4.3. Workshop “Culinary skills: making full use of food and valuing the Brazilian Cerrado biome”

To enhance participants’ culinary skills and integrate them into FNE resources, Culinary Workshops were organized. These workshops covered various aspects, including the comprehensive use of food, using leftovers, incorporating unconventional food plants (PANCs), and valuing the fruits of the Brazilian Cerrado biome.

The culinary workshops were offered by teachers from the Nutrition and Dietetics Technical Course, coordinators of the extension project, and were in line with the Principle of Food and Nutrition Education, which addresses the appreciation of cooking as an emancipatory practice [4].

2.4.4. Workshops “Information and Communication Technologies: inno-vative strategies for secondary education”

Initially, a workshop was held in which participants interacted with an audiovisual and cultural producer, learning techniques for producing photographs with a cell phone. Afterwards, another workshop on the use of artificial intelligence tools to help create digital art was offered by the IT teacher.

Other workshops were also held to present the possibility of using graphic design platforms such as Canva®. The Instagram® and Spotify podcasters® applications were explored in workshops as communication strategies. The incorporation of Digital Information and communication technologies (DICTs) in the workshops corresponds to the recommendations of the National Common Core Curriculum (BNCC) for secondary education, which considers that technology and computing topics should be worked on in a cross-curricular way, from an interdisciplinary perspective [6].

3. Experience results and evaluations

3.1. Results and evaluations of the workshop “Sensory experience: a full perception of food”

Guided by the music teacher, the participants realized the multi-sensory possibilities that food offers when tasting it. There were various experiences to awaken all the senses while eating.

During the stimulation of visual and auditory perceptions, participants experienced the dissonance between perceptions, such as an image of natural landscapes accompanied by Beethoven's Symphony No. 5, known for its dramatic and powerful melody. Thus, this experience provided participants with varied emotions through the use of different musical elements, such as rhythm, melody, harmony and dynamics, which presented together with the images diversified the possibilities of the participants' perceptions.

The experience also highlighted points such as the importance of mindfulness when eating, the lack of which is often caused by everyday stress. For example, the participants tasted a fresh apple in a quiet environment. On this occasion, it was possible to hear the sounds of chewing and swallowing. Afterwards, they listened to an audio that was initially calm and then more agitated as they tasted the apple. In this way, it was possible to demonstrate how our senses are integrated and how they can influence our perceptions.

These different perceptions therefore have an impact on people's food choices, quality of life and health. Fig. 1 shows photographic records of the different moments of the workshop.

The experience was very well evaluated by the participants, who reproduced the knowledge acquired through an activity called the “Sensory Booth”, held during National Cerrado Week, on the IFE campus itself. In the “Sensory Booth”, sight was stimulated through the contemplation of flowers, branches and fruit from the Cerrado. Touch, through the textures of these same elements. Hearing was stimulated with a voice and guitar performance by students who brought songs that covered the Cerrado. Taste and smell were tested with a tasting of foods native from the Cerrado.

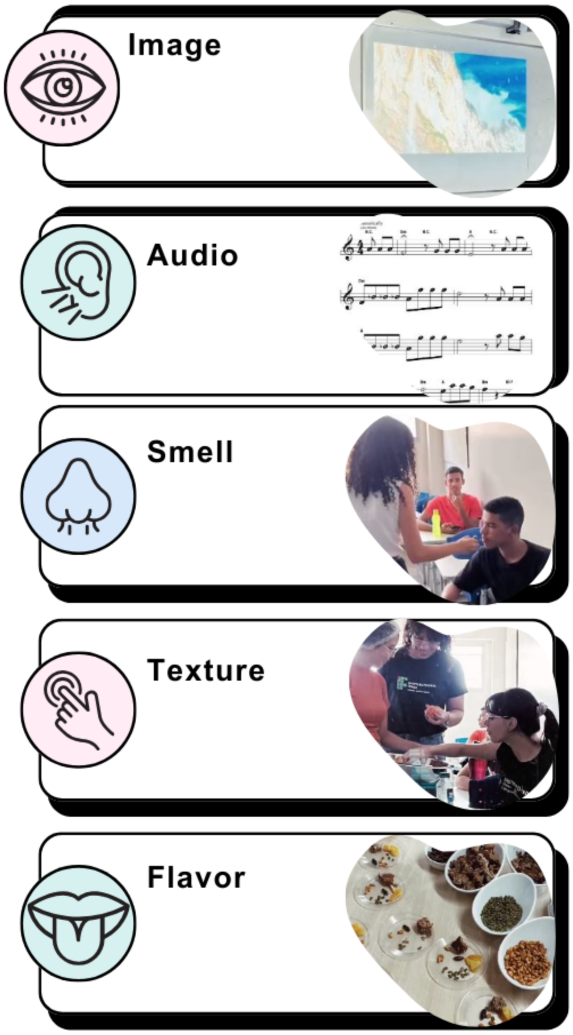

Figure 1. Sensory experience workshop

This activity provided its audience with an immersion in the biome and raised awareness about the importance of its preservation. All participants were invited to evaluate the experience using a Google Forms form.

The activity received 39 evaluations and all of them said they would recommend this sensory experience to an acquaintance. In a general evaluation of the project, which was carried out qualitatively, participants wrote passages such as: "I thought the project was really well done and well structured and done with a lot of dedication"; "Very good, super organized"; "Very interesting". Fig. 2 shows the different elements that composed the experience.

Figure 2. Sensory experiences developed by participants in the "Sensory Booth", presented during National Cerrado Week, 2023

3.2. Results and evaluations of the workshop "Craft skills and communication: puppet making and storytelling"

The felt puppet-making and storytelling workshops worked with the students from the perspective of fine arts, performing arts and early childhood education. During the workshop on making felt puppets, the participants received instructions on how to use templates to draw on the felt fabric, to optimize the use of the fabric and to plan the appropriate sizing. All the instructions were taught using an active methodology, so that each participant was able to make a puppet. Taking advantage of the availability of materials, the participants also made small fruits out of felt.

In the storytelling workshop, participants learned about the importance of adapting language. Considering that the resources developed during the workshops would be used to carry out FNE actions, the participants worked on adapting various technical terms inherent to the science of nutrition to ensure better understanding, especially among children. In addition, notions for creating theater scripts were covered, in order to promote the sustainability and reproducibility of these actions.

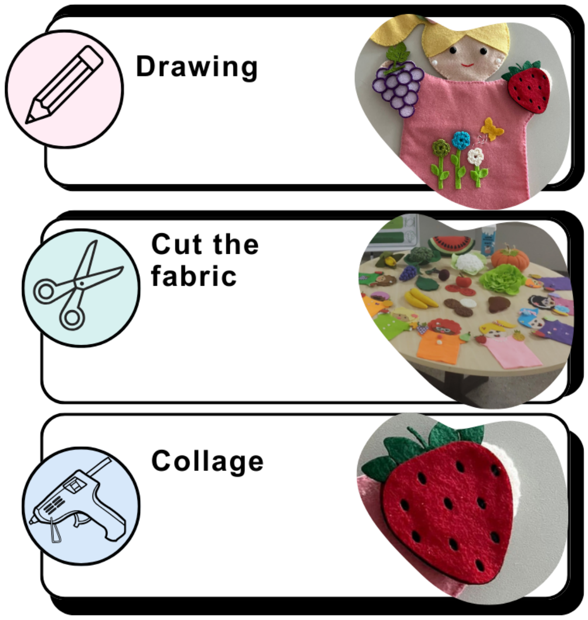

Figure 3. Puppet-making workshop

Figs. 3 and 4 show photographic records of the different moments of the felt puppet making and storytelling workshops.

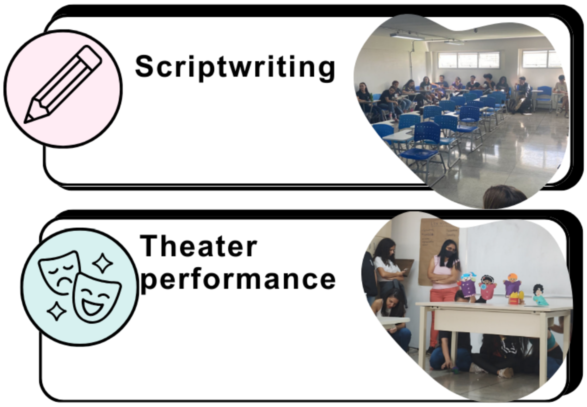

Figure 4. Storytelling workshop

The development of storytelling skills for children is part of the intention to carry out FNE practices in early childhood education. According to the BNCC, the methodology of storytelling should be encouraged for this age group, as it helps to develop children's ability to learn about the world and themselves, as well as promoting self-confidence [12]. In addition, storytelling allows children to be stimulated in affective and intellectual aspects when they listen to stories, as their thinking is directed towards finding a definition for what they are listening to and so their meanings are developed [13].

Puppet theater allows schools to dialogue with the artistic and cultural movement, contributing to the development of interpretation, orality and citizenship [14]. In early childhood education, the practice of storytelling using puppets conveys beauty, sensitivity, playfulness and affection. This builds a link in the teaching and learning process, promoting learning [14].

Through these workshops, the students produced permanent materials for FNE, such as felt puppets, decorated scenery for puppet shows and scripts for stories about food and nutrition aimed at children. These resources were used in the theaters performed at the FNS Show that took place during National Cerrado Week (August/2023) and Science and Technology Week at the Federal Institute of Education Science and Technology (October/2023). Both events were held on the premises of the IFE and were attended by external audiences.

Spectators at the puppet show held at the FNS Exhibition during Cerrado Week were invited to evaluate the presentation. This evaluation was carried out virtually and was accessed via a QR-code that led to a Google Forms form. A total of 63 evaluations were obtained, 98.4% of which were positive.

3.3. Results and evaluations of the workshop “Culinary skills: making full use of food and valuing the Brazilian Cerrado biome”

The workshop “From the backyard to my lunchbox” gave students the opportunity to practice cooking by making fruit sorbet from ingredients harvested in the participants' own backyards. By bringing fruit from their homes, the students shared their origins, stories, and family recipes. At the same time, the importance of making full use of food was also discussed, and a recipe for a banana peel cake was made. The two foods produced were served simultaneously at the tasting. Fig. 5 shows the main stages of processing.

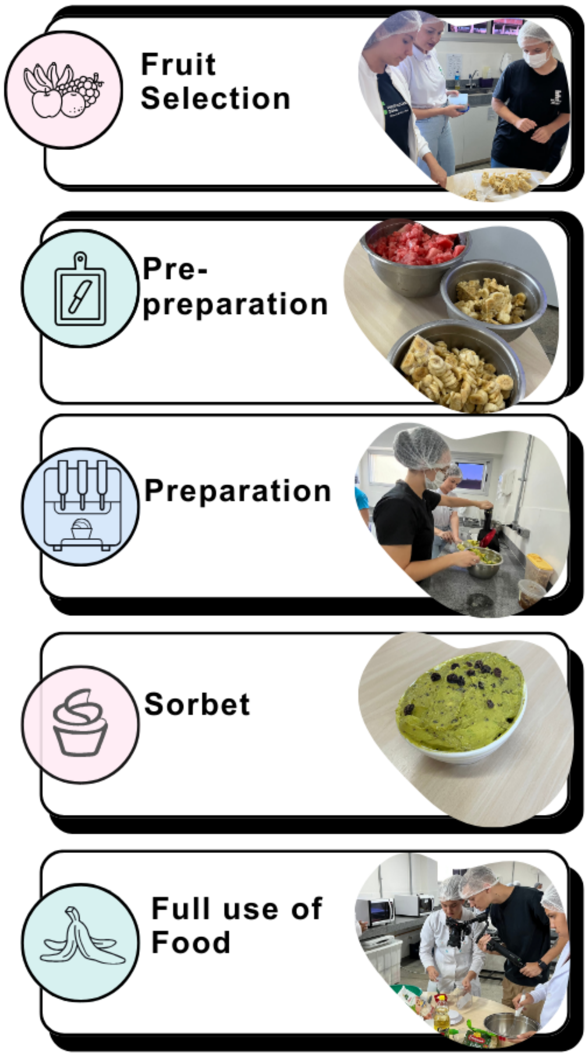

Figure 5. Culinary skills workshop: from the backyard to my lunchbox, making fruit sorbet

The strengths of this workshop include the use of seasonal fruit, which provides better nutritional value; the availability of these fruits in the students' backyards or those of family and friends, resulting in low-cost recipes; the full use of fruit by using the banana peel to make a cake, reducing food waste and adding nutritional value to other formulations, as well as diversifying the menu; and the preparation of recipes that are well accepted by the teenage public, such as sorbet, a preparation similar to ice cream with the difference of being prepared only with frozen fruit, without the addition of milk and sugar. All these aspects are in line with the principles of emancipatory FNE [3-4].

During the tasting, it was possible to discuss the interference of the carbohydrate and fat content of each fruit tested and the consistency of the sorbets. Fruits with a higher concentration of these nutrients, such as bananas and avocados, achieved the creamy consistency expected of this recipe. On the other hand, fruits such as watermelon, tangerine and acerola, due to their higher water content, did not reach the consistency of sorbet, becoming more similar to a fruit zest.

This workshop allowed for a broader reflection, encouraging participants to make healthier food choices that are also socially sustainable.

3.4. Results and evaluations of the workshop “Information and Communication Technologies: innovative strategies for secondary education”

The DICTs workshops enabled students to develop skills in photo and video production, the use of artificial intelligence (AI) websites, and the use of virtual tools such as Canva® and the Spotify podcasters® application. From these workshops, the students acquired better performance in producing virtual content (Fig. 6).

The first step was to improve the publications made on the extension project's social networks, which are informative and/or educational themselves. Subsequently, the Podcast of the Program “Minha Marmita, Nossa Saúde” was created and launched, which currently has 5 episodes published and has been widely disseminated, with a reach beyond the institution. Thus, the incorporation of DICTs into the workshops proved to be effective, aligning teaching with the students' reality, improving engagement and learning.

In addition, with the workshop on the use of AI websites, the students learned how these tools can help them in their studies and daily activities, in a responsible and conscious way. These technologies are part of their realities, and guidance is fundamental so that they can

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take ownership of these tools and add this knowledge to their training and future professional life.

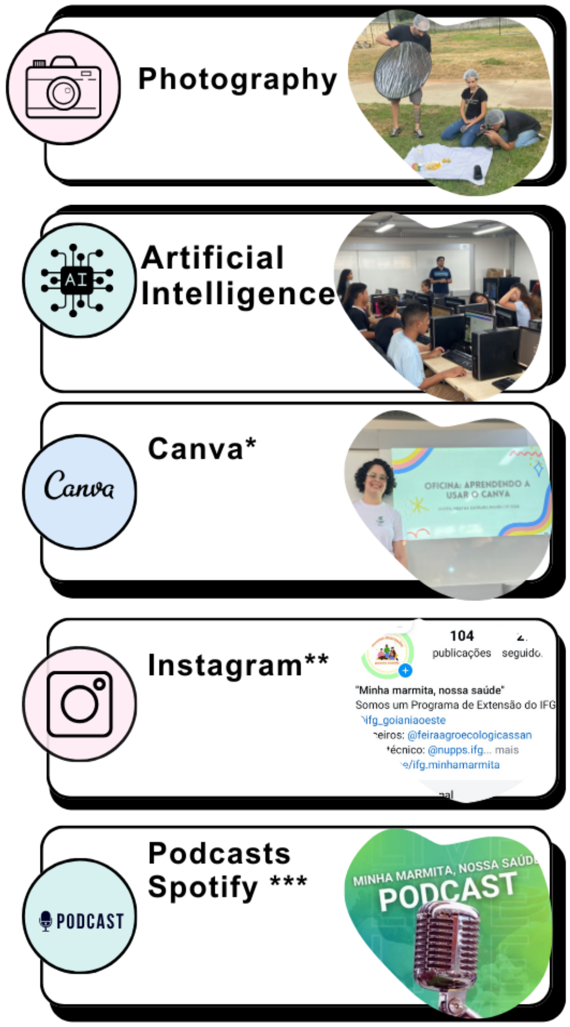

Figure 6. Information and Communication Technologies workshops: innovative strategies for secondary education: *https://www.canva.com/pt_br/free/ **https://www.instagram.com/ifg.minhamarmita ***https://open.spotify.com/show

4. Acknowledgements

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Efficiency of the Pirenópolis City Wastewater Treatment Plant in Relation to Environmental Regulations

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Abstract. In the context of increasing tourist demand and urban expansion in Pirenópolis, Goiás, Brazil, this research investigates the efficiency of the local sewage treatment plant in meeting environmental regulations, aiming to assess its compliance with standardized discharge standards. The sewage treatment system in use is described, the current regulations for effluent discharge are identified, and the parameters of the plant's effluent, provided by the Saneamento de Goiás company, are evaluated. The results reveal satisfactory efficiency in pollutant removal from the sewage. Additionally, the low number of existing connections suggests underutilized capacity at the plant, highlighting the potential to expand the coverage of the sanitation system.

Keywords. Wastewater Treatment, Efficiency, Discharge Standards.

1. Introduction

Water is vital for human life and plays crucial roles in public health, economic development, recreation, and ecological balance (Benetti *et al.*, 2003). The National Water Resources Policy, established by Federal Law No. 9,433/1997, aims to ensure the availability of quality water for current and future generations (Brazil, 1997). The National Water Agency (ANA) highlights the importance of sanitation and water pollution control to guarantee this availability (ANA, 2017).

In Brazil, 84.9% of households have access to water supply (SNIS, 2022a), but only 63.2% of the population has adequate sewage disposal, and 52.2% of the sewage is properly treated (SNIS, 2022b). CONAMA Resolution No. 430/2011 requires that treatment systems remove at least 60% of the Biochemical Oxygen Demand (BOD) before discharging effluents into water bodies (Brazil, 2011), but many cities do not meet this standard (ANA, 2017).

Sewage Treatment Plants (ETEs) are essential for controlling pollution caused by organic loads and other contaminants in sewage (Von Sperling, 1996a). In Pirenópolis, the growing urban expansion and the increase in weekend visitors present challenges for maintaining the quality of sanitation services and water resources, which are critical for public health and environmental preservation.

1.1. General Objective

To evaluate the efficiency of the Pirenópolis-GO Sewage Treatment Plant (ETE) by comparing the parameters of Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), suspended solids, hydrogen potential (pH), and temperature between raw and treated sewage, also verifying its compliance with current environmental regulations.

1.2. Specific Objectives

To describe the sewage treatment system of the Pirenópolis ETE.

To identify the effluent discharge regulations concerning Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), suspended solids, hydrogen potential (pH), and temperature parameters.

To evaluate the effluent parameters at the Pirenópolis ETE and the efficiency of its treatment.

1.3. Methodology

The aim of this study is to conduct a comparative analysis between the BOD, COD, suspended solids, pH, and temperature parameters of the effluent from the Pirenópolis Sewage Treatment Plant (ETE) and the standards required by environmental regulations.

To achieve these objectives, three main procedures were employed: a literature review to characterize the area and the sewage treatment at the ETE, a documentary research to identify the regulations and laboratory results from Saneago, and a case study to analyze the effluent's compliance with the regulations. The most recent laboratory data, covering a full year, were requested from Saneago to capture seasonal variations. The research adopts a qualitative approach to evaluate the results of the laboratory tests.

2. Literature Review

2.1. Sanitary Sewage

The term "sewage" refers to the waste generated by water use in various activities, encompassing sanitary sewage, which is the wastewater from a community and includes domestic, industrial, agricultural waste, as well as infiltration and stormwater (Ávila, 2005). According to the Brazilian Technical Standard NBR 9648/86, domestic sewage is the "liquid discharge resulting from the use of water for human hygiene and physiological needs" (ABNT, 1986, p. 1). This sewage originates from residences, commercial buildings, and institutions, and is directed to treatment plants.

The main parameters related to sewage, according to Von Sperling (1996a), include solids, organic matter indicators (BOD and COD), nitrogen, phosphorus, and fecal contamination indicators. Solids are classified according to their size, state, and settling capacity. Total solids are determined by evaporation at 103°C, and volatile solids (organic matter) are separated from fixed solids (inorganic matter) after heating to 550°C. The classification includes dissolved solids and suspended solids, with the latter being categorized as settleable or non-settleable (Jordão & Pessoa, 2011).

Biochemical Oxygen Demand (BOD) measures the oxygen required to biologically stabilize organic matter in a sample over 5 days at 20°C. BOD is an indicator of organic pollution in water and ranges between 100 and 400 mg/L for domestic sewage, with an average of around 300 mg/L (Von Sperling, 1996a). Chemical Oxygen Demand (COD) quantifies the oxygen required to oxidize organic matter using potassium permanganate or dichromate, ranging from 200 to 800 mg/L for domestic sewage, with an average of around 400 mg/L. The COD/BOD ratio is typically between 1.7 and 2.5 (Jordão & Pessoa, 2011).

The temperature of sewage, usually between 20 and 25°C, affects microbial activity and sewage decomposition, being ideal in the range of 25 to 35°C. Higher temperatures can reduce oxygen solubility and cause unpleasant odors (Mendonça & Mendonça, 2017).

pH measures acidity or alkalinity, with values between 6.5 and 7.5 for sewage, and significant deviations can impair microorganism growth during treatment (Ávila, 2005). Older sewage may have a pH below 6 (Jordão & Pessoa, 2011).

2.2. Sanitary Sewage System

Federal Law No. 11,445/2007 defines the Sanitary Sewage System (SES) as the set of activities and infrastructure for the collection, transport, treatment, and final disposal of sanitary sewage. The SES offers significant benefits, such as improved public health and reduced costs related to disease treatment and water supply. The main components of a public sewage system include building connections, collector networks, main collectors, interceptors, outfall sewers, sewage pumping stations (EEE), sewage treatment plants (ETE), and discharge devices.

There are three main types of sewage systems: unitary, partially separated, and fully separated. The fully separated system, widely adopted in Brazil, uses independent pipelines for stormwater and domestic sewage, allowing for more efficient treatment and cost reduction (Ávila, 2005).

2.3. Sewage Treatment Plant

Self-purification is nature's ability to absorb and decompose sewage contaminants, achieving balance without harming the local ecosystem (Ávila, 2005). In sewage treatment plants, this principle is replicated with technology under controlled and efficient conditions (Von Sperling, 1996a).

NBR 12209 describes an ETE as a set of units and equipment designed to reduce the pollutant loads of sewage and treat residual matter. ETEs remove organic matter, suspended solids, and pathogenic organisms from domestic sewage, using physical and biological processes, and in some cases, advanced treatments to remove nitrogen and phosphorus (Leme, 2010).

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2.4. Preliminary Treatment

Preliminary sewage treatment is essential for removing coarse solids and sand, using physical methods such as screening and sedimentation. Typically, this process includes a flow measurement unit, such as the Parshall flume, which correlates the liquid level with the flow rate (Von Sperling, 1996a).

The removal of coarse solids is performed using bar screens, rotary screens, or grinders. In screening, particles larger than the spacing between the bars are retained, and cleaning can be manual or automated (Von Sperling, 1996a).

Sand is removed in grit chambers or sand traps, where dense grains settle at the bottom of the tank, while lighter organic matter remains suspended and is directed to the subsequent treatment stages (Mendonça & Mendonça, 2017).

The removal of coarse solids protects subsequent stages and transport devices, as well as preventing abrasion damage and blockages in the system (Leme, 2010).

2.5. Primary Treatment

Primary treatment focuses on removing settleable suspended solids, using physical sedimentation as the main mechanism (Libardi Junior, 2020). A significant portion of these solids is organic matter, and the removal of these simple solids reduces the BOD load that needs to be treated later.

Primary treatment uses clarifiers to allow dense solids to settle at the bottom, forming raw primary sludge, and flotation units to remove grease, oils, and fats that float on the surface (Leme, 2010).

Typically, the removal of suspended solids at this stage ranges from 40 to 70%, while the removal of BOD and coliforms is between 25 and 40% (Libardi Junior, 2020).

2.6. Secondary Treatment

In secondary treatment, the goal is to eliminate dissolved organic matter (soluble BOD) and suspended organic matter (suspended or particulate BOD). Dissolved organic matter is not removed by physical processes such as sedimentation, while suspended organic matter is largely removed in primary treatment but may still leave residues in the liquid solution (Von Sperling, 1996a).

This treatment uses biological processes that simulate the natural oxidation and stabilization of organic matter, but under controlled and accelerated conditions. Organisms such as fungi, protozoa, and bacteria are responsible for stabilization, with bacteria being the most important in BOD removal.

The treatment may involve aerobic microorganisms, which require oxygen, or anaerobic microorganisms, which do not tolerate oxygen (Oliveira, 2004). Common methods include stabilization ponds, activated sludge, biological filters, and anaerobic treatment (Von Sperling, 1996a). Biological reactors are essential but are often combined with other units to ensure complete contaminant removal and meet effluent quality requirements (Ávila, 2005).

2.6.1. Stabilization Ponds

Stabilization ponds are a simple and effective method, consisting of shallow excavated tanks with earth slopes. They treat domestic sewage and industrial waste and can be adjusted for different effluent standards. Treatment occurs through biological processes such as anaerobic bacterial oxidation, anaerobic fermentation, and photosynthetic reduction of algae (Jordão & Pessoa, 2011).

Sewage remains in the ponds for a hydraulic detention time necessary for organic matter stabilization, with solar radiation as the primary energy source. Warm regions are ideal for stabilization ponds due to the temperature (Von Sperling, 2002). Despite advantages such as simplicity and low cost, ponds may require large areas and can present odor problems if poorly designed (Jordão & Pessoa, 2011). Variants include anaerobic, facultative, strictly aerobic, maturation, polishing, aerated, and macrophyte ponds, with particular emphasis on facultative and maturation ponds (Von Sperling, 2002).

2.6.2. Facultative Ponds

Facultative ponds are notable for their simplicity and use of natural processes. Sewage enters at one end and exits at the other after

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several days, passing through anaerobic and aerobic zones. The anaerobic zone at the bottom of the pond performs anaerobic digestion, while the aerobic zone at the surface oxidizes dissolved organic matter with oxygen produced by algae. The facultative zone between these two areas allows microorganisms to function under varying oxygen conditions (Fonseca, 2005).

Environmental factors such as evaporation, precipitation, temperature, and solar radiation affect the efficiency of facultative ponds (Jordão & Pessoa, 2011). These ponds can be used for primary treatment of raw sewage or secondary treatment of pre-treated effluents (Mendonça & Mendonça, 2017).

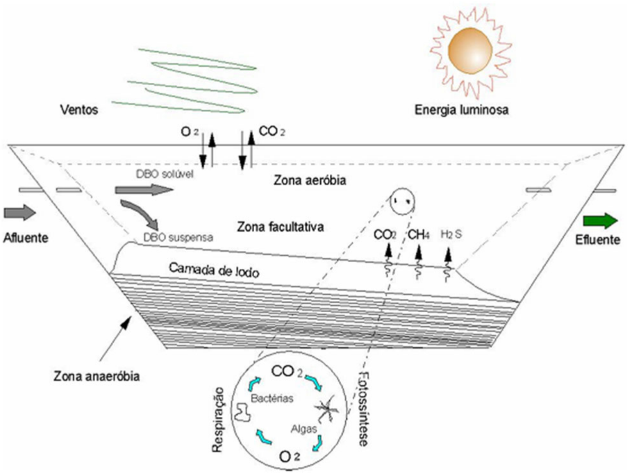

Figure 1. Zones in a Facultative Pond
Source: Fonseca (2005)

2.6.3. Maturation Ponds

Maturation ponds are primarily aimed at pathogen elimination, prioritizing this function over further BOD reduction. They are effective for polishing the effluent from treatment systems and serve as a cost-effective alternative to conventional disinfection methods like chlorination (Von Sperling, 2002).

Pathogen elimination occurs through ultraviolet solar radiation, high pH, and high oxygen content, with shallow ponds facilitating sunlight penetration and ensuring adequate effluent oxygenation (Libardi Junior, 2020).

2.6.4. Anaerobic Treatment

Anaerobic treatment is a process for removing organic matter from sewage, operating in environments without free oxygen. In this process, microorganisms convert complex organic compounds, such as carbohydrates, proteins, and lipids, into methane and carbon dioxide (Ávila, 2005). Anaerobic treatment systems are divided into conventional and high-rate systems.

In conventional systems, the slow growth rate of anaerobic biomass makes process control more difficult and results in slow recovery under adverse conditions. These systems include sludge digesters, septic tanks, and anaerobic ponds, which require large volumes and long hydraulic retention times due to the absence of efficient solids retention mechanisms (Chernicharo, 1997).

On the other hand, high-rate systems retain large amounts of active biomass through retention mechanisms, allowing for the use of more compact reactors with smaller volumes. These systems are classified into two types: attached growth and dispersed growth. In attached growth, the sludge adheres to an inert material, as in anaerobic filters, where microorganisms form a biofilm. In dispersed growth, bacteria form flocs or granules, as in the upflow anaerobic sludge blanket (UASB) reactor, which has good settleability (Chernicharo, 1997).

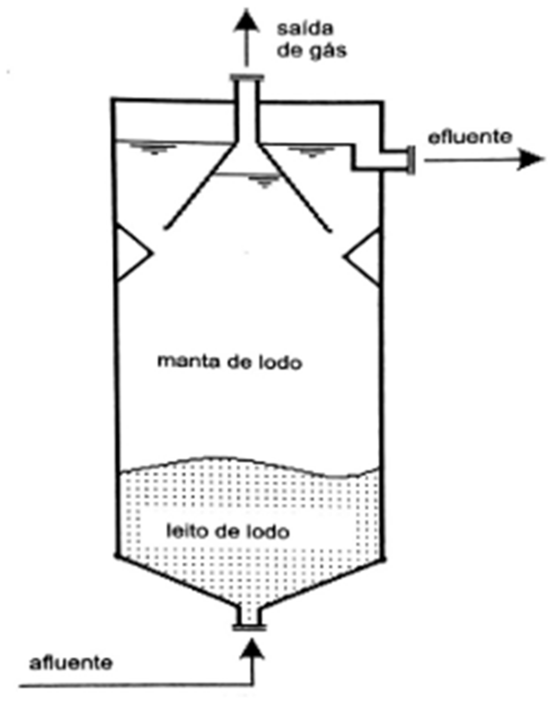

Figure 2. Schematic Representation of an Upflow Anaerobic Sludge Blanket (UASB) Reactor. Source: Chernicharo (1997)

UASB reactors have several advantages, including low solids production, low energy consumption, reduced land area requirements, lower implementation costs, methane production, biomass preservation, tolerance to high organic loads, applicability at different scales, and low nutrient consumption. However, they also have disadvantages, such as unsatisfactory removal of nitrogen, phosphorus, and pathogens, insufficient effluent quality to meet environmental standards without post-treatment, disturbances caused by organic and hydraulic load shocks, slow startup without adapted seed sludge, and issues with odors and corrosion (Chernicharo, 1997).

The upflow anaerobic sludge blanket (UASB) reactor, also known as RAFA, DAFA, or RALF, operates with the upflow of sewage through a dense and active sludge bed. Organic matter stabilization occurs in all zones of the reactor, driven by the upflow of sewage and gas bubbles. A gas-solid separation device at the top of the reactor allows methane gas collection and the return of solids to the reactor body, ensuring that the effluent is released clarified and that biomass concentration remains high. The design of these reactors is relatively simple and does not require sophisticated equipment, making their implementation easier. However, the process can take 4 to 6 months to start up, although this time can be reduced with the use of inocula, and the risk of odors can be minimized with careful design and proper sealing (Von Sperling, 1996a).

2.7. Tertiary Treatment

Tertiary treatment aims to remove specific pollutants that may be toxic or non-biodegradable, as well as to complement the removal of pollutants not fully eliminated during secondary treatment (Von Sperling, 1996a).

This stage may involve chemical processes for the removal of phosphorus, nitrogen, and pathogenic organisms, as well as techniques such as aeration, activated carbon adsorption, filtration, ion exchange, membrane separation, and disinfection with chlorine and ozone. However, tertiary treatment is still relatively uncommon in Brazil (Leme, 2010).

2.8. Regulations

In Brazil, the regulation of effluent discharge into water bodies is governed by a series of environmental laws and standards at different levels. The National Water Resources Policy (Law No. 9433/1997) establishes the classification of water bodies into categories to ensure adequate quality according to intended uses and to reduce pollution costs through preventive actions (Brazil, 1997). CONAMA Resolution No. 357/2005 defines the criteria for classifying water bodies based on the predominant uses of water, whether current or future (Brazil, 2005).

CONAMA Resolution No. 430, dated May 13, 2011, complements and amends Resolution No. 357, stipulating that discharged effluents must not compromise water quality beyond the goals set for each class of water body (Brazil, 2011).

For water bodies classified as special class, the discharge of effluents, even if treated, is prohibited to preserve their exceptional quality (Brazil, 2005). In other classes of water bodies, effluents must comply with specific quality standards and the available flow or volume conditions.

In the case of effluents from sanitary sewage treatment systems, the legislation sets criteria such as a pH between 5 and 9, a temperature below 40°C, a concentration of settleable materials below 1 mL/L, and a Biochemical Oxygen Demand (BOD) of 5 days at 20°C below 120 mg/L, with exceptions provided if a minimum BOD removal of 60% is guaranteed or if self-purification studies are conducted (Brazil, 2011). Other specifications include an oil and grease concentration of up to 100 mg/L and the assurance of no floating materials.

Table 1. Conditions for Effluent Discharge Established by Resolution No. 430/2011 – National Environmental Council. Source: Adapted from CONAMA Resolution No. 430/2011 (2011)

Parâmetro	Limites
DBO	Máximo de 120 mg L-1 Remoção mínima de 60%
pH	5 a 9
Temperatura	< 40 °C

State and municipal environmental agencies may have additional regulations based on

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federal standards, which are sometimes more stringent. For the state of Goiás and the municipality of Pirenópolis, no stricter legislation was found beyond the federal standards concerning BOD, pH, and temperature parameters, indicating that federal legislation serves as the basis for effluent control in these areas.

3. Case Study

3.1. City of Pirenópolis

The municipality of Pirenópolis, located in the eastern mesoregion of Goiás and in the microregion surrounding the Federal District, is known for its cultural, historical, and natural wealth. Situated approximately 150 km from Brasília and 125 km from Goiânia, it covers an area of about 2,200.369 km², with a population of 26,690 people, according to the 2022 census (IBGE, 2022).

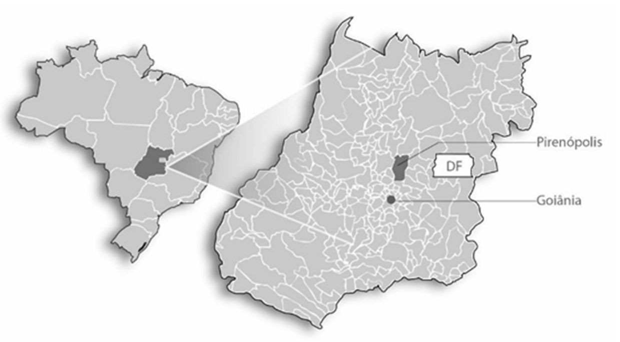

Figure 3. Location Map of the Municipality of Pirenópolis. Source: Avelino Filho & Britto (2020)

Originally called Meia Ponte, Pirenópolis originated during the gold cycle of the 18th century when the discovery of mines brought prosperity to the region (Jayme & Jayme, 2002). The city was notable for the wealth generated by mining and its strategic location, connecting several important routes in colonial Brazil (Pohl, 1976). After the decline of mining, the economy of Meia Ponte—later renamed Pirenópolis in 1890 in honor of the Pyrenees Mountains (Conceição *et al.*, 2010)—shifted towards agriculture and livestock, maintaining its traditions and culture (Oliveira, 2001).

In the 20th century, the construction of Goiânia and Brasília brought economic changes to Pirenópolis, with quartzite extraction becoming a new economic activity (Bueno & Curado, 2018). Tourism, initially modest, began to develop in the 1970s, driven by the natural beauty and historical heritage of the city (Lôbo & Lôbo, 2014). The designation as a national heritage site by IPHAN in 1989 was a significant milestone for the growth of tourism, which led to a considerable increase in population and the development of tourist infrastructure (Godinho & Oliveira, 2010).

The city's unplanned growth, driven by tourism, led to problems such as real estate speculation, increased cost of living, and environmental degradation (Oliveira, 2022). The lack of urban planning resulted in challenges related to basic sanitation, security, and waste management (Lôbo *et al.*, 2014). Basic sanitation, essential for public health and quality of life, became a critical area that needed to be addressed.

The focus of this study is the efficiency of the Pirenópolis sewage treatment plant, a crucial component of environmental sanitation, which includes the management of water, sewage, and solid waste (Bittencourt & Paula, 2014). Analyzing the efficiency of this treatment plant is essential to identify weaknesses and assist in the formulation of public policies aimed at improving sanitation services and, consequently, the quality of life in the city.

3.2. Water Resources

The region of the Pireneus State Park, located between Pirenópolis, Cocalzinho de Goiás, and Corumbá de Goiás, serves as a watershed divide between the Paraná and Tocantins river basins. This area has several perennial watercourses due to the hydrogeological properties of quartzite, which retain water during the rainy season and gradually release it during the dry season (Silva *et al.*, 2023). The springs in the region form the Corumbá River, which belongs to the Paraná basin, and the Almas River, which is part of the Tocantins basin (Silva *et al.*, 2023).

Pirenópolis is primarily located within the Tocantins-Araguaia hydrographic macro-region, with 96.8% of its territory within this basin and 3.2% in the Paraná basin (Pirenópolis, 2023).

The most important water bodies in Pirenópolis include the Padre Souza River, Dois Irmãos Stream, Escuro Stream, Patos River,

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Almas River, and Corumbá River. The Almas River, which flows through the municipal seat, is classified as class 2, which requires the preservation of its quality due to its importance in the region (Pirenópolis, 2023).

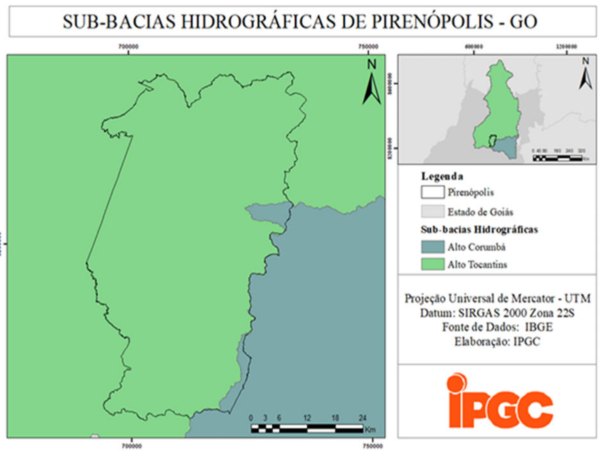

Figura 4. Sub-bacias Hidrográficas do Município de Pirenópolis. Source: Pirenópolis (2023)

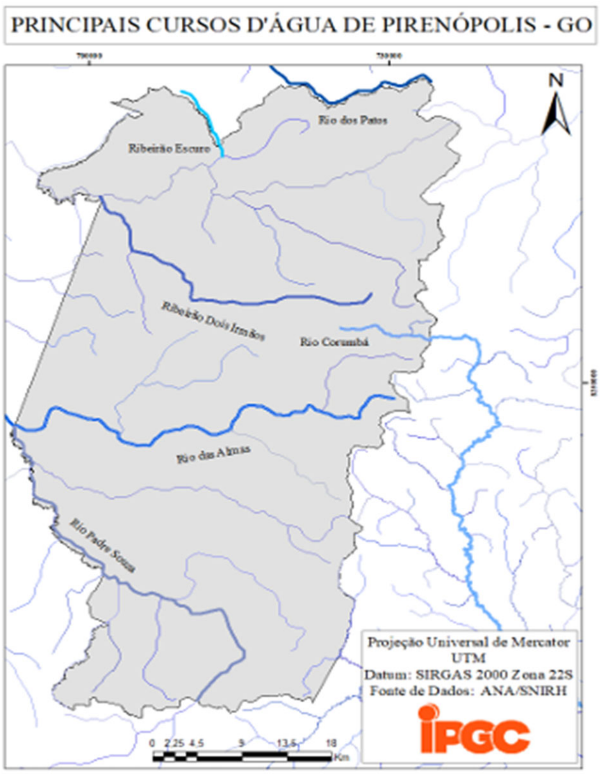

Figure 5. Main Watercourses of the Municipality of Pirenópolis. Source: Pirenópolis (2023)

3.3. Water and Sewage Services in Pirenópolis

Water and sewage services are essential to ensure the supply of safe drinking water and the proper management of liquid waste, forming the foundation of basic sanitation services. These services encompass everything from the collection, treatment, and distribution of potable water to the collection, transportation, treatment, and proper disposal of effluents, playing a vital role in protecting public health and preserving the environment.

3.4. Water Supply System

According to Federal Law No. 11,445/2007, the water supply system includes all activities and infrastructure necessary to provide potable water to the public, from collection to household connections and metering (Brazil, 2007). In Pirenópolis, Saneago manages two water supply subsystems: Andorinhas and Frota. The urban area has a distribution network of 117,239.20 meters, with 9,152 active connections (Pirenópolis, 2023).

The Frota subsystem involves water collection from a spring on Morro do Frota, with a raw water pipeline and a Simplified Treatment Unit (UTA) that performs disinfection using chlorine gas. Of the three treated water reservoirs, only the one on Morro do Frota is operational (Pirenópolis, 2023). The Andorinhas subsystem has surface water collections from the Almas River and Barriguda Stream, as well as underground collections from deep wells. This subsystem includes a raw water pumping station, three raw water pipelines, a Water Treatment Plant (ETA Andorinhas) with direct filtration, and six reservoirs, four of which are operational (Pirenópolis, 2023).

In 2021, 100% of urban residences were served with treated water; however, this statistic does not reflect the reality of the rural area, where unregulated growth is a challenge (Oliveira, 2022, p. 69). In 2022, the total population served with treated water was 64.39%, with an average consumption of 232.49 L/inhabitant/day (Snis, 2022a).

4. Some Conclusions about Sanitary Sewage System

Pirenópolis' sanitary sewage system is of the absolute separator type, but the presence of illegal connections compromises this separation. The system includes a collector network, an interceptor, a Sewage Pumping

Station (EEE), a force main, and a Sewage Treatment Plant (ETE) (Pirenópolis, 2023). The collector network, built between 2012 and 2021, is 12,661 meters long and does not cover all neighborhoods. In 2022, the urban service coverage was 22%, and in 2023, there were about 1,000 connections (Pirenópolis, 2023). Data from Snis (2022b) indicate that the total population served was 14%.

Figure 6. Sanitary Sewage System of Pirenópolis. Source: Pirenópolis (2023)

The Sewage Pumping Station (EEE), located in the Jardim Esmeralda neighborhood, pumps the sewage from the interceptor to the Sewage Treatment Plant (ETE) and includes preliminary treatment with manual screening of the sewage. In 2023, the projected flow rate was 31.3 L/s, with two helical pumps and one backup pump, operating 4 hours a day (Pirenópolis, 2023).

Figure 7. Pirenópolis Sewage Treatment Plant (ETE). Source: Google Maps (2024)

The Pirenópolis ETE has structures such as a screen, grit chamber, Parshall flume, UASB reactor, two parallel modules with facultative and maturation ponds, and a drying bed (Pirenópolis, 2023). The treatment capacity of the ETE is 37.5 L/s, and in addition to receiving sewage from the EEE, it also receives effluents from septic tank cleaning trucks. The treated effluent is discharged into the Almas River, downstream from the city's water intake.

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TOMATEID: Code Development Steps to Differentiate between Maturation

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Abstract. This proposal aims to present the aspects that guide the development of code for differentiation between ripening stages of tomatoes in green and ripe conditions, corresponding to a stage of the research project named: TomateID: a system for the intelligent classification of industrial tomatoes. To this end, images were collected in a controlled environment for training purposes, divided into 48 for each class. The Roboflow platform was used for preprocessing and feature extraction, and YOLO was employed for the training, testing, validation, and deployment phases. The model did not make any errors in classifying the tomatoes in any of the categories.

Keywords. Agro 5.0, Machine Learning, Factory Planning, Tomato Cultivation.

1. Introduction

The present proposal aims to describe the steps involved in the execution of the research project: TomateID: a system for the intelligent classification of industrial tomatoes. The objective of this project is to identify superficial defects in tomatoes destined for processing through the use of machine learning. The purpose is to train an algorithm that will classify tomatoes based on the ripening stage.

In general terms, machine learning, a field of artificial intelligence, involves the development of algorithms that enable autonomous output generation from input data based on defined criteria. This approach allows for the analysis of a larger volume of data, enabling faster and more accurate responses [1].

It is worth mentioning that the use of technological tools support the decision-making and the management of agroindustry. They also assist in the production chain and various other activities. Digital agriculture involves the incorporation of digital technologies at all stages of the value chain, aiming to promote competitive advantages and generate socio-environmental benefits [2].

Brazil ranks among the largest global producers of tomatoes, where the fruits are processed and also subjected to fresh consumption. This vegetable is the second most economically significant in the country. Equally important is the economic relevance of this activity in the state of Goiás, where it ranks among the top ten agricultural crops.

In tomato cultivation, product classification is associated with qualitative and quantitatively measurable characteristics through technical criteria established by the Ministry of Agriculture, Livestock and Supply (MAPA) through Ordinance No. 278 of November 30, 1988. During the process of unloading the bulk-transported fruit, at least four samples of 5 kg each are taken, corresponding to the approximate weight of a crate.

For this reason, there is a justification for developing a technological tool that optimizes the tomato classification process in accordance with normative criteria, considering the types of serious defects as well as general defects that can be measured in the field through the use of imaging.

2. Methodology

The process of generating the classification code to initially distinguish between green and ripe tomatoes involved several interdisciplinary stages that combine data science, image processing, and machine learning. This method is crucial for applications in precision agriculture, where the automation of fruit sorting can significantly enhance the efficiency and quality of the process. Utilizing the Roboflow platform for preprocessing and feature extraction, and YOLO (You Only Look Once) for the training, testing, validation, and deployment phases, allows the integration of these technologies to build a robust, scalable, and high-performance pipeline for automated classification.

The starting point for developing a classification system is the collection of an image dataset. The captured images in question are of tomatoes at two stages of ripeness, under controlled lighting conditions and from various angles. Care was taken to ensure that these images were representative of all sorts of tomatoes to be classified.

A total of 120 images were collected in a controlled environment. Of these, 96 were used for training, divided into 48 from the "green" class and 48 from the "ripe" class. Additionally, 16 images were used for testing—8 from the "green" class and 8 from the "ripe" class—and 8 images were used for validation, comprising 4 from the "green" class and 4 from the "ripe" class. Each image is manually annotated with the corresponding label, indicating whether the tomato is "green" or " ripe." This labeling process is crucial for creating a supervised dataset, necessary to train the classification model.

3. Theoretical Framework

3.1. Conceptual Approach to Machine Learning

In the context of image classification, machine learning has been widely utilized due to its ability to handle large volumes of data and efficiency in identifying complex patterns within images. Conceptually, it can be understood as "[the] study of techniques and algorithms that enable machines, based on examples or past experiences, to improve their performance in certain processes or solve problems autonomously" [3].

For instance, texture analysis in digital images is an essential technique, as discussed by Büchner in his work on the GLCM technique for texture analysis [4]. For tasks such as classifying the ripeness stages of tomatoes, algorithms like SVM, detailed by Mishra [5], and Naïve Bayes, discussed by Brownlee [6], demonstrate how machine learning algorithms can be trained to differentiate between subtle visual characteristics that distinguish a green tomato from a ripe one.

3.1.1. Image Classification and Convolutional Neural Networks (CNNs)

Image classification, which is the main challenge addressed by machine learning techniques, involves assigning labels to images based on their content. Convolutional Neural Networks (CNNs) are widely used for this purpose due to their ability to extract and identify visual features directly from images. CNNs consist of convolutional layers, which apply filters to images to detect visual patterns such as edges, textures, and shapes, essential for the classification of objects within the image.

In the TOMATEID project, the use of CNNs, particularly the YOLO (You Only Look Once) model, enables an efficient approach for detecting and classifying tomatoes at different stages of ripeness. YOLO is one of the most advanced real-time object detection algorithms and is widely recognized for its high accuracy and speed. It operates by dividing the image into a grid and then predicting bounding boxes and class probabilities for objects in each grid cell, allowing for the simultaneous detection of multiple objects.

3.1.2. Importance of Annotation and the Dataset

The quality and representativeness of the dataset used for training, especially in image classification tasks, are critical factors for the success of the model. In the case of TOMATEID, the images were captured under controlled conditions, ensuring uniformity in lighting and angle, which is crucial for reducing noise in the data and enhancing the accuracy of the model.

Manual annotation of the images, where each tomato is labeled as "green" or "ripe," is a fundamental step in the creation of the supervised dataset. This labeling enables the model to learn the specific characteristics associated with each stage of ripeness. The annotation process must also be rigorous, ensuring that each label is correctly assigned, as any errors can lead to a reduction in the model's accuracy.

With the extracted features, the next step was to train a machine learning model. The data were divided into training, testing, and validation sets to ensure that the model could generalize well to new examples.

4. Results and Discussion

During the training phase, the model learns to associate the feature vectors of the images with the corresponding labels, adjusting its parameters to minimize the loss function. Training is an iterative process, where performance is constantly monitored on the validation set, allowing for fine-tuning of the hyperparameters.

In the dataset in question, the algorithm iterated over the training data for 30 epochs, achieving excellent results. This number of epochs allowed the model to effectively learn the underlying patterns in the data.

For evaluating the model, the main metrics used to validate a model trained with YOLO are:

1. mAP (Mean Average Precision): It measures the average precision of the model in detecting objects across different classes. A higher mAP value indicates that the model is more precise.
2. Precision: It indicates the proportion of correct detections among all detections made by the model. High precision means few false positives.
3. Recall: It demonstrates the model's ability to find all real objects in the images. High recall means few false negatives.
4. F1-Score: It combines precision and recall into a single metric, demonstrating the balance between them. A high F1-Score is ideal.
5. IoU (Intersection over Union): It measures how well the bounding box predicted by the model overlaps with the actual object's box. The higher the IoU, the more precise the object's localization.
6. Loss (Perda): During training, the loss indicates how far the model is from making perfect predictions. A lower loss indicates a better model.
7. Inference Time: It measures the time it takes for the model to process an image. A shorter time is crucial for real-time applications.

Here are the key points regarding the performance of the YOLO model over 30 epochs of training:

- Box Loss (train/box_loss and val/box_loss):
  - Train/box_loss: It decreased from 1.58 to 0.77, indicating that the model is improving in predicting bounding boxes.
  - Val/box_loss: It also decreased, with some fluctuations, suggesting that the model is generalizing well, albeit with variations.

- Classification Loss (train/cls_loss and val/cls_loss):
  - Train/cls_loss: It decreased from 4.36 to 1.39, indicating that the model has become more accurate in class identification.
  - Val/cls_loss: It droped from 4.62 to 1.35, suggesting good generalization to new data.

- DFL Loss (train/dfl_loss and val/dfl_loss):
  - Train/dfl_loss: It reduced from 1.64 to 1.03, indicating that the model is well adjusting the box displacement predictions.
  - Val/dfl_loss: It followed a similar pattern of reduction.

- Precision (metrics/precision(B)): It started low but reached approximately 95% from epoch 10, demonstrating a good ability to avoid false positives.

- Recall (metrics/recall(B)): It improved and stabilized around 95%, indicating that the model could detect most of the relevant objects.

- mAP50 and mAP50-95 (metrics/mAP50(B) and metrics/mAP50-95(B)):
  - mAP50: It was high during training, reaching close to 99%.
  - mAP50-95: It started at 0.23 and increased to 0.67, demonstrating good average precision across different overlap thresholds.

- Learning Rate (lr/pg0, lr/pg1, lr/pg2): It remained low, helping the model converge without overfitting.

Fig. 1 presents the loss and accuracy metrics over the 30 epochs of training and validation for the YOLO model used to classify tomatoes at different stages of ripeness. The graphs show the evolution of bounding box loss, classification loss, and distortion focal loss (DFL), as well as the precision, recall, and mAP (Mean Average Precision) metrics during training.

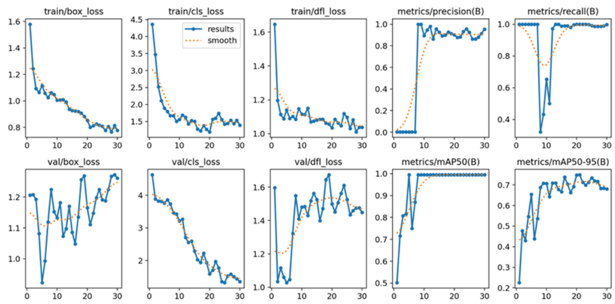

Figure 1. Performance metrics of the YOLO model during training and validation. The graphs include losses (box, cls, dfl) and metrics (precision, recall, mAP50, mAP50-95) in both phases. (Source: Prepared by the authors)

Once trained, the model is tested on a separate dataset that was not used during training. This step is crucial for evaluating the model's ability to generalize to new images of tomatoes. Metrics such as accuracy, precision, recall, and F1-score are used to quantify the model's performance, ensuring it is reliable enough for real-world applications, as illustrated in Fig. 2, regarding the testing phase.

Figure 2. Model testing phase. (Source: Project archive)

Subsequently, the performance of the classification model was evaluated using the confusion matrix (Fig. 3). This tool considers the combination of actual and predicted classes, which are organized in rows and columns, respectively. At this stage, different performance metrics were analyzed to assess the model's effectiveness in distinguishing between green and ripe tomatoes.

For this purpose, the structure of the table is composed of the following: True Positives (TP) refer to cases where the model correctly identified a ripe tomato as such. In contrast, False Positives (FP) are indicated when the model incorrectly classified a green tomato as ripe. True Negatives (TN) represent cases where the model correctly classified a green tomato as not ripe. Finally, False Negatives (FN) are cases where the model failed to recognize a ripe tomato, incorrectly classifying it as green.

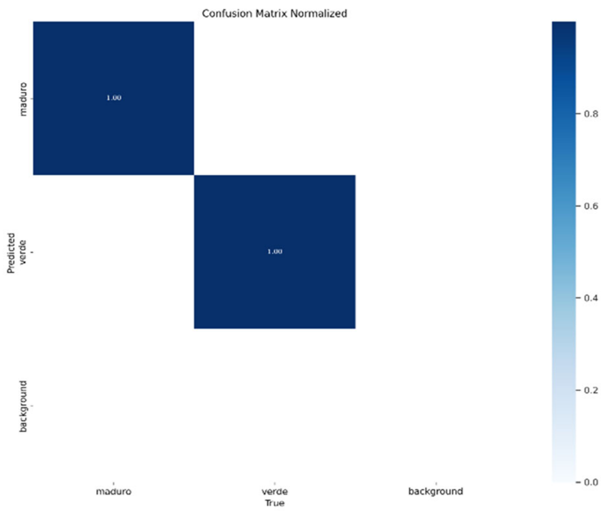

Figure 3. Confusion matrix. (Source: Prepared by the authors)

As observed, the matrix shows the proportions of correct and incorrect classifications made by the model. The model correctly classified 100% of the ripe tomatoes as ripe (True Positives - TP); unripe tomatoes as unripe (True Negatives - TN), and there were no False Positives (FP) or False Negatives (FN). This indicates that the model made no errors in classifying the tomatoes into any of the categories. However, it is important to consider that perfect results may, in some cases, indicate that the model is overfitting the training data and may not generalize well to new data.

Thus, the results obtained so far meet the established objectives regarding the optimization of the fruit classification process. In the next stage, defect identification will be incorporated, followed by classification according to defect types.

Considering the level of technological maturity, the application presents a TRL 3, which means that the system has been demonstrated in a laboratory environment, and its technical feasibility has been proven in a controlled context. However, the development of the application is a complex process that involves a combination of technologies and practical considerations, which may require adjustments during the execution of the proposal to ensure its suitability in a field environment and its integration with industrial systems.

5. Final Considerations

The integration of technologies such as machine learning with modern agricultural practices reflects the trend of Agro 5.0, where technological innovation is employed to optimize production processes and enhance decision-making at various stages of the production chain.

The present study describes the stages inherent to a phase of the project's development: TomateID: a system for the intelligent classification of industrial tomatoes, illustrating the complementary relationship between teaching, research, and extension activities in the execution of projects that align with market demands. At the same time, the importance of integrating different areas of knowledge is evident, aiming to incorporate concepts that are applicable in practice.

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Initial Teacher Training in Focus: Enhancing Teaching Learning with Active Methodologies in the Internship

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Abstract. This research presents the teaching learning process as measured by the teaching projects produced within the scope of the Pedagogical Residency Program, considering it as a Supervised Curricular Internship at IF Goiano. This qualitative study, descriptive in nature, used narrative collection from undergraduates/researchers in the Bachelor's Degree in Biological Sciences program. Its objective is to analyze the contributions of the teaching learning process in the PRP, mediated by the development of teaching projects. The actions undertaken describe the developed projects and their contributions to teacher training, linked to the Rosa de Saberes Education Center at IF Goiano, Rio Verde Campus. The results highlight that the development of teaching projects in the PRP helps undergraduates develop research skills and knowledge necessary for the practice of teaching.

Keywords. Methodologies, Teaching, Teacher Training, Projects.

1. Introduction

Given the various social and technological changes and their influence on educational practices, teaching work increasingly demands the redefinition and innovation of teaching strategies and methodologies.

In this context, the training of teachers who are researchers of their own practice becomes relevant, as argued by Paniago [10], Nóvoa [8], and Alarcão [1]. Developing research and investigation skills enables teachers to problematize and analyze the strengths and weaknesses of the teaching-learning process. This diagnostic process, in turn, allows the development of innovative strategies that stimulate active and personalized learning, which is where active methodologies come into play.

According to Moran [7], there are two central concepts in the current educational scenario: active learning and hybrid learning. The author states that active methodologies involve the active and reflective participation of students in all stages of the educational process, emphasizing experimentation and creation under the supervision of the teacher. Meanwhile, hybrid learning stands out for its flexibility, combining and integrating spaces, times, activities, materials, and technologies meaningfully, utilizing both physical and digital elements [7].

It is evident that Moran [7] and Valente [14] share a similar perspective, aligning their ideas with the proposals for integrating active methodologies with ICTs, which serve as a basis for enhancing the teaching-learning process. There are various possible paths, but the most relevant is the one focused on the implementation of active methodologies and the creation of learning environments that favor knowledge construction and the integration of ICTs into curricular activities. For this to happen, institutions and, particularly, classrooms need to be rethought [14].

Methodologies, as general guidelines for teaching, materialize through specific strategies, differentiated approaches, and adapted techniques. Active methodologies focus on the effective participation of students in knowledge construction in a flexible, interconnected, and hybrid manner. In this context, Moran [7], considers that the combination of active methodologies with flexible and hybrid teaching models offers a contemporary and effective approach to education.

For Moran [7], intentional learning, especially in the formal school environment, is structured by three main active, hybrid movements: individual construction, where each student charts and chooses their own path; group construction, which expands learning through interaction and collaboration with peers; and tutorial construction, where the student learns with the guidance of more experienced mentors, curators, or mediators [7].

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Moran [7] emphasizes that at all these levels, guidance or supervision is essential to ensure deeper learning. However, in individual construction, the primary responsibility lies with the student, while in group construction, the richness and quality of collaboration are crucial. The teacher's role in this context is that of a guide and tutor, ensuring that students remain protagonists of their own learning process.

Thus, the development of teaching projects contributes to the integration of the undergraduate into their daily professional life, dealing with various situations that stimulate the development of skills and knowledge essential for teaching. Additionally, it encourages active student participation, allows for the development of interdisciplinarity and transdisciplinarity.

Therefore, this research is integrated into the teaching and research practices developed at the Rosa de Saberes Education Center at the Rio Verde Campus, aiming to analyze the contributions of the teaching learning process in the PRP, mediated by the development of teaching projects, with the objective of describing the projects developed by undergraduates in the Biological Sciences Bachelor's Degree program and identifying their contributions to teacher learning.

2. The Pedagogical Residency Project of IF Goiano

The Pedagogical Residency Program (PRP) was launched in 2018 as one of the actions by CAPES – Coordination for the Improvement of Higher Education Personnel – under the National Policy for Teacher Training. It seeks to integrate licentiate students into their work environment by promoting institutional projects that enhance initial teacher training and contribute to the construction of professional identity [3].

The institutional project of the Federal Institute of Goiano, titled "Insertion into Teaching through Research in Basic Education: Praxis Woven in Collaboration," aims to promote teaching insertion through research by implementing institutional actions and projects in qualified basic education schools with a duration of 18 months, as per PRP Regulation No. 24/2022 [4].

IF Goiano has the following subprojects: Pedagogy, Chemistry, Mathematics, Biology, Physical Education, and Interdisciplinary (Biology, Chemistry, and Physical Education). These are developed over 420 hours distributed in two modules (210 hours each), encompassing various institutional actions involving the study of theoretical and epistemological knowledge; conducting diagnostics in schools and classrooms; preparing and developing the Pedagogical Action Plan (PAP); compiling portfolios; and sharing results to promote problematization, investigation, and dialogue with various agents involved in the educational process.

3. Development of Knowledge and Research: Productions at the Rosa de Saberes Education Center

The Rosa de Saberes Education Center at IF Goiano is a space dedicated to the development of teaching, research, and extension projects focusing on issues related to Education and the teaching-learning process in Basic and Higher Education. It also serves practical classes for undergraduate courses, especially Licentiate programs, valuing the various skills necessary for teaching. Additionally, projects such as the "Beija Flor Circuit" event, the Interdisciplinary Laboratory of Educators (LIFE), the Center for Afro-Brazilian and Indigenous Studies (NEABI), and spaces for training in the Teaching Initiation Program (PIBID) and Pedagogical Residency (PR) are developed here. Below are some projects produced and developed by Biological Sciences Licentiate students linked to the Rosa de Saberes Education Center.

3.1. Project: "From the Morphology of Mint to its Essential Oil: Practices in Teaching Biology and Chemistry"

This project was carried out under the Pedagogical Residency Program, Edital No. 24/2022 [4], in 1st and 3rd-year high school classes for the Biology subject.

The objective was to use a garden and Cuban Oregano (Plectranthus amboinicus (Lour.)) as pedagogical tools for developing strategies and methodologies that integrate Biology and Chemistry disciplines. Additionally, it aimed to demonstrate the extraction of essential oil in Chemistry and the reconstruction of a Clonal Garden through cuttings of the

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chosen species in Biology.

During the PRP residency, several classes were conducted to contextualize topics supporting practices in Biology and Chemistry. The study subjects discussed included: Limiting Factors of the Ecosystem, Classification of Living Beings, Cloning, and Essential Oils.

For the topic of Ecosystem Limiting Factors, addressed in eight 1st-year classes, we discussed biotic and abiotic factors, associating them with inter and intraspecific relationships through shared reading and dialogic exposition in the school's Clonal Garden.

In the Classification of Living Beings content, also covered in 1st-year classes, images and diagrams were projected using a data show to discuss the existence of different species of macaws and fruits, understanding the importance of Taxonomy and the classification system created by Linnaeus. Subsequently, we discussed the taxonomy of Cuban Oregano (Plectranthus amboinicus).

Regarding the Cloning content developed in 3rd-year classes, we highlighted biotechnological procedures used in cloning, emphasizing the process of cuttings. Students then performed the practice of cutting and planting Cuban Oregano.

In both 1st and 3rd-year classes, we elucidated what essential oils are, their economic importance, and their significance to plants using dialogic expository classes with visual resources such as images and diagrams. We also discussed the structures responsible for producing and storing essential oil—the glandular trichomes.

To complement the theoretical knowledge, microscopes were used to demonstrate the tector and glandular trichomes present in Cuban Oregano.

As a result, exploring the Clonal Garden and Cuban Oregano as pedagogical tools contributed to interdisciplinarity between Chemistry and Biology. In this context, Libâneo [6] discusses the importance of developing means that consolidate previous content, becoming fundamental for assimilating subsequent content. Thus, interdisciplinarity complements and provides subsidies for learning development in other knowledge areas, allowing a broader view of the discussed theme. Furthermore, integrating disciplines through teaching projects contributes to class engagement, stimulating student interest and active participation.

Regarding the teaching-learning of licentiate students in initial training, Paniago, Clarimundo, and Nunes [11] discuss that developing projects brings the licentiate student closer to their professional reality, dealing with situations that contribute to their training and formation of teaching praxis.

Therefore, exploring the Clonal Garden and Cuban Oregano through teaching projects became a valuable active methodology, contributing to the development of active student learning and professional teacher training, as it encourages licentiate students to explore different teaching strategies and resources, developing aspects such as oratory and interpersonal interaction, among other important attributes for teaching practice.

3.2. Project: "Working with Cells in Science Education"

During the residency, one of the most impactful moments was the practice conducted using 3D-printed models of plant and animal cells in the LabMaker at the Rio Verde Campus, utilizing the principles of Maker Education and Active Methodologies. It is worth noting that the Maker movement is still expanding in Brazil, especially in the educational field. Dale Dougherty [5], considered the creator of the term "maker movement," states that this movement establishes "making" as an innate characteristic of everyone. The author advocates the importance of encouraging young people to explore, create, discover, and follow their own paths.

With this teaching approach, we developed our practice in an 8th-grade class composed of 24 students. We presented how the residency took place, highlighting the use of 3D-printed cell models, the objectives achieved, and the impact on students' teaching-learning, helping them understand how organisms are formed from the cell to a complete living being. As teaching strategies and resources, we used dialogic exposition with slide support, 3D-printed cell prototypes, paints, brushes, and data show-projected slides.

At the beginning of the class, we conducted a diagnostic to identify students' knowledge about the topic by asking questions like: "Do you know what a cell is?" or "What is the smallest particle of living beings?". We encouraged students to respond, valuing their participation and prior knowledge. During our exposition, we presented two types of cells, animal and plant, explaining their main structures, similarities, and differences to prepare them for the practical activity.

3.3. Project: "Production of Didactic Materials Using 3D Printing for Genetics Teaching in the Context of Supervised Curricular Internship"

This teaching and research project was conducted during the Supervised Curricular Internship (SCI) at the Federal Institute of Goiano. As future teachers, we considered it important to prepare to mobilize new methods, strategies, and teaching resources in the classroom. Currently, new approaches are being demanded, making it essential for teachers in initial training to have access to different teaching-learning approaches and new methodologies that can be used in basic education.

Our concerns about transforming traditional teaching-learning processes, where students assume more passive roles and teachers are the sole holders of knowledge [9], into processes where teachers adopt researcher and mediator roles and students become protagonists of their learning led us to develop this project within the SCI practices of Licentiate courses at IF Goiano.

In developing this research, we conducted an initial diagnostic to identify the state of science teaching and learning among students in the final years of elementary and high school, subsequently developing didactic materials using 3D printers, and finally evaluating these materials in real classroom situations, recording observational data in a field diary, a valuable data collection instrument in qualitative research.

This article was written collaboratively through dialogue among two interns, two supervising teachers, and an IF Goiano guiding professor.

The following steps were essential for the research development: 1) Diagnostic to identify the teaching and learning process using Google Forms in 7th to 9th-grade elementary school classes; 2) Modeling and printing of didactic-pedagogical materials using 3D printers; 3) Evaluation of selected and produced didactic materials in real classroom situations.

In this case, we will present actions involving a 9th-grade elementary school class focusing on genetics teaching and learning.

As previously elucidated, genetics is a content difficult to understand for students, a view shared by both teachers and students, as presented in the data. Through dialogue (interns and training teachers), we analyzed the need to enrich classroom lessons with video lessons and materials produced by Maker printers, showing how Science and Biology studies are conducted, specifically on genetics content. Students, through 3D-effect videos, could observe the organization of genetic material and how it forms an individual. In addition to video lessons, the materials produced by the Maker printer helped enrich the class, as students handled the materials, observing and sketching them in their notebooks.

3.4. Project: "Teaching and Learning of Natural Sciences and Biology Based on Maker Education"

The project was conducted with 7th-grade (Elementary School) and 2nd-year (High School) classes in the subjects of Science and Biology.

Its objective was to produce 3D didactic materials to contribute to the teaching and learning process of topics such as Cells, Microorganisms, Earth's Layers, the Greenhouse Effect, and the Ozone Layer.

Thus, after investigative analysis through diagnostics, we identified the need to rethink conventional approaches, such as using the whiteboard and textbooks, aiming to develop teacher autonomy and stimulate student learning.

Regarding the practice conducted in the 7th-grade on Earth's Layers, we problematized the topic with students through a dialogic expository class, aiming to contextualize the topic. To complement the understanding of concepts, a

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"Earth's Layers" prototype was created using a 3D printer, produced by students in the LabMaker at IF Goiano, Rio Verde Campus, a space dedicated to the production of didactic materials. Another maker practice was constructing and painting a polystyrene material demonstrating the Earth's layers. This didactic material was also presented by the students at a science fair, where they verbalized and shared the practices they had developed themselves.

For the Ozone Layer topic, we conducted two experiments in the laboratory, demonstrating the importance of gases present in the Ozone Layer in filtering the ultraviolet light emitted by the sun, a process essential for the protection of the Earth.

As for the practice conducted in the 2nd-year, we contextualized the topic "Cells" through a dialogic expository class and the use of 3D-printed cells to facilitate understanding of cell types (Eukaryotic and Prokaryotic) and their organelles. Collaboratively, students painted the 3D cells with gouache paint, assigning a specific color to each organelle, and socialized their functions throughout the practice.

For the "Microorganisms" topic, we contextualized the subject through a board game that involved a dynamic with two groups. They rolled the dice and had to answer some questions, making the proposed topic more engaging.

Additionally, the students got to know the LabMaker at IF Goiano, Rio Verde Campus, and the process of prototyping materials, becoming familiar with the Microworld and the 3D-printed Cells and Microorganisms.

In this context, Maker Education enables the construction of artifacts that complement the didactic strategies used. Raabe and Gomes [12] emphasize the contribution of the Maker culture to the teaching process. Besides helping to understand the discussed topic, it positions the student as the protagonist of their learning. Furthermore, we aligned ourselves with active methodologies, as discussed by Valente [13] and Bacich and Moran [2], which are alternatives that stimulate active student learning by moving away from traditional teaching, stimulating interest, attention, participation, and redefining the teacher's own praxis.

4. Final Considerations

The importance of teaching and learning Natural Sciences based on theoretical approaches such as didactic strategies and active methodologies is unquestionable for teacher learning during supervised curricular internships. These approaches enable future teachers to develop essential knowledge and skills for effective, creative, and innovative pedagogical practice. By integrating theories with concrete pedagogical practices, we as licentiate students are trained to face classroom challenges critically and reflectively, adapting to the needs of our students and the educational context in which we operate.

Moreover, by experimenting with these active methodologies, future teachers become more prepared to create a dynamic and collaborative learning environment, where students are encouraged to engage actively in their own learning process. Thus, the supervised internship transcends the simple curricular requirement, becoming a fundamental opportunity for professional growth, significantly contributing to the formation of more competent, conscious, and committed educators who strive for excellence in education.

5. Acknowledgments

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Decision-Making Based on Statistical Data: Building a Recreational Gymkhana through the Use of TDIC

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Abstract. This work was developed in the discipline of Information and Communication Technologies in the Teaching of Science and Mathematics, of the Doctoral Course in Education at the Federal University of Uberlândia – UFU. The idea is to practice the concept of Data Wise Improvement Process (DWIP), which seeks to make decisions based on data. The project was applied to high school students from the Federal Institute of Goiás – IFG, on the Itumbiara campus. The intention was for those involved to make decisions based on statistical data, and the entire process was mediated by Digital Information and Communication Technologies – TDIC.

Keywords. Education, High School, Statistics, Technologies.

1. Introduction

Knowledge in Statistics is present in the most varied areas of knowledge, and its use, most of the time, is associated with research that seeks in its use ways of knowing, drawing conclusions and directing paths to many relevant topics. Second [1], in the search to overcome students' difficulties in assimilating the contents of Statistics, emerged in the mid-1990s, Statistical Education (EE), a field of research focused on the teaching and learning of Statistics, valuing practices associated with the problems of the student's daily life, who becomes aware of their social aspects, finding in Statistics space for the development of critical education. From this perspective, situated in a world in constant evolution and digitalization, educators are constantly looking for new methods to teach mathematical knowledge and, more than that, we try to make sense of what we teach. Along these lines [3] writes about critical mathematics education, bringing reflections on political issues of mathematics education, more specifically focusing on the issue of democracy. In this same work, he differentiates three ways of knowing that can guide mathematics education:

a) Mathematical knowledge: related to the ability to use algorithms and mathematical formulas, more present in traditional mathematics education;
b) Technological knowledge: deals with the ability to apply mathematics to the creation of models, beyond pure mathematics;
c) Reflective knowledge: refers to the competence to reflect on the models built and to know how to evaluate them.

Thus, [3] states that technological knowledge and reflective knowledge are different, but they are not independent. The first of them seeks answers to solve a problem and the second analyzes and reflects on these answers. Thus, approaches that ignore reflective knowledge must be reviewed so that we arrive at an epistemology of critical mathematics education.

In an application of statistical knowledge, [2] studied in Brazil the concept of Data Wise Improvement Process (DWIP), which uses data for decision-making and process improvement. He applied the method to three teachers and three technicians in a private school and proved an improvement in the quality of work for this group. DWIP is a method developed by the Harvard Graduate School of Education, and has been applied and studied in schools for more than a decade, showing very significant results in its practice.

EE is not limited to the fact that students perform calculations and manipulate data, but is concerned that they know how to critically question the statistical information presented and evaluate the validity and relevance of this information in different contexts. This critical thinking ability is essential in a world where information is constantly expanding.

With this framework, we sought to develop a didactic proposal with the objective of developing critical EE, focusing on the use of data for decision making. Thus, this practice seeks to develop in students the importance of analysis, data and evidence, which will emerge in the training process and, with this, can present statistically based solutions. Following the work, the methodology used will be presented, the results obtained through forms that were applied

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to the students and thus describe the impact of this activity.

2. Methodology

The activity was developed in the context of the Statistics discipline, at the Itumbiara-GO unit of the Federal Institute of Education, Science and Technology of Goiás (IFG), with students from the 2nd year of the technical course in Chemistry integrated with high school. This discipline is annual with a workload of 54 hours distributed in a meeting of 90 minutes per week throughout the school year.

The students in question had already studied, within descriptive statistics, the following topics: types of variables, organization of data in tables and graphs, measures of centrality and measures of variability. For the proposed activity, in addition to the contents already studied, the elaboration of questionnaires, notions of sampling, notions of inference and the use of software for calculations and presentations were explored.

The main methodology used in the activity was problem solving, in this case, the problem must be solved based on data and evidence generated by the students themselves. For the development of the activity, the DICT were used, including the virtual learning environment - VLE Moodle, Google Meet for synchronous training, electronic forms for data collection, electronic spreadsheets for data organization and analysis, software for presentation, artificial intelligence - AI and others depending on the needs of the process and knowledge of the participants. The students, during the course, shared the collection instruments and partial results in the VLE and, at the end of the activity, presented a report describing the entire path and resources used to reach the proposal for a solution to the question presented. These posts were used as an evaluative instrument.

Seeking a proposal with greater engagement on the part of students and other teachers, we present a transdisciplinary proposal, involving, in addition to Mathematics, teachers in the areas of Physical Education and Arts, with the theme Recreational Gymkhana. The students were challenged to answer the following question: "Present, supported by data and evidence, a proposal for a one-day recreational gymkhana, which involves 6 (six) activities with the following characteristics: cultural/arts, sports, fine motor skills, gross motor skills, knowledge and surprise tests?"

To answer this question, the following script was suggested, which may have changed according to the deliberations with the students:

i. Divide students into teams and by activity;
ii. Research about activities that fit the characteristic (at this stage, the help of Physical Education and Arts teachers will be very important);
iii. Define the methods for data collection and carry it out;
iv. Organize the results obtained in tables and graphs;
v. Decision-making and preparation of the group's report;
vi. Joint preparation of the Gymkhana and writing of the final report.

The final report will be evaluated by the professors involved and submitted to the institution's management to assess the feasibility of carrying out the gymkhana.

3. Results

The project showed positive results, but faced some challenges and limitations. The activity was started during a period of strike, which made it difficult for all students to get involved. In addition, many students did not have access to computers at home, which limited the writing of reports and the use of some digital tools available for smartphones. The need for ongoing support for the use of DICT was also identified as a challenge, with many students preferring to contact the teacher directly rather than seeking the instructions available in the VLE. Despite these obstacles, the groups complied with the proposed activities, which were developed in a very significant way.

The data collected through questionnaires applied to the participating students provided valuable *insights* into their perceptions and experiences with the project. All students reported that the activity contributed significantly to their training process in statistics. The

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comments written by the students highlighted the practical application of statistical concepts and the development of analytical skills through data collection and analysis, construction of graphs and tables, and the use of tools such as Google Forms and electronic spreadsheets.

All students reported that they had used some AI, some reported that they had never used Google Forms before the project, but saw the introduction of these technologies as a valuable opportunity to explore new technologies and learnings. Other students mentioned that the activity helped them to better understand the importance of statistics in everyday contexts and to develop group work and project development skills.

The difficulty of some students in reading and following the instructions provided in the VLE required a greater effort on the part of the teacher to ensure that all students were at the same level of understanding. Despite these difficulties, the students' effort to overcome limitations and actively participate in the project was considered a significant intellectual advance.

The impact of the project on the students' education was evidenced by the answers to the questionnaire. The students reported a greater understanding of statistical concepts and an appreciation of the practical skills developed during the activity. The practical experience of data collection and analysis, combined with the use of digital technologies, contributed to the theoretical understanding and development of analytical skills of the students.

Most students understand that most of the statistical contents studied were explored, especially with regard to data collection and organization. The only content that was not strongly explored, according to the notes, was the part of variability measures.

The last question of the questionnaire dealt with the following question: "Do you believe that the development of this activity contributed to the process of training students in relation to the discipline of Statistics?" All students understood that the activity contributed to their training process in relation to the discipline. To the request to justify the reasons for this answer, about how the activity was developed and contributed to learning, here are some of the students' answers to this question, transcribed as they appear in the questionnaire:

"Por conta dos conceitos básicos de estatística que foram trabalhados de forma diferente e num ambiente totalmente diversificado da sala de aula"

"A atividade contribuiu para mostrar onde podemos utilizar estatística no nosso cotidiano"

"A atividade me ajudou a compreender como é construído um projeto, e quais são suas principais ideias base para construí-lo. Contribuiu para me inteirar mais com a matéria e trabalhar em grupo"

"Dando uma noção da coleta de dados, trazendo a moda, referente a qual atividade foi mais selecionada"

"Me ajudou a entender como são feitas as coletas de dados e entender a importância das tabelas e gráficos na exposição deles."

"pois exigiu a coleta de dados, criação de gráficos e tabelas. Essas tarefas me proporcionaram uma experiência prática valiosa na aplicação de conceitos estatísticos, como análise de dados e representação gráfica, fortalecendo minha compreensão teórica e habilidades analíticas."

"Em análise crítica, nas habilidades técnicas para desenvolver a coleta de dados, no entendimento prático para melhor compreensão dos dados obtidos."

"A atividade contribuiu para o processo de formação em estatística, pois foi uma atividade leve e descontraída onde tivemos que colocar em prática os aprendizados da matéria"

"Acredito que a atividade em sí contribuiu significativamente para nossa formação na disciplina de Estatística. Utilizamos ferramentas estatísticas para desenvolver uma proposta de atividade para um evento, o que incluiu a análise de gráficos e a interpretação de dados coletados através de uma pesquisa.

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Esse processo aprimorou nossa compreensão e aplicação prática dos conceitos estatísticos."

The activity also provided students with the opportunity to apply their knowledge in a real-world context, which helped reinforce the relevance of statistics in their lives. The students highlighted the importance of statistics in making informed decisions and the usefulness of the skills developed for future academic and professional projects.

4. Final considerations

Participation in the project showed the students involved that making a decision based on statistical data is a complex process, which involves many steps, but which also promotes a better understanding of the whole problem. The integration of DICT in the teaching of statistics enriched the students' learning, provided a diversified environment, with multiple possibilities and paths to develop each stage of the project. The practical experience of data collection and analysis, combined with the use of digital technologies, contributed to the theoretical understanding and development of analytical skills of the students.

Future initiatives should consider expanding access to technologies and the development time of activities, in order to promote strategies to involve all students more effectively. The continuous proposition of similar activities can develop the training of students and teachers, to a habit of always taking into account statistical data and evidence for decision-making. In this regard, knowledge about the use of DICT is essential to ensure the success of these projects and advances in this area.

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Socio-Environmental Education and Extension: Interdisciplinary Approaches to Sustainability

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Abstract. Halting the ongoing degradation of natural resources essential to human survival from the perspective of sustainable development is complex, involving interconnected ecosystems associated with economic processes that prioritise profit over socio-environmental priorities. The research aims to analyse the potential of socio-environmental education through extension practices at the Federal Institute of Goiás - Rio Verde Campus. The methodology is qualitative, descriptive, analysing data and discourse and interviews. Theoretical references for socio-environmental education, from the perspective of critical environmental education, university extension and relevant legislation. The aim is to contribute to excellence in academic training and stimulate a critical perception of its social role.

Keywords. Sustainability, Environmental Education, Extension.

1. Introduction

Halting the ongoing degradation of natural resources essential to human survival from the perspective of sustainable development is complex, involving interconnected ecosystems associated with economic processes that prioritise profit over socio-environmental priorities. The research aims to analyse the potential of socio-environmental education through extension practices at the Federal Institute of Goiás - Rio Verde Campus. The methodology is qualitative, descriptive, analysing data and discourse and interviews. Theoretical references for socio-environmental education, from the perspective of critical environmental education, university extension and relevant legislation. The aim is to contribute to excellence in academic training and stimulate a critical perception of its social role.

Promoting sustainable development in both urban and rural areas is a complex issue, as it involves interconnected ecosystems associated with economic processes and different interests, whose current practices prioritise profit maximisation over socio-environmental priorities.

Environmental management in urban areas involves many complex processes in an attempt to mitigate the damage caused by the occupation and use of land and natural resources, such as the collection, proper disposal and utilisation of waste, and the recycling of solid waste. Conservation and recovery of springs and degraded green areas, increasing green areas to naturally absorb rainwater, implementing rain gardens, proper management of water resources. Reducing noise, air and water pollution, among others.

There are several obstacles to the sustainable management of the environment and water resources in the recovery of areas damaged by anthropogenic action in urban areas, and the most viable and cost-effective way is preventative action. Monitoring water and air pollution, preserving significant parts of native vegetation areas, riparian or gallery forests, which in addition to harbouring a great diversity of species, prevent the silting up of watercourses, as well as the importance of maintaining this native vegetation and wetlands due to their natural water filtering capacity. However, avoiding actions that harm the environment comes up against major obstacles due to conflicts of interest motivated by economic factors.

In rural areas, wetlands and green areas are obstacles to agribusiness production, while in urban areas, buildings, property interests and financial speculation contribute to a huge increase in the value of urban land and property rents. Most of this occupation is carried out by the less economically favoured population, who, unable to find other alternatives, build their homes in areas unsuitable for building, the so-called risk areas, on the banks of streams and rivers or on hillsides.

Houses built improperly on the banks of rivers, in areas also known as flood plains, cause various problems, such as soil erosion, total suppression of riparian forests and, consequently, pollution and silting up of

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watercourses and water pollution. And it can also cause social vulnerability, as the areas at risk are unsuitable for building, subject to flooding or landslides. This disorderly occupation process has been replicated in most Brazilian cities. Considering the importance of conserving water quality and maintaining its natural characteristics, free of chemical components and other pollutants, for the healthy survival of all living beings and all the processes that depend on it, and also the need for urgent action to conserve both quality and quantity, although this is a widely discussed topic, in practice, effective action in this direction is rarely made possible by public authorities and is still little demanded by society.

Public health depends heavily on the quality of the water supplied for consumption, as well as on sustainable practices in the production of food free of agrochemicals and with the least possible impact to avoid the depletion of natural resources. These are basic conditions from an economic point of view for a country to be able to maintain growth for a longer period of time. But it is also necessary to consider other factors, not just economic ones, when making decisions that impact on the environment and consequently jeopardise human survival and biodiversity. Faced with the population's diminishing capacity to demand and influence political decisions; for better living conditions, for the right to consume quality water and breathe clean air, free of pesticide residues, industrial pollutants and chemicals, and also to consume healthier food free of pesticide and preservatives.

It is important to stress the importance of guaranteeing access to natural resources that are fundamental to maintaining the quality of human life, maintaining ecological balance and ensuring that society participates more actively in the defence of socio-environmental rights through educational processes. Socio-environmental problems are a multidisciplinary issue. There is an abundance of studies in which researchers warn about the non-sustainable nature of current economic processes and the need for changes in the process of exploiting natural resources. The influence of science and technology on socio-environmental issues is undeniable and already consolidated economic systems also rely heavily on research, teaching, science and technology to establish more sustainable economic practices. And scientific knowledge can be disseminated, improved and validated through extension projects and programmes focused on identifying and proposing ways of tackling regional socio-environmental problems.

The guidelines for the curriculum of extension, to be implemented at the IF Goiano - Campus Rio Verde, address educational practices in the sense of stimulating dialogical interaction, social commitment, participation and contact with complex and contemporary issues present in the social context, allied to the students' citizenship education marked and constituted by the experience of their knowledge. In this context, it can be seen that these guidelines are present in Freire's main reflections.

Faced with the implementation of extension curriculum, how is the Instituto Federal Goiano - Campus Rio Verde-GO organising itself to implement these changes in everyday academic life? What strategies are being implemented to meet the growing demand for extension activities? Due to the obligation for students to fulfil 10% of their total course load in extension activities as a requirement for completion of undergraduate courses.

Due to the difficulties presented by educational institutions in general in meeting the new regulatory requirements and the demands of extension curriculum, as well as the fact that efforts are being mobilised for the implementation of the Rio Verde Botanical Garden in a space within the area of this campus, this is an opportune time to carry out this research, as a way of understanding how the academic community organises itself to meet the growing demand for extension practices, in accordance with the new legal requirements.

Furthermore, how can these demands be aligned with the interests of the external community, with a view to social and sustainable development, to build a quality training environment that can stimulate critical and reflective thinking about contemporary social problems?

The research indicates the proposal for a multidisciplinary extension programme focusing

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on socio-environmental education at the Federal Institute of Goiás - Rio Verde Campus. The multidisciplinary programme will be geared towards meeting the demands of extension curriculum, aiming not only to contribute to excellence in the academic training process, but also to stimulate students' critical perception of their social role, through teaching-learning relationships with the community, thus enhancing the occurrence of social transformations.

The general aim of the study is to analyse the potential of socio-environmental education for extension practices at the Instituto Federal Goiano - Campus Rio Verde. More specifically, it aims to identify the main teachers, extension workers, events, projects and activities focused on socio-environmental education carried out at the Instituto Federal Goiano.

It also seeks to understand how actions are being taken to set up the Rio Verde Botanical Garden and what projects are planned and underway.

2. Discussion and Results

The contemporary evolutionary process and advances in technology and the media have brought a great deal of agility and practicality to practically all areas of human activity. However, it is worth reflecting on and analysing why or why not processes that interfere with the ecological balance, which have already been widely publicised and alerted to by the scientific community as urgent agendas, are being ignored in practice, such as the use and occupation of land in Permanent Preservation Areas in urban areas and, due to these and other practices, the decline in the quality of life of a large part of contemporary Brazilian society. According to Alves (2022):

> The two main characteristics of Brazil's demographic dynamics in the 21st century will be population ageing and urbanisation. Faced with the climate and environmental emergency, only by investing in infrastructure, eliminating poverty, reducing inequalities and building ecological cities can we think of urban sustainability with social well-being (Alves, 2022).

From the perspective of education as an element that transforms its own environment, in this context the rules for the curricularisation of extension were established for undergraduate courses in Brazil, highlighting the inseparability of teaching, research and extension,

Extension in Brazilian higher education is an activity that is integrated into the curriculum and the organisation of research, constituting an interdisciplinary, political, educational, cultural, scientific and technological process that promotes transformative interaction between higher education institutions and other sectors of society, through the production and application of knowledge, in permanent articulation with teaching and research.

In line with the guidelines set out in the aforementioned resolution, which stipulates that 10 per cent of the total curricular workload in higher education courses should be made up of extension activities, we highlight Articles 5 and 6, which structure the conception and practice of the Higher Education Guidelines:

i. the dialogical interaction of the academic community with society through the exchange of knowledge, participation and contact with complex contemporary issues present in the social context;
ii. the students' civic education, marked and constituted by the experience of their knowledge, which, in an interprofessional and interdisciplinary way, is valued and integrated into the curriculum;
iii. promoting initiatives that express the social commitment of higher education institutions to all areas, especially communication, culture, human rights and justice, education, the environment, health, technology and production, and labour, in line with policies linked to the guidelines for environmental education, ethnic-racial education, human rights and indigenous education;
iv. promoting ethical reflection on the social dimension of teaching and research;
v. encouraging the academic and technical community to contribute to tackling issues facing Brazilian society, including through economic, social and cultural development; (...)
vi. acting in the production and construction of up-to-date and coherent knowledge aimed at social, equitable and sustainable development, in line with Brazilian reality.

Art. 7º Extension activities are considered interventions that directly involve communities outside higher education institutions and that are linked to student training, under the terms of this

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Resolution, and in accordance with specific institutional rules. (Brazil, 2018).

This research aims to give continuity to some of the issues analysed in the Master's dissertation in Regional Development, the theme of which was 'Permanent Preservation Areas in urban areas: challenges and guidelines for socio-environmental management in Rio Verde-GO', where some problems related to management were raised; of water resources, of occupation and building in wetlands destined for preservation, of urban land use and occupation, intensely waterproofed which with urban expansion, can further intensify, situations of flooding and inundation compromising the health and quality of life of the urban population.

This model of urbanisation has been replicated in the majority of Brazilian cities, with the implementation of canalisation, the straightening of river and stream beds, the draining of springs and wetlands and the implementation of marginal roads along watercourses, which can aggravate the occurrence of waterlogging and flooding and require effective preventive administrative action to avoid or minimise the impacts of major urban floods such as those that occurred in the state of Rio Grande do Sul in April 2024.

Reflection on the vulnerability of the contemporary urban population to situations that could interrupt the supply of electricity, water or food, as well as the conditions of access to safe and decent housing. These are socio-environmental issues that can be included in the educational context, to raise critical awareness and the perception of the importance of the role of organised civil society, in an active and democratic way, in the urban planning process and in the establishment of public policies related to the environmental management of cities, encouraging more equitable decisions aimed at social and environmental well-being.

Municipal environmental management can be understood as a political-administrative process that entrusts the local government, both in the executive and legislative spheres, and with the participation of organised civil society, to formulate, implement and evaluate environmental policies expressed in plans, programmes and projects, to order the municipality's actions to ensure environmental quality as the foundation of citizens' quality of life, in line with sustainable development guidelines and based on local reality and potential (Huller, 2010).

According to the precepts of Resolution No. 07 of December 2018, which in its Article 6, Item VII, 'the performance in the production and construction of knowledge, updated and coherent, aimed at social development, equitable, sustainable, with the Brazilian reality.

In accordance with the precepts of Resolution No. 07 of December 2018, which in its Article 6, Item VII, 'the performance in the production and construction of knowledge, updated and coherent, aimed at social, equitable, sustainable development, with the Brazilian reality

According to the questions presented, the aim of this research is to analyse the potential of socio-environmental education at the Instituto Federal Goiano - Campus Rio Verde, supported by current regulations to implement the curricularisation of extension, as a way of promoting a teaching-learning process capable of including in students' training, contexts that aim to solve or minimise the problems experienced by contemporary society, which in addition to professional training, aims to establish relationships of knowledge exchange with the local community and the development of critical and reflective awareness about sustainable development and social responsibility.

Although the legal guidelines call for the development of projects that favour improvements in teaching, research and extension activities and the expansion of relations between the academic community and external communities, it is known that legal determinations alone are not enough to promote the expected results. The research approach will be qualitative, descriptive and will go through the theoretical frameworks of socio-environmental education, from the perspective of critical environmental education and university extension frameworks, analysing documents relating to the Botanical Garden and University Extension projects, going through the legislative field relating to environmental education and university extension.

According to Cusati, I.; Santos; Cusati, (2021), 'The case study approach makes it possible to study the functioning of an institution and determine focuses for change or intervention.' And from this perspective, the transformations planned for the implementation of the JBRV, as well as socio-environmental issues, find greater support in this approach.

In this case study, the instrument used for data collection will be an interview with the academic community of the Rio Verde campus. Photographs and videos will be used to record events and facts related to the implementation of the Rio Verde Botanical Garden aimed at socio-environmental education that took place in adition:

> [...] the most distinctive feature of the case study is the belief that human systems develop completeness and integration, that is, they are not simply a collection of parts or traits. The case study therefore fits into a holistic research tradition according to which the characteristics of a part are largely determined by the whole to which it belongs. Understanding the parts requires understanding their interrelationships within the whole. It is a systemic view that assumes that the elements of an educational event, for example, are interdependent and inseparable and a change in one element implies a change in the rest (Sturman, 1988, p. 61 apud Moreira, 2002).

These characteristics are aligned with the socio-environmental issues involved in this study: in nature there is an ecological balance where the elements that make it up are interconnected, and there is a chain reaction to anthropic action in the environment. Similarly, human relations and the inseparability of teaching, research and extension. Case study:

1. Data collection: Semi-structured interviews, participant observation and document analysis.
2. Discourse Analysis,
3. Coding: Use of qualitative analysis software (NVivo) to code the data.
4. Thematic Analysis: Identification of recurring themes and patterns in the discourses.
5. Critical Interpretation: Critical analysis of the discourses, considering the social and cultural context.

One of the results of the research is the proposal for a multidisciplinary extension programme focusing on socio-environmental education at the Federal Institute of Goiás - Rio Verde Campus. The multidisciplinary programme will be geared towards meeting the demands of the curricularisation of extension, aiming not only for excellence in the academic training process, but also to stimulate a critical perception of its social role, through teaching-learning relationships with the community, thus enhancing the occurrence of social transformations. During the research process, it is also hoped to find ways to promote the active participation of the local community in projects or events that promote socio-environmental education practices and the mutual exchange of knowledge between the local and academic communities, or other similar activities related to the implementation of the Botanical Garden.

3. Acknowledgements

I thank my advisor, Professor Clézio dos Santos, who guides me in the paths of this research, which seeks to work with the training of researchers in the area of geography teaching, to all the professionals who are part of the PPGEduc graduate program. And to the entire academic community of the Federal Rural University of Rio de Janeiro and the Federal Institute of Goiás.

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Exploring The Cerrado: Challenges and Opportunities in the Integration of Robotics in Science Education

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Abstract. This article presents ongoing researchaimed at analyzing the potentialities and limits of the experiences of Inventive Mathematics Education, with robotics, in teaching about the Cerrado. The methodology is qualitative, with a cartographic research and intervention design. The objectives are expected to be achieved by developing a proposal using robotics as an educational tool. Additionally, it seeks to understand the students' learning experiences during the development of the proposal, which so far includes the production of 16 models containing the phytophysiognomies of the Cerrado.

Keywords. Biology, Inventive Mathematics Education, Science Teaching, Robotics.

1. Introduction

The problem addressed is that "the scientific community and society in general do not always clearly understand the differences that exist within the Cerrado itself. Understanding each physiognomy of the Cerrado as a unique environment becomes relevant to make its conservation viable [1]. The incorporation of Inventive Mathematics Education [2-5], combined with robotics, as a pedagogical resource in the Natural Sciences curriculum, represents a different approach to the teaching-learning process of important ecological themes, such as the phytophysiognomies of the Cerrado. This research aims to address the limits and possibilities of this educational experience, bringing possible contributions to pedagogical practice and to the teaching of Science.

The variety of landscapes of the Cerrado "determines a great floristic diversity, which places the flora of the Cerrado biome as the richest among the savannas in the world" [6], "its biodiversity is still little known, which seems ironic, as it is the richest and most threatened tropical savannah on the planet" [1]. Therefore, phytophysiognomies become a relevant theme for the teaching of Natural Sciences. However, teaching Cerrado phytophysiognomies may face challenges, including the lack of pedagogical strategies for its approach.

The proposal to use Inventive Mathematics Education [2-5], with robotics, emerges as a possibility to face these challenges. Natural Sciences teachers can use this proposal to teach phytophysiognomies. By provoking the production of a different and interactive approach, which integrates mathematical, scientific and technological concepts, through the production of diversified actions and practices, it is possible to contribute to the enhancement of students' learning, stimulating their curiosity, inventiveness and critical thinking.

Investigating the limits and possibilities of this approach is important to understand how it can contribute to teaching the phytophysiognomies of the Cerrado. By analyzing students' learning potentialities and experiences, as well as the challenges faced by educators, this research can contribute to developing new educational practices.

Additionally, producing a proposal for teaching Cerrado phytophysiognomies using robotics will provide an applicable resource for educators interested in adopting this approach in their classrooms.

This research can bring relevant contributions, enhancing and sensitizing the educational practice, supporting a significant approach to the teaching of Natural Sciences, especially regarding the phytophysiognomies of the Cerrado.

2. Literature review

Considering the relevance of the theme for teaching Cerrado phytophysiognomies with robotics, a search will be conducted in the CAPES thesis and dissertation database to understand how the Strictu Sensu works, focused on the area of teaching, have addressed this theme. The following terms will be used: robotics and phytophysiognomies of the Cerrado, robotics and Cerrado, robotics and science teaching, Inventive Mathematics Education [2-5].

"The scenario of inventive productions has provoked scientific and technological advances from which new knowledge and new learning emerge" [5]. Learning involves the invention of problems that can emerge during problematization experiences, distinct from recognition experiences [5]. In this context, an inventive environment can drive scientific and technological advances, generating new knowledge and learning, involving the creation of problems during problematization experiences, distinct from recognition experiences.

The idea is brought that "the invention of problems and the experience of problematization are configured as other paths that are not limited to the acquisition of content or the resolution of problems" [4]. This allows considering “cognitive subjects as effects of their actions and practices.” For this, Silva [4] sought in autopoiesis, a theoretical field that explains, within biology, the potential that living beings have to produce themselves autonomously.

For a better understanding, we bring an excerpt of what the theoretical field mentioned above (autopoiesis) proposes. [7] report that "recognizing that what characterizes living beings is their autopoietic organization allows us to relate a large amount of empirical data on cellular functioning and their biochemistry" and also add that: "The concept of autopoiesis, therefore, does not contradict this body of data - on the contrary, it is based on them and explicitly proposes to interpret them from a specific point of view, which emphasizes the fact that living beings are autonomous units. We use the word "autonomy" in its ordinary sense - that is, a system is autonomous if it can specify its own laws, what is proper to it. We are not suggesting that living beings are the only autonomous entities: they certainly are not. But one of the most evident characteristics of living beings is their autonomy. We are proposing that the mode, the mechanism that makes living beings autonomous systems is autopoiesis, which characterizes them as such" [7].

Thus, "educational robotics can be used as a device for the development of actions and practices of inventive learning, in which those involved have the possibility of producing themselves (autopoiesis)" [4].

In his doctoral research, Silva [4] found that "using robotics in an inventive way to tension and problematize Mathematics classes, provoked processes of authorship and autonomy in the interns" of a class of the Mathematics Degree Course at UEG-Campus Southwest, Quirinópolis (Goiás State, Brazil), "who did not limit themselves to following ready-made and generalized methods", in this way, [4] And those involved in his research considered, through "the conceptions of autopoiesis, that the interns were autonomously self-producing in the midst of their authorship processes in the space-time of the teaching internship" [4].

Immersed in this context, [3] they defend Inventive Mathematics Education [2-5] as a set of actions and practices that promote mathematical knowledge through a field of problematizations. In this context, the subjects involved collectively self-produce, inventing both themselves and the world around them, in a process called inventive-self-formation.

In this context, robotic devices play a significant role in Inventive Mathematics Education [2-5] when integrated with mathematical knowledge, they go beyond simple problem solving, representation, or interpretation of the world. These devices can potentialize, tension, and trigger unpredictable actions and practices, promoting the invention of problems, the invention of worlds, and the invention of the self [3].

2.1. Inventive Mathematics Education

As mentioned earlier, in the doctoral research of, it was found that the inventive use of robotics in [4] Mathematics classes provoked experiences of authorship and autonomy among interns of the Mathematics Degree course at Quirinópolis. These interns were not restricted to following traditional and generalized methods, concluding that the interns self-produced autonomously during the teaching internship, developing their own authorship processes.

Based on research carried out between 2017 and 2020, it discusses the importance of an inventive educational approach in the training of mathematics teachers, considering the

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production of transformations through pedagogical practice. It brings as an example the use of robotics and practical activities developed in the Mathematics course at the State University of Goiás. It also brings the concept of Inventive Mathematics Education [2-5] as a central idea, proposing that teacher training goes beyond the static representation of mathematical knowledge and opens up to new possibilities of learning and interaction with knowledge [5].

[5] to explain the actions and practices of Inventive Mathematics Education (EMI) highlights five main approaches, which he names as "clues" that challenge traditional teaching methods, provoking an even more dynamic teaching that can enhance student learning, with the intention that educators and researchers explore these "clues", providing a formative environment rich in discoveries and innovation, without following a linear reading, but rather a free exploration that allows questions and new learning in the educational field.

For a better understanding of Inventive Mathematics Education addresses the transition from Representational Mathematics Education (EMR) to Inventive Mathematics Education [2-5]. Representational Mathematics Education (EMR) would be limited to the representation and reproduction of pre-existing knowledge, operating within the Permanent Representational Zone (ZRP), where teachers and students only replicate already established methods and concepts, without generating new knowledge. On the other hand, Inventive Mathematics Education [2-5] seeks to break away from this approach, moving to the Field of Production of Difference (CPD), where learning is based on invention and the creation of new worlds and knowledge. Inventive Mathematics Education [2-5] values experimentation and the production of subjectivities, allowing students and teachers to be co-creators of knowledge, going beyond mere representation and imitation. This approach emphasizes the importance of invention, both in the educational process and in the interaction with the objects of knowledge, promoting a more dynamic and inventive education [5].

In Fig. 1, he provokes an idea of Inventive Mathematics Education "in unpredictable and vibrant movements that pulsate in the composition of difference" [5]. The research promotes a reflection on traditional methods in Mathematics Education. Such traditional methods could stabilize the pedagogical practice by limiting themselves to the superficial reproduction of knowledge through repetition. Instead, Inventive Mathematics Education [2-5] encourages the creation of new problems and ideas, allowing for more dynamic teacher training, open to differences and constant learning, while keeping pedagogical practice always active and questioning [4-5].

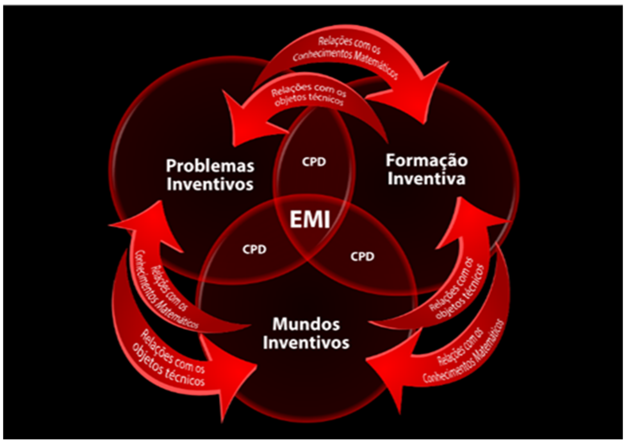

Figure 1. Clues from Inventive Mathematics Education (EMI) [5]

Inventive Mathematics Education [2-5] goes beyond the application of mathematics to solve problems or represent reality, it emphasizes the use of mathematics for the invention of problems and the invention of worlds. In this sense, the individual (re)invents himself by employing mathematical knowledge during the invention of problems and worlds, so the use of Inventive Mathematics Education [2-5] can enable the student, through robotics, to invent himself during the invention of problems and worlds [2].

In relation to the invention of worlds, it is possible to consider that "when a different knowledge is produced, a world is invented". Thus, the models elaborated with the objective of exploring the theme of the Cerrado are like inventive worlds that can provoke the teaching and learning of the different phytophysiognomies of this biome [5].

After approaching a brief context of the conceptions of Inventive Mathematics Education [2-5] with robotics, we will address in the next items how the relations with this perspective can contribute to the production of knowledge of Natural Sciences aimed at the teaching and learning of the phytophysiognomies of the Cerrado.

3. Methodology

The path adopted during the research leads to consider that the experiences, which occurred in the space-time of the classroom, during the experience of Inventive Mathematics Education [2-5] with robotics, in the process of teaching and learning the phytophysiognomies of the Cerrado present characteristics of cartographic research, since, according to [8] becoming a cartographer requires more than just theoretical reading on the subject, It is necessary to practice, go to the field, follow processes, throw yourself into the water, experiment with devices, inhabit a territory, fine-tune attention, change perspective and practice writing, always considering the collective production of knowledge. In this approach, the cartography method is considered linked to the experiences of collective production of knowledge.

The proposed research also presents characteristics of an intervention-research, which in turn is part of the line of participatory research that broke with dominant assumptions in social research, such as the separation between theory and practice and between subject and object, considered basic to ensure the neutrality of the researcher [9].

In the research in question, the students (subjects researched) and the use of robotics during the experiences of Inventive Mathematics Education [2-5] in the process of producing the proposal of teaching and learning phytophysiognomy of the Cerrado (object of research) are not constituted as previous poles, but as an effect of the practices of knowing. In this sense, it is assumed that students are not constituted as previous poles in this research, but as effects of experiences of knowledge during the use of mathematical and robotic knowledge in the midst of the production of the proposal of teaching and learning of the phytophysiognomies of the Cerrado.

To analyze the actions and practices of students in contact with robotics, during theexperience of Inventive Mathematics Education in the process of producing the proposal for teaching and learning the phytophysiognomies of the Cerrado, two axes of analysis will be considered:

AXIS I: analysis of the students' experiences during the organization and development of the proposal for teaching phytophysiognomies of the Cerrado with robotics.

AXIS II: analysis of the limits and possibilities of using the proposal for teaching phytophysiognomies of the Cerrado, with the use of robotics by Basic Education Science teachers.

4. Results

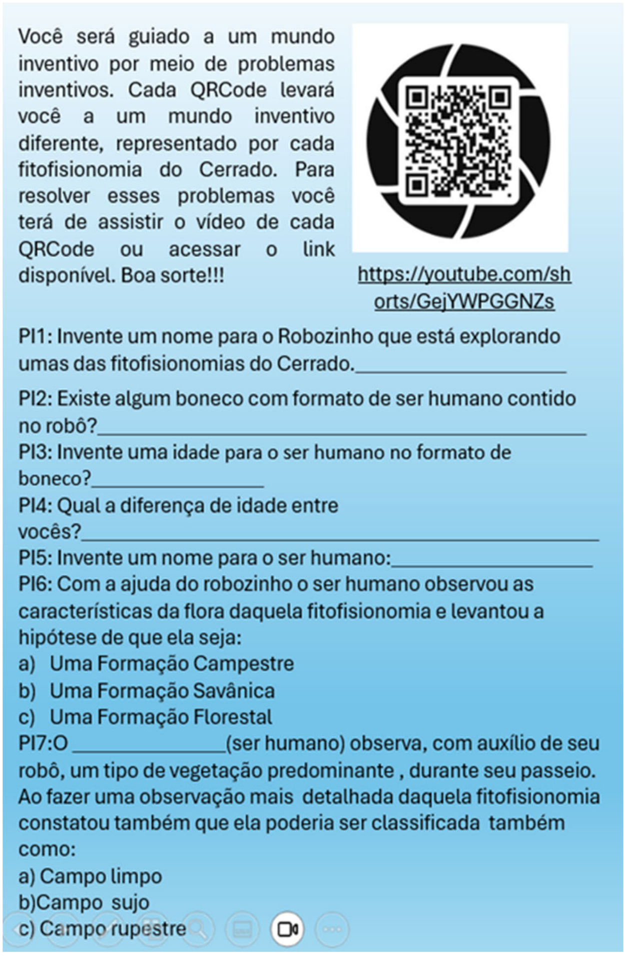

Figure 2. Inventive problems about one of the phytophytosonomines of the Cerrado

The use of robotics and mathematical knowledge, during the production of the inventive worlds (materialized in the format of models) of the phytophysiognomies of the Cerrado, resulted in the partial confection of an educational product. This educational product is a hybrid book containing inventive problems that, in order to be solved, the reader/student

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must read a QR-Code or access a link that gives access to a YouTube video, which presents a little robot interacting with the inventive world (model) of one of the phytophysiognomies of the Cerrado.

PI8: Os elementos, presentes na maquete, podem ajudá-lo a assimilar o tipo de vegetação predominante nessa fitofisionomia. Existe um vegetal que está fora da escala de representação, ou seja, sua forma e seu tamanho estão desproporcionais em relação aos demais. Qual a cor desse vegetal?____________________

PI9: Invente uma medida para a dimensão retangular preenchida com ________________ (preencher com o nome da fitofisionomia observada pelo ser humano durante o passeio de robô).

PI10: Com base nos dados que você inventou, na questão anterior, determine a área e o perímetro da região ocupada pela fitofisionomia que poderia ser identificada corretamente pelo ser humano durante seu passeio com robô?_________________

PI11: Caso você fosse o inventor do cenário identificado pelo ser humano, em seu robô, como você produziria as gramíneas e os arbustos que são predominantes nessa fitofisionomia?____________________________________
____
____
____

PI12: Faça uma desenho original contendo a fitofisionomia explorada nessa aula. Tente expressar, em forma de desenho, as ideias e os conceitos que você aprendeu até o momento.

Figure 3. Inventive problems involving mathematical concepts and phytophysonomies

Inventive problems are questions that lead the reader/student to solve problems and also to identify some characteristics of the Cerrado phytophysiognomy chosen to be studied. The inventive problems also lead the reader/student to find solutions to possible errors in scaling, performing mathematical calculations (according to the interpretation of the reader/students) and identifying the lack of characteristics in the phytophysiognomy analyzed, as shown in Figs. 2 and 3.

In addition to the actions and practices of Inventive Mathematics Education [2-5], the ideas that guided the preparation of the book are aligned with the BNCC (National Common Curriculum Base). An example of this are some of the general competencies of Basic Education, such as Competency 2, in which the student is expected to exercise intellectual curiosity and use scientific methods to investigate causes, test hypotheses, solve problems and create technological solutions based on varied knowledge, as shown in Fig. 4 [10].

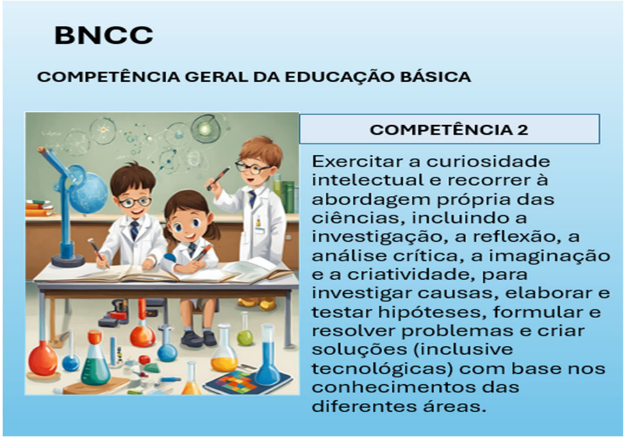

Figure 4. One of the General Competencies of Basic Education

The cover of the book is also under construction. So far, AI (Artificial Intelligence) has been used to create an image that is the result of the association of the terms: Cerrado, Inventive Mathematics Education, phytophysiognomy and robotics (Fig. 5).

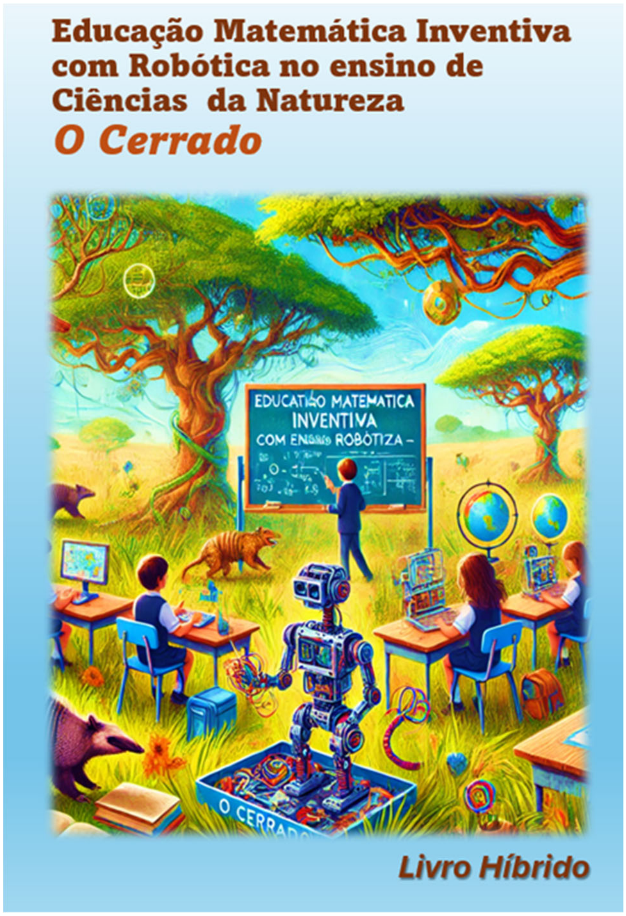

Figure 5. Book cover with image created by AI (Artificial Intelligence)

It can be seen from the image created by AI (Artificial Intelligence), in Fig. 5, that the

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information, which feeds it, also induces a somewhat distorted production of the Cerrado Biome, as the AI inserted plants and animals with different characteristics from the fauna and flora of the Cerrado.

For the construction of the book, mentioned above, some steps were followed, from the presentation of the proposal to the production and editing of the videos of the robots interacting with the models. In all stages, there was student involvement. Figs. 6 and 7 record Stage 1, which was the presentation of the proposal to the students.

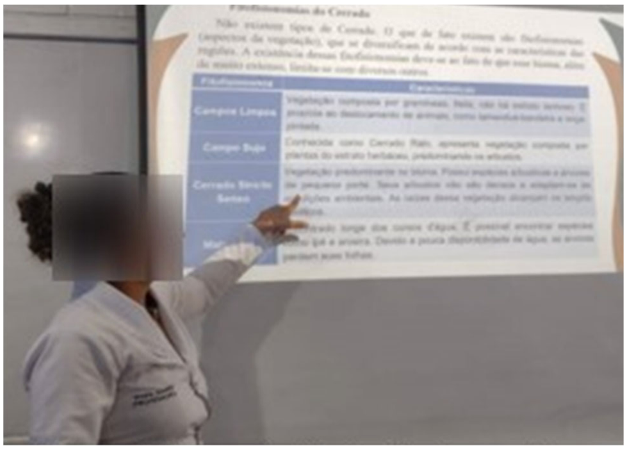

Figure 6. Presentation of phytophysiognomies to students

Figure 7. Presentation of the proposed interaction between robots and models (inventive worlds)

After the presentation of the proposal, a partnership was established with a robotics teacher for the assembly of line-following robots from the Lego Kit, establishing Step 2 (Fig. 8). After assembling and programming their robots, the students were challenged to invent problems, worlds and themselves, during the materialization of the models in which the robots were programmed to follow a line. In this way, they used Inventive Mathematics Education [2-5] to face the challenges presented. Fig. 9 shows the moment when one of the robots executed its programming by following a black line on a blue surface.

Figure 8. Assembling one of the line-following robots (Lego Kit)

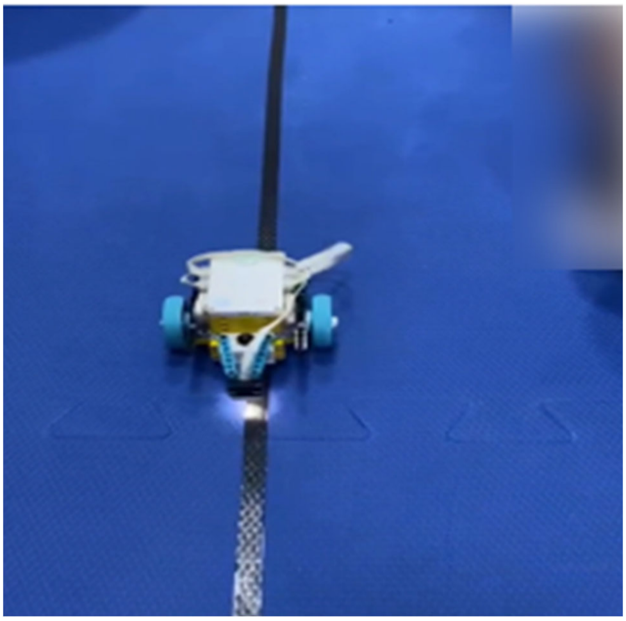

Figure 9. Testing the programming of a line follower robot

Stage 3 was configured as the planning for the invention of worlds that were materialized in the form of models, already thinking about the robot's interaction with them. Fig. 10 shows that

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the students are planning the invention of worlds.

Figure 10. Inventive World Planning (model)

Figure 11. Pre-assembly of the Inventive World (model)

In step 4, the students made a pre-assembly of the inventive world (models) so that later the robotics teacher could help them test the robots (Fig. 11).

In Stage 5, after the pre-assembly, the robotics teacher was invited to participate in the class to tutor the students, leading them to invent problems whose solution would be to make the robot read colors and thus "walk" through the model (Fig. 12).

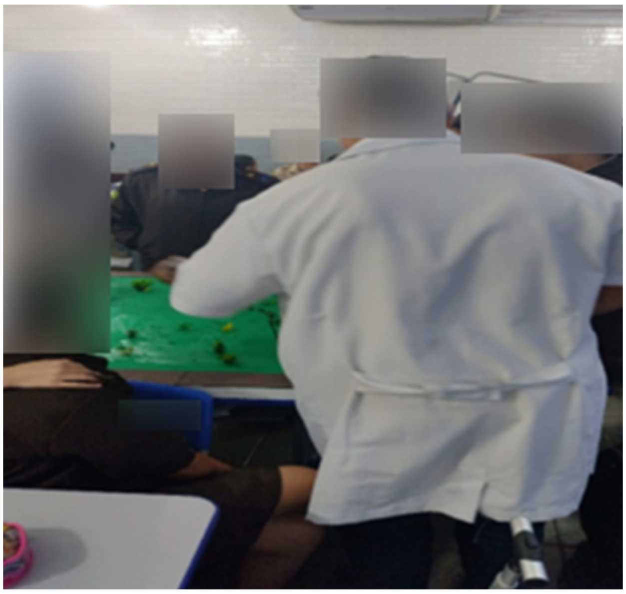

Figure 12. Partnership with Robotics teacher

Fig. 13 shows Step 6 that took place during the Robotics class.

Figure 13. Testing robot programming in the Inventive Worlds of Cerrado phytophysiognomies

The Robotics teacher made all the models available (Fig. 13) so that the students could test the programming of the line-following robots.

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Figure 14. Video edited and produced

Fig. 14 represents the final stage for the production of the book. The figure is a screenshot of the video that was edited and posted on YouTube [11].

In the video, a line-following robot interacts with the inventive world of one of the Cerrado's phytophysiognomies: Campo Sujo. The video will open after reading the QR Code to solve the inventive problems of the pages of the book, presented in Figs. 2 and 3, in this article.

The actions and practices of Inventive Mathematics Education [2-5], with robotics, in the teaching of the phytophysiognomies of the Cerrado, offered a scenario of challenges and opportunities. The Cerrado biome, rich in biodiversity and ecological uniqueness, offers a fertile field of opportunities for exploring inventive learning, but it also brings challenges that raise a reflection on the teaching and learning process of these phytophysiognomies.

Robotics presents some possibilities that can transform teaching about the Cerrado into a rich and engaging experience. Firstly, robotics allows mathematical knowledge to be used in an inventive way, enabling inventive learning [12], enabling the student to be the author of his own knowledge, inventing himself and producing himself as the author of these experiences, that is, putting into practice the concept of autopoiesis. Through a practical and interactive approach, students can explore the phytophysiognomies of the Cerrado in an engaging and provocative way during the production of other knowledge.

In addition, Inventive Mathematics Education [2-5] together with robotics has enabled an interdisciplinary integration, where projects can combine Mathematics, Natural Sciences and Geography, for example. This approach can promote a dynamic understanding of the Cerrado and its characteristics, showing students how different areas of knowledge interconnect in a real context.

The implementation of robotic projects also contributes to the development of important skills. Students have the opportunity to learn programming, solve problems, and collaborate as a team, skills that are increasingly valued in today's world. In addition, these projects can raise awareness about the importance of preserving the Cerrado, stimulating discussions about sustainability and conservation.

Lastly, the use of robotics in teaching can lead to greater student engagement. Technology tends to capture students' interest, making learning Natural Sciences and Mathematics more engaging and relevant. By integrating Inventive Mathematics Education [2-5] with robotics in teaching and learning about the Cerrado, students can see the practical application of the concepts they study, strengthening their understanding and appreciation of ecosystems.

Two of the main challenges have been perceived so far. One of them is the complexity of the concepts involved in the phytophysiognomies of the Cerrado, as well as the uniqueness of each phytophysiognomy. Even the term "phytophysiognomy" presents complexity in pronunciation. The other challenge is the fact that it is necessary to use some technical knowledge to accurately classify phytophysiognomies, such as: relief, soil type and altitude, and it is necessary to make connections between ecological theories and educational practice. In this research, so far, Inventive Mathematics Education [2-5], with robotics, has proven to be a proposal to help overcome these challenges, stimulating the student to deepen the concepts and technical knowledge necessary in the identification of each phytophysiognomy of the Cerrado.

During construction, the students not only had to invent and solve problems, but also apply knowledge of Natural Sciences and Mathematics to develop the models.

In the present research, the students assembled and programmed robots to interact with the models related to the phytophysiognomies of the Cerrado. At the same time, they did not limit themselves to just fixed representations, that is, they did not follow a "standardized formula" to represent and solve problems. On the other hand, they lived unpredictable experiences in which they invented their worlds, their problems and themselves, in line with the perspective of a more inventive training and intensification of transformations in the educational environment [13].

5. Acknowledgments

I thank the State Department of Education for the partnership signed with the Stricto Sensu Graduate Program Professional Master's Degree in Science Teaching, which allowed me to become a researcher for the project presented in this article. I also thank the professors of the program for their academic contributions, especially my advisor prof. Dr. Marcos Roberto da Silva who, with knowledge and wisdom, has guided and led me. To the Commander of the State College of the Military Police, Corporal Edmilson de Souza Lemes, Major Flávio de Paula Pinto, for his support in carrying out the research. Last but not least, I would like to thank my co-worker, Professor of Robotics Lourival Carvalho, who readily accepted the partnership to carry out the ongoing research.

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Application of an Investigative Experimental Activity in Elementary Education: Newton's First Law

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Abstract. When planning physical science activities, it is crucial to ensure that all experiences guide students towards scientific knowledge. It is important to verify whether students are not only engaged due to enthusiasm but also able to arrive at a coherent explanation aligned with the teaching proposal through their speech and reflections. In this paper, we will discuss teaching Science in Elementary Education through an investigative experimental activity on physical knowledge, specifically Newton's First Law, known as the "Law of Inertia." We will present some important definitions related to a lesson on physical knowledge and also the outline used in implementing the experimental activity. Finally, we will analyze and discuss the stages developed in the lesson, paying special attention to the stage where the children produced a report in the form of drawings and/or writing about the experimental activity conducted.

Keywords. Science Teaching, Physical Knowledge, Inquiry-Based Teaching.

1. Introduction

The recent curriculum reforms and large-scale external assessments emphasize the importance of student engagement in investigation and argumentation in the classroom [1]. According to the authors, this reflects the intention for students to engage with the conceptual, social, and epistemological elements of science as educational and disciplinary goals. Thus, teaching Physics from this perspective can contribute to presenting the subject as "a field of knowledge and, therefore, as a social way of constructing knowledge about the natural world" [1, p.44].

"[...] reflecting on the teaching and learning of Physics involves considering whether students are given the opportunity to engage in scientific practices and how these are implemented in the classroom" [2, p. 45]. The author highlights the importance of inquiry and argumentation in the process, which are essential practices in this field of knowledge. The type of argumentation referred to by [3] should be understood as "[...] any discourse in which students and teachers present their opinions in class, describing ideas, presenting hypotheses and evidence, justifying actions or conclusions they have reached, explaining results obtained" [3, p.100].

To implement physical science activities in schools, it is essential to create conditions for collaborative work. The exchange of experiences and theoretical knowledge are fundamental. When planning physical science activities, it is necessary to ensure that all experiences lead students toward scientific knowledge. It is important to verify whether students are engaged not only by enthusiasm but also whether they are able to arrive at a coherent explanation aligned with the teaching proposal through their discussions and reflections [4] and define seven stages for a lesson on physical knowledge.

- Present the problem: In this stage, the teacher organizes the class into groups and presents the problem and the materials to be used, being careful not to carry out these two actions simultaneously to avoid losing the students' focus and impeding the development of the activity.
- Students handle the materials: This stage provides the opportunity for all students to handle the presented materials, allowing them to become familiar with them. If there is any sign of monopolization of the materials, the teacher should intervene.
- Students manipulate the objects to achieve the desired effect: At this point, students will act on the objects to achieve the desired effects, testing their hypotheses for solving the problem. The teacher should visit each group, asking them to show how the experimentation process is going, giving them the chance to verbalize their actions and checking if the students understand the problem.

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- In the "how" stage, the teacher should disband the initially formed groups, regroup the class into a single group, and arrange the students in a semi-circle. At this moment, students are asked to articulate how they conducted the experiment to solve the problem, meaning they should describe the actions taken.
- In the "why" stage, students must justify what happened, explaining why the object reacted in such a way, in other words, explaining why their solution solved the problem.
- During the writing and drawing stage, the teacher should ask students to draw and/or write about the experiment conducted on a blank sheet of paper. This activity should be done freely by the students and should take place immediately after the previous stages, not be postponed to another class or time. This activity should not be used by the teacher to grade students, but rather to understand the students' comprehension.
- When relating the developed activity to everyday life, the teacher should connect the experiment to the physical world around them, bringing in everyday situations where it is possible to notice the occurrence of the facts observed in the experiment.

When presenting a problem to elementary-level students, they will attempt to solve it. However, this problem should be a situation that presents a challenge and for which there is no ready-made answer. When this type of problem is solved by the student, and they are asked to draw what they learned, the student will represent their knowledge of the activity developed [5]. The use of language (written and drawing) is important; even children who show little mastery of writing do not refrain from recording, according to their developmental levels, the experience they had during the activity [6].

The student's action should not be limited to manipulation and observation. In this sense, solving a problem through experimentation involves reflection, reports, discussions, deliberations, and explanations. However, solving the problem does not mean that the activity is finished; that is, knowing how to do it is important, but understanding, that is, mastering it in thought, is essential. In this sense, it is necessary to create conditions for students to be able to do it so that they can then understand what they did. For this case, they need to think about how they managed to solve the problem and why the solution worked [4].

Given the above, this work is the result of research aimed at investigating the teaching of Natural Sciences in the early years of elementary education, associated with the Graduate Program in Science and Mathematics Education at IFG (Federal Institute of Education, Science, and Technology of Goiás) - Jataí Campus, which stems from a perspective on the central role of investigation and argumentation in Science teaching. The assessment proposal consisted of the development of an investigative experimental activity on Newton's First Law, which was later applied to a third-grade class in elementary school at the Romoalda de Barros Municipal School. This school is located in the Estância district, approximately 40 km from the city of Jataí-GO, and is considered a rural school.

2. Application of the Activity

This activity, focused on physical knowledge, follows the stages outlined by [4] and was proposed to the students through the following problem situation: How can you knock an eraser off a toy car after setting it in motion, without touching the car and without touching the eraser?

The activity was applied to a third-grade class in an elementary school located in a rural area of the municipality of Jataí-GO. On the day of the application, fifteen students were present, and they were divided into three groups, each containing five members. To solve the problem, each group received, as shown in Fig. 1, a toy car, an eraser, and a pencil case (to serve as an obstacle).

In light of the above, this work is the result of the final evaluation of the course "Natural Sciences in the Early Years of Elementary Education" of the Graduate Program in Science and Mathematics Education at IFG (Federal Institute of Education, Science, and Technology of Goiás) - Jataí Campus, which is based on a

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view of the central role of investigation and argumentation.

Figure 1. Example of materials used in the activity

The objective of this activity was for the children to understand that the rubber placed on the toy car's hood would be launched in the same direction as the car moved when the cart hit the obstacle (Fig. 2). The scientific explanation of this problem is much more complex, involving concepts from Newton's First Law 'Law of Inertia,' which states: 'Every body continues in its state of rest or uniform motion in a straight line unless it is compelled to change that state by forces applied to it' [7].

Figure 2. Group of students solving the problem

After the students solved the problem, we collected the materials and organized the class in a semicircle (Fig. 3). Then, we moved on to the stages where they explained how they solved the problem and why the rubber fell off the car when the car hit the obstacle. During this stage of reflecting on the 'how' and the 'why,' students can build their understanding of physical phenomena [4]. While presenting to the class and describing their actions, logical links and connections between their actions and the reactions of the objects are established.

Figure 3. Steps for "how" and "why"

Next, we moved on to the next stage, which was contextualization, i.e., relating the activity to the students' daily lives. At this stage, we used examples related to traffic, such as when it is necessary to brake a car suddenly and everything inside the car continues to move, being thrown forward or backward, depending on the direction in which the car is moving. Another example applied was when someone is pedaling a bicycle and brakes the front wheel, causing the cyclist to be thrown forward.

Finally, we proceeded to the last stage of the lesson on physical knowledge, where we asked the students to write and/or draw, on a blank sheet, something that represented the activity conducted.

3. Analysis and Discussion

To anonymize the participants of the activity, we numbered the students from one to fifteen preceded by the letter E, so we will identify them as E1, E2, E3, E4, E5, E6, E7, E8, E9, E10, E11, E12, E13, E14, and E15.

"The time required for the development of this activity, encompassing its five stages, should be between 50 to 65 minutes. The time allocated for each stage of the activity varies according to the students' needs, who usually take between ten to fifteen minutes to solve the proposed problem, fifteen to twenty minutes for the discussion of the how and why with the class, and twenty to thirty minutes to prepare their reports." [6, p. 224]

During the phase when the students were trying to solve the problem, testing their Testing hypotheses, we noticed that the time they took to solve the problem was relatively short, around seven minutes. As soon as one group managed to solve the problem, the other groups realized how they could also solve it using their materials.

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In the stage where students become aware of how the expected effect was produced, we highlighted phrases like from student E3: 'It was easy, we got it, it was easy. We put the bottle right in the middle, then we threw the car, the car hit, the rubber fell, done, easy.' And from student E7: 'Uh..., I put the case in front, then E8 threw the car, and the rubber slid off the car.' It can be seen that students were indeed able to mentally reconstruct the experimental activity, understanding the physical phenomenon involved.

“It is during the stages of reflection on the how [...] and the search for the why [...] that students have the opportunity to build their understanding of physical phenomena [...] as they tell the teacher and the class what they did and describe their actions, they establish, in thought, their own conceptual, logical-mathematical, and causal coordination”. [4, p.22]

In the stage where students were asked to write and/or draw what they understood from the activity, it was observed that most produced only drawings, one produced only text, and other productions combined drawings and text. Regarding the production where the student used only text, it can be classified as a descriptive text, as the student described the activity performed step by step: 'I fixed it to knock down the rubber, I put the bottle in front of the car and hit the car against the bottle and the rubber slid and fell off the car.'

Three productions presented both drawing and writing, one of which included a header with the name of the school and the date. The second production presented a descriptive text: 'Today we did some really cool activities, it was very cool, we did an activity with the car and we gathered around to discuss and talk.' It can be seen that the student enjoyed the activity dynamics, showing satisfaction with the experiment.

The third production presents only two words: 'And it fell,' but we can classify this text as complementary to the drawing, as seen in Fig. 4, since without the text, it is not possible to understand the fall of the rubber.

In the analysis of the drawings, we adapted the categories used by [6]. We categorized the drawings into: drawings out of context—those that do not illustrate the developed activity—and drawings within context. The latter were further classified into simple drawings—those that illustrate only the materials used—and complex drawings—those that demonstrate the continuity of the rubber's movement.

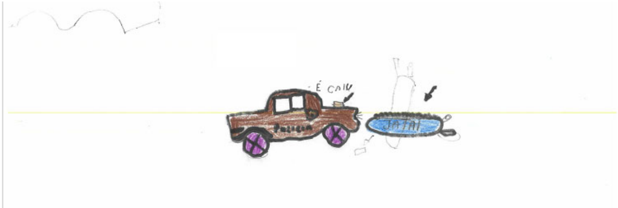

Figure 4. Drawing with text considered complementary

Among the fifteen drawings produced by the children, two drawings (Fig. 5) were classified as out of context of the developed activity, as they did not demonstrate the investigative experimental activity performed.

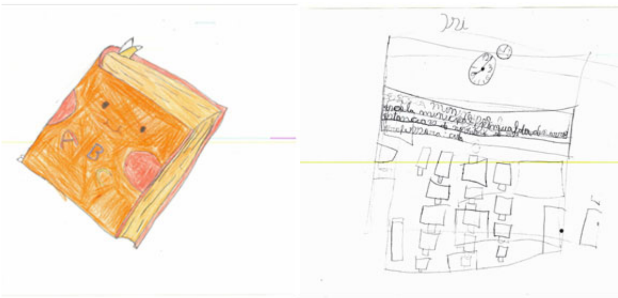

Figure 5. Drawings considered out of context

Twelve productions can be classified as simple drawings, as they presented only the materials used in the activity, that is, the car, the rubber, and the obstacle (case or bottle). We highlight four drawings of this category in Fig. 6.

Within the Twelve productions classified as simple, we highlight the production of student E15 (Fig. 7), which includes a drawing representing one of the examples we used during the contextualization phase. In this phase, we provided some examples of everyday situations so that the students could observe the same phenomenon involved in the experimental activity. It is evident that the student understood the activity conducted and was able to relate it to a situation from their daily life, representing this situation in their drawing.

One of the productions (Fig. 8) can be classified as a complex drawing, as it illustrates that the rubber, after the car hits the obstacle (although the obstacle is not present), falls off the car. We can perceive the indication of movement through the drawn lines that symbolize the fall of the rubber.

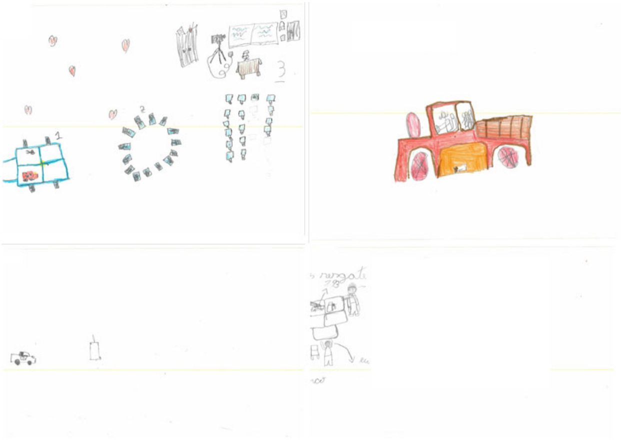

Figure 6. Highlight of four productions

Figure 7. Drawing illustrating the stage of contextualization

Figure 8. Drawing classified as complex

After the analyses, it can be inferred that, since the students in this class are not yet fully literate and do not have a strong command of writing, a large part of the class chose to use only drawings as the most efficient means to express their thoughts.

4. Final Considerations

We observed the children's satisfaction with the proposed experimental activity, particularly due to the emotional involvement of the class in most cases. This leads us to conclude that the children felt motivated to carry out the investigative experimental activity.

During the contextualization phase, the children showed concern about the use of safety equipment by traffic agents (drivers and passengers). We believe that, in addition to the concepts covered in the experimental activity, we significantly contributed to raising students' awareness about traffic safety.

Regarding the students' productions, we understand that, due to the fact that the children are not yet proficient in written language, they opted for drawing. However, it is evident that all the children made an effort to express their experiences through drawing, each according to their level of understanding during the development of the activity.

We believe that drawing can be a valuable assessment tool, not as a means of classification but as a way for the teacher to perceive the level of understanding of the students and identify the class's difficulties. Subsequently, the teacher can address the knowledge not understood by the students, resolve doubts, and offer more appropriate solutions, promoting the improvement of the children's reasoning.

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Birds of Serra de Jaraguá State Park

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Abstract. Brazil is among the countries with the greatest ornithological diversity and is home to an enormous wealth of species. This study sought to identify the bird species found in the Serra de Jaraguá State Park. The methodology used for the survey was direct observation during the transect route and photographic recording of the species sighted, between the months of March and October 2022. 97 species belonging to 35 families and 16 orders were recorded, of which the best represented families were: Thraupidae, Tyrannidae, Psittacidae and Columbidae. Through this project we were able to identify and catalog the species found in the UC.

Keywords. Protected Areas, Ornithofauna, Biodiversity, Cerrado.

1. Introduction

There are more than 10,000 known bird species on the planet [18]. On a global scale, Brazil disputes the title of richest country in birds with Colombia and Peru, coming in second place with a total of 1,971 recorded species [21], The Brazilian Committee of Ornithological Records (CBRO) is responsible for recording the birds that occur in Brazil, and according to the 13th list of birds by [18] Pacheco the Brazilian territory is home to around 1,971 species of birds, of which 854 species occur in the Cerrado, which represents 45% of the world total, 32 of which are endemic to the biome [3].

The Cerrado is the second largest biome in South America, occupying approximately 23% of the entire national territory, totaling an area of 1,983,017 km² [10], considered the largest savannah in the world in terms of biodiversity and covering a large part of Brazilian territory [13]. The extensive anthropogenic transformation of the Cerrado has the potential to produce major biodiversity losses, especially in view of the limitations of protected areas, which are small and concentrated in a few regions. Strassburg [27] and Sousa [26] describe that the Cerrado biome is in a vulnerable state of protection, where only 7.5% of areas are publicly protected and 20% of private land is set aside for conservation.

According to Campos and Castro [4] it should be noted that experience has shown that areas protected from anthropic action are vital for conservation and preservation, helping to maintain species and communities that would not survive in unprotected areas. The Serra de Jaraguá State Park is a conservation unit (UC), created by State Law No. 13,247, of January 13, 1998, located in Goiás, in the municipalities of Jaraguá and São Francisco, with an area of 2,828.6613 ha, with the Cerrado as a biome in 100% of the park's extension [2].

Therefore, through this work, we sought to carry out a primary survey of the richness of bird species found in the Serra de Jaraguá State Park, with the aim of getting to know the diversity of species that can be found within the UC, to fill gaps in biodiversity.

2. Materials and Methods

The work was carried out in the Serra de Jaraguá Conservation Unit, located at 15°45'25“south latitude and 49°20'02” west longitude, in the municipalities of Jaraguá and São Francisco, in the state of Goiás [2].

Figure 1. View of the landscape of the delimited transect in the Serra de Jaraguá Conservation Area, with discrepancies in the phytophysiognomies visible. Source: Wikiloc-trilhas

The linear transect method was used to carry out the qualitative survey, which consisted of traveling at a constant speed along a pre-defined path, in which the species detected visibly on both sides of the trail were observed and recorded, using the methodology of Cullen

[5], Roos [24] e Missano [17], as a reference. The route was delimited using a pre-existing trail in the UC area, and the “wikiloc-trails” application was used to illustrate the route taken, as shown in Fig. 1.

Data was collected weekly from March to October 2022, in the morning. The data was collected using the following methodologies: active search along the transects, as well as visual recording, which is a complementary method to the ornithological observation census [20, 23, 29]. The records were made using a Canon EOS Rebel T5 camera, EF-S 18-55mm and EF-S 55-250mm lenses for identification records and photographic documentation to elucidate the species during the work, and the birds sighted were noted down along the way.

Species identification was based on guides such as: Aves do Brasil Oriental - Guia de bolso [25]; Aves do Cerrado - espécies visitantes em uma área em recuperação no Distrito Federal [14]; and the WIKIAVES [10] database, available at https://www.wikiaves.com.br/index.php. The systematics and scientific nomenclatures followed the updated list of the Brazilian Bird List, made by the Brazilian Ornithological Committee [9]. The conservation status of the species was based on the International Union for Conservation of Nature's Red List of Threatened Species [12].

3. Results

This work identified 97 species of birds distributed among 35 families and 16 orders. The most representative families were: Thraupidae with 13 species, such as *Sicalis flaveola, Nemosia pileata, Volatinia jacarina*, among others; Tyrannidae with 11 species, such as *Pitangus sulphuratus, Megarynchus pitanga, Suiriri suiriri*; Psittacidae with 10 species, such as *Ara ararauna, Brotogeris chiriri, Eupsittula aurea*; Columbidae with 6 species and Picidae with 5.

4. Discussions

When our observation results are compared with other studies, such as the one carried out by Sousa [27] in the region of the permanent preservation area of IF Goiano - Campus Ceres, Goiás, the representativeness of the families identified were: Thrauipidae (14 spps.), Tyrannidae (11 spps.), Psittacidae and Hirundinidae (7 spps.), and Icteridae (6 spps.). Perreira [20] in the region of Morrinhos - GO, recorded that the most representative families were: Tyrannidae (18 spps.); Thraupidae (14 spps.); and Pssitacidae (8 spps.), and Ferreira [7] in Goiânia - GO, recorded that the most numerous families were: Tyrannidae (15 spps.); Thraupidae (14 spps.), followed by Psittacidae (9 spps.) and Picidae (6 spps.), and it is possible to note that there was a similarity between the results obtained from the richness of families identified, noting that the three most representative families in this study were also found in other studies analyzed.

Among the orders, the most visible was the Passeriformes order with 44 species, representing 45.36% of the total species identified, as shown in Fig. 2. This order is characterized as the most diverse in terms of bird species, representing more than half of the bird species found in Brazil [17, 20].

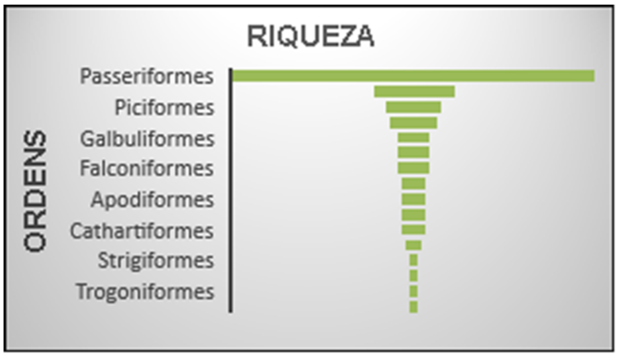

Figure 2. Graph of the richness of bird orders recorded in the Serra de Jaraguá UC. Source: The authors (2023)

Among the orders with low representativeness, we can highlight the Pelecaniformes order, encompassing the Threskiornithidae family with 2 species, *Theristicus caudatus* and *Phimosus infuscatus*, and the Ardeidae family also with 2 species, *Bubulcus ibis* and *Pilherodius pileatus*. This lower representativeness can be associated with their biology, since the presence of species of this order is associated with humid environments, footpaths and watercourses [8].

According to literature on endemic species such as Leite [16], Braz and Hass [3], three species endemics to the Cerrado biome were observed in the UC, corresponding to 9.37% of the total endemic species of the Cerrado biome. These species were *Saltatricua atricollis*

(Batuqueiro), *Lepidocolaptes angustirostris* (Arapaçu-do-cerrado) and *Alipiopsitta xanthops* (Papagaio-galego), the latter also being a threatened endemic species. The low level of endemism observed, coupled with the fact that the Cerrado biome has the second highest number of endemic species, calls for measures to promote the detailed study of these species and their biology [23].

The low level of endemism may also be associated with the degree of conservation and direct and indirect anthropization in the park, highlighting the expansion of the surrounding agricultural frontiers and sporting and leisure events that generate a large flow of people in the UC, and consequently a large accumulation of untreated waste altering and causing environmental degradation, all of which can be linked to the low endemic diversity of the local.

Considering the conservation status classification of the IUCN Red List of Threatened Species [12], two species were observed with some degree of threat, both belonging to the Psittacidae family, the species being *Alipiopsitta xanthops* (Galician Parrot) and *Aratinga auricapillus* (Red-fronted Jandaia), both found in near-threatened status (NT).

Of these species, both are psittaciformes that have been suffering from changes occurring in the Cerrado, the *Alipiopsitta xanthops* (Galician parrot) is considered endemic and is in the category of near threatened (NT) nationally, due to possible population decline due to the rapid loss of its habitat, as well as the threat of trafficking [1]. While the species *Aratinga auricapillus* (Jandaia-de-testa-vermelha) is threatened due to its high sensitivity to fragmented environments and habitat loss and is therefore considered an important bioindicator of environmental quality [6]

Among the species recorded, we noticed that some had between 1 and 3 records, and only appeared during the breeding/spring period: Pteroglossus castanotis (Araçari-castanho), *Aratinga auricapillus* (Jandaia-de-testa-vermelha), *Setophaga pitiayumi* (Mariquita), *Alipiopsitta xanthops* (Papagaio-galego), *Amazona aestiva* (Papagaio-verdade), *Empidonomus varius* (Peitica), *Piranga flava* (Fire-breasted Sandpiper), and *Myiodynastes maculatus* (Bem-tevi-rajado), the latter being associated with migratory patterns, seeking a habitat with a greater abundance of food for the breeding period.

5. Conclusion

This work found that the birds diversity index of the park's is characterized as satisfactory, considering the total number of species sighted (97 species), of which 3 bioindicator species and 3 endemics to the Cerrado were recorded, supporting the park's conservation status as an area used by birds as a source of food, shelter and reproduction.

It can be said that this work provides an initial reference of the composition and richness of the birds found in the Serra de Jaraguá, thus demonstrating the importance of conserving natural areas and investing in future research.

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Environmental Education in the 8th Grade of Elementary School II in a Full-Time School: Analysis and Practices

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Abstract. This study aimed to diagnose the approaches to environmental education in an 8th grade class of Elementary School II in Iporá, specifically because the students are more mature in this year of study, in a Full-Time Education Center (Cepi) of the state education network and to make the teachers and students studied, through diagnosis, persuasion and action, develop practices in their daily lives that positively transform, that is, preserving the environment for present and future generations, in an ethical manner. A qualitative approach was adopted and direct observations of the school environment and interviews with students and teachers were carried out, through questionnaires composed of open and closed questions. It was verified how environmental education is worked in the school, highlighting the importance of the teacher, the students and the institution. It was possible to diagnose that the students have a concerned behavior because they seek to do their part in preserving the environment. The teachers responded that the school develops Environmental Education and Environment projects. Students demonstrate some knowledge regarding the environment and environmental ethics, but at school there is little pedagogical encouragement for the development of skills in this area, which can be seen in the absence of solid waste separation because it is something well publicized in various media and activities involving interaction with the natural environment.

Keywords. Diagnosis, Geography and Teaching, Environment, Environmental Ethics.

1. Introduction

The United Nations (UN) Conference on Human Development and the Environment took place between June 5 and 16, 1972, in Stockholm, Sweden, and brought together 113 countries. It was a historic milestone as it was the first major international meeting with representatives from several nations to discuss environmental issues. Its results included the drafting of the Stockholm Declaration, with 26 principles, and the creation of the United Nations Environment Program (UNEP). In addition to air pollution, which was already a concern for the scientific community, the conference also addressed water and soil pollution resulting from industrialization and the pressure of population growth on natural resources (Ribeiro, 2001). One of the effects in Brazil was the beginning of discussions on the environment, with repercussions on institutional, economic and educational actions. The objective of this study is to conduct a case study to diagnose the approaches to environmental education in an 8th grade class of Elementary School II in Iporá, specifically, in a Full-Time Education Center (CEPI) [1] of the state education network, and to make the teachers and students studied, through diagnosis, persuasion and action, develop day-to-day practices that positively transform the environment in an ethical manner.

This research sought, based on participatory research, to generate and evaluate the diagnosis based on day-to-day actions, the understanding of concepts, that is, definitions about the environment and the importance of caring for it among 8th grade students and teachers of the Geography subject in a full-time Elementary School II in Iporá-Go.

The Full-Time Education Center offers Elementary School II, from 6th to 9th grade, with three 6th grades, three 7th grades, two 8th grades and two 9th grades, totaling around 300 students.

The title of the research was chosen as Environmental Education in the 8th grade of Elementary School II in a Full-Time School: Analysis and Practices because we wanted to have diagnoses and practices of environmental education by students and teachers at the school and see how they are contributing to building a positive, healthy and sustainable school environment, which is the responsibility of all members of a society.

According to Guitarrara [2], twenty years later, that event was succeeded by the United Nations Conference on Environment and Development, also called ECO-92, in the city of Rio de Janeiro, between June 3 and 14, 1992.

This event was held at a historical and economic moment in which the world's concern for environmental preservation was not growing. The conference was designed to discuss ways to reconcile economic development with environmental preservation, an objective translated through the concept of sustainable development. In Brazil in particular, Eco-92 was a milestone for national environmental actions, including in education. One of these results was the creation, in 1998, of the National Curricular Parameters (PCN), which indicate as one of the objectives of elementary education the development of students capable of feeling integrated, dependent and capable of transforming the environment, identifying its elements and their interactions and actively helping to build a better environment for present and future generations (MEC, 1998) [9].

Environmental education was established by law no. 9,795, of April 27, 1999, which in its Article 2 states that it is an important and permanent component of national education, and should be articulated at all levels and modalities of formal and non-formal education. Environmental education in rural schools is very important, to contextualize the reality of students in rural areas. The 8th grade students are made up of teenagers aged 12 to 14, who are developing their personalities and maturing mentally. They must seek to understand the local problems and realities in which they are inserted and then develop their ability to think about broader issues, such as the Brazilian and global environmental situation. In this way, the students will be able to spread good behavior and actions among their families and in society in general. Since the environment is a topic of broad spatial scale, the results depend on collective actions and the consequences will come in the short, medium and long term, whether negative or positive, to which the young citizens will directly contribute.

The author of this study was familiar with the school environment due to the completion of the Supervised Internship I and the participation in the Institutional Program of Scholarships for Teaching Initiation (PIBID), starting in 2022. Having the experience was favorable when it came to observing and comparing the responses obtained from students and teachers in relation to what was observed in the day-to-day life of the school.

Therefore, the objective of this research was to investigate the effectiveness of environmental education in the Geography discipline, examining how teachers and students perceive, apply and incorporate concepts about the environment. The specific objectives of this research are: 1) To evaluate the diagnosis and practice of Environmental Education by Geography teachers, investigating how this theme is incorporated into the school routine and its relevance in the curriculum. 2) To analyze the understanding and involvement of 8th grade students in environmental education activities, examining the impact of these actions on the formation of sustainable values and attitudes. 3) To carry out environmental and geographic studies. 4) To analyze the involvement of teachers and students with environmental education. 5) To verify the strategies used by teachers to integrate environmental education into the Geography curriculum, aligning their practices with the guidelines of the National Curricular Parameters. 6) To identify the barriers and challenges faced by both teachers and students in promoting environmental education at school. 7) Seek to analyze the level of understanding of teachers about environmental education.

The aforementioned research was motivated by the need to diagnose the effectiveness of environmental education in the subject of Geography, specifically in the 8th grade of Elementary School II. It is based on the legislation that incorporates environmental education; thus, we sought to address this topic in a transversal manner in the school, aiming to form citizens who are aware and committed to the environment. Environmental education happens in the long term.

The research methodology was organized as follows: We first started from the context and object of study, since the research was carried out in a Full-Time Elementary School II, specifically in an 8th grade class composed of 23 students enrolled in the subject of Geography, during the second semester of 2023. The choice of this object of study was motivated by previous contact with the institution through the supervised internship in Geography, the Institutional Program of Scholarships for Initiation to Teaching (PIBID) and the extension project Cinema in the Community.

In the methodological approach, a qualitative approach was adopted to conduct the research. This methodology allowed for participatory research, direct observations of the school environment, and interviews with students and teachers. Data collection instruments included questionnaires composed of open-ended and closed-ended questions with participants. Familiarity with the school environment was acquired during Supervised Internship I and participation in the Institutional Program for Teaching Initiation Scholarships (PIBID). This prior experience facilitated observation and comparison of responses obtained from students and teachers with the school's daily practices. Regarding the Data Collection Instruments and Procedures, we followed the guidance of Lima et al. [4] on qualitative research, focusing subjectively on the object analyzed, exploring its specificities, experiences, and individual experiences. During the study, interviews were conducted and questionnaires were applied to students and teachers to investigate the diagnosis, level of conviction, and action in relation to environmentally sustainable practices for preserving the environment for present and future generations.

In the Data Analysis, the collected data were treated. The comparative analysis of students' responses with those of teachers allowed us to verify the approach to the topic of Environmental Education in the classroom and its impact on students' interest. And the research was based on studies by authors such as Oliveira [8], Lima et al. [4], Mendonça [6], Reigota [5], Brazil [3] and González Rey [7], which provide relevant theoretical foundations for the topic addressed. This methodology was structured to provide a comprehensive understanding of the effectiveness of Environmental Education in the Geography discipline, highlighting both teachers' perceptions and students' involvement in sustainable practices within the school environment.

2. Results and Discussions

According to Oliveira [8], the 1998 National Curricular Parameters (PCN), in the Cross-Cutting Theme Environment section, state that teachers should assist in the lifelong education of conscious, sensitive, and willing people to make decisions and act in a socio-environmentally committed manner.

There were changes in the delimitation of the six cross-cutting themes (Ethics, Health, Environment, Sexual Orientation, Cultural Plurality, and Local Themes), and today the TCT - Contemporary Cross-Cutting Themes of the BNCC - Common National Curricular Base (Brazil, 2017) are used. There was a reduction and rigidity of the themes: while the National Curricular Parameters (PCN) addressed six themes, the Common National Curricular Base (BNCC) points out six macro-thematic areas. Contemporary Cross-Cutting Themes – TCT – are themes that must be addressed in a mandatory manner in the curriculum and pedagogical proposals, and are governed by the National Common Curricular Base (BNCC). One of the characteristics of TCT is that they are studies that are not linked to a particular discipline, and can be worked on in an intradisciplinary, interdisciplinary or transdisciplinary manner, and are distributed across six thematic macro-areas. Regarding Contemporary Cross-Cutting Themes, the six thematic macro-areas addressed by the BNCC are: Citizenship and Civics, Science and Technology, Economy, Environment, Multiculturalism and Health.

The approach to Cross-Cutting Contemporary Themes is essential for a hegemonic discourse of comprehensive education aligned with the demands of today's society. The National Common Curricular Base (BNCC), outlines six thematic macro-areas that permeate the school curriculum, addressing issues that are crucial for the civic education of students. These macro-areas encompass a series of topics and sub-themes that reflect the challenges and opportunities of the contemporary world. The approach present in each of these macro-areas highlights the importance of their inclusion in the educational context for the integral development of students.

When dealing with the environment, teachers must present and discuss it in a way that is contextualized with the students' daily lives and schoolwork, so that they can express socio-environmental awareness through behaviors and cultural and artistic manifestations. The State Department of Education must provide teachers with time to conduct solid research and prepare a class with data and information from different media outlets, such as television, radio, and social media, as these are the means through which students come into contact with a variety of subjects. This will allow for the interpretation and analysis of socio-environmental reality, taking into account students' readings and values outside of class.

Teachers and students can also research other sources when developing their work, such as supplementary bibliography and discussions with teachers from other disciplines and people in society, such as specialist teachers, government technicians, leaders, doctors, agronomists, and former residents of the countryside or the city. In this way, teachers and students will be able to develop a critical and rational view of the environment, based on real and contextualized facts.

Environmental education must be taught in a cross-cutting manner, that is, it must be part of all school subjects, with full scope and on an ongoing basis. According to Reigota (2008, p. 12) [5]:

Environmental education, as an educational perspective, can be present in all subjects. Without imposing limits on its students, it has a permanent educational character. It, by itself, will not solve the complex environmental problems of the planet, but it can have a decisive influence on this by forming citizens who are aware of their rights and duties.

The Political Pedagogical Project (PPP) of the Full-Time Education Center (CEPI) [1] of Aplicação, from 2002 [1], states that the school is based on the fundamental principles of human dignity, and with the purpose of providing:

The integral development of the student and his/her participation in the work of the common good; the understanding of the rights and duties of the human person, of the citizen, of the State, of the family and of the other groups that make up the community; respect for the fundamental dignity and freedom of the human being; preparation for the mastery of scientific and technological resources, which allows young people and children to use their potential so that they can defend the environment, ensuring its preservation; among others (Goiás, 2002 apud Goiás, 2022, p. 9).

Isolated attitudes were observed on the part of some teachers focused on the environmental education of students and the school community. In this sense, they developed the following actions from 2022 onwards: “Sustainability and Mathematics” project; “Climatology” project, as an Extension Project of a Professor from the Iporá Unit of UEG – State University of Goiás; they promote debates, research and observations; they follow the BNCC skills, where the contents in the geography combo are more generalist; in the Environment Elective, taught by the school's Geography Teacher, there was planting of trees and cleaning of classrooms in 2023, which brought up the issue of working with recycled materials; there are informal conversations about facts and events related to caring for the environment. According to Gonzalez Rey [7], the classroom, in addition to being a setting interconnected with the teaching and learning processes, has new elements of meaning and significance, originating from other “zones” of the social experience of students and teachers, inseparable from the stories of the human beings involved and the social subjectivity of the school.

If each person does their part and thinks that their help can motivate others to put these good behaviors into practice, they can achieve something great, locally and internationally. Knowing how to diagnose the problems that negatively impact the environment so that they feel sensitized and act motivated to help and solve them.

According to Lima et al. [4], in Elementary Education the objectives of diagnosing environmental problems and potentials are sought. According to Mendonça (2005, p. 8) [6], Geography has dealt with environmental issues since its inception as one of its main concerns. In these 200 years of industry on the planet, the production of material goods and their consumption has been very rapid.

As there was no respect for the movement of the elements that make up nature, the environment has been degraded. This degradation has harmed society's quality of life in many ways: changes in water and air quality, ecological "accidents" linked to deforestation, fires, marine, lake and river pollution and the death of many animal species that are currently in danger of extinction, human agglomerations in urban-industrial centers, the demographic explosion in the socio-economic-political context of the 20th century, the development of the ideology of consumerism after the 1950s has exaggerated the differences in living conditions due to human misery and the concentration of wealth, for example with the emergence of money magnates. For example, rivers, valley bottoms and residential sectors on the outskirts share space with garbage and misery. According to Mendonça (2005, p. 12) [6], the quality of life of human beings at the end of this millennium has shown a huge decline, while there has been major progress in science and technology.

According to Mendonça (2005, p. 72) [6], observing the scope of the environmental theme and its important characteristic as a social issue, students can thus help to preserve the environment positively within their school community by replanting trees, a garden, planting a lawn, planting shade trees at school, helping to keep toilets clean, consuming drinking water and school meals responsibly, i.e., avoiding waste, helping to clean the classroom and other school environments, accompanied by the supervision and support of teachers until the activities are completed.

According to Lima et al. [4], preserving the environment depends largely on the diagnosis and positive action of people in a society. Citizenship should encompass activities and notions that help to positively evolve the environment. It is very important to know how to educate people from childhood, adolescence, youth, adults and the elderly, through lifelong learning in environmental education in schools and other places. Schools are part of a system that is inserted into society as a tool for raising awareness and socializing between human beings and the environment, and whose primary function is to offer its students a meeting of ideas and practices where these students can, through their daily lives, develop behaviors and actions capable of transforming not only their school, but also acting consistently in their learning, thus building their identity as people actively engaged within society.

The school environment is well-known, because the Supervised Internship I and the Institutional Program for Teaching Initiation Grants (PIBID) were carried out. The fact of having the experience and experience of being in the same place more than once was favorable when it came to observing and comparing the responses obtained from students and teachers with what was observed in the school's day-to-day practice. Because it refers to a broader theme, the responses are very diverse, but there is agreement on many points. The students had difficulty immediately understanding what is involved behind this theme. During visits to the school, it was noted that there are no selective waste collection bins in common areas, such as the backyard, patio, and hallways, and there is no information highlighting the need to care for the environment. The school has a vegetable garden, and the activities to develop this garden are carried out by the students and teachers themselves. Based on the analysis, it was diagnosed that although environmental education is more present in the school's Geography classes, environmental education is also developed in a multidisciplinary way, incorporating activities from other areas. According to Lima et al. [4], the need to address the topic of environmental education is necessary because it is at this time in school that many personalities are being formed; whether they are concerned or not, they are acting as citizens and their contribution will be left, whether good or bad. Environmental education must be part of the school's daily routine in a comprehensive, multidisciplinary, transdisciplinary and interdisciplinary manner, that is, it must be developed beyond the subjects on the school curriculum and beyond the classroom; it is something that must be adapted to life in each and every aspect.

According to Lima et al. [4], the issue is to understand the difficulties and strengths of these students on the subject, highlighting the diagnosis as a means of change, because once sensitized and aware, these students will be able to review their behaviors and actions and improve their behavior regarding good practices for a better future.

According to Lima et al. [4], the issue is to understand the difficulties and facilities of these students on the subject, highlighting the diagnosis as a means of change, because once sensitized and aware, these students will be able to review their behaviors and actions and improve their behavior regarding good practices for good development around them.

3. Data-Facilitated Analysis

The following are the analyses prepared based on data obtained through field research conducted with an 8th grade class of Elementary School II, in a full-time school located in Iporá. It is important to highlight that when conducting the field research, several data collection techniques were used, including direct observations, interviews and questionnaires. These approaches allowed a deeper understanding of students' perceptions on environmental issues, as well as their daily practices related to the environment.

Understanding Environmental Education is a fundamental aspect in the process of forming conscious citizens who are committed to preserving the environment. By applying a questionnaire to students, we sought to analyze the level of students' understanding of this very important topic. Analysis 1 presents the responses obtained for the question related to understanding Environmental Education, offering valuable insights into students' knowledge and understanding in this specific area. This analysis will allow a better understanding of the students' starting point in relation to Environmental Education, contributing to the planning of more effective educational strategies that are targeted to the needs and profile of the students.

Analysis 1: Students' Perception of Environmental Education

Do you know what Environmental Education is?
Source: The author (2024)

The conversation with the students began with the aforementioned question, using it as a starting point to introduce the topic. The results obtained through the questionnaire revealed that 17 students (73.91%) stated that they had knowledge about what Environmental Education is, while the other 6 students (26.09%) responded more hesitantly, indicating a partial understanding of the topic.

It is interesting to note that approximately three-quarters of the students demonstrated that they had an understanding of the concept of Environmental Education. However, the presence of a quarter of students who responded more hesitantly suggests that this is caused by deep-seated factors and that there is a need for a more comprehensive and enlightening approach to the topic in the long term in many classes, aiming to consolidate knowledge and promote a deeper understanding of the importance of Environmental Education.

Analysis 2 addresses the question of whether the school carries out projects related to the Environment or Environmental Education, providing an insight into the existence of initiatives in this area within the educational institution.

Analysis 2: Question related to whether the school develops a project on the Environment/Environmental Education

Does your school develop any project on the Environment/Environmental Education?
Source: The author (2024)

The data collected in the questionnaire revealed that 20 students (86.95%) stated that their school developed some project related to the Environment or Environmental Education. Only 2 students (8.70%) responded that they did not know if the school had such projects, while the remaining 4.35% mentioned that projects focused on the topic had already been developed in the past.

It was observed that the majority of students, approximately 87%, are aware of the existence of projects on the Environment or Environmental Education at their school. However, approximately 8% of the students showed uncertainty regarding this information, indicating a possible lack of communication or knowledge about the activities developed at the institution. In addition, approximately 5% of the students reported that previous projects had already been carried out, evidencing the school's history and commitment to this topic over time.

Analysis 3 investigates whether, through the classes taught by the Geography teacher, the school develops projects on the Environment or Environmental Education, addressing environmental issues in the classroom.

Analysis 3: Presence of Environmental/Environmental Education

Does the Geography Teacher work on the topic of Environmental Education in the classroom?
Source: The author (2024)

Analysis 3 reveals that 11 students (47.83%)

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answered affirmatively to the question about whether the Geography teacher addresses the topic of Environmental Education in the classroom, while 12 students (52.17%) answered negatively. It can be seen that approximately 48% of the students acknowledge that the Geography teacher addresses the topic of Environmental Education in his/her classes. However, approximately 52% of the students indicated that this topic is not addressed by the Geography teacher in the classroom.

These results show a division in the students' perception regarding the Geography teacher's approach to Environmental Education, highlighting the need for a more in-depth analysis of the teaching methods used and the pedagogical strategies employed in this context. Thus, it is clear that the teacher makes use of cross-cutting themes.

Analysis 4 investigates whether there are texts on environmental problems in the textbooks.

Analysis 4: Presence of texts on environmental problems in textbookss at School

Are there texts on environmental issues in the textbooks?
Source: The author (2024)

Analysis 4 shows that 18 students (78.26%) answered affirmatively to the question about whether textbooks contain texts that address environmental issues, while 3 students (13.04%) answered negatively. Those who answered "I don't know" represented 2 students (8.70%). It can be seen that approximately 78% of students acknowledge that textbooks contain texts about environmental issues. However, approximately 13% of students indicated that there are no texts about environmental issues in textbooks. And approximately 9% of students responded that they did not know whether textbooks contain texts about environmental issues. These results show that most students say that there are texts about environmental issues in textbooks.

We asked students about their contributions to the preservation of the natural environment, the domestic environment, and the school environment.

To contextualize Analysis 5, which presents the grouping of students' responses by themes, we observed a variety of positions and practices related to environmental preservation. This analysis organizes student responses into specific categories, providing a detailed view of individual attitudes and perceptions toward the environment. Topics covered include concerns about waste, specific care for plants and trees, recycling, fire prevention, and pollution diagnosis. Each category reflects varying degrees of student commitment to environmental sustainability, ranging from simple everyday actions to more elaborate commitments to conservation and care for the environment, both in home and school settings. This thematic grouping provides valuable insights into how students perceive and respond to environmental issues in their daily lives.

Analysis 05 – Grouping of student responses by themes
Source: The author (2024)

Analysis 5, which groups students' responses by themes related to environmental preservation, we can observe a significant diversity of perspectives and practices among students. The "Trash" category reveals that most students demonstrate a concern with the correct disposal of waste, whether by avoiding throwing it on the ground or promoting selective collection both at home and at school. Some students show a more proactive commitment, such as one who mentions taking maximum care of the environment by disposing of trash consciously. On the other hand, there are responses that reflect a lower level of diagnosis, such as students who claim not to know how to deal with trash properly. The "Care" category highlights a student who emphasizes the importance of care, covering different environmental aspects in his responses. In contrast, the "Fires" and "Pollution" categories present specific responses, indicating a specific sensitivity to avoid environmental damage such as fires and pollution. The topic "Recycling" is mentioned by a student who practices separating recyclable materials, while "Planting trees" reveals individual initiatives to care for the natural environment. In short, Analysis 5 illustrates not only the diversity of students' approaches to environmental conservation, but also suggests areas where environmental diagnosis and education can be strengthened to promote more sustainable and responsible practices among students.

Below, we present the analyses prepared based on data obtained from teachers at a full-

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time school located in Iporá. It is important to highlight that when conducting the field research, several data collection techniques were used, including direct observations, interviews and questionnaires. These approaches allowed a deeper understanding of teachers' perceptions of environmental issues, as well as their daily practices related to the environment.

Understanding Environmental Education is a fundamental aspect in the process of forming conscious citizens who are engaged in preserving the environment. By applying a questionnaire to teachers, we sought to analyze the level of teachers' understanding of this very important topic. The level of interest of students in relation to the Environment in the Geography discipline was adopted on a scale ranging from zero to five. Analysis 6 presents the answers obtained for the question related to the level of interest of students in relation to the Environment in their discipline, offering insights into the knowledge and understanding of teachers in this specific area. This analysis will allow a better understanding of the starting point of teachers in relation to Environmental Education, contributing as a tool for planning more effective educational strategies targeted to the needs and profile of teachers.

Analysis 6: What is the level of interest of students in relation to the Environment in your discipline

In general, what is the level of interest of students in relation to the Environment in your subject?
Source: The author (2024)

The conversation with the teachers began with the aforementioned question, using it as a starting point to introduce the topic. The results of the questionnaire revealed that three teachers (75%) rated the level of interest of students in relation to the environment in the Geography subject as 3, on a scale of 5. One teacher (25%) gave a score of 4 for the students' interest, indicating a substantial interest in the environment in this subject.

It is interesting to note that the majority of teachers considered the students' interest at level 3. However, the presence of a quarter of the teachers who rated this interest as level 4 suggests the importance of a more comprehensive and enlightening approach to the topic. This is essential to consolidate knowledge and promote a deeper understanding of the relevance of the environment in Geography classes.

Analysis 7 presents the main environmental issues that most arouse the students' interest, offering insights into the initiatives related to this topic in the educational institution.

Analysis 7: Which environmental issues attract the most attention of students

What environmental issues attract the students' attention the most?
Source: The author (2024)

The survey data revealed that each teacher identified different environmental issues as being most attractive to students: one teacher (25%) mentioned "deforestation, animal extinction"; another mentioned "natural disasters"; a third pointed out "environmental preservation and climate issues directly linked to the environment"; and a third mentioned "deforestation and air and river pollution".

Thus, it is clear that the teachers' responses varied regarding the environmental issue that most attracts students' attention. While two teachers highlighted deforestation, the others provided different answers, demonstrating the diversity of students' perceptions and interests on the topic. This issue is complex and raises different approaches among educators.

Analysis 8 investigates the adequacy and sufficiency of teaching material support for teaching environmental issues, offering an insight into the use and effectiveness of the teaching material adopted by the educational institution.

Analysis 8: Teaching material support is sufficient/adequate for teaching environmental issues

Is the support of the teaching material sufficient/adequate for teaching environmental issues?
Source: The author (2024)

According to Analysis 8, the results show that teacher responded affirmatively. Another mentioned "yes. Books, videos...". A third stated that both the material from the State Department of Education (SEDUC) and the book from the Araribá project address environmental issues, but highlighted the lack of projects to involve students in this topic. The fourth teacher responded "yes. The textbook adopted is in accordance with the BNCC skills".

Although 100% of the teachers responded positively, it is important to note that one of them expressed the need for more projects to involve students with environmental issues. Three teachers considered the textbook sufficient or adequate for teaching these topics, with one of them also mentioning the SEDUC material as teaching support, and another highlighted the consonance of the adopted book with the BNCC skills.

Analysis 9 investigates whether teachers develop Educational Objects aimed at environmental education and, if so, what these objects are.

Analysis 9: Does the teacher develop educational objects aimed at environmental education? Which ones?

Do you develop Educational Objects aimed at Environmental Education? Which ones?
Source: The author (2024)

According to Analysis 9, the results show that 01 teacher responded affirmatively, mentioning the project "Sustainability and Mathematics". Another teacher also responded positively, indicating the use of debates, research and observations as methods to address environmental issues. On the other hand, 02 teachers responded negatively (50%). One of them explained that the environmental agenda is not prominent in his work, as he prioritizes following the BNCC skills and the contents are more generalist in combination with the Geography discipline.

These results reveal a division among teachers regarding the integration of environmental themes in teaching, with half adopting specific practices to address sustainability and the other half focusing on contents more aligned with general curricular requirements.

Analysis 10 investigates whether teachers develop Practical Activities focused on Environmental Education and, if so, what these activities are.

Analysis 10: Does the teacher develop Practical Activities focused on Environmental Education? Which ones?

Do you develop Practical Activities aimed at Environmental Education? Which ones?
Source: The author (2024)

According to Analysis 10, the teachers' responses revealed different approaches to the integration of environmental issues into their educational practices. One teacher indicated that the environmental agenda is not highlighted in his/her work, prioritizing following the BNCC skills and more generalist content in combination with Geography. Another teacher highlighted practical activities such as planting trees and cleaning classrooms, in addition to introducing the topic through the Environmental Elective, which includes the use of recycled materials. Two other teachers mentioned initiatives such as informal conversations about environmental issues and the implementation of a Climatology project, which is an Extension Project of a Professor of the Geography Degree Course at the Iporá Unit of the State University of Goiás.

Of the four teachers interviewed, three (75%) stated that they develop practical activities focused on environmental education, while one (25%) indicated that the environmental agenda is not central to their practices. This diversity of approaches suggests a need for a more in-depth analysis of the teaching methods and pedagogical strategies used in the Geography discipline, aiming to improve students' communication and understanding of environmental education.

The results indicate that students are aware of environmental initiatives at school, but there is room for improvement in dissemination and engagement with the activities carried out. In addition, the school's history and commitment to this topic over time is evident, but there is a need for a more comprehensive and enlightening approach to consolidate knowledge and promote a deeper understanding of the importance of environmental education.

Although all teachers agree that the teaching material available is sufficient for teaching environmental issues, there is a clear indication that more projects and initiatives need to be developed to increase students' engagement with environmental issues. This initiative can help to strengthen students' interest and broaden their understanding of the challenges and sustainable practices related to the environment.

4. Final Considerations

The level of knowledge shared by teachers regarding Environmental Education was verified. It was observed and seen that they seek to talk about and develop activities on this very important topic for the efficiency, effectiveness and efficacy of the education for the lives of students who are sensitized and aware of helping to preserve the environment, because it depends a lot on the behaviors, conduct, attitudes, acts and actions of the teacher, since being in a profession linked to these students can transform the students' worldview, hence the great importance of teachers being in continuous training.

With this research, it was possible to identify the importance given to the Environment and Environmental Education by 8th grade students in a Full-Time School. It was verified with the class and teachers whether the topic of Environmental Education is addressed in the classroom and whether the school develops any project with the objective of diagnosing the students in relation to the importance of Environmental Education. With the answers to the questionnaires, it was possible to reach the result. Firstly, most students said they knew what the topic was about, but some students also showed a certain affinity with the subject, while some were interested and motivated when talking about the environment in school, while others were indifferent.

As a result obtained through the application of the questionnaires, it was possible to diagnose that the students have a concerned behavior, but there are those who do not even care about their classroom. The Geography teachers made it very clear in their responses to the questionnaires that the school is currently developing Environmental Education and Environment projects, addressing cross-cutting themes.

The survey drew the attention of the school community to the importance of good behavior, committed to the environment around them. The class participated, making it possible to present the subject and share knowledge about Environmental Education and Environment with the teachers in the classroom. When you look at the authors who address the subject, you can see the wealth of information on the subject and how it can be explored in the classroom in order to establish a parallel between the school and the students' families and environmental education and the environment. Environmental education was effective in the Geography discipline. Teachers and students perceived and practiced concepts about the environment. Teachers and students became aware of the importance of adopting sustainable daily practices.

The effectiveness of environmental education in the Geography discipline was understood, specifically in the 8th grade of Elementary School II. Environmental education was addressed transversally in the school, as it aimed to form citizens who are aware and committed to the environment.

The Geography teachers perceived and practiced environmental education, including the topic in their daily school routine, as they consider its importance in the curriculum. The students understood and the 8th grade students were involved in environmental education activities, influencing the formation of sustainable values and attitudes. The strategies adopted by the Geography teachers to integrate environmental education into the Geography curriculum were satisfactory, as they aligned their practices with the guidelines of the National Curricular Parameters. There was the promotion of environmental education by teachers and students. The environmental education practices in the Geography discipline contributed to a school environment that is aware and aligned with national educational objectives.

The research was developed and applied in practice, and now the only thing left to do is to improve and complement these experiences and experiences obtained during this training. Students who are well educated can do many things to improve the environment at school and develop positively as citizens, sharing this

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knowledge outside of school. The biggest challenge for these young citizens is outside of school, in acting committed to the well-being of the environment and thus, through their good example, achieving the diagnosis and positive behaviors, conduct, attitudes, acts and actions of other people in relation to the preservation of the environment.

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Gender, Sexuality, Disinformation, and Educational Politics in Brazil

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Abstract: This article discusses the theme of gender and sexuality in the context of Brazilian educational public policies and the process of disinformation and dissemination of fake news, based on the alliance of neoliberalism-neoconservatism. This process of disinformation it has the purpose of inhibiting and even prohibiting, through laws projects, the discussion and inclusion of sexuality and gender issues in legal educational documents. It is used for this, misleading terms such as "gender ideology" in the public debate. For this purpose, documents such as the Federal Constitution (CF) of 1988, Lei de Diretrizes e Bases (LDB, 1996), Parâmetros Curriculares Nacionais (PCN's, 1997/1998) and Base Nacional Comum Curricular (BNCC, 2018) and various legislative proposals attached to the law project 7.180/2014. It was verified that such documents do not properly contemplate the themes of gender and sexuality, mainly due to the lack of systematization and the indication of directions for the effectiveness of the contents with the students and these documents have been frequently suffered attacks so that they continue not stimulating the effective emancipation of society in relation to knowledge about gender and sexuality.

Keywords. Gender, Sexuality, Sex Education, Educational Public Policies.

1. Introduction

This study examines the intersection of gender, sexuality, and educational policies in Brazil, focusing on misinformation and the spread of fake news. The aim is to analyze how structural machismo has influenced public educational policies over the years, drawing upon legal documents such as the 1988 Federal Constitution [1], the 1996 Law of Guidelines and Bases (LDB) [2], the 1997/1998 National Curriculum Parameters (PCNs) [3], and the 2018 National Common Curricular Base (BNCC) [4].

Currently, there is a resurgence of conservatism in Brazil, which seeks to suppress discussions on sexuality and gender in educational legislation [5]. This movement has gained momentum since 2010, fueled by the spread of misinformation and fake news through social media, and supported by a neoconservative and neoliberal agenda. Conservative and neofascist movements, bolstered by neoliberal hegemony, promote meritocracy and individualism in opposition to income redistribution and solidarity [6].

2. Development

Neoliberalism and neoconservatism have hindered advancements in public policies and rights related to sexual diversity, redefining and deregulating previously guaranteed rights. Since 2014, anti-gender discourses, supported by conservative and religious groups, have sought to ban the discussion of these topics in educational documents, using the term "gender ideology" to discredit inclusion policies [5].

Educational discourse should be grounded in truthful information and scientific theories to promote diversity and respect for differences [5]. It is essential that students understand social markers such as gender, race, and class within an integrated view of society [7]. Schools must foster debates on gender, gender-based violence, sexism, racism, and homophobia to combat various forms of violence against women and sexual minorities.

Structural machismo, which defines social roles and gender norms from childhood, results in persistent inequalities between men and women, as well as among sexual minorities. This system of oppression is maintained by patriarchal institutions and reinforced by a historical naturalization of sexist values. Consequently, public educational policies can either reproduce inequalities or promote social transformation, depending on the approach taken [8-9].

Critical reflection is necessary to understand how educational policies can challenge conservatism and structural machismo, promoting sexual diversity and combating inequalities. Schools should serve as spaces for contestation and transformation, contributing to inclusion and social justice. Social mobilization and the development of effective public policies are essential to destabilize hierarchies and oppressions related to heteronormative standards and to promote a more inclusive and equitable education.

We analyze the evolution of Brazilian educational legislation regarding gender and sexuality, highlighting the changes that have occurred over time and the challenges faced in implementing these issues in the school curriculum.

Since the 1920s, sexual education in Brazilian schools began with a hygienist approach and faced significant resistance, especially from the Catholic Church [10]. This model of sexual education was discontinued in 1950. With the redemocratization following the Military Dictatorship and the support of social movements such as the Feminist Movement, the inclusion of topics related to the body, sexuality, and gender began to be discussed in school curricula. From the 1970s onwards, there was a considerable increase in debates about the inclusion of these topics [11].

During the deliberation of the bill that resulted in the Law of Guidelines and Bases of National Education (LDB) between 1988 and 1996, there was no explicit discussion of gender and sexuality. However, the LDB reaffirmed principles from the Federal Constitution related to the respect for pluralism of ideas and pedagogical freedom [5]. In the 1980s, the increase in HIV/AIDS cases led to the inclusion of topics on contraceptive methods and sexually transmitted diseases in educational documents. With the publication of the LDB in 1996, the 1997 National Curriculum Parameters (PCNs) introduced "Sexual Orientation" as a cross-cutting theme [3]. However, the approach was mainly restricted to the prevention of sexually transmitted infections and teenage pregnancy, neglecting broader issues such as gender, diversity, and prejudice [11].

The inclusion of sexual orientation in the PCNs, though significant, caused interpretive confusion due to the use of the term "Sexual Orientation" instead of "Sexual Education." While sexual orientation refers to the categorization of sexual desire, sexual education encompasses a broader discussion of human sexuality. This limitation reduced the cross-cutting and interdisciplinary nature proposed by the PCNs, resulting in an insufficient approach to gender and sexuality issues [12].

With the publication of the National Common Curricular Base (BNCC) in 2017, the approach to gender and sexuality in the school curriculum was considered a setback compared to the 1997 PCNs. The BNCC addressed sexuality in a very restrictive manner, focusing primarily on sexually transmitted infections and contraceptive methods. The term "gender" appeared more prominently in areas such as Art, Literature, and Portuguese Language, but the broader discussion of gender relations and sexuality was limited [13].

The notion of "gender ideology" emerged as a discursive strategy used by conservative groups to discredit the teaching of these topics. Conservative movements, supported by various religious denominations and political figures, promoted campaigns against the inclusion of gender and sexuality in the school curriculum, as evidenced by the "*gay kit*" episode and the "*mamadeira de piroca*" controversy during election campaigns. These groups have pressured for changes in legislation, with bills aimed at prohibiting the discussion of gender and sexuality in schools and prioritizing family values over school education.

Misinformation and fake news have been tools used to manipulate public opinion and discredit progressive education, creating a repressive environment against pedagogical practices that address gender and sexuality issues. This interference has negatively impacted educational policies and the BNCC, resulting in a more restrictive and less inclusive approach to these topics in school curricula. The lack of an adequate discussion on gender and sexuality contributes to the perpetuation of prejudice and inequalities in the school environment and society in general.

3. Final considerations

We understand that there is still a long way to go in terms of educational public policies related to gender and sexuality issues. The analysis of educational legislation, such as the Law of Guidelines and Bases of National Education (LDB), the National Curriculum Parameters (PCNs), and the National Common Curricular Base (BNCC), reveals that despite the initial

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progress with the introduction of Sexual Orientation as a cross-cutting theme, there was a significant regression in 2017 when the BNCC excluded the terms gender and sexual orientation from its scope.

The guiding documents for school practices and curricula fail to adequately address these themes, primarily due to the lack of systematization and clear guidelines for their implementation. Moreover, these documents have faced continuous attacks, which have hindered the effective promotion of knowledge on gender and sexuality.

The discussion of sexuality and gender is deeply rooted in cultural and socio-historical aspects, reflecting the structural machismo of society, which manifests in various forms of violence against women and sexual minorities, as well as in wage disparities and other social aspects that perpetuate inequality.

The conservative discourse and the spread of false information on digital media have contributed to the marginalization of movements advocating for the rights of these minorities. The actions of the conservative bloc in Congress, with the introduction of bills aimed at restricting rights and prohibiting the discussion of diversity and human rights, also have a negative impact.

In this context, schools emerge as a crucial space for promoting respect for diversity, human rights, and gender equality, which are essential for the development of students' critical and emancipatory thinking. Public policies that encourage debate on these topics in schools are crucial and should be promoted. For instance, it is suggested that the subject of Education and Sexuality be included in Pedagogy and Teacher Education courses, as well as the incorporation of discussions on sexual education and gender in school curricula.

The lack of a broad debate, free from moral judgments in schools, contributes to a society dominated by misinformation and intolerance, resulting in various forms of violence. Therefore, it is essential to promote an educational environment that fosters open and informed discussion about gender and sexuality to effectively address these issues.

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Handmade Microscope as a Teaching Resource in Public Education

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Abstract. Recent advances in technology and the ongoing discussions in teaching methodologies are gradually changing and improving science education, making it more student centred and its applications more relatable to day-to-day reality. In this article we present the development of a simple, but extremely useful tool in science education: a handmade microscope, built with simple and recycled materials, and using the facilities of a public institution Lab Maker. The aim is to increase students' interest in science, as well as offering a budget possibility for every school to have a basic microscope for students access and experimentation.

Keywords. Accessible Learning Materials, Brazilian Public Schools, Handmade Microscope, Recycled Materials.

1. Introduction

Recent advances in technology, ongoing discussions and improvement in teaching methodologies are gradually changing the educational environment. One of the results of such development is the improvement of student performance and access to information. Some examples of methodologies are: problem-based learning, project-based learning, flipped classroom, gamification, debate, workshop, case study, seminar and shared reading. Educational approaches based on technological projects also promote a more dynamic and interactive school environment, allow the development of skills and increase students' interest in subjects, in science and biology [1], for example. The combination between education and technology allows students to stimulate research and become primarily responsible for their own learning.

A good example of technological tool that benefits education and provides meaningful advances is the microscope - an optical instrument that allows the magnification of images [2] - the observation and the exploration of several structures are possible (such as cells, microorganisms, crystals, among other small objects), since those are often invisible to the naked eye. The microscope has revolutionized scientific knowledge however, due to the high costs of having a microscope involved, from buying to maintenance, it is not affordable and many students, in institutions all around the world, especially in poorer areas, may never have the chance to experience using one. The amazing problem-solving skills of the maker culture.

Maker culture is a learning and production strategy based on the idea that everyone can create, repair, produce and modify objects with their own hands based on research, testing and simulation [3], that is, individuals become subjects for creation and innovation. The benefits of this approach include team collaboration, knowledge sharing, proximity to science, creativity, personalization and critical thinking - essential aspects in the process of educating individuals. Furthermore, the maker culture also values the use of emerging and innovative technologies – such as 3D printers, 3D pens and laser cutters – that facilitate the production process. In this approach, students can deal with technology, reused materials and can also develop skills and be able to acquire knowledge in a practical way.

With the idea of increasing a new education methodology, working with technology and developing student's skills, this article will present the development of a handmade microscope and its importance.

2. Methods

The development of a handmade microscope, made from scratch, arose from research with microscopes and the idea of creating an accessible and affordable way of working with science. In addition to creating a useful model to be made by students in practical classes, that can allow access to scientific knowledge for every institution through their own microscope.

The project was developed at the LabCEFET

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Maker facilities, located in Belo Horizonte, which is open to schools and institutions to access. The materials for the development were acrylic, tree screws, one laser pen lens, a flashlight and MDF boards reused from furniture – easy-to-reach items.

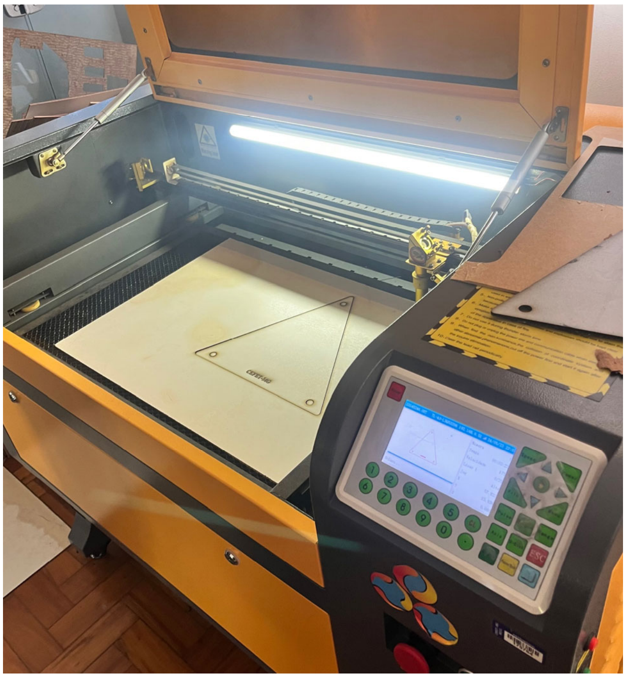

Figure 1. Laser Cutting and Engraving Machine

Figure 2. Handmade microscope

In the laboratory, we use a CNC L6040 Laser Cutting and Engraving Machine (Computer Numerical Control) as shown in Fig. 1 for precise cutting and engraving of MDF reused from old furniture and acrylic plates through high-power laser emission. The MDF and acrylic base model had a triangular shape to save materials. Holes were also made in the bases to place the screws.

The microscope was then completely assembled, using the bases, screws, laser pen lens and flashlight as shown in Fig. 2. From this, using a cell phone and positioning its camera in the direction of the lens, it was possible to observe and record the items through photos.

3. Results and discussion

Figure 3. Leaf

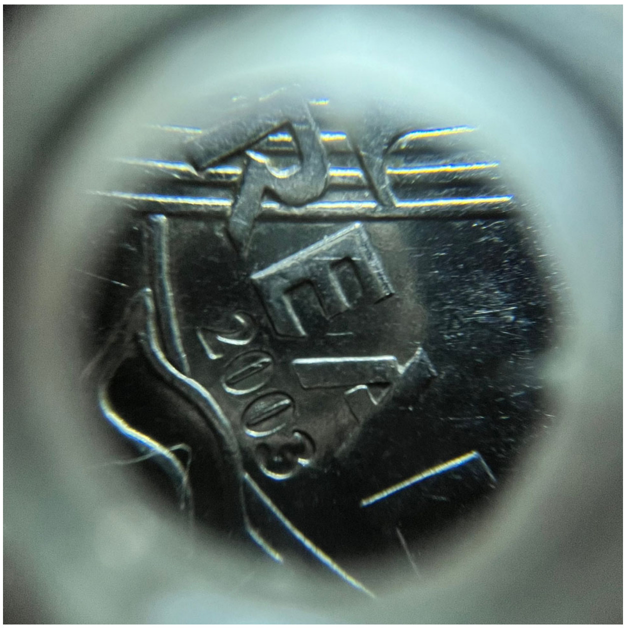

Figure 4. Coins

With the microscope assembled and

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adjusted, it was possible to test it observing and photographing different items. During the tests carried out, different types of objects were used to verify the functionality of the handmade microscope, as leaf (Fig. 3), coins (Fig. 4), shells (Fig. 5), ant (Fig. 6), grains of rice (Fig. 7) and sand (Fig. 8).

Figure 5. Shells

Figure 6. Ant

With the tests we could see details, specific parts of the leaf and its divisions, some structures of the ant and the transparency in the grains of sand. Those things contribute to understanding the importance of the microscope as a knowledge amplifier.

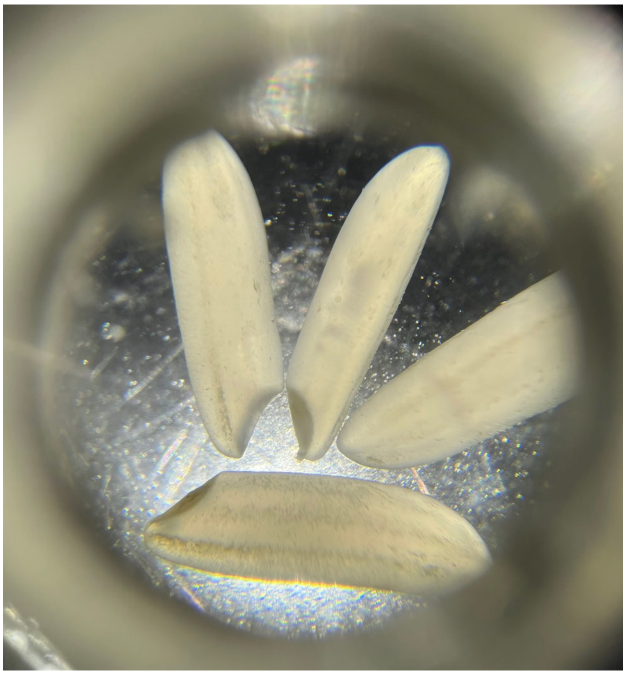

Figure 7. Grains of rice

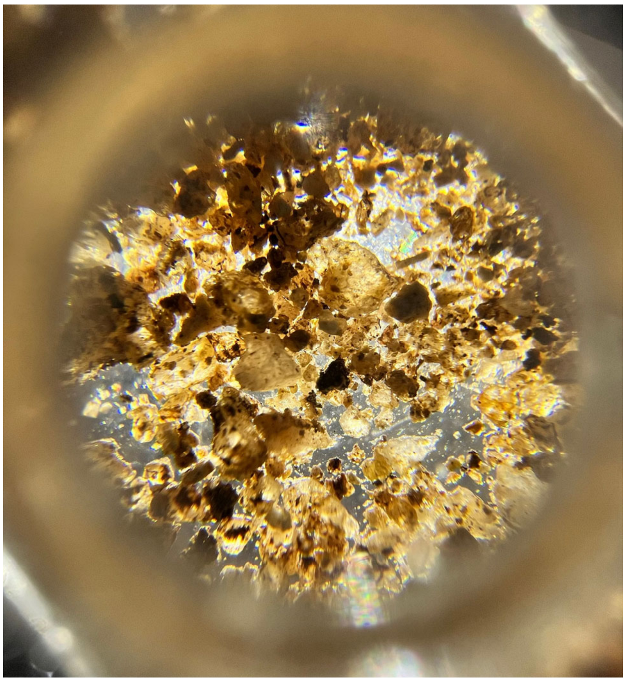

Figure 8. Grains of sand

The main purpose for creating the handmade microscope was to benefit public schools in the Belo Horizonte area - schools maintained by the government that usually don't have the necessary infrastructure to scientific research, nor funds to acquire instruments and tools like a microscope. The production we propose is easy and cheap, and teachers and students just need

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a cell phone to use it. This makes access and participation in the creation process possible.

The possibility of demonstrating enlarged images of topics of study fosters students' general interest, which leads to questions, creative manifestations and possibly to future discoveries and innovations. Interested and engaged students will certainly have a positive impact on society, evidencing the importance of a good relationship between science, technology, society and, why not, even the environment.

4. Conclusion

It is scientifically proven that the brain can assimilate more knowledge when the theory is combined with practice. According to researchers, practicing can enhance neural routes and make them faster and more effective [4]. In other words, materializing ideas force us to absorb the content and stimulate us to find solutions to challenges, in addition to achieving learning. The practice work on science education is a unique resource for the knowledge about the scientific process, the development of important cognitive tools and capabilities and the increase of students' motivation. In that way, the handmade microscope offers an excellent possibility for students to practice and test what they have learned at school, making education more productive.

Besides that, it is very important to develop new interesting means for teaching and learning, especially for young students having their first contact with science. In a nutshell, starting with this project, teachers and schools administrators could provide the students access to new experiences, allowing them to use the handmade microscope in subjects, such as science and biology, to see small animals and plants for example, developing scientific skills with practical tasks and activities.

An even more ambitious proposal would be providing means for each student to produce and take home their own microscope, to use it to analyse plants, small animals, or even their food, making science more relatable and part of their daily lives, and possibly sparking interest in their families too. Further research and collaborations for funds and supplies are to be made to achieve such goals.

5. Acknowledgements

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Itinerant Biological Science Workshops Project: An Innovative and Inclusive Proposal

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Abstract. Biology, as a complex field, presents challenges in the teaching-learning process, particularly in the assimilation of concepts and their connection to everyday life. To address these difficulties, pedagogical workshops were developed with undergraduate students, targeting public school students in the Vale do São Patrício region. The project, carried out by Biological Sciences students from IF Goiano - Campus Ceres, aimed to improve initial teacher training and facilitate Basic Education teaching. The workshops used dynamic and innovative practices to make scientific knowledge more accessible, inclusive, and engaging, highlighting the importance of diverse pedagogical resources.

Keywords. Biology, Inclusion, Initial Teacher Training, Itinerant Workshops, Scientific Dissemination.

1. Introduction

The way of thinking about education is constantly changing, different theories of the teaching-learning process have been developed over time to say how this process can be advanced to obtain more effective results. However, on the other hand, there is little effort and recognition for the development of the individual capabilities of each student at school [1]. The study of practices and applicability of the teaching-learning process provides the teaching professional with a basis for developing students, not only as a student, but also as a thinking and socially active being [4]. Just as Jean Piaget (1896-1980) believed that the work of educating should not be limited only to the sphere of transmitting content, but go further in favoring and exercising the student's cognitive abilities.

For a long period, education and the teaching-learning process had as its central axis the figure of the teacher, who was seen as the owner of all knowledge, while students were nothing more than depository figures, incomplete individuals, in whom the Teachers shared their knowledge during classes. Thus, Paulo Freire says that education must be more active, where knowledge exchanges occur, and these exchanges are the bases for developing linear knowledge of the content portrayed. Therefore it is correct to state that “the educator is no longer the one who only educates, but the one who, while educating, is educated, in dialogue with the student who, when being educated, also educates”, in other words, knowledge is a two-way street, where both sides, master and student, teach and learn[3] .

Knowing that the teaching of Biological Sciences in Basic Education schools continues for times, limited to expository classes, even because there is a lack of investment in teaching materials and instruments for practical classes, the teacher is in a constant process of re-elaborating new methodologies. One option to mitigate this situation is the adoption of workshops on dynamic pedagogical practices, which will be aimed at the content covered in the classroom, using practical means so that students are able to assimilate what they have already seen in theory. Experimentation and practical classes are important methodological approaches for the teaching-learning process, being seen as a way to facilitate and stimulate the search for knowledge [5].

Practical activities arouse interest in students, providing reflections that are capable of leading them to an investigation process. Therefore, it is estimated that these practical classes are planned taking into account the various stimulating factors for students, within their individualities, so that they can build their own knowledge, enriching their teaching-learning process [2].

From this perspective, recognizing the presence of students with disabilities in the classroom is essential for promoting an inclusive educational environment and for the full development of each student. It is important to recognize that access to education for students *Deaf*[1] is not limited to just physical presence at school and in the classroom, but requires comprehensive measures that promote true

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inclusion and guarantee its permanence [8] . In this sense, we recognize that the use of pedagogical resources that facilitate inclusion is extremely important to promote effective learning for both students Deaf, as well as for the listeners.

In the outlined context, we support the relevance of incorporating practical pedagogical workshops with an inclusive approach in the teaching-learning process. This strategy not only provides support to teachers who face difficulties teaching students Deaf, but also enriches the educational experience of all students.

In view of the above, this report aims to present and analyze the contributions of practical Biological Sciences workshops, held in public Basic Education schools in Goiás, which lack adequate laboratory infrastructure. The analysis was based on observations made during the implementation of the project recorded in field diaries and final reports of the Supervised Curricular Internship (ECS). The workshops are part of the extension project entitled "Itinerant Biological Sciences Workshops", designed and conducted with students from the Biological Sciences Degree course. The workshops cover a variety of topics related to biological sciences and, simultaneously, promote the dissemination of scientific knowledge and the inclusion of students with special needs.

2. Development

The project proposal consisted of developing practical-pedagogical workshops, applying active methodologies, with a central focus on exploring topics related to Biological Sciences. Initially, the target audience for the workshops were basic education students, from public schools located in the Vale do São Patrício region, in the north of the state of Goiás.

Initially, a survey of the real needs of students in the schools involved was carried out through the ECS phase that provides for school diagnosis. This survey was developed based on visits to the project's partner institutions, observations and conversations with those responsible for the institutions and teachers, in addition to analysis of the content taught, duly recorded in a field diary. After data collection, up to ten different types of workshops were designed and executed, thematic made it possible cover topics such as: Environment, Health, Hygiene, Fauna and Flora of the Cerrado, General Biology, Natural Resources, Zoology, Botany, Anatomy, among other topics of relevance within the study of Biological Science.

In general, conducting the workshops involved the collaboration of two undergraduate students, under the guidance of a supervising teacher from the school, with each workshop lasting an average of up to 2 hours. The workshops were scheduled for a specific period of the day, involving the participation of all students at the school or, on some occasions, specific classes. To promote interaction, classes could be allocated in different spaces or, in some situations, different classes could be combined.

A notable example occurred in an action carried out in a public school in the city of Jaraguá, Goiás. During this activity, while the workshops were given to students, workshops were held in parallel for the school's teachers. In this context, experts in the areas of nutrition and mental health led these workshops, bringing their specific and qualified knowledge for this purpose.

During the workshops, a variety of activities were implemented in order to involve all students. For each session, support materials were prepared for the presentation of the topic, including natural and synthetic anatomical pieces, plant specimens collected in the cerrado, microscopes and magnifying glasses (as illustrated in Figure 1), sound resources and teaching materials created by the students of the course *Degree in Biological Sciences*.

Figure 1.Students participating in the Workshop that aimed to explore human and animal cells. Source: authors

These workshops proved to be incredibly stimulating and played a key role in the growth of everyone involved. For the educators present, these experiences revived the core of scientific education, reminding them that "It is in the laboratory space that the science teacher can mediate the construction of knowledge in a critical and reflective way, deconstructing the idea of ready-made science with a mere script of instructions"[7]. Likewise, for students, exploring the microscope during the workshops provided a fascinating experience that stimulated curiosity and offered a completely new perspective on the content. This aligns with the idea that "when the student has the possibility of manipulating objects and/or laboratory equipment, such as the microscope, for example, the subject favours rapprochement and, consequently, the confrontation and construction of knowledge" [7].

Since the purpose of the workshops was to promote inclusion, their design was aimed at meeting the needs of students with special needs. In this context, we prepared resources that included bones and complete skeletons of several animal species, as well as preserved animals carefully arranged in hermetically sealed glass containers (as shown in Figure 2).

Figure 2 Materials used in inclusive workshops. Designed especially for students Deaf. In A, plant materials collected in the cerrado. In B, materials used in human and animal anatomy and physiology workshops. Source: authors

To conduct comparative analysis during the inclusive workshops, anatomical images of the human skeleton were used, displayed in slide presentations, together with anatomy atlases. Subsequently, some students endeavoured to assemble the complete skeleton, manipulating the bones, which resulted in a series of intriguing observations and questions about the functions of the bones, their interconnections, as well as the divergences and affinities between different animal species.

The methodological approach adopted "in addition to arousing interest in students, enabled the formation of basic knowledge of the real constitution of body parts and facilitated the understanding of the processes that can disrupt their physical and functional integrity"[6].

3. Final Considerations

Throughout the activities carried out, the lack of resources and adequate infrastructure in schools to carry out educational practices became evident, as well as the need for greater appreciation of these approaches by the entire school team. It is important to highlight that, even with simple and accessible materials, it is possible to design engaging, captivating and inclusive activities.

The workshops, conducted on an itinerant basis, also played a significant role in the training of undergraduate students in the Biological Sciences Degree course, as this experience provided future teachers with a more realistic understanding of the challenges faced in education in public schools, emphasizing the importance of introducing scientific knowledge in the school environment.

With the aim of promoting the dissemination of educational practices and scientific dissemination in schools, this work presented some of the actions we implemented, which can be adapted and applied in other institutions according to the individual needs of each educator.

4. Acknowledgments

We would like to express our gratitude to the Instituto Federal Goiano for the valuable support provided during the completion of this project. We also wish to extend our thanks to the Brazilian Society for the Progress of Science (SBPC) for the enriching partnership we established throughout this project.

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Working on Ethnic-Racial Diversity and Science with Elementary School Students in Their Final Years

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Abstract. This text is the result of research conducted as part of the Supervised Curricular Internship, focusing on the perceptions of basic education students regarding the ethnic-racial issue. The primary objective is to analyze students' perceptions of ethnic-racial diversity and to contribute to a pedagogical proposal for Anti-Racist Education. More specifically, the goals are to assess students' understanding of ethnic-racial diversity, recognize the importance of Indigenous peoples in the formation of the Brazilian population, reflect on racism in our society, and implement a pedagogical proposal based on the observed needs. The research adopts a qualitative approach and is conducted in two stages: diagnosis and intervention. The data collection tools include a Google Forms questionnaire, the Padlet platform, and observation with field diary recordings. The target audience for the project consists of 7th-grade students in the final years of Elementary School at a full-time state public school in Rio Verde, Goiás. Initial results from the first stage of the research indicate that students are not frequently engaged in discussions on this topic, with racist jokes and remarks prevailing among them.

Keywords. Diversity, Science Teaching, Internship, Racial.

1. Introduction

The main objective of the Supervised Curricular Internship is to introduce student teachers to the educational environment, allowing them to understand its dynamics both inside and outside the classroom. Specifically, the Supervised Curricular Internship plays a role in integrating the training of future teachers for Basic Education by involving them in activities that combine teaching, research, and outreach for practical application in their professional careers [1].

The target audience for this project consists of 7th-grade students from the Maria Ribeiro Carneiro Full-Time Education Center in Rio Verde, Goiás. The project is divided into two thematic sections: the first on indigenous peoples and the second on racism and racial discrimination.

The general objective of the project is to analyze students' perceptions of ethnic-racial diversity and contribute to a pedagogical proposal for Anti-racist Education. More specifically, the aim is to assess students' understanding of ethnic-racial diversity, highlight the importance of indigenous peoples in the formation of Brazilian society, reflect on racism in our society, and intervene with a pedagogical proposal addressing the identified needs.

The applied methodology is qualitative in nature, and the research process consists of two stages: diagnosis and intervention. Discussing ethnic-racial diversity in schools is important for promoting anti-racist and anti-prejudice education. Upon completing the first stage of the Supervised Curricular Internship, it was found that, in the host school, discussions on this topic were concentrated in the high school level, primarily through elective courses and projects. However, it was also observed that racist comments often emerged among the students.

As a result, there was both interest and a need to address ethnic-racial diversity with the students, supported by Law Nº 10,639, of January 9, 2003, which mandates the teaching of Afro-Brazilian History and Culture in elementary and high schools, both in public and private institutions [2].

2. Projects in the Supervised Curricular Internship

To begin with, Paniago, Clarimundo, and Nunes, highlight the importance of interns developing research skills during the Supervised Curricular Internship, as their goal is to position research within the internship as “an element that connects the formative practices of the Higher Education Institution (HEI) and the future working environment of teachers in basic education schools” [3].

Additionally, Paniago, Clarimundo, and Nunes, emphasize that the diagnosis and development of projects in the Supervised

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Curricular Internship are methodological strategies that allow future teachers to develop their praxis, attitudes, and investigative skills. The Supervised Curricular Internship is characterized as a time that enables the development of investigative skills in the process of training future teachers [3].

Developing projects in the Supervised Curricular Internship becomes an ally to basic education, as it responds to the needs of the school, from the teaching-learning process to the school's organizational process. Working with projects in the Supervised Curricular Internship allows for the development of "active, investigative attitudes in the learning process of basic education students, enabling teachers to link systematic scientific knowledge with issues from the students' socio-cultural and environmental context" [3].

3. Ethnic-Racial Diversity in Science Education

The document National Curriculum Parameters establishes some objectives for Elementary Education, emphasizing that students should be able to "[...] understand and value the plurality of Brazilian sociocultural heritage, as well as the sociocultural aspects of other peoples and nations [...]" [4].

In contrast to what is established by the National Curriculum Parameters, the presence of discussions about diversity in schools is characterized by Abramowicz, Rodrigues, and Cruz, who state that "the school is based on an imposition of a particular knowledge, rationality, aesthetic, and a single epistemic subject [...]" [5].

Regarding ethnic-racial diversity and ethnic-racial relations, Verrangia and Silva, understand it as "those established between different social groups, and between individuals from these groups, informed by concepts and ideas about the differences and similarities related to the racial belonging of these individuals and the groups to which they belong." [6].

Concerning ethnic-racial diversity, Jesus, Paixão, and Prudêncio, discuss that contemporary media increasingly display individuals who have been humiliated and suffered violence due to belonging to a particular ethnicity. Such episodes only reflect a portion of what many Brazilians endure daily due to prejudice, with such violence being, it is important to note, illegal [7].

Such demonstrations highlight the need for more discussions on ethnic-racial relations in different spaces and in educational research [7].

Therefore, it is necessary to have more frequent discussions in the classroom, as it reflects the prejudiced and racist behavior of society.

Regarding the teaching of science and diversity, "one possible way for science education to commit to promoting citizenship education is the inclusion of discussions on ethnic-racial relations" [7].

To assist science teachers, Verrangia and Silva, grouped themes and issues related to ethnic-racial diversity into five categories, suggesting work procedures as well as readings for further exploration: The mentioned groups are: a) Impact of Natural Sciences on social life and racism; b) Overcoming stereotypes, valuing diversity, and Natural Sciences; c) Africa and its descendants and global scientific development; d) Science, media, and ethnic-racial relations; e) Traditional knowledge of African and Afro-Brazilian origins and Science. The following are the suggested work and readings [6].

Diversity is a present reality in Basic Education schools, and science teachers play a fundamental role in promoting an inclusive and respectful environment. However, many teachers may face challenges in dealing with diversity in their classrooms, including cultural, socioeconomic, linguistic, and skill differences, which deviate from the objectives established in the National Curriculum Parameters for Elementary Education.

4. Diagnosis

In the research process, there are two stages: the diagnostic stage, which aims to understand students' perceptions about the defined theme, and the intervention stage, which will be based on the findings from the previous stage. The research is currently in the second stage, with the diagnostic phase already completed.

The diagnosis involved two research tools: field observation with a field diary and document analysis.

Regarding the diagnostic stage, it is not merely a panoramic and superficial view of the school and the factors influencing educational processes. “It consists of an ongoing, continuous process of problematization, identification of needs, possibilities, (re)planning, development of actions, and reflection, as school routines and educational processes are constantly evolving” [8].

According to the completed diagnosis, it was possible to identify that discussions on ethnic-racial issues were present only at the high school level, deviating from what is established by the National Curriculum Parameters for Elementary Education.

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Zero Waste School Project. IFG Campus Goiânia

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Abstract. The Zero Waste School Project (PERZ) has implemented environmental education in 26 schools since 2017.

The Federal Institute of Science and Technology of Goiás (IFG) Campus Goiânia implemented compost bins in the courtyard for internal and external participation and a vegetable garden for practical classes in the gastronomic laboratory of the Integrated Kitchen Technician and Bachelor of Tourism courses.

Playful strategies, exhibition of recycled materials, lectures, distribution of vegetables, planting efforts, gastronomic workshops, composting, distribution of seedlings and other practices motivated students and the community to change the problem of waste, producing healthy food and influencing family behavior.

Keywords. Zero Waste, Composting, Solid Waste, Environmental Education, School.

1. Introduction

Waste management with an environmental education project aimed at educational institutions aims to promote minimization, greater reuse of waste generated and its environmentally appropriate final destinations as a final result. In this sense, the Zero Waste School Project (PERZ) introduced the zero waste culture in participating schools in Goiânia, which, among several proposals for changing habits, prioritizes combating the indiscriminate use of natural resources, waste of water, energy and materials and to the inadequate disposal of waste, and to this end it focuses on training multipliers as a strategic way of supporting its actions [1]. The project worked with modern concepts, defended by several authors, who consider that "environmental education is a critical educational dimension that enables the formation of a citizen-student subject, committed to environmental sustainability, based on an apprehension and understanding of the world as complex" [2].

The zero waste practices developed in schools go beyond simple selective collection, they encourage students to work within the scope of conscious consumption and the understanding of techniques for adequate waste segregation, reuse and reuse of the waste generated. The concept of sustainability supported by the circular economy was introduced through the establishment of the organic cycle, from the consumption of natural foods, to the allocation of organic waste for composting with the production of organic compost, important for improving the soil and developing plants with the establishment of vegetable gardens supplying food to the school and thus closing this chain. This adds the practice of horticulture and the promotion of dietary health to the project, through the cultivation and consumption of fresh food produced by the students and educators themselves. It ends up enabling savings in the urban cleaning service with the decentralization of the treatment of waste that would go to the landfill, enabling the segregation of this waste directly at the generating source, with less contamination and the redirection of recyclables with greater economic value for the cooperatives of recyclable material collectors.

By working on the issue of waste management, covering the entire chain involved in the process and mainly awakening students' interest and adherence to zero waste practices and habits, the project can form multipliers with the potential to disseminate the concepts learned beyond the school environment. The development of the project highlights the importance of the role that schools play as agents of socialization, sensitizing future generations on issues that are fundamental to society and, as solid waste generating units, demonstrate the potential they have in promoting waste reduction.

The Zero Waste School Project was developed in Goiânia based on the consolidation of the Zero Waste Goiânia Residency Project, implemented in 2016 in the capital, with the challenge of bringing the concept of non-generation, reduction, reuse, recycling and adequate final disposal of solid waste in 100 selected family homes [3]. Based on this model, there was a need to expand the

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project to the education network in the municipality of Goiânia, as a way of providing schools with zero waste practices in line with the Municipal Environmental Education Policy and the Municipal Solid Waste Policy, aimed at reality of the school community, in order to promote positive cultural changes for students and encompass a greater number of people involved in the project.

Initially Goiânia was chosen to start the project because it is the capital of the state of Goiás and therefore has the power to influence other municipalities, and the choice to develop this project in schools is also due to the great power of multiplication that schools have in their communities. Considering the total of 280,731 students and 13,093 teachers and a total population of 1,466,105 inhabitants [4], there is a percentage of 20.04% of this class in relation to the total population, which represents a high power of influence in the city, where approximately for every 5 inhabitants of Goiânia, 1 is at school, either as a student or as a teacher.

The Zero Waste School Project was created through a partnership between the Zero Waste Society (SRZero) and the Community Integration and Action Society OSCIP Vida Melhor, with the support of more than 40 institutions, including the State Department of Education, Culture and Sport of Goiás (SEDUCE-GO), the Municipal Department of Education of Goiânia (SME), the Public Ministry of the State of Goiás (MP-GO) and more than 40 volunteers.

Training educators in waste management promotes the development of environmental education practices carried out daily, giving participants a sense of belonging and consequently the adoption of practices in their daily lives, even outside the school environment.

2. Objectives

The general objective of PERZ was to implement zero waste practices in the public education system in Goiânia with a focus on composting and natural food production, promoting environmental education and closing the cycle of organic matter in schools.

To achieve the general objective of the project, it was important to establish the following specific strategic objectives:

1. Train educators in the public education network regarding the integrated management of solid waste in schools, through the application of the principle of the 5 R's (Rethink, Refuse, Reduce, Reuse and Recycle);
2. Monitor and support the development of PERZ in each selected school together with its educators and school community; and
3. Develop an interaction network with the school community, in order to share information, practices and experiences, encouraging new multiplier agents as a strategy for self-sustainability, continuity and expansion of PERZ.

3. Methodology

Firstly, PERZ was implemented in stages, namely:

1. Registration and selection;
2. Evaluation of selected schools;
3. Training of Educators;
4. Monitoring and Follow-up Visits;
5. Development Visits; and
6. Closing of the first stage of the Project.

PERZ adopted as its implementation method the Cycle of 7 Steps of Zero Waste Residency applied to school reality (Fig. 1), focusing on the 5th Step – Composting.

Figure 1. Manual "7 steps to a Zero Waste Home"

The development of the entire Project took place through coordination and partnerships between the private sector, the government and civil society. The financial resources were made possible by the Public Ministry of the State of Goiás through the signing of a Conduct Adjustment Term with companies that committed environmental infractions.

Figure 2. Composting Kit from the Goiânia Zero Waste School Project and manufacturing process

After formalizing the resource, project planning included preparatory actions for the project to be launched and implemented, according to the items described below.

i. Partnerships - Initially meetings were held at MP-GO seeking to present the Project's partnership proposal to the various public, private and third sector segments. Then, partnerships were made to implement and publicize PERZ and in return, the partners had their logos published in the media and at project events.
ii. Training – 3 training courses were held (named “FurAção”) with the aim of training volunteers in the composting process and in the manufacture of low-cost compost bins from reused buckets in order to be delivered to participating schools in the form of kits for composting.
iii. Human resources - More than 40 volunteers were involved, including professionals and students. They acted as a support team in organizing events, follow-up and monitoring visits, evaluation of schools, administrative and communication services, dissemination on social networks, installation of compost bins and the vegetable garden, application of compost and other environmental education activities.
iv. Material resources - The main material resource used in the project were low-cost composters to replace the acquisition of industrialized composters, with a reduction of around 90% in the final cost. The manufacture and use of reused compost bins was something innovative to the traditional process, as can be seen in Fig. 2.

In addition to the kit, different resources were used in each stage, of which the following stand out:

i. Check-List: printed or Googleforms, using a smartphone and applied during monitoring visits;
ii. Online questionnaires: used to monitor the project; and
iii. Event Assessment Questionnaires: prepared with the aim of knowing the satisfaction of educators and obtaining feedback for continuous improvement, including the training event.

A total of R$ 52,000.00 real was spent to execute the project for the execution of 1 academic year of the project, acquisition of materials, payment of professional fees, fuel, production of educational materials (booklet, banner, banner, stickers), website, social media feed, among others. Partnerships were also made to publicize the project, loan of auditoriums and sound and image equipment, donation of buckets, which brought savings for the execution of the project.

The following dissemination strategies were used: sending invitations and letters to municipal, state and federal authorities and leaders, creating the project website and social networks, as can be seen in Table 1.

Table 1. Media used in the Zero Waste School Project

Media	url
FACEBOOK	https://www.facebook.com/escolaresiduozero/
INSTAGRAM	https://www.instagram.com/escolaresiduozerogyn/
YOUTUBE	https://www.youtube.com/channel/UCQscclc5rVNYo0NxZfnMszw
WEB SITE	http://www.escolaresiduozero.com.br

Publicity events such as workshops, lectures and exhibitions were held to publicize the project in various institutions. Among them, the following stand out: Global Action and International Environmental Film and Video Festival – FICA 2017, National Science and Technology Week at IFG Câmpus Goiânia from 2017 to the present day. Banners, banners and t-shirts were used at the events. There was also spontaneous media, with several news items being broadcast and several interviews carried out on radio, TV, printed newspapers, blogs and websites.

3.1. Educational materials

On the project website, at training events and on social media, the following educational materials were made available to better prepare the public involved in the project:

- Home Composting Manual with Earthworms and Guide for Planting Small Urban Gardens (Forest Address);
- Manual 7 Steps to a Zero Waste Home (SRZero);
- Manual for Organic Waste Management in Schools (ISWA);
- Manual for Making Low-Cost Compost Bins (SRZero and OSCIP Vida Melhor – PERZ);
- Composting and Organic Cycle Infographic Banner (SRZero and OSCIP Vida Melhor – PERZ);
- Stickers and graphic material from the IFG Sustainable campaign.

3.2. Registration and selection of public schools

Registration was carried out between the day the project was launched (May 10th in the MP – GO auditorium) and May 26th 2017, by filling out the Registration Form on the project website containing questions relating to the school's general data, those responsible, training and data of the school team, actions developed, projects involved, waste generation and management. The criteria for selection required that schools be from different administrative regions of the city, from different levels and phases of education, from the 3 spheres of government (municipal, state and federal), that demonstrated real interest in participating, through engagement with work : volunteers, campaigns in general, joint efforts and other similar projects; and that had multidisciplinary teams willing to implement and maintain the project.

3.3. Monitoring and follow-up visits

Visits were carried out for monitoring and possible adjustments in the implementation of PERZ. The visits took place from the 2nd to the 11th of August 2017 and aimed to monitor the development of zero waste practices in schools, the composting process and installation conditions of the composters through an employee checklist, informal interview, observations of the agents environmental issues, delivery of a solid waste management booklet to schools and educational material for the composting station and also with the aim of clarifying any doubts the participants may have.

3.4. Closing of the first phase of the project

The event took place on November 9, 2017, where participating schools presented their results through videos of the best moments of conception, implementation, operation and maintenance of their projects, including student involvement events and the school community. Educators and schools received the PERZ participation certificate after completing all participation stages.

3.5 Other stages

The zero waste school project continued with its actions in the same format as in 2017. In 2019 we included 8 more schools in the municipality of Goiânia and expanded to the city of Jandaia with 5 schools in the project. Due to the Covid-19 pandemic, the project and consultancies were paused, returning in 2021 with the city of Jandaia adding 2 more schools to the project, and Escola Americana started on the project in 2024, totaling 26 schools served by the Zero Waste School project.

4. Results and discussions

For the 2017 registration and selection stage, a total of 62 valid registrations were carried out in 17 days among the 797 educational establishments located in Goiânia [4]. On May 29, 2017, the results of the 10 selected schools were announced as this was the amount possible to be implemented with the funds raised. The schools selected in 2017 were

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located in different regions of the city, which favors the dissemination of zero waste culture throughout different parts of the territory. The experience was also experienced in different age groups of education, from kindergarten, through primary education, 1st and 2nd phase, to higher education. The group was made up of schools from the 3 federative entities as a way of making education and environmental policies compatible at municipal, state and federal levels. In the following years, the project served another 16 schools, we sought to expand to other municipalities and networks, such as the private education network that was included in the program in 2024.

4.1. Assessment of selected schools

At the beginning of the project, the selection was based on the Registration Form, using this data, visits were made to the best-scoring schools, with the aim of evaluating and carrying out an initial diagnosis of the reality of each school. The evaluation stage of the selected schools took place through the application of questionnaires and technical visits by the PERZ team to the school facilities. The aim was to verify whether the schools met the requirements described in the Registration Notice, within the profile of schools designed to be multipliers. Furthermore, the evaluation was concerned with surveying the initial state of educational facilities, the behavior of the school community towards solid waste management and the level of perception of environmental sustainability of schools, as can be seen in Figs. 3 to 10.

Figure 3. Schools' perception regarding the identification of waste (left) and volume of waste (right)

Figure 4. Forms of digital communication (left) and social networks practiced in schools (right)

Figure 5. Consumption of disposables (left) and food in schools (right)

Figures 6. Use of plastic bags (left) and separation of recyclables in schools (right)

Figure 7. Types of containers (left) and waste separated in schools (right)

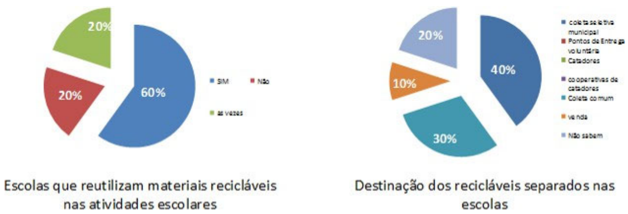

Figure 8. Reuse (left) and disposal of recyclables in schools (right)

Figure 9. Service of public selective collection (left) and composting in schools (right)

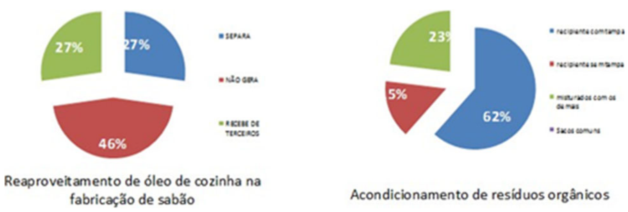

Figure 10. Reuse of residual frying oil (left) and packaging of waste in schools (right)

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The assessments carried out in the schools served to prove that they were within the desired profile for participation in the project, demonstrating some type of involvement with environmental actions and differentiated management initiatives with their waste, even if it was not in 100% of all schools nor in 100% of the situations experienced in their daily lives.

4.2. Training of educators

After the schools were selected and evaluated regarding their facilities and team of educators, those selected actively participated in the Educator Training event in Composting Organic Waste and Making Low-Cost Compost Bins, which was attended by 48 educators from the 10 selected schools, plus 2 invited schools and the Goiás Drug Dependency Recovery Center (CREDEQ).

The training carried out at Colégio Lyceu de Goiânia, on June 13, 2017, was developed through a theoretical and practical approach of the participants, as can be seen in Fig. 11.

Figure 11. Theoretical and practical part of the Training Event for educators at PERZ schools

The theoretical part was taught through 4 modules:

1. Integrated solid waste management in schools.
2. Evaluation of participating schools.
3. Composting organic solid waste.
4. Guidance for preparing the project in schools.

The practical part was taught through workshops on making low-cost compost bins and operating the vermicomposting process.

4.3. Monitoring and follow-up visits

Fig. 12 shows the monitoring and follow-up actions developed by the PERZ management team in the participating schools.

As can be seen, banners on the organic matter cycle via composting were distributed, the location of the compost bins was redistributed and reorganized, doubts were answered and locations for the installation of vegetable gardens were verified.

Figure 12. Monitoring and follow-up actions carried out during visits to schools

4.4. Development visit

The PERZ actions developed in the institutions included activities promoted by educators involving students, in partnership with the NGO Ecomamor and project volunteers, culminating in the implementation of school gardens and floor compost bins, using the static

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pile method to complement the treatment of compostable solid waste that could not be sent to the bucket composter (vermicomposting).

4.5. Federal Institute of Education, Science and Technology of Goiás (IFG)

At the Federal Institute of Goiás (IFG) Goiânia campus, the action involved 25 volunteers in the installation of the vegetable garden on July 29, 2017, with the coordination of the Kitchen Technician (EJA), Integrated Technician in Environmental Control, Environmental and Sanitary Engineering courses and Bachelor of Tourism. The purpose of the garden is to serve the Gastronomic Laboratory with the aim of reducing expenses when purchasing materials to be used, such as vegetables, subsidizing gastronomy classes, in addition to promoting donations to the school community and applying zero waste practices. in the unit, as can be seen in Fig. 13.

Figure 13. Actions at the Federal Institute of Goiás (IFG)

With PERZ, around 2,000 students were served in the 10 participating schools, with 2 vegetable gardens being implemented and another 5 revitalized. Due to spontaneous demand, 5 schools also implemented floor composters (static pile method) in addition to vermicomposting in buckets.

As a reinforcement measure for the consolidation of PERZ, a partnership was signed with the National Rural Learning Service (SENAR) to promote a course for participants on agroecological planting and the development of urban gardens.

4.6. Closing the first stage of the project

After implementing the project in schools, they presented the results of their actions at the PERZ Closing Seminar as a way of proving the commitment made with the project management entities, as a way of exchanging knowledge and experience between the participants, as a way of inspiration from other schools that did not participate in the project but learned about its development through this event.

Five schools participated in this event, presenting a video of their results. The Certificate was delivered to them on the closing day and to the others at another time.

To date, there have been 10 schools in the first stage of the project, in 2019 8 schools in Goiânia and 5 in Jandaia, in 2021/22 two schools in Jandaia and in 2024 one school in Goiânia, totaling 26 schools served by the project.

4.7. Reinforcement visits

After the end of the implementation stage of the project in schools and with the presentation of the results, the representatives of the schools in the Zero Waste School Project continued to be supported by the project team with consultancy, support in the actions developed by the schools and other projects resulting from the implementation of the composting system or vegetable garden in schools.

5. Conclusions

Based on the work carried out, it was concluded that the implementation of a multidisciplinary project involving different areas of knowledge, different actors and partners, mixing theoretical and practical knowledge, with application in the daily life of the school as a strategic way of solving school problems was extremely positive. community itself, in this case, solid waste, hunger and malnutrition.

It was important to implement PERZ through different strategies, in each school, according to the age group of the students. Within the political pedagogical projects of the participating schools, there were support activities such as theater, music and playful games.

Family involvement was fundamental for the implementation of PERZ and one of the strategies presented to the community and the students' parents was “Family Day”, incorporated into the school's political pedagogical project, which also includes the subject of agroecology. Once the involvement of the school community increases, the number of multipliers and consequently the scope of the project increases.

By separating organics from waste, a significant reduction or even no generation of leachate in the waste that goes to landfill can be seen. It was observed that schools that already carried out selective collection began to separate more quantities of recyclables, according to reports from participants.

The production of liquid humus (biofertilizer) saves irrigation water by 10%, as the material must be diluted in a proportion of 1:10 in water, in addition to providing the nutrients necessary for the development of cultivars, as well as the use and application solid humus which, by retaining moisture in the soil, saves the amount of water per irrigation and the number of times needed to irrigate, restoring or improving the quality of the soil.

It has been proven that composting can be used as an important environmental education tool, given the involvement of the school community and the students and teachers themselves, from the separation of waste, the feeding of organic waste into the compost bin, the collection of humus, the application to the soil, the planting of vegetables until the harvest and consumption of food, which motivated the participants to close the cycle of organic matter in the school itself.

It is concluded that the inclusion of this strategy in school environmental education proposals is very useful and helps to mobilize the school community, serving as an example for educational establishments at all levels and in different regions.

The work carried out in a shared manner between different levels of government, in solving local problems, serves as a positive model for other regions of the state and country by putting global thinking and local action into practice.

It can be seen that the Zero Waste School Project applied to public education in Goiânia, under municipal, state and federal domain, in various phases of education, has been an advance in the educational segment, serving as a success story for other schools. What proves that the project will continue is the involvement of the school community through the assimilation of zero waste practices (conscious consumption, selective collection, recycling, composting, adequate waste disposal and formation of multiplier networks). The installation of compost bins and a school garden are strategies that make it difficult to stop or give up on the project as it is an intangible asset valued by teachers, students and families.

It is essential for the school to accept the concept of shared management and social control, where the school, through other partners, introduces activities related to environmental management and education, bringing more multidisciplinarity to projects and involvement of all types of audiences.

The power of multiplication of the educational segment has revealed that work with the school community combined with waste management projects (selective collection and composting) and urban agriculture can enable the municipality to achieve the goals set by the National, State and Municipal Policy for Basic Sanitation and Integrated Solid Waste Management, so that the environment is protected and the population has a better quality of life.

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Anatomical Drawings in Horses: A Didactic Strategy for Teaching Anatomy to the Deaf

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Abstract. This text deals with a study on the inclusion of deaf students at a Federal Institute ofEducation, Science and Technology. Anatomy plays an essential rolein this course, as it is the basis for understanding how organisms function. However, teaching anatomy is often challenging, especially for Deaf students, due to the complexity of terminology and the lack of signs in LIBRAS for many anatomical terms. This qualitative study presents a teaching experience that used the production of anatomical drawings of live horses as a didactic strategy to facilitate the understanding of anatomical structures by Deaf students.

Keywords. Anatomy, Deaf People, Horses, Teaching Strategy.

1. Introduction

Anatomy, given its complexity and the extensive technical vocabulary involved, invariably presents a considerable challenge for students on their learning journey. The task of memorizing a wide range of anatomical terms, understanding the three-dimensional interrelationships between structures, and applying this knowledge in practice can prove to be a challenge for students and teachers.

Considering the relevance of anatomy in academic training in various higher education courses, this text reports on a teaching strategy aimed at the anatomy teaching-learning process, with a focus on deaf students. We understand that learning anatomy can be especially challenging for this audience due to the complexity of the terminology and the scarcity of signs in Brazilian Sign Language (LIBRAS) for many anatomical terms. The lack of adequate resources for translating and adapting to sign language can make it difficult to understand and participate fully in theoretical and practical classes, which requires teachers to adopt inclusive and innovative teaching strategies to ensure equal access to anatomical knowledge.

The inclusion of students with disabilities in educational institutions is not just limited to their physical presence, as true inclusion requires prioritizing accessibility as a fundamental principle. In this context, Deaf students often have lower academic performance compared to their hearing peers. However, this discrepancy is not due to Deaf students' cognitive limitations, but rather to the difficulties faced by educators in the literacy and communication process with this group of students.

In this context, there is the need to implement educational strategies that encourage and enable education professionals to improve their teaching skills.It is widely recognized that the learning of Deaf students is optimized through the adoption of bilingual approaches and the use of visual resources that facilitate the teaching-learningprocess. Such measures play a key role in promoting inclusion and ensuring a more accessible and equitable education for all students.

Other authors stress the importance of recognizing that access tohigher education for Deaf students goes beyond simply being physically present in higher education institutions or classrooms. It is essential to adopt comprehensive measures that promote true inclusion, ensuring the permanence and academic success of these students.

The implementation of projects that complement the content taught in theoretical and practical Animal Anatomy classes plays a fundamental role in improving the teaching of this subject. These projects give students the opportunity to apply their anatomical knowledge in practical contexts, including the creation of visual representations of anatomical structures. This approach not only prepares students for face challenges in the field of Animal Anatomy, but it also enriches the teaching process, making it more engaging and dynamic.

An image can be defined as a visual message made up of signs, constituting a tool for communication and expression. In this sense, although in verbalized language words play a crucial role in the ability to generalize and in the application of classificatory reasoning, the use of visual resources is equally valuable. This benefits all students and, in particular, Deaf students, by facilitating the understanding of content in a more accessible and effective way.

This text describes a study focusing on the teaching experience of including deaf students at the Federal Institute of Education, Science and Technology (IF Goiano), Ceres Campus. The main objective of the study was to share the paths taken to teach Animal Anatomy to a deaf student enrolled in the Zootechnics course. Using a qualitative approach, this study presents the steps followed in the teaching practice, which employed the creation of anatomical drawings of live horses as a didactic strategy to improve the understanding of anatomical structures by deaf and hearing students.

Initially, we discussed some theoretical aspects related to the inclusion of Deaf students in higher education. Next, we address the didactic strategy in question, examining its role in the teaching-learning process of Deaf students. Finally, we present the practical experience of teaching anatomy as a tool to promote educational and social inclusion.

2. Development

In this report, we look at a long-term extension project that has been running for almost a decade, entitled "Itinerancy of the Anatomy Laboratory at IF Goiano - Campus Ceres". From this main project came the sub-project called "Exhibition and Art in Anatomy Teaching". This sub-project proposed an innovative approach to teaching the subject of Animal Anatomy offered in higher education courses in the areas of Biological and Agricultural Sciences at IF Goiano, Campus Ceres. This approach had a special focus on the inclusion of a deaf student and used illustrations applied to the anatomy of live horses as a didactic strategy to make the understanding of anatomical structures more accessible.

Initially, the deaf student took part in the theoretical-practical classes provided for in the curriculum for the subject of Animal Anatomy. The theoretical lessons took place in the classroom in an expository and dialogical manner and used projected visual resources, as well as the presence of a LIBRAS interpreter to help with communication. The practical classes were held in the Anatomy laboratory.

Subsequently, the student took part in an action promoted by the Extension Project during an institutional event. For this activity, three adult mixed-breed equines were selected from the IF Goiano's equine therapy center in Ceres, Goiás, as well as a Mini Horse owned by a student participating in the project. These animals were chosen because of their docility and ability to interact with people.

The students involved in the project conducted detailed research into the anatomical structures of horses, focusing on these animals in particular, using specialized literature on the anatomy of domestic animals as a reference. They then selected appropriate illustrations depicting various equine organs and anatomical structures.

Figure 1. Anatomical representations in horses: A) illustration of the respiratory system (lateral view); B) students illustrating the urinary system (top view); C) representation of the equine fetus and anatomical structures involved in pregnancy, such as the uterus, umbilical cord, cervix and birth canal (lateral view). (Source: authors)

To paint the illustrations on the animals, water-based gouache paints were purchased, ensuring that they were non-toxic and safe for the animals. The horses were properly prepared, thoroughly washed and dried before the painting process began.

Using the illustrations as a guide, the students, including the Deaf student, applied the anatomical drawings to the animals' coats. This painting process took an average of around 2 hours to complete (Fig. 1B). The paintings represented various anatomical structures, including bone, muscle and internal organ systems, covering approximately 40 to 60% of the equine body area. It is worth mentioning that no drawings were made of the animals' heads. It is important to emphasize that all stages were carried out with extreme care and consideration for the animals' welfare

After the paintings were completed, the horses were presented during the institutional event. All the project participants, including the Deaf student, gave detailed presentations of the anatomical structures represented in the animals. Skeletal, respiratory and muscular systems were covered, as well as a visual representation of a fetus in the uterus of a pregnant mare (Figs. 1A and 1C).

To preserve the animals' well-being, they were thoroughly washed after the show, ensuring that any paint residue was removed. Throughout the process, the horses remained calm and docile, without showing any aggressive behavior, even during the post-event washing.

The implementation of the horse painting project represented a valuable opportunity to promote interaction between Deaf students, their hearing peers and teachers. As well as stimulating creativity, this initiative strengthened the bonds between the participants, contributing to an enriching and inclusive educational environment. Promoting social interaction is fundamental for buildingand sharing knowledge between students and teachers, emphasizing the relevance of improving teaching resources and related methodologies.

The paintings made of the horses offered a direct visual understanding of the anatomy, allowing the Deaf student to explore the anatomical structures and relationships independently. This approach enabled a detailed analysis of different anatomical layers and angles, further enriching the learning experience. The inclusion of Deaf students in higher education is crucial, and the anatomical paintings proposed by this project play a fundamental role in reducing communication barriers, promoting a more equal education.

The Brazilian Ministry of Education (MEC) recognizes the importance of curricular adaptations as a necessary educational response to ensure the inclusion of all children students, including the deaf. However, it is essential to understand that making these adaptations effective requires a change in mentality and effective structuring of school environments, going beyond the simple formal inclusion of all students.

We recognize that the participation of Deaf people in visual projects plays a crucial role in ensuring their full and equal involvement in various activities and initiatives. However,it is equally essential to highlight the indispensable role of LIBRAS interpreters in thiscontext.

Deaf people acquire knowledge mainly through visual means, and the mixture of languages can hinder the acquisition of knowledge due to differences in linguistic characteristics. Therefore, the presence of LIBRAS interpreters is essential in complementary projects involving Deaf students.

In order to promote the effective inclusion of the Deaf, it is not enough just to present conceptual content in LIBRAS; it is necessary to develop appropriate teaching strategies that take into account their specific learning characteristics. In this context, other authors highlight the importance of facing the challenge of teaching increasingly complex content to the Deaf Community in order to better understand the challenges of this area of knowledge.

Therefore, overcoming the challenges faced by Deaf students requires a comprehensive approach. This includes improving the training of education professionals, implementing effective pedagogical strategies and gaining a deep understanding of the needs of students and teachers.

In this context, it is important to note that teaching practices for Deaf students present unique challenges, such as the communication barrier, since Sign Language is the first language of most Deaf people, while teaching is often conducted in oral language. The need for LIBRAS interpreters, accessible teaching materials and inclusive pedagogical strategies is evident. In addition, it is essential to consider the diversity within the Deaf community, including linguistic variations and specific learning needs. Promoting inclusion and equal opportunities for Deaf students requires an ongoing commitment to awareness-raising, teacher training and curriculum adaptation, ensuring that all students have access to a quality education.

3. Final considerations

With the aim of sharing the trajectory involved in teaching Animal Anatomy to a deaf student enrolled in the bachelor's degree course in Zootechnics at IF Goiano, Campus Ceres, we identified that the inclusion of deaf students requires innovative pedagogical approaches, centered on access to knowledge. In addition, we highlight the importance of using visual resources and practical projects to enrich the teaching-learning process, making the content accessible to both deaf and hearing students.

This didactic strategy not only sought to deepen understanding of equine anatomy, but also promoted interdisciplinarity between students from different courses at IF Goiano, Campus Ceres. It also helped to improve the visual representation of anatomical structures and to evaluate the positive impact of this approach on the teaching of Animal Anatomy, which is an integral part of the bachelor's degree course in Zootechnics.

It is essential to emphasize that this teaching experience was not limited to meeting the specific needs of Deaf students, but also had the purpose of sensitizing the institution to the importance of inclusion and pedagogical innovation in the context of higher education.

4. Acknowledgements

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Exploring the Potential of Robotics Tournaments in Science and Mathematics Education: Challenges and Opportunities

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Abstract. This paper presents partial results of an ongoing research project that explores the limits and possibilities of robotics tournaments for learning science and mathematics. The research, which takes a qualitative approach, includes a literature review, monitoring of robotics teams in public schools and the application of questionnaires and interviews during tournaments such as the Brazilian Robotics Olympics and the First Lego League. Linked to the MARC Project at the State University of Goiás, the research aims to answer: What are the limits and possibilities of robotics tournaments for teaching and learning in Science and Mathematics? The final product will be an interactive e-book.

Keywords. Robotic Devices, Science Teaching, Inventive Mathematics Education, Teacher Training.

1.Introduction

The challenges faced in the classroom have always been significant, especially when it comes to capturing students' attention and curiosity about their own learning. Which methodologies are most effective and engaging? In this context, knowledge is a process constructed by human beings, requiring time, interest, an investigative spirit, scientific thinking, student protagonism and the opportunity to generate innovations [1].

Being a teacher in the digital age presents a series of challenges and opportunities, mainly due to the wide range of technological options available. According to [1], “Different training experiences can cause dislocations, moving our learning, and at the same time enhance our educational actions and practices in the most diverse contexts, updating and setting in motion the production of knowledge.” This concept emphasizes the importance of continuous and diversified training in building an educator who is open to new possibilities for doing education. Such experiences are described as capable of “causing shifts,” in other words, a transformation in the educator's perspective, which enriches not only individual learning, but also strengthens pedagogical practices, updating and expanding the production of knowledge.

In a dynamic educational scenario such as educational robotics, these (trans)formative experiences are fundamental. By coming into contact with different methods, theories and practices, educators are challenged to re-evaluate their approaches and incorporate new knowledge into their daily practice. This can broaden teaching possibilities, promoting a more inclusive learning environment.

What's more, by allowing this knowledge to be constantly renewed and shared, the educator keeps in line with contemporary innovations and demands in education, especially in technological and interdisciplinary areas such as robotics.

Faced with current demands, especially after the rapid technological advances of recent years and the variety of resources available, teachers have had to reinvent themselves, leave their comfort zones, challenge themselves, study again, understand the new teaching techniques and methodologies available and go further, reinventing themselves while creating new teaching and learning alternatives [1].

In the vast universe of pedagogical tools and possibilities for creation and invention, educational robotics has been gaining ground, driven by robotics tournaments and the demands of the job market, which puts a strain on the work of educators in the classroom.

In light of this, [2] explains that robotics can be integrated into the school curriculum to develop problem-solving skills, critical thinking and teamwork. She argues that educational robotics facilitates practical and contextualized learning, making abstract concepts more tangible for students.

Teaching educational robotics in elementary school in an attractive and effective way involves strategies that can engage students in active learning environments.

On the other hand, it is understood that the use of robotics in an educational environment can go beyond problem solving. In this sense, [3] states that “learning is, above all, the invention of problems, an experience of problematization. The experience of problematization is distinct from the experience of recognition.” [3] also points out that “this learning does not end with the solution of immediate problems, but extends its effects and its capacity for problematization.”

In the context of educational robotics, with all the learning processes involved in the classroom and later in participating in robotics tournaments, it is necessary for both teachers and students to be open to the challenges that these events entail. In this way, it is possible for participants in robotics tournaments to go beyond simply solving the problems proposed in the competitions, to the point of problematizing the world around them.

For [4], the learning process is essential for human beings, who are naturally social. The learning process is vital for social integration, the development of personal and social skills, and the ability to contribute to and benefit from the community. Learning is a fundamental part of the human experience that promotes individual and collective growth. Along these lines, [5] addresses the importance of active methodologies and the integration of emerging technologies, such as educational robotics, in the teaching-learning process.

In addition, research by [1] points to the possibility of using technical objects, such as robotics, as devices for inventing problems, inventing oneself and worlds. From this perspective, the inventive use of both robotic devices and mathematical knowledge is present in the Research Project: MARC - Mathematics Applied to Robotics and Science, of the Postgraduate Program in Science Teaching - Professional Master's Degree in Science Teaching at the State University of Goiás - Central Campus. This project investigates the limits and possibilities of robotics tournaments held in Brazil in the learning process of primary school students at a state public school in the city of Goiânia-GO.

In this research, robotics is considered to be the study of robots, focusing on their ability to perceive and act autonomously and intentionally in the physical world [6]. This field has several aspects, including educational robotics, which is aimed at the school environment as a way of working on scientific initiation in the disciplines of Science and Mathematics with students, organized into teams, who in turn develop robots based on the challenges proposed for participation in tournaments.

Robotics tournaments in Brazil reveal a trajectory of growing interest and development in the area of educational robotics. Among robotics tournaments, we can highlight competitions such as the FIRST LEGO League and the Brazilian Robotics Olympics, which play a significant role in challenging students to apply theoretical knowledge in real situations, with the hypothesis of promoting cooperation between teams. These events can also contribute to the development of socio-emotional skills, such as resilience, time management and presentation skills.

The introduction of educational robotics and participation in tournaments is hypothesized to promote academics, inclusion, equity and preparation for the 21st century job market. It is possible that those involved in robotics programs tend to perform well in subjects such as mathematics and science. Educational robotics can bring about new learning, regardless of the students' socio-economic background.

Robotics tournaments are events that aim to awaken in participants, called robotiquers, human and fundamental values such as discovery, innovation, impact, inclusion, teamwork and fun - called Core Values, created by Woodie Flowers (1943 - 2019) [6].

The aim of this ongoing research is to find out what the limits and possibilities of robotics tournaments are for teaching and learning science and mathematics. In this sense, it seeks to answer: What are the limits and possibilities of robotics tournaments for teaching and learning in Science and Mathematics?

1.1. Competitions in Brazil

In order to understand the world of robotics tournaments, some of the main competitions held in Brazil are described below.

1.1.1. Brazilian Robotics Olympiad (OBR)

The OBR is a national competition that aims to encourage educational robotics in schools at all levels. It is one of the most important competitions in the country and covers various categories, from construction and programming challenges to theoretical knowledge tests.

1.1.2. Brazilian Robotics Competition (CBR)

Organized by the Brazilian Computer Society (SBC), the CBR is a competition that promotes robotics at a national level, with categories for different age groups and educational levels. The competition focuses on building and programming robots to face specific challenges.

1.1.3. FIRST Robotics Competition (FRC) Brazil

Part of the global FIRST Robotics program, FRC Brazil is a robotics competition for high school students. Teams must build robots to perform tasks in a specific field of play, combining engineering, programming and teamwork.

1.1.4. RoboCup Brazil

RoboCup is an international competition with local branches in Brazil. It focuses on robotics and artificial intelligence, with categories including robot soccer games, rescue competitions and home robotics.

1.1.5. RobotChallenge Brazil

Part of the international RobotChallenge competition, which focuses on technical challenges for robots in various categories, such as autonomous robots and combat robots.

1.1.6. Robotics Symposium (SBR)

Organized in conjunction with academic events. Although not exclusively a competition, the SBR often includes robotics challenges and competitions, providing a platform for the demonstration and discussion of advances in robotics.

1.1.7. Robotics Festival

Organized in various cities and states, Robotics Festivals are regional events that include competitions, workshops and exhibitions of educational robotics.

1.1.8. RobôTeca

In some cities, local and regional competitions, such as RobôTeca, are held to promote robotics among schools and communities.

1.1.9. Brazilian Robotics Education (ERB)

Events organized by educational institutions and companies to promote educational robotics, usually in the form of competitions and workshops.

1.1.10. FIRA

The Federation of International Sports Association (FIRA) was founded in South Korea in 1996 and aims to encourage and foster technological development for children, teenagers and adults. FIRA BRASIL is a competition made up of State Stages and a National Final which annually qualifies 16 teams from Brazil for the FIRA ROBO WORLD CUP.

These tournaments have contributed significantly to the development of educational robotics in Brazil, promoting student engagement with technology and encouraging innovation and teamwork.

1.2. Robotics tournaments

In Brazil, some robotics tournaments are free and open to public school teams. Here are some examples:

1.2.1. Brazilian Robotics Olympiad (OBR)

The OBR is known for being an accessible competition, with free registration for teams. It is widely promoted to public and private schools throughout Brazil.

1.2.2. Brazilian Robotics Competition (CBR)

The CBR offers opportunities for public school teams to participate, with registration that can be free or subsidized depending on the conditions of the event and the year.

1.2.3. Robotics Festival

Many regional robotics festivals, such as the SESI Robotics Festival, are free and open to public schools. These events are organized in various regions of Brazil and promote the participation of students in competitions and practical activities.

1.2.4. Robotics at School

This is a project that can include free regional competitions aimed at public schools. The project is an initiative aimed at including robotics in the school curriculum and frequently organizes events for students.

1.2.5. Public School Math Olympiad (OMEP)

Although focused on mathematics, the OMEP can include educational robotics competitions as part of its activities, with free participation for public schools.

1.2.6. Brazilian Robotics Fair (FBR)

Organized in some regions of Brazil, the FBR promotes free events for public schools, with an emphasis on educational robotics and project exhibitions.

1.3. A review

In order to identify existing academic production on the subject of robotics tournaments, a search was carried out in the CAPES Theses and Dissertations Database. By typing in “robotics tournaments” on the CAPES Theses and Dissertations Database website (Table 1).

Table 1. Academic production in CAPES Theses and Dissertations Database

Year	Ref
2020	[30]
2022	[31]
2022	[32]
2023	[33]

Four papers were found from 2020 to the present day and they address significant aspects related to the context of robotics tournaments. When typing the words “robotics tournaments” into Google Scholar, the following works were found in Table 2.

Table 2.

Year	Ref
2020	[34]
2019	[35]
2014	[36]
2022	[37]
2017	[38]
2024	[39]
2022	[40]
2022	[41]
2020	[42]
2015	[43]
2022	[32]
2022	[44]
2020	[45]

Between 2014 and 2024, i.e. a period of ten years, the above research and work shows the importance of educational robotics in student learning and the inclusion of students in tournaments with the aim of awakening new skills and competences and arousing interest in areas of knowledge such as Science, Mathematics, Physics and Engineering, encouraging these students to pursue professions linked to technology and robotic knowledge.

Robotics tournaments can play an important role in teaching science and mathematics, as they encourage students to apply theoretical concepts in practical and challenging situations. These events can provide an opportunity for students to integrate knowledge from different disciplines, such as physics, mathematics and technology, promoting interdisciplinary and contextualized learning. By designing, building and programming robots, students develop problem-solving skills, critical thinking and creativity, as well as improving skills such as teamwork and communication. These competitions can stimulate interest in science and mathematics, making learning more dynamic and engaging, and preparing students to face real challenges. In addition, robotics tournaments can help to demystify the idea that Science and Mathematics are difficult or inaccessible subjects, promoting a more positive and engaged view of these areas of knowledge.

In this scenario, we have as a possibility the production of actions and practices of Inventive

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Mathematics Education with the use of robotics in concurrence with [1] by identifying that "the materialization of inventive worlds functioned as problematization scenarios, in which it was possible to develop different relationships with mathematical knowledge and technical objects."

Further details and possibilities regarding the use of robotics as a device for materializing inventive worlds, which can be used in the teaching and learning of Science and Mathematics, can be accessed free of charge in the e-book Inventive Mathematics Education [1].

The actions and practices in the book Inventive Mathematics Education open up possibilities for using mathematical and technological knowledge from a perspective that can go beyond problem-solving and representing the world, to the point of opening up the invention of problems, the invention of self and of worlds, which can contribute to both the teaching and learning of science and mathematics, as well as robotics tournaments.

Teaching science in primary and secondary schools, as well as biology in secondary schools, presents a number of challenges, even with the abundance of technological and pedagogical resources available today.

The digital age has brought a variety of educational tools, such as interactive platforms, virtual simulations, educational videos, and online experiments, which potentially make learning more accessible and engaging. However, the effective integration of these resources into the classroom environment requires specific skills on the part of educators, who often face difficulties in keeping up with rapid technological changes and incorporating them into the traditional curriculum to enhance learning. In addition, the need to contextualize scientific learning to make it relevant to students' everyday lives and to develop critical and investigative thinking requires active methodologies that may not be widely implemented in schools.

The diversity of student profiles and unequal access to technology are also barriers that need to be overcome to ensure that everyone has the same learning opportunities. Therefore, the challenge lies not only in the use of new resources, but also in teacher training and the creation of inclusive pedagogical strategies that make effective use of these tools to promote science and biology teaching that is dynamic, accessible and transformative.

It is possible to incorporate the actions and practices of Inventive Mathematics Education into everyday classroom life for teaching Science and Biology, and jointly form teams to take part in robotics tournaments, because when students develop research for projects with themes that are determined by the tournaments, new educational skills and competencies are incorporated into learning.

One possibility in both science and mathematics teaching would be to let the students themselves create and develop the problem situations, and thus be able to act more and more as protagonists in the creation and invention of themselves, the invention of worlds and problems, during their relationships with the knowledge produced.

As can be explored in the book in Fig. 1, we have infinite possibilities for materializing an inventive world.

Figure 1.Possibilities (Source: [1])

After presenting this initial overview, we'll move on to some aspects of the research methodology in the next section.

2. Methodology

With the aim of answering the question "What are the limits and possibilities of robotics tournaments for teaching and learning in Science and Mathematics?" this qualitative research is underway and consists of a literature review and survey, monitoring two robotics teams, Danger's Lego and Lego 9 ¾, both from CEPI Dr. Antônio Raimundo Gomes da Frota (CEPI FROTA).

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After monitoring these teams, some questionnaires will be applied and field interviews will be carried out during robotics tournaments underway this year, such as the Brazilian Robotics Olympics and the First Lego League.

In order to identify and analyze the limits and possibilities of robotics tournaments for the teaching and learning process in Science and Mathematics, the development and collection of data with the students will take place both in the classroom and during these tournaments,

At the time of writing, the students, who are called robotiquers, are preparing their robots for the Brazilian Robotics Olympiad, which will take place on September 14 and 15 this year. The robots they have built have been designed together and once the best prototype has been defined, the assembler begins to build the robot's design.

As [14] points out, doing science involves various actions, such as observing, describing, comparing, classifying, analysing, discussing, formulating hypotheses, theorizing, questioning, challenging, arguing, suggesting procedures, judging, evaluating, deciding, concluding, generalizing, informing, writing and reading. The language of science must be used in such a way as to develop understanding, mastery and practical skills in science teaching.

The role of the teacher is fundamental in this context, as their intervention must be intentional and well-founded, using strategic resources to keep students engaged in challenges that stimulate learning.

3. Educational Robotics Tournaments: Challenges and Opportunities for Teaching and Learning in Science and Mathematics.

This paper presents partial results on the limits and possibilities of robotics tournaments in the teaching of science and mathematics. These tournaments have highlighted their potential to promote interactions between students, providing a practical and motivating learning environment.

During the observation of the teams for the Brazilian Robotics Olympiad, it was identified that Team Lego 9 ¾ split into two: Team Lego 9 ¾ and Team Mega Lego. Likewise, Team Danger's Lego split into Team Danger's Lego and Team Mib Lego.

Two teams with 4 members and two teams with 3 members were formed.

Below are some results related to the assembly and programming of robots by the teams.

3.1. Robot 1

The project was developed by all members of the Mega Lego team, with the aim of competing in the Brazilian Robotics Olympiad (OBR) and aiming to win one of the following awards: Robustness Award, Programming Award, Public School Award, Design or Dedication Award. The robot programming was carried out by two students, although all team members were knowledgeable about the logic and operation of the programming.

Figure 2. Robot 1 (Source: the authors)

To build the robot, the following components were used: three large EV3 motors, an EV3 color sensor, LEGO rubbers from the EV3 expansion kit, four wheels compatible with the EV3 treadmill, connectors, twelve axles of different sizes, four bushings and eight half bushings, thirty beams of varying sizes, two frame plates, one EV3 medium motor, two NXT light sensors, two LEGO EV3 plastic tracks, one EV3 brick, one EV3 ultrasonic sensor, two simple LEGO Spike gears, and six 5x7 frames.

The claw used is simple to operate, designed with an elastic band to allow the rescued victim to enter and be directed to a compartment, being subsequently released into the rescue area. Programming was carried out on the EV3 Classroom platform and currently progress includes almost complete implementation, with only red line identification and programming for the rescue area remaining. Robot 1 from different angles can be seen in Fig. 2.

3.2. Robot 2

The construction of the robot was a collaborative effort by the Danger's Lego team, who, through discussions and analysis, came to the conclusion of the most suitable design. Initially, the project envisaged a smaller and more compact robot, but this model did not achieve the desired performance. The team then opted for an alternative design, in which the engine is mounted in a vertical position.

Figure 3. Robot 2 (Source: the authors)

The robot's main purpose is to follow a line and avoid obstacles, with the aim of maximizing the score and providing fun for the participants. For construction, the following components were used: seven small frames, three medium frames, three large motors, three color sensors, six wheels, fifteen half bushings, six normal bushings, an ultrasonic sensor, fifteen beams, three torches and nine axes. The programming was developed on the NXT platform, with the line follower implementation already completed. However, the team faces difficulties in programming the sensors and seeks to resolve these issues through consultations with colleagues who have mastered programming and by watching tutorials on YouTube. Robot 2 from different angles can be seen in Fig. 3.

3.3. Robot 3

The construction of the robot involved all members of the Mib Lego team, with the purpose of ensuring that the robot completed the entire route and reached the rescue area. The programming was carried out by A*, who has already developed the line follower function. However, the team still faces difficulties with programming the sensors. To overcome these challenges, A* is seeking help from colleagues from other teams who have greater expertise in the area. He will then share best practices and strategies for programming with other team members.

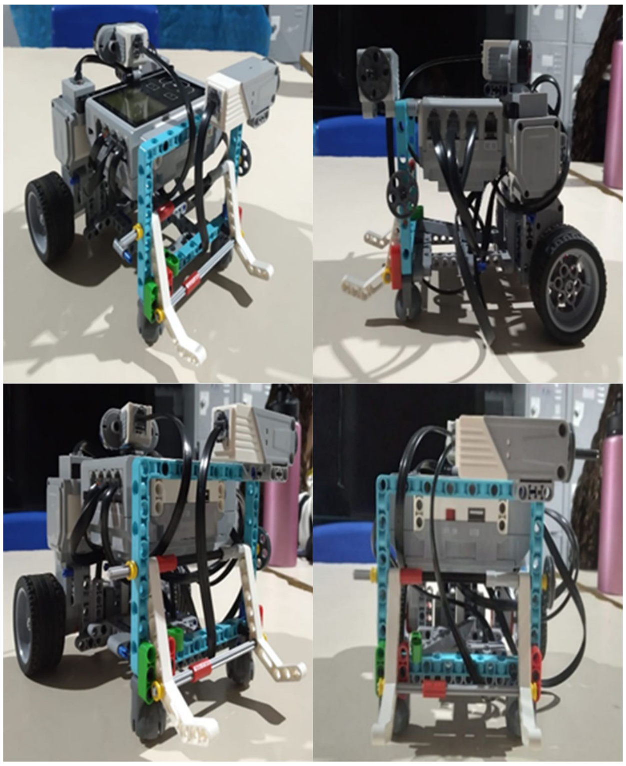

Figure 4. Robot 3 (Source: the authors)

The components used to build the robot include two EST motors, an EST medium motor, a LEGO medium frame and an ultrasonic sensor, as well as two color sensors. The robot's claw was designed to push the victim, and the programming was developed on the EST platform. Robot 3 from different angles can be seen in Fig. 4.

3.4. Robot 4

The construction of the robot began with the search for ideas and inspiration in YouTube videos, specifically in the Ecto 1 model made in LEGO. The Lego 9 3/4 team discussed the best model and made adaptations based on the pieces available in the Robotics Laboratory, reaching the conclusion that a more compact design would be more efficient. Two members focused on assembling the robot, but all team members contributed and helped in the process.

The assembly was carried out by all team members, with the purpose of focusing on teamwork and obtaining the maximum score from the evaluating table. They take advantage of breaks during recess and lunch to work together on improving the robot's design.

Figure 5. Robot 4 (Source: the authors)

Components used include: twenty small frames, one large frame, thirty-one beams, two plates/airfoils, twenty half bushings, two bushings, six shafts, one medium motor, two large motors, two color sensors, one ultrasonic sensor and four wheels.

The programming was carried out on the Spike platform, with the basic programming of the line follower, front and rear motors, and grippers already completed. However, the main schedule is still pending. When they face difficulties, the team seeks help from other teams. Robot 5 from different angles can be seen in Fig. 5.

Inside the Robotics Laboratory, students began programming the robots and carried out the first tests for adjustments. This environment provided the necessary infrastructure for the team to develop and refine their skills, allowing for experimentation and adjustments to the robots' programming as needed to optimize their performance.

An image of a robot after being programmed to follow a black line on a white surface can be seen in Fig. 6.

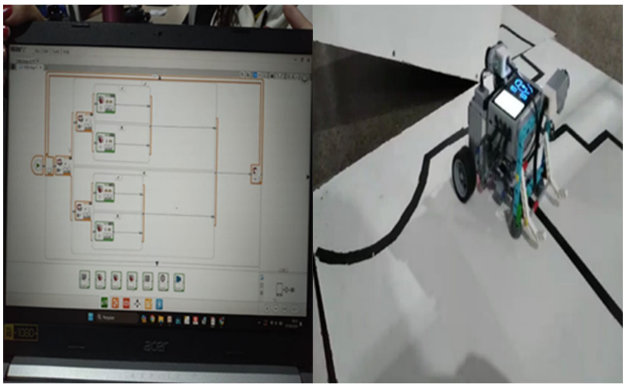

Figure 6. Programming and circuit (Source: the authors)

Even in the face of important results during the construction and programming of robots by students, there are limitations to consider, for example, the lack of financial and material resources can restrict the participation of public schools in robotics competitions, creating barriers to integration of this technology into the school curriculum [7]. According to this source, “The scarcity of resources in public institutions limits the inclusion of robotics programs, negatively affecting participation in tournaments and educational equity.”

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Furthermore, the lack of specific training for teachers in STEM areas compromises the effectiveness of tournaments as an educational tool. According to [8], “The lack of adequate training for teachers in technological areas can result in a superficial implementation of robotics tournaments, compromising their educational potential”.

Another challenge to be overcome is the excessive focus on competition, which can divert attention from educational objectives and generate stress among students, as pointed out by [9]: “The pressure for results and heightened competitiveness can generate an environment of anxiety, detracting from the learning experience.”

To overcome these limitations, it is essential to invest in continuous and specialized training for teachers, as highlighted by [8]: “Adequate training for teachers is crucial so that they can use robotics as an effective educational tool, enriching the teaching process and learning".

Furthermore, public policies that ensure access to robotics kits for public schools are essential so that technology does not become a barrier to educational inclusion. [12] emphasizes that “Effective public policies can facilitate the integration of robotics into the school curriculum, promoting an interdisciplinary approach and expanding access to technological resources”.

On the other hand, robotics tournaments offer promising possibilities, such as increasing student engagement and motivation. Educational robotics, according to [10], “significantly increases student motivation, improving engagement in Science and Mathematics subjects”. These tournaments also promote the development of essential skills, such as teamwork, problem solving and critical thinking, crucial for students' comprehensive education [11].

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On the other hand, robotics tournaments offer promising possibilities, such as increasing student engagement and motivation. Educational robotics, according to [10], “significantly increases student motivation, improving engagement in Science and Mathematics subjects”. These tournaments also promote the development of essential skills, such as teamwork, problem solving and critical thinking, crucial for students' comprehensive education [11].

By evaluating the limitations and exploring the possibilities of robotics tournaments, it is possible that their positive impact on the educational process can provoke students to invent themselves [1] in the face of future challenges, both academic and professional.

According to [15] “Ideas regarding the materialization of robots, which were unattainable in the past, have gradually become reality amidst the various scientific and technological transformations experienced by humanity in recent years. During this process, the definitions of what we can consider a robot grew stronger.”

Therefore, this world of educational robotics is being unveiled every day within classrooms, but there are still many challenges to be faced, many hypotheses will be raised and observations will be made to answer “What are the limits and possibilities of robotics tournaments for the teaching and learning process in Science and Mathematics?”

4. Final Considerations

The research is ongoing and involves the analysis of the actions and practices of students from two robotics teams from a state school in Goiânia-GO, during the 2024 school year. The analysis takes place in elective Educational Robotics classes, during training, preparations and participation in the practical competitions of the Brazilian Robotics Olympiad and the First Lego League, scheduled to take place between August and December 2024.

It is expected that, in addition to the partial results presented so far, the research will bring contributions about the limits and possibilities of robotics tournaments in the teaching and learning of Science and Mathematics. As a result, an interactive e-book will be created that will address these limitations and possibilities, in addition to providing information about the robotics tournaments available for public schools, including their stages and registration rules.

This e-book will also provide details about the main robotics tournaments held in Brazil, making it a useful resource for those interested in forming robotics teams in public schools. The material will offer guidance for teachers on how to form and train teams, the desired profile of students and the registration procedures and deadlines for school units that wish to participate in these events.

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Indigenous Food Context in Brazil's Midwest: Habit, Restriction, Imposition, and Food (in)Security of Indigenous Peoples of the Brazilian Cerrado

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Abstract. This work aims to highlight the food context of indigenous peoples in the Brazilian Midwest, which includes, among other things, plants, animals, songs, instruments, techniques, and rituals that have been maintained, modified, reintroduced, and even extinct in contact with non-indigenous people. Conversely, indigenous peoples have been subjected to restrictions, deprivations, impositions, changes, and food insecurity. The choice of the theme was influenced by the desire to reflect on the right to their own survival from the contexts of indigenous (sub)food in the Cerrado.

Keywords. Avá-Canoeiro, Indigenous Food Security, Karirí-Xocó.

1. Introduction

In the Brazilian Midwest, indigenous traditions and cultures from various regions of the country contribute to forming the cultural identity of the Cerrado biome and, by extension, its cuisine. However, this study notes that most indigenous peoples have been subjected to physical, moral, spiritual, and even dietary violence, including, among other aspects, restrictions, deprivations, impositions, changes, and insecurities related to eating. To emphasize this state of affairs, we present the dialogue lived with indigenous peoples in/of the Cerrado through meetings, conversations, and "readings" of indigenous texts, mostly oral and written by indigenous authors. These readings are represented by closely listening to the reports on the food context of the Avá-Canoeiro (Goiás) and Karirí-Xocó (Brasília), as well as the choice of academic publications that directly or indirectly address the food and dietary of these peoples.

This is, therefore, a work that dialogues with Brazilian indigenous knowledge, aiming to highlight elements of their food universe, such as consumed foods, preparation methods, instruments, and techniques used, as well as the context surrounding them, which includes songs and invocations present in food rituals, habits, stories, restrictions, modifications, deprivations, and food insecurities suffered in contact with non-indigenous people. We have, therefore, developed a knowledge base on the indigenous food context in/of the Midwest, considering the scarcity of works on the subject, as well as drawing attention to the diversity of more than 50 indigenous peoples in the Midwest region alone, including the Avá-Canoeiro, Tapuia, Karajá, Tapirapé, Javaé, Xambioá, Xavante, Xerente, Nambiquara, Terena, Kaiapó, Kaingangues, Bororo, Guarani, Suiá, among several others.

The intent is to report part of the authors' experiences with Brazilian indigenous peoples, aiming at a better understanding of the habits, techniques, choices, appropriations, modifications, impositions, restrictions, and (in)securities of the indigenous peoples of the Midwest. This experience is also about food and its contexts: songs, prayers, healing processes, traditional medicine, taboos, among other subjects of indigenous cosmology and its material and immaterial culture.

For the present research, 173 audiovisual files were handled, including 126 photos and 47 videos referring to the face-to-face experiences with *cacica* Tanoné Kariri-Xocó, the first female chief in Brazil. In addition, we compiled 13 audio recordings totaling about seven hours, as well as 88 visual files resulting from knowledge exchanges about the Avá-Canoeiro, conducted with professor and linguist Ariel Pheula do Couto e Silva, a scholar and speaker of the Avá language.

We have therefore organized a knowledge base on indigenous food practices in the Cerrado, based on oral and written literature from teachers, leaders, and indigenous authors, as well as consultations with academic documents such as master's and doctoral theses, scientific articles, monographs, books, videos, magazine texts, in addition to data analysis from government agencies such as the Brazilian Institute of Geography and Statistics (IBGE) and the National Indian Foundation (FUNAI).

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2. Indigenous Food in the Brazilian Midwest

According to the 2022 Brazilian Demographic Census conducted by IBGE, the Brazilian Midwest region is, after the North and Northeast, the region with the largest indigenous population. However, proportionally to its total population, it has the highest percentage of indigenous people. Due to the historical demographic representation of indigenous peoples in the Brazilian Midwest, the diversity of dishes and ingredients present in the region's cuisine also stems from contributions from indigenous populations. Indigenous habits were historically and geographically passed on to colonizers. Some dishes of indigenous origin, such as "peixe na telha" (fish on the tile) and "peixe com banana" (fish with banana), are common in the Midwest region, specifically in Mato Grosso. There are also dishes like roasted pacu stuffed with cassava flour farofa, common in Mato Grosso do Sul. Indigenous influence in food is also visible in dishes like "arroz com pequi" in Goiás, "mojica de pintado" in Cuiabá, and game meats such as capybara and paca, common in gourmet restaurants in Brasília, as well as piranha broth, common in Campo Grande, the capital of Mato Grosso do Sul. Cassava and its derivatives – flour, beiju, grolado, etc. – are considered the main staples of Brazilian indigenous food, including that of the Avá-Canoeiro, Tapuia, Karajá, and Karirí-Xocó in Goiás. But for many other peoples, like the Xavante in Mato Grosso, the staples of their cuisine also include corn and sweet potatoes.

Geographical characteristics greatly influence the development and consolidation of how food is produced. The way of eating depends on the environment where the indigenous people live, and for this reason, different indigenous peoples have different hunting and fishing techniques. Indigenous peoples of the Upper Rio Negro typically hunt *paca*, peccary, monkeys, and birds like the curassow. The Xavante, who inhabit the Midwest, hunt emu, paca, and capybara.

As might be expected, proximity to non-indigenous people has caused changes in the diet of peoples in the Midwest. Among the Paresí people in the municipalities of Tangará da Serra and Conquista D'Oeste in Mato Grosso, cassava and its derivatives, such as beiju, as well as the collection of fruits like *mangaba* and *pequi*, hunting, and fishing are still the main sources of food. However, in recent decades, processed foods such as soft drinks and cooking oils have become part of their diet, leading to diseases that were previously non-existent in the villages.

3. Food (in)Security of Indigenous Peoples in the Brazilian Midwest

Empirical studies and fieldwork serve to demonstrate the influence of non-indigenous people on the change in dietary habits of various indigenous peoples in the region. In one of these studies, the food security situation of the Teréna people in the Água Azul, Olho D'Água, and Oliveiras villages in Mato Grosso do Sul was described, based on an investigation of 49 families with children under 5 years of age. Information was obtained on income, family density, maternal education, and children's food consumption. It was found that the prevalence of families with some degree of food insecurity reached 75.5%, with 20.4% experiencing severe insecurity, 32.7% moderate insecurity, and 22.4% mild insecurity. A large part of the families (67.3%) lived in fear of running out of food. A quarter of the women interviewed reported having experienced hunger in the month prior to the interview, and 14.3% said the same occurred with the children in the house. More severe situations of food insecurity were observed in families with lower per capita monthly income, lower maternal education, higher household density, larger number of children per family, and whose children's diet was insufficient, especially in protein and iron. The access to food by this population does not mean that such families are effectively protected. Even for those who perceived themselves as secure (around 25%), there is still the possibility that they are being maintained by receiving food baskets, which perpetuates dependence on emergency actions that tend to become permanent, not to mention that the distributed food does not correspond to this population's eating habits, and its quantity is not compatible with the average family size.

A study conducted in 257 households in the Bororó and Jaguapirú villages in the Dourados indigenous reserve (Mato Grosso do Sul) on Food Insecurity among Indigenous Families in Dourados found that, in the past, these peoples

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depended on agriculture, hunting, fishing, and gathering for their subsistence, but after contact with non-indigenous people, their food practices, techniques, living, and health conditions were transformed. They began to consume processed foods such as sugar, oil, bread, biscuits, and canned goods. There was an increase in the consumption of carbohydrate, fat, and sodium-rich foods, and a decrease in the intake of vitamin, mineral, and fiber-rich foods, leading to diseases previously uncommon among indigenous populations, such as diabetes and high blood pressure.

In the Kuikuro village in the southern part of the Xingu Indigenous Park in Mato Grosso do Sul, Professor Pioni Atsua Kuikuro] reached a similar conclusion when conducting research with elementary school students and leaders of that people, resulting in the publication of material on traditional foods and industrialized foods in the Kuikuro community. The reports explain that in the past, this people only consumed traditional foods such as roasted fish, beiju, and cassava broth. When non-indigenous people introduced industrialized foods, these became widely consumed, especially by children and young people. Sometimes at school, they reject traditional foods in favor of industrialized foods. This has resulted in the appearance of the same diseases observed among the Bororo and Jaguapirú peoples.

Several authors highlight that proximity to non-indigenous people results in another problem for indigenous peoples. By altering their food tradition, an important element of oral culture passed down through generations in these peoples, there is a risk of losing the ability to transmit their knowledge, including food habits, techniques, and management, to future generations, especially in peoples considered on the brink of extinction, like the Avá-Canoeiro.

In well-known research, which deals with Socio-Diversity, Indigenous Food, and Nutrition, it is observed that in many indigenous areas, hunting or fishing is no longer possible. In others, agriculture has become difficult because the small size of the reserve territory does not allow the land to rest for the next planting, as is the case with the Guarani in Mato Grosso do Sul.

In other cases, such as with the Xavante in Mato Grosso, the indigenous people regained their properly demarcated lands, but these had already been so exploited by colonizers that they are not suitable for cultivation according to indigenous production methods. The Xavante were forced to adopt non-indigenous practices with some mechanization, use of fertilizers, and pesticides.

The presence of non-indigenous people brought among the Karajá Xambioá, residents of the banks of the Araguaia River in the states of Goiás, Tocantins, and Mato Grosso, a strong impact on their eating habits, setting aside traditional foods. Agencies that should protect indigenous traditions have a share of responsibility in this. There was an encouragement at some point by FUNAI for the indigenous people to stop cultivating traditional foods as they brought food from the city. As a result, the indigenous people stopped planting. Today, many traditional foods no longer exist, and there are foods that children do not even know.

According to several authors, the main foods of the Xambioá were sweet potato, yam, cassava, and fruits like watermelon and banana. In the summer, they migrated to river beach areas where they planted quick-harvest foods like cassava and yam, with which they made flour, dough, puba, and grolado (cooked dough of carimã or puba) to eat with fish, turtle, and wild game. In the winter, they all returned to the village as the rivers flooded the beaches. During this period, the diet consisted of corn, banana, game, and fish. Since the 1960s, however, significant changes have occurred in the lives of the Xambioá with the first marriages to non-indigenous people. Other types of food were planted, such as beans and rice. Beef, salt, and pasta were introduced into their diet.

Several types of typical dishes of the Xambioá people's traditional diet ceased to be practiced, such as eating roasted or cooked monkey, cooked white stingray, or cooked or roasted chameleon. All these foods were prepared without any seasoning. Currently, some traditional foods are still consumed by the people, such as (a)cari-irabese, cari-preto, cari-da-praia (freshwater fish that live at the bottom of rivers, common in the Paraná River, also known as 'cascudo').

With the Xavante from the Nossa Senhora da Guia-Hu'uhi village, located in the São Marcos

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Indigenous Territory in the municipality of Barra do Garças, Mato Grosso, something similar occurs, as described by elementary school teacher Romano Tsorodadze Tserenhe'Omo. In the article "Change of Dietary Habits among the Xavante", he explains that after contact with non-indigenous people, FUNAI began to help with the health of local indigenous people and introduced rice production. Subsequently, industrialized foods brought from the cities, as well as pork, beef, and chicken with the use of salt, became common. Rice became the main food consumed by all the Xavante. In this sense, the elders call the young 'the rice-raised beings.' Instead of traditional foods, they now also eat sweets, biscuits, porridge, milk, coffee, caramel, and soft drinks, in addition to consuming alcoholic beverages.

4. Avá-Canoeiro Food Contexts

Contact with non-indigenous people had a great negative impact on the survival of the Avá-Canoeiro (Goiás and Tocantins), affecting their social structure and interfering with their cultural, dietary, and behavioral habits.

During the construction of the Furnas Hydroelectric Plant between the late 1950s and mid-1960s, the presence of the Avá-Canoeiro at the construction site, where they obtained food and alcoholic beverages from the workers, posed risks to their physical integrity, as reported by Cristhian Teófilo da Silva.

In the late 1980s, the indigenous people used to visit non-indigenous people only in pairs, with the indigenous Iawi (now deceased) being a constant presence and the one to whom everyone attributed the initiative and interactivity of the meetings. Nakwatxa (also deceased) was seen as the most "withdrawn" and reluctant to engage with non-indigenous people, and Tuia, a girl, was subordinate to the decisions of the others. The visits resulted in the acquisition of tools, sugar, coffee, and tobacco, as well as ready-made or cooked foods, which they used.

In the early 1990s, the head of the FUNAI post (Walter Sanches) mentioned that, in addition to food and utensils, the Avá-Canoeiro received bottles of cachaça and cans of oil, which they consumed raw; they had access to the leftovers from the canteens at the construction site, which they scavenged for food. The Avás also had access to gas cylinders, refrigerators, and stoves, with food contamination being common, as well as the consumption of still-frozen food and soft drinks.

It is reported, that the diet of FUNAI employees and the Avá-Canoeiro consists mainly of rice, beans, and fried dried meat with pieces of fat. Vegetables such as cassava, carrots, pumpkin, among others, are mixed into the rice. Alternatives to fried meat included fish, eggs, chicken, and sausage. The meals were also accompanied by pasta, juices, and fruits.

Despite their dependence on FUNAI's food supplies, the members of the group still maintained remnants of their original dietary habits. According to several authors, Nakwatxa had more diverse eating habits, preparing young japi (a bird known regionally as João-Congo) and armadillo to eat after a quick cooking and cleaning of the innards. It is explained that there are expressions of disgust toward certain animals being treated as food, but only on rare occasions did the author of the account observe the indigenous people refusing them. The animals considered smelly and therefore unsuitable for consumption include capybara, alligator, deer, jaguar, wolf, and snake. As for the preparation of hunted animals, they were roasted and kept nearly burned over the fire or wood stove, where the Avá-Canoeiro would scrape off meat, bones, organs, and marrow until the entire animal was consumed.

Researcher Lorranne Silva, who works with the Avá-Canoeiro, notes that the indigenous people are aware of the fragility of their position as unilateral "recipients" of goods and the partial dependence they develop on the employees from that moment on. The only guarantee they have of being attended to lies in their ability to charm the white people. The fact that they have to wait for employees to replenish their pantry, cut trees for a new field, treat small wounds, and the irritation demonstrated at the scarcity of medicine and industrialized foods, or the reluctance to help them with any task, reveals their awareness of their subordination to the will of non-indigenous people.

The traditional foods that are part of the group's diet include: cassava, corn, rice, beans, peanuts, coconut, pineapple, sweet potato, pumpkin, yam, honey, banana, papaya, and

Cerrado fruits (such as mangaba, pequi, araçá, baru, buriti, cagaita, cajuzinho, embaúba, gabiroba, ingá, jatobá, jenipapo, marmelada, murici, mutamba, among others). Among the hunted animals are: tapir, bush dog, capuchin monkey, coati, collared peccary, capybara, tapiti, agouti, peccary, paca, tegu, among others. Due to their nomadic lifestyle to escape persecution by non-indigenous people, the Avá-Canoeiro's diet was significantly altered.

Unable to plant crops, with little hunting, fishing, and gathering, during times of flight, they resorted to eating cattle, pigs, chickens, bats, hummingbirds, rats, and various other animals found in the area where they settled. Honey was still a food collected in the Cerrado and used by them. It is noted that forced dietary changes highlight the physical limits they endured to carry out intense displacements, stemming from the need to survive. As a result, there was an even greater introduction of industrialized foods. The use of oil, sugar, coffee, biscuits, soft drinks, pasta, among others, is significant and has impacted the health of the Avá-Canoeiro, leading to the emergence of diabetes, high cholesterol, and obesity among the members of this group.

Linguist Ariel Pheula do Couto e Silva, in his "Contributions to the Knowledge of the History of the Avá-Canoeiro Language and Culture," states that the Avá-Canoeiro were/are "for a long time deprived of their right to mobility and access to food security, as in a state of captivity, what they planted had to be shared with other indigenous people." Additionally, regarding changes in planting and hunting practices in contact with non-indigenous people, the surviving group no longer had the ability to maintain the traditional Tupí-Guaraní agriculture, which included planting cassava, corn, sweet potato, and peanuts, and began to rely mainly on gathering, hunting, and fishing. It has been known since the first reports about the "Canoeiros" how they collected in farms—both utensils and tools, as well as corn—and how they customarily hunted, especially seeking horse meat.

Some foods had a significance beyond their consumption, such as pequi, as highlighted by Ariel Silva regarding how this fruit marks "temporality" for the Avá-Canoeiro (dry and rainy seasons), along with other elements of nature such as insects and other fruits. According to this author, Avá-Canoeiro temporality would be marked by the observation of the relationship between the state of existence of one object or the occurrence of an event and the state of existence of another object or the occurrence of another event. For example, a medium-sized pequi would indicate the planting period for corn, as it would signify a higher frequency of rain and sufficient water in the soil; while the consecutive existence of four different types of cicadas, along with the appearance of certain types of fruits, would indicate the progression of the rainy season.

Regarding an Avá-Canoeiro and Tapirapé food taboo, both from the Brazilian state of Tocantins, and the relationship between food, pregnancy, and the physical development of a child, Ariel Silva highlights the importance of the mother for the "proper formation" of the child in her womb. A recent case of a baby born from an interethnic marriage between an Avá-Canoeiro woman and a Tapirapé man is cited: when born with a cleft lip, the father commented that the mother had violated a taboo regarding the handling of fish. The relationship of the pregnant wife with the fish was believed to have affected the nature of the child. After learning that surgery would "adjust" the child's body—the upper lip and the roof of the mouth would be sutured—the parents began to accept her.

Regarding the intercultural food taboos of the Avá-Canoeiro and Tapirapé and changes in food practices, instituted even by "survival food", it is noted that in addition to the contact with hunting and the effects of breaking their restrictions, both the Avá-Canoeiro of Tocantins and the Tapirapé underwent re-significations in their food taboos, adopting, due to food scarcity in the case of the Avá-Canoeiro, and due to intense contact with the Karajá in the case of the Tapirapé, other types of animals in their hunting preferences. In this way, within the relationships between Avá and Tapirapé, the Tapirapé are sometimes highlighted as "those who eat terrapins," and the Avá-Canoeiro of Tocantins are highlighted as "those who eat bats."

5. Summary of Discussions with Professor, Researcher, and Linguist Ariel Pheula do Couto e Silva, Avá-Canoeiro Language Speaker

Between May 8th and 10th, 2024, we interviewed Professor Ariel Pheula do Couto e

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Silva from the Institute of Letters of the University of Brasília in Pirenópolis. He used audio capture with a total average duration of seven hours, from which the main excerpts were synthesized as follows.

In 2012, Professor Ariel began working with the Avá-Canoeiro indigenous people, and by 2013, he was proficient in the language of this people. As a result, he was requested by the National Indian Foundation (FUNAI) and the Special Secretariat of Indigenous Health to act as an interpreter in the Avá-Canoeiro language and to disseminate their culture, contributing to the guarantee of their rights to interculturality, food, and health.

According to his report, the Avá-Canoeiro were a gathering and hunting group. Before the massacre that occurred in the 1950s/60s, perpetrated by land invaders, they had knowledge of cultivation habits, including the ancient Tupí-Guaraní technology that used a stick the size of a forearm driven into the ground in cassava fields, allowing it to be planted as a cutting.

After the massacre, the Avá-Canoeiro could no longer maintain cultivated areas. In 1983, after the FUNAI contact, its immediate policy was to encourage the planting of fields and producing surplus for sale. "It was interesting to see the Avá planting rice. It was neither necessary nor part of their traditional culture," says Ariel, remembering that they had no habit of storing, much less selling products. Since they suffered a significant population reduction due to the massacre, the small remaining group could not manage large fields.

The Avá-Canoeiro are good gatherers and hunters. Gathering is extremely important to them. It was done during walks along trails to see if they found traces of any game (*mae*). They observed gathering reference points for fruits and seeds (*ayna*), but also took the opportunity to maintain an understanding of time. The concept of time is related to food because it has to do with the moment of abundance of a certain food.

In the Avá-Canoeiro language, there is a word that pertains to the existence of something in abundance (*oikupakato*). It is from this concept that they carry out food gathering in nature. In an area with a lot of fruit, they gather (*wega*, literally "take with oneself") only enough for themselves and their family for about two days because they know that they can return and gather more. It doesn't make sense to take more fruit to store and spoil. They take only what is needed for consumption and leave the rest on the tree for the birds and other animals. On the next gathering, they might also find an animal to hunt.

The fact that they gathered food in "places with abundance" on farms was interpreted differently by the farmers. In the cornfields (ïi), the indigenous people were accused of theft. The concept of theft does not exist in small societies where everyone knows each other. If someone takes something of yours, you know who and where it is. There is the concept that if someone took something from another person, you can negotiate and make an exchange. If there is a cornfield, in the Avá-Canoeiro's concept, that food exists in abundance, and therefore it can be gathered, but not all of it. The same goes for cattle (*tapilete*, literally "true tapir"). If there is abundance, they can gather and hunt enough to eat because for them, there is no "mine," only the collective. The walks are fundamental. They will provide gathering and hunting opportunities.

Before the massacre, they planted fields (*ko*) using the technique known as coivara, a term of Tupí origin that means "to grab the sticks from the field." It begins with burning the superficial forest to prepare the soil for planting. The land is used for 10 to 20 years, then they leave the place and open a new field elsewhere. With each change, they move closer to the new field, creating villages. This indigenous planting technique is still used today by traditional communities and river dwellers.

According to Professor Ariel, the massacre prevented the updating of knowledge about the Avá-Canoeiro. During the period of flight, they changed their habits and traditions. Gathering and hunting, which were men's functions, became women's functions because the only surviving man was a child who took over cooking, a task usually done by women.

They also changed the time and manner of gathering and hunting. They started gathering and hunting at dusk, hunting small animals, and

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eating nocturnal birds and small rodents. In the same way, they changed the time to make fire for food preparation to dawn, when it begins to get light, and the sun has not yet appeared. As it is cooler, the smoke stays low due to the temperature. At these times, no one can detect their presence.

The way of cooking food was also lost, such as the practice of smoking, as it is a lengthy process. Fishing was also lost. Women stopped making clay pottery and began using basketry utensils made of vine, which are lightweight and facilitate the collection of raw materials at night.

Some beliefs still persist despite everything, such as the case of associating certain animals or natural phenomena with diseases. For example, when a seriema (*agakuga*) sings, they do not leave the village, not even to hunt or fish, as it is a prelude to something bad; when there are many frogs (*juí*) singing, they must take precautions, such as avoiding bathing at night, as the frog's spirit can enter them and leave their body cold, requiring the shaman to perform a ritual to expel the entity and cure the illness; the alligator (*xigamana*) has a powerful entity that enters the person's body and also leaves them very cold, making it difficult to remove the illness. If a pregnant woman fishes, cleans, or eats fish, the child is born with a fish mouth (cleft lips). A lunar or solar eclipse is also a prelude to bad things that may happen.

The Avá-Canoeiro's diet changes according to how they lived before the massacre, during the times of survival flight, and after contact with non-indigenous people. This time is very important to explain how the Avá will deal with food: preparation times, types of preparation, and the foods they will have access to, what they will hunt and gather. Today, something that becomes important for the Avá-Canoeiro is preservation for stockpiling, which is uncommon among indigenous peoples, especially since it is unnecessary as we do not have cold winters.

The smoking technique was used before the massacre, but it was lost during the period of flight, when they began using a simpler technique similar to roasting (*apypay*), like the traditional Brazilian barbecue. After contact, they began preserving food in oil on top of the wood stove. They use this same process with pequi.

They also use meat drying, placing it on a kind of clothesline, which is in the route where bees (*eila*) and a wasp called *cabutrio* or "carnivorous" pass by: the bees and the wasp suck all the liquid from the meat, doing this faster than the fly, so the meat does not rot. This process is done with meats and sausages. Bees are important because, in addition to preserving meats, they extract honey (*eilaty*) from them, which serves as both medicine and food. They also use honey from a wasp called enxu.

After two centuries of persecution culminating in the massacre of the people, fishing ceased to be practiced. Planting was also abandoned after the massacre, only returning after contact and with great effort by FUNAI. When the Avá made contact with FUNAI in 1983, their lands were recognized and officially demarcated in 2023. In a way, the Avá-Canoeiro indigenous land is a protection area for the hydroelectric plant, as it prevents people from fishing at the dam. Right from the first village, the idea of introducing rice planting, which was FUNAI's policy, began. This planting caused losses for various other indigenous peoples, such as the Krahô and the Xavante, because they replaced traditional crops with rice.

After contact, the Avá-Canoeiro maintain small fields (*ko*), small crops, and little hunting. With the construction of the Serra da Mesa hydroelectric plant, they have free access to the Furnas Hydroelectric Plant post, where they obtain oil, salt, sugar, and a whole range of non-indigenous food. Due to this free and unrestricted access, diseases such as hypertension and diabetes have emerged. Today, Professor Ariel states, there is a conflict between agencies and institutions regarding how to support the Avá-Canoeiro. This conflict of interest hinders the members of the group from accessing the royalties provided by Furnas, which prevents the purchase of food, clothing, and medicine.

6. Kariri-Xocó Food Contexts: Dialogue with Ivanice Tanoné, Leader of the Kariri-Xocó

Between August 26th and 28th, 2023, at Toca Vó Quirina, in the rural area of Uruaçu, Goiás, we had a dialogue with Ivanice Tanoné Kariri-Xocó, the first female cacique (chief) in Brazil. Information and records of stories told by

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her indicate that she was born in the state of Alagoas. Today, Tanoné lives with over 70 people of her people in the northwest region of Brasília, the Federal Capital of Brazil, in an area known as Terra Indígena do Bananal, which was recently recognized. Tanoné is one of the few female indigenous leaders in the country.

The cacique speaks of the importance of passing on the teachings she learned from the elders to the younger generation, including the preparation of food and the healing of diseases. Among the Kariri-Xocó, knowledge is passed orally from the elders to the younger ones.

She reported that, despite the growing consumption of industrialized foods, traditional dishes are still widely used. For example, beiju made with starch and grated coconut; corn couscous accompanied by goat's milk, used for breakfast; roasted fish and fish with sauce made with coconut milk, tomatoes, and cilantro, accompanied by pirão (a type of porridge made from cassava flour); feijão-de-corda and feijão-de-arranco; and rice pudding cooked with cloves and cinnamon, served in the morning or at night. The men take care of the planting in small fields (cassava, corn, feijão-de-corda, feijão-de-arranco, sweet potato, etc.), tend to small gardens, and raise chickens, ducks, and goats.

In the past, Tanoné recounts, the Kariri-Xocó fed entirely on game meat, fishing, and the planting of small-scale crops. The planting of cassava was shared by men and women. The men dug the holes in the ground while the women placed the seeds and seedlings. Fishing was a collective activity. The men fished in the middle of the river, and the women from the riverbank. The food was and continues to be processed in clay pots and containers made by the women. The dry wood collected by the men is used for the fire.

During the menstrual period, she explains that the young woman cannot plant because if she does, the field "will be ruined by caterpillars." They are only allowed to plant three days after the menstrual cycle. In confinement, after the child is born, the woman eats a lot of pirão made from cassava flour. This teaching is passed down by the elders.

But things changed, according to Tanoné, with the proximity to non-indigenous people. "They built a road through the middle of the colony (indigenous land), where the extensive field was planted, and the area became insufficient for the planting that fed the entire village. The solution found was to create small, discontinuous fields, and as they were insufficient, we started going to the city to buy mainly rice and beans," Tanoné reports.

Today, the Kariri-Xocó still have small gardens where they plant vegetables, pumpkins, sweet potatoes, macaxeira, watermelon, feijão-de-corda, feijão-de-arranco, corn, tomatoes, and herbs. The cacique explains: "I try to maintain a healthy diet as I learned from my mother and grandmother. But I worry because the young people eat city food, like soft drinks and sugary products." She fears that this diet will bring diseases like diabetes and high cholesterol, reducing their lifespan. "I fear they won't have the lifespan and quality of life of my mother, who is 97 years old today."

Despite living with non-indigenous people, Tanoné asserts that the traditions of her people will never end. The non-indigenous can enter the village, but she does not renounce her culture and the millennial heritage passed down by her ancestors. No matter how much she respects non-indigenous culture, having to live with it, Tanoné has been maintaining her traditions and respect for the Great Spirit in the village. Indigenous culture continues and is passed on to the younger ones so that it is not forgotten. Tanoné observes that "in the past, young people listened more to the elders. Today, it is difficult to make young people keep the tradition. We are losing our culture to the media. That is why it is important to be resistant with our beliefs, languages, customs, and cultures."

During the experience, while preparing a meal of roasted fish at night, Tanoné sang the Toré, a very important ritual involving singing, dancing, and religiosity, common to several indigenous peoples of the Brazilian Northeast, including the Kariri-Xocó, part of whom migrated to the Midwest in search of better living conditions, settling mainly in Brasília.

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7. From the Canoe(ing) to Here: Some Considerations

The study conducted is the result of intercultural experiences with indigenous peoples of the Cerrado and leads us to realize that, for survival, habits were changed in a history of violence—territorial, physical, spiritual. The dialogues established—of both approach and conflict—lead to the understanding that indigenous peoples, involved in processes of violence, either attempt to (re)approach their indigenous identity or distance themselves from it, likely as a survival and existence strategy in the world.

If the way indigenous peoples eat is an expression of their territoriality, which in many cases resists so many historical processes of exploitation, extermination, or integration, as well as their songs, dances, and customs, as several authors discusses in "food as heritage" within the context of indigenous school education, it is imperative to recognize the pressing need for consistent public policies aimed at ensuring the integrity of their culturally situated reserves—both spatially and in terms of preserving rivers and forests, and consequently, their food.

In this aspect, living on their lands and having self-determination to conduct their way of life is a right of indigenous peoples. They have their own histories, knowledge of nature, deities, cuisine, a classless organization, ancestral knowledge passed down orally from generation to generation. Unfortunately, indigenous peoples are not regarded as full Brazilian citizens.

Historically, indigenous peoples are marginalized, either by being excluded from decisions about their own social organization and means of expressing and surviving in the world or by being marginalized in terms of their food.

In an interview with a TV channel in 2023, the environmentalist, writer, and philosopher Ailton Krenak—the first indigenous person elected to the Brazilian Academy of Letters—offers a clue about what might underlie the treatment given by the Brazilian state to indigenous peoples. In his view, an important aspect differentiates the way of life of these peoples and that of non-indigenous people. It was observed that, for the former, water is a natural resource, while for indigenous people, water is an entity of nature, a living being. For non-indigenous people, nature is a source of natural resources; for indigenous people, nature is life. Krenak concludes that such different worldviews lead non-indigenous people to treat indigenous peoples as inferior beings, incapable of extracting the economic potential from nature. This dominant view, according to him, fuels the barbarities committed against indigenous peoples in Brazil, ranging from the imposition of religions foreign to them, the expulsion from their own lands, to genocide, as recently occurred with the Yanomami and, in the recent past/present, with the Avá-Canoeiro.

In the article "The Mutilated Citizenships" (from the collection The Prejudice, São Paulo, USP, 1996-1997), the geographer and writer from Bahia, Milton Santos, arrives at a conclusion similar to Krenak's and also makes a similar correlation for the relationship between whites and blacks in Brazil. In a country where the middle class rejects citizenship and the poor cannot aspire to it, the "mutilated citizenship" of blacks is observed, whether in work, remuneration, the place where they live, access to basic rights, or the treatment they receive from the police and the justice system. They are seen, like indigenous people, as second-class citizens, deprived of individuality. This, according to the author, is at the root of racism.

Here, we can speak of "racisms" concerning indigenous peoples, whether institutional, territorial, linguistic, cultural, or even dietary, as is the case with the Avá-Canoeiro, subjected to "survival food."

In Milton Santos' understanding, "natural resources" are exploited by corporations dominated by whites, including in indigenous lands; meanwhile, blacks and indigenous people do not even have access to the essential conditions of life, to social services. Indigenous people, like blacks, do not make progress in their condition as a social group. "Globalization" expels other techniques, other knowledge, other ways of being in the world. Indigenous people, Milton Santos points out, are treated as "nature," not as human beings. There is confusion between the "ecological cause" and the "indigenous cause," which "folklorizes" the situation of these peoples.

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The question remains: how can this research contribute to the lives of the Avá-Canoeiro and Karirí-Xocó? Even in a small, localized, and incipient way, the next step would be to rework this study, especially the word lists and lexical sets from these peoples' universe, and to propose, together with them, the creation of a small illustrated encyclopedic dictionary, divided by Avá-Canoeiro and Karirí-Xocó socio(inter)cultural contexts.

8. Acknowledgements

We thank all the nearly 300 Brazilian indigenous peoples who fight for their existence in the world.

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Linear Regression Model to Study the Factors Affecting COVID-19 Mortality in 21 European Countries

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Abstract. The current research concerns data analysis with machine learning techniques using python programming language. More specifically, factors such as GDP per capita, median age, percentage of smokers, prevalence of diabetes and cardiovascular disease, are being studied in 21 European countries for their effect on mortality from COVID-19 with the help of a linear regression model. The dataset used in this research comes from ourworldindata.org and it covers the period from the end of January 2020 to September 15, 2022.

In the first part of this study, the correlation of stringency index with deaths from COVID-19 is analysed and the results show that 12% of total deaths per million is correlated with the index, while new deaths per million is correlated by 15%. In the second part, a linear regression model is constructed for the analysis of the abovementioned factors. In conclusion, the model explains 14.9% of total deaths per million from COVID-19.

Keywords. Data Analysis, COVID-19 Mortality, Linear Regression, Machine Learning, Stringency Index.

1. Stringency Index

The COVID-19 Stringency Index is a measure of the severity of government policies implemented to control the spread of the disease. It is based on several indicators, such as school closures, travel bans and workplace closures [3].

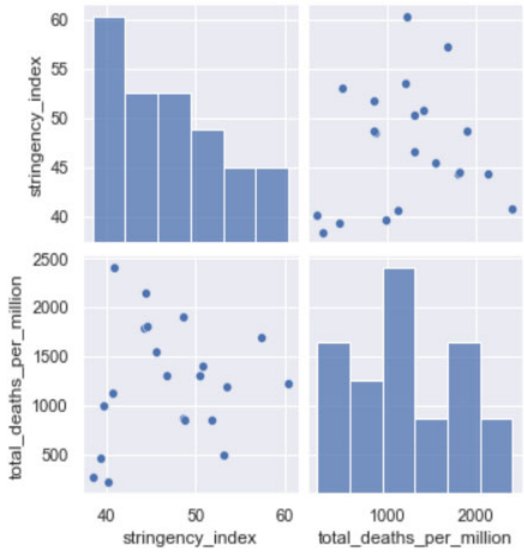
2. Data

They have come from various sources such as John Hopkins University in the USA, WHO and ECDC. They consist of 216,816 records and 67 variables and concern 243 countries and regions. Each entry is for one day and one country/region.

3. Correlation of stringency index and deaths from COVID-19

The methodology followed is as follows:

- 21 European countries are examined, more specifically Finland, Denmark, Switzerland, Norway, Sweden, Hungary, Belgium, Czech Republic, Slovakia, Poland, France, Ireland, United Kingdom, Netherlands, Portugal, Spain, Germany, Cyprus, Austria, Italy and Greece.
- The stringency index average is calculated for each country
- For each country the average of total deaths per million is calculated (total deaths per million)
- For each country, the average number of new deaths per million (new deaths per million) is calculated
- Finally, a comparison is made between the mean of the stringency index and the means of the two other variables respectively.
- The results are as follows: The correlation of new deaths per million with stringency index is 0.15. Similarly, the correlation of total deaths per million with stringency index is 0.12.



There is correlation between the index and deaths from COVID-19, but small, which contradicts the literature, which reports a strong correlation [8]. The different results of the present study are explained by considering a much longer period, with a large spread of the virus and large variations in the stringency index, thus its small impact on deaths from COVID-19.

4. Multiple linear regression model

Data from 21 European countries are analyzed and the factors under consideration are: gdp per capita, median age, diabetes prevalence, cardiovasc death rate and smokers. The model is built using multiple linear regression of the Statsmodels python library.

First, the data are cleaned, grouped by month and the average of each variable is found. The model that was built concerns all 21 countries and not each country separately. Finally, the data are normalized.

From the results, it follows that the model is statistically significant, as the probability of the null hypothesis (H0), given by Prob (F-statistic) = 4.85×10^(-17), is very small. The R2 index, which shows how correlated the dependent variable total deaths per millions is with the linear combination of the independent variables, is 0.149.

With the help of the P-value, at a confidence level of 5%, only the variable smokers have a P-value = 0.823 > 0.05 and is removed from the model. It is run again with the remaining variables and remains statistically significant as Prob (F-statistic) = 9.58×10^(-18). The R2 index remains at 0.149. In this model, all variables are statistically significant at the 5% confidence level.

The conclusions drawn are the following:

- The variable gdp per capita has a negative effect on the dependent variable (total deaths per million) with a coefficient of -918.157.
- The media age variable has a positive correlation with the dependent variable, with a coefficient of 397.002.
- The diabetes prevalence variable has a negative effect on total deaths per millions, with a coefficient of -794,899.
- The cardiovasc death rate variable has a positive correlation with the dependent variable, with a coefficient of 876.124.

5. Conclusions

GDP per capita was found to have a negative effect on total deaths per million. Richer countries therefore have the ability through advanced infrastructure and systems to limit mortality from the COVID-19 disease. The variable median age has a positive effect on the dependent variable. Therefore, countries with an increased median age of the population are more vulnerable to deaths from COVID-19. In addition, the prevalence of diabetes in the population has a negative impact on total deaths per million, which is unexpected as the sources report diabetes as a major cause of disease burden. The variable cardiovasc death rate has a positive effect on the dependent variable, which also results from the literature.

In conclusion, the model explains 14.9% of mortality from COVID-19. This finding is very important, because it demonstrates that non-health factors (GDP per capita, median age) also affect deaths.

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Gamification as a Methodology of Active Learning in Biology Teaching

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Abstract. The increasing integration of gamification as an active approach, through the incorporation of playful elements in the teaching-learning process, has triggered significant changes in basic education. The article discusses the perceived advantages, the challenges faced and the strategies for implementing gamification in Biology teaching, highlighting its transformative potential in education. The research, based on bibliographic investigations, collected qualitative data through online questionnaires produced on Google Forms, applied to basic education professionals (teachers and pedagogues). The results show that gamification can promote student engagement, reveal improvements in the understanding of content related to natural sciences and contribute to the development of cognitive skills and abilities. As highlighted by general competency 5 [1]. Understand, use and create digital information and communication technologies in a critical, meaningful, reflective and ethical way in different social practices (including school practices) to communicate, access and disseminate information, produce knowledge, solve problems and exercise protagonism and authorship in personal life and collective.

The research indicates that 80% of teachers and pedagogues interviewed consider gamification in teaching Biology to be a very effective approach, especially when combined with other methodologies that enhance the teaching-learning process, thus providing a more stimulating and collaborative learning environment [2]. According to respondents, gamification as an active methodology facilitates the personalization of teaching for students with different learning paces and skill levels [3]. Furthermore, 30% of respondents see gamification as a promising strategy for increasing student participation and interest, highlighting its potential to transform the educational environment and engage students in a more meaningful way. The study demonstrated that the gamified approach goes beyond the mere transposition of content into a game format, providing an interactive environment that simulates real challenges, opposing traditional teaching seen as outdated by students and teachers [4]. Elements such as scores, difficulty levels and rewards contribute to creating a healthy competitive atmosphere, motivating students to overcome obstacles. This strategy even transcends the virtual environment when applied in the real world, in the classroom in analog contexts [5].

Data analysis highlights the need for curricular adaptation to address the needs of the world of work and contemporary society, where gamification emerges as a bridge between the academic environment and the everyday reality of students [6], acquisition of technological resources and provision of teacher training that seeks the integral formation of the student. Therefore, it is essential that the teacher recognizes the importance of teaching methods that not only promote content mediation, but also stimulate curiosity, reflective criticality and cooperation between those involved in the teaching-learning process [7]. Investing in strategies that effectively integrate gamification into the curriculum can not only revitalize the educational process, but also cultivate students' lasting interest in science.

Keywords. Gamification, Active Learning, Teaching Biology, Student Engagement.

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Exploring Active Methodologies in Science, Cultural Diversity and Environmental Education

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Abstract. In Brazil, the debate on Cultural Diversity, the Nature of Science (NOS), and Active Methodologies has intensified over the past few decades. These topics cannot be overlooked when considering the needs of both teachers and students at all educational levels. Educational institutions are part of society, and teachers will inevitably encounter controversial issues. Latin America, and specifically Brazil, is a region characterized by a population with diverse ethnic backgrounds, creating a society with significant cultural diversity. Historically, culture has often been used to exclude "the Other," as seen in examples like the enslavement of Black people and the marginalization of the poor.

Understanding science requires grasping what is referred to as the "Nature of Science" (NOS). It is understood as a set of elements that address the construction, establishment, and organization of scientific knowledge. Internally, it includes the scientific method and the relationship between experiment and theory. Externally, it involves social, cultural, religious, and political factors that influence the acceptance or rejection of scientific ideas [1]. In this context, promoting a better understanding of the Nature of Science, along with discussions about the genesis of scientific knowledge and the internal and external factors that influence it, has become increasingly important in the training of more critical and globally aware teachers and students [1].

Among the scholars who discuss this topic, we can highlight athors, who summarize the consensual aspects of the Nature of Science (NOS) [1] into five key points: “Science is mutable and dynamic, with the goal of explaining natural phenomena; there is no universal scientific method; scientific theory is not simply a consequence of observation/experimentation and vice versa; science is influenced by the social, cultural, and political context in which it is developed; scientists use imagination, personal beliefs, external influences, among other factors, to do science.” Contrary to popular belief, the construction of science reveals a fundamental characteristic of every scientist: they are ordinary human beings. As such, they make mistakes, use their beliefs and expectations to formulate and legitimize their ideas, and have both strengths and flaws [1].

This is clear that discussing the Nature of Science involves examining how it is constructed and that is, the elements, actions, factors, and influences that underpin scientific ideas [1]. This naturally involves questioning the notion of a single scientific method. Moreover, scientific knowledge is built using various methods that include experimentation, the formulation and verification of hypotheses, the conceptions and expectations of scientists, and more. Science is not isolated in a bubble, invulnerable to the events around it.

Scientific knowledge is a human creation, and since scientists are members of a Society with its culturals, political, historical, and economic models, so they bring their conceptions, beliefs, and aspirations to the scientific process. Therefore, discussing the Nature of Science inevitably involves clarifying its inseparability from the world and from humanity, as well as mutability, just like that of human beings and its limits of validity in some context [1].

It is therefore necessary to make a concerted effort to incorporate the Nature of Science as a broad and integrated project in both teacher education, where educators need to develop a more accurate understanding of Science and how this could help student learning, where simplistic and distorted conceptions must be addressed, questioned, and ultimately overcome. Looking forward, the scenario appears promising. The idea of constructing a virtual boat, proposed by the teacher-educator, naturally emerged from the need to explore active methodologies more deeply, especially those aligned with engaging digital technologies that connect scientific content with cultural diversity and could get more reflexetion and criticals ideias. Finally, the creation of a conceptual map also could help to explore diverse content in this context, leading to new reflections and developed procesual teacher's evaluations for a learning in an integrated manner

Some studies highlight the importance of Active Learning Methodologiesas tools that can contribute to cognitive development and increase student engagement in teaching activities [2]. The implementation of these methodologies enables students to develop skills such as autonomy, the ability to question reality, teamwork through collaboration, and reflection on their actions and decisions. On the other hand, the teacher assumes a vital role as a facilitator and activator in the learning process. These Active Learning Methodologies [2-3] include various teaching approaches such as Problem-Based Learning, Cooperative Learning, Flipped Classroom, Project-Based Learning, Discussion Circles, Debates, and Gamification. The goal is to cultivate competencies like critical thinking, problem-solving, communication, and teamwork.

Blended Learning, as described by Morán, is a teaching method based on Active Learning Methodologies [2] designed to strategically enhance student agency. It is an educational approach that combines elements of in-person and online learning, integrating both modes in a cohesive manner to provide a more flexible and personalized experience tailored to individual student needs. Among the various strategies within Blended Learning, we have Station Rotation, where students alternate between face-to-face and virtual activities.

Despite the solid theoretical foundations of learning and development presented by key researchers such as Piaget, Vygotsky, Dewey, and Ausubel, which underpin the active learning approach, as discussed by authors like Diesel, Baldez, and Martins [5], we observe that these concepts are still not adequately incorporated by teachers, both in initial and continuing education.

According some athors [3-4], learning is achieved through a balance between activities, challenges, and contextualized information. Well-planned challenges are essential to mobilize the intellectual, emotional, personal, and communicative competencies desired in the learning process, both for teachers and students. This research focuses on the use of the Hybrid Active Methodology of Station Rotation as a teaching strategy in Ecology. It aimed to answer the guiding question, "How can the Station Rotation approach assist the teaching-learning process in Ecology, focusing on the Preservation of the Cerrado?" Our objective was to study the teaching-learning process through the development of activities based on Blended Learning, using Station Rotation in the teaching of Ecology with first-year high school students.

We conducted a Descriptive Field Research with a qualitative approach, divided into two phases: first, a Literature Review, and second, Field Research. The research took place at a State Military Police School in Goias (CEPMG). The participants were 33 students from a first-year high school class and 13 teachers who taught this class. This approach was carried out in three different environments within the school (community square; project room and classroom), with the presence of all students who signed the participation terms and were authorized by their parents to participate in our proposed activity, while 4 students from this class were absent for personal reasons.

During this stage, we organized six stations with activities that we will describe. The “Lontra”, “Seriema”, and “Lobo guara” stations were set up inside the classroom, while the Sapo” Cururu” and “Curuja Buraqueira” stations were installed in the project room. The” Cajuzinho do Cerrado” station was positioned in the common area. We chose this arrangement because of the nature of the game, which encourages interaction and dialogue, and we also decided that the “Cajuzinho do Cerrado” station would be placed outside to allow students to express themselves freely, without interfering with the other groups. The names of each of the Learning Stations were democratically decided by the students through voting, all the names refer to the fauna or flora of the cerrado as we can see in Fig. 1, presented next, in this we can see the disposition and dinamicity of activities.

The students collaboratively decided the order in which they would participate in each station. Each group spent 25 minutes at each station, followed by two minutes designated for transition between stations. During the development of the activities proposed at the stations, the students demonstrated excitement and engagement, and were eager to move to the next station to participate in the next activity.

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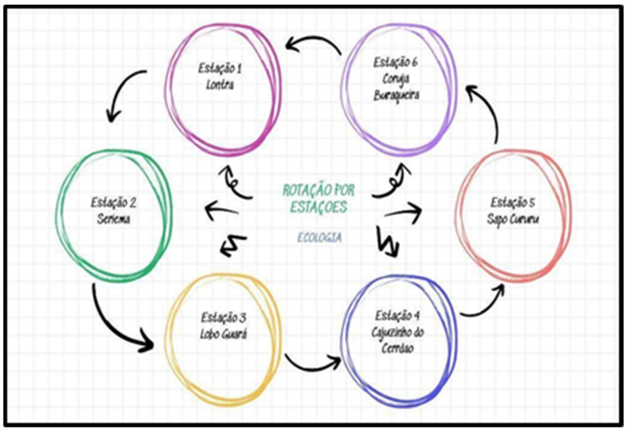

Figure 1. Scheme of the Station Rotation Methodology developed by us with the students

These students also contributed to the evaluation of the Station Rotation activities and their learning in Ecology. An E-book titled "Using Station Rotation as a Teaching Strategy in Ecology" was developed and later evaluated by the participating teachers. The data were analyzed using Bardin's Content Analysis, considering the researcher's notes in her Field Journal throughout the study. We used tables, graphs, and data categorization for this analysis.

We talked with these students on the vision of the Cerrado, its importance for the environment and the possible causes of its degradation according to some authors studied by us [6-7]. According these, it is the second largest Brazilian biome, surpassed in area only by the Amazon. Thus, the students were able to see that this is "[...] the savanna located in the central region of Brazil, with approximately two million km^2" [6]. Being considered less exuberant than the first biome, it seems its importance needs to be worked on and recognized by all Brazilians.

Also according to these authors [6-7], despite its significant importance, this environment has faced a worrying loss and fragmentation of its native areas of its remnants that represented, in 2019, only almost half of the original area of this biome. The lack of environmental awareness and economic interests have neglected its relevance and caused worrying loss and fragmentation of its native areas.

We presented materials that dealt with the Cerrado located in the central region of Brazil, occupying 21% of the national territory. However, about half of the area would have already been replaced by pastures or transformed into agricultural areas. And our students had undertands and talked about this in yours activites demonstrad theirs protagonism and make some propose. These students reported that engaging in classroom discussions and exchanging ideas with peers makes them feel valued, thus stimulating their curiosity and interest in the topic. This protagnism could be perceived in Fig. 2.

Figure 2. Part of students actively had participating in these proposed activities

This engagement of students in this kide of activity, as we have observed, corroborates the ideas defended by authors [3-5] who discuss active methodologies [4] of teaching proposal and they argue that teachers need to seek new paths and new teaching methodologies that focus on the protagonism of students, favoring motivation and promoting more autonomy with their students.

Another group was reading and discussing one of the texts in an external environment so that they could dialogue more freely and then present their ideas and learnings to the class. They were also attentive and showed great interest in learning and positioning themselves critically. When working with active methodologies, it is important to give students the freedom to position themselves and exercise their protagonism [4-5]. We can see them in Fig. 3.

In the Fig. 4, we had presented onother group that student the low environmental and they are envolving at the dicussion.

We believe that this E-book can assist teachers
We believe that this E-book can assist teachers in promoting lessons aligned with Active

Methodologies [4], enabling students to build a more autonomous and motivating learning experience in Ecologyand in the sustenabilite of Brazilian's Cerrado. This research highlighted the relevance of applying this methodology, as the proposal sparked student interest, encouraging collaborative work and critical-reflective thinking about environmental education, knowledge, and active social participation. We emphasize that deforestation and the destruction of fauna and flora were the aspects most discussed by students during the development of this activity.

Figure 3. Students discussing the supporting texts in a group outside the classroom

Figure 4. A group of students discussing texts on environmental laws and enforcement at Cerrado biome

Finally we think it is important too, more discussions with these students about the quality of water and the paper that this biome has and why it is considered "the barth of lakes and rivers" of many hydrographic's basins in our country and that we must take a good care of this.

We considere that Active Learning Methodology of Rotation by Seasons, used as a teaching strategy in Ecology, incorporating elements of the Cerrado, proved to be a transformative process in the routine of our classes. The students perceived these activities as dynamic, capable of providing interaction, decision-making and reflection on the studied theme. We emphasize that this teaching methodology has the potential to change the dynamics of school classes, in addition to being an accessible strategy for teachers and adaptable to different realities.

In this proposal we were work with active metodology discouss about the importance to conserve Cerrado's Biome and the students were participate so critical and take decisions for take care our evironement and thouth some solution for a development sutenible at this environment. We believe that this aprouch possibilite to help these studentes know more about the nature of science, that was mutable and dinamicity [1] and they affim that they like it because after our study they coul undertand and explaining about ecology and the relevance to preserve and works with sustentability ideas.

Keywords. Basic Education, Cerrado Biome, Teacher Training and Learning.

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Active Methodologies in Chemistry Teaching: An Innovative Approach with the 'Chemistry Uno' in Youth and Adult Education

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Abstract. The teaching of Chemistry in High School, especially in the context of Youth and Adult Education (Educação de Jovens e Adultos - EJA), faces significant challenges, due to the complexity of the concepts and the high level of abstraction required. Many students find it difficult to understand topics such as atomic structure, chemical bonds, chemical reactions and stoichiometric calculations. These topics, which are fundamental to understanding chemistry, are often perceived as abstract and disconnected from students' daily lives, which can lead to a lack of engagement and interest in the subject [1-2].

To begin with, the traditional teaching methodology, often centered on expository classes and the memorization of formulas and concepts within the classroom, often fails to capture students' interest. The lack of adequate and modernized physical infrastructure in schools contributes significantly to this problem, as it limits the implementation of teaching strategies that could stimulate students' interest, creativity, autonomy and participation. In many institutions, including those that provide Youth and Adult Education (Educação de Jovens e Adultos - EJA), the absence of laboratories for practical classes is notable, which worsens the feeling that chemistry is an inaccessible and uninteresting subject. This can lead to student demotivation and low content retention, especially among those who already face additional challenges related to returning to studies and reconciling with school education [3].

Thus, faced with the challenges mentioned in teaching chemistry, there is a need to adopt new pedagogical approaches. In this scenario, active methodologies emerge as a powerful solution to revitalize the teaching of chemistry, offering a student-centered approach, which places the student as the protagonist of their own learning. Unlike the traditional model, active methodologies encourage students' direct participation in the learning process, encouraging them to seek solutions, collaborate with colleagues and apply knowledge in practical and contextualized situations. These methodologies include a variety of strategies, such as problem-based learning, the flipped classroom and, most prominently, gamification [4].

Figure 1. Playing the Chemistry Uno game with 2nd year EJA students

Gamification in education transforms learning into a dynamic and engaging experience, especially in complex subjects like chemistry. Incorporating game elements, this approach facilitates the internalization of abstract concepts by proposing challenges and rewards that encourage the practical application of knowledge. Historically, games have always played an essential role in education, from Plato and Aristotle, who highlighted the value of "learning through play," to cultures such as the Romans and Mayans, who used games to teach social values. Gamification revives and adapts these ancient practices, making learning more meaningful and fun, preparing students to apply complex knowledge in a playful way [4-5].

A notable example of the application of active methodologies in the teaching of chemistry is the "Chemistry Uno" project. Developed by Dr. Thaís Petizero Dionísio, the game adapts the rules of the popular card game Uno to teach chemistry concepts. The Chemistry Uno cards are modified to include chemical symbols, energy sublevels, location on the periodic table and the respective names of the elements, allowing students to interact with the content in a playful and practical way [6].

Based on research on the use of active gamification methodology in teaching chemistry, the game "Chemistry Uno" was carried out in the context of the Pedagogical Residency for students in the 2nd year of EJA in High School, as well as in the undergraduate course in Chemistry, in the 7th period, in the subject of Academic Practices on Organic Chemistry (APOC).

One of the most interesting aspects of the game is its flexibility, allowing adaptations depending on the content covered. For example, in the APOC subject, the game was reorganized to include a dynamic where, by having just one card and declaring "Chemistry," the player chooses a number from 1 to 10. This number corresponds to a question related to the content of organic chemistry. If the player got the answer wrong, he would draw 10 cards and continue in the game. This adaptability of the game opens up possibilities for the inclusion of a wide variety of content within chemistry, not limited to a single theme. With this, "Chemistry Uno" becomes a powerful and versatile tool in teaching the subject, capable of engaging students and facilitating the assimilation of complex concepts in a playful and interactive way, all within an environment that favors healthy competition and collaboration. This dynamic not only facilitates the understanding of complex concepts, but also transforms the learning experience into something more accessible and motivating. For EJA students, who often face additional difficulties, this active methodology has proven to be particularly effective, resulting in greater engagement and motivation [1, 4-6].

Furthermore, the Chemistry Uno served as a practical tool for Chemistry Degree students, allowing them to experiment with active methodologies and understand how these strategies can be implemented in their future pedagogical practices [7].

The use of didactic games such as the Chemistry Uno, within a broader approach to active methodologies, represents a revolution in chemistry teaching. By transforming the subject into an interactive, hands-on experience, these games help students see chemistry not as a set of disconnected, difficult concepts, but as a network of interconnected ideas that can be explored in fun and meaningful ways. As a result, these active methodologies, combined with gamification, not only increase student motivation and engagement, but also improve knowledge retention and performance, offering innovative solutions to the challenges faced in traditional teaching [4-6].

Keywords. Youth and Adult Education, Chemistry Teaching, Active Methodologies, Pedagogical Practices, Chemistry Uno.

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Playful Activities to Enhance Curricular Content in the Final Years of Elementary School

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Abstract. Contemporary society is characterized by countless communication mechanisms, which encourage a wide range of information, and this directly reflects the demands of new needs in the most diverse areas of knowledge, leading teachers to reflect more on their teaching practice. Within this context, there are countless challenges for educators, and it is necessary to break away from the traditional aspects of teaching and adopt a new didactic-pedagogical stance.

For Massa (2015), it is no longer possible to educate using the same process adopted years ago. Students live in a different reality, marked by technology, constant change and the agility of everyday life. The author also mentions the importance of didactic mediation, reinforcing playful and creative interaction in the classroom. In the same vein, Moraes and De La Torre (2004) state that a new look at the process of building knowledge is needed to enable awareness and a profound transformation in education.

Currently, science teaching is still strongly influenced by the positivist conception, which inspires the traditional trend in education. This positivist idea of science conceives reality as something immutable and objective, and reflects directly on the way teaching is done, presenting knowledge as something to be transmitted to students, leaving them to adapt to the world, so that they can get to know it through their experiences (Souza & Chapani, 2013).

It is within this context that the search for new teaching methodologies, that playful activities appear as an alternative, making the school environment different, and can be used to instigate and motivate students to learn.

Playful activity is characterized by Antunes (2011) as being an articulation between playfulness and playfulness. It is through playful activity that human beings develop in the most diverse aspects, including cognitive, social and emotional aspects. Negrine (2000) also stresses that playful activity is a human creation and not just a purely biological determinism. In addition, the author stresses the importance of the correlation between play and playfulness by saying that these concepts have been shaped according to human development.

Play is a fundamental element in culture, since playful activities are cultural creations that stem from people's relationships with each other and with society. This allows teachers to use their creative capacity to teach in an attractive and differentiated way, with the faithful purpose of improving learning by piquing students' interest in the subject (Huizinga, 2014).

More directly, Dohme (2003) understands playful activity as an activity that leads to a pleasurable situation and expresses playfulness and fun. However, he points out that playful activities include games, songs, stories, dramatizations, dances and visual arts.

Within this context, the aim of this work was to delve deeper into two curricular contents set out in the guiding documents for education, based on the development of playful activities in two classes in the final years of elementary school.

This study was carried out in the context of the Science subject, involving 6th and 8th grade classes at a private educational institution in the municipality of Anápolis, Goiás. The culmination took place during the first school term and over five consecutive weeks. The theme addressed in each grade was chosen based on the curriculum content covered in the classroom, based on the teacher's identification of the content in which the students had the greatest difficulty in understanding and assimilating. With this in mind, a theme was chosen for the 6th grade class and another for the 8th grade class.

In the 6th grade class, the subject was cytology. The proposal was organized into 4 activities. The first was a round table discussion entitled: “Unraveling Cytology and the microscopic world”. Initially, a title was attached to the board to start discussions, at which point the students were invited to explain their knowledge of the subject. After they had spoken, the central words of the subject were written on the board by the students. At the end of the first activity, a story was told about microscopy and the discovery of the cell, with the script being an author's production based on the content worked on in class and curiosities about the subject.

The second proposal consisted of making a parody about cell organelles. For this activity, the class was divided into two groups, with the intention of each group producing a part of the parody. The choice of rhythm, as well as the other aspects, was left up to the students.

Thirdly, the students were instructed to make edible didactic models of plant, animal and bacterial cells, as well as representing and identifying their respective organelles, so that they could become an object that facilitated learning. To conclude the activities, the students recorded videos to be posted on the school's social networks.

In the 8th grade class, the topic covered was the classification of plants, and the proposal was organized into 4 activities. The first activity also consisted of a conversation circle and the telling of a story entitled: “The trail of enchantment: getting to know the kingdom of plants”, which recounted the adventure of a group of students on a school trip, where they got lost in the woods with a very studious colleague who admired plants. They had the opportunity to get to know and learn about plants.

The second and third stages focused on the angiosperm group, looking at the evolutionary novelties of this group: the presence of flowers and fruit. The second stage involved collecting flowers in and around the school garden. After collecting the flowers, the students had a moment to review the content, followed by observation of the structures present in the flowers, the importance of flowers in reproduction and the process of pollination.

To approach the second evolutionary novelty of the angiosperm group, a workshop was held entitled Science in cooking: making a salad to classify fruit. This stage sought to emphasize the difference between fruit and pseudo-fruit and their respective categories, through the preparation of a fruit salad.

At the end of these activities, the students were invited to record videos reporting on the knowledge they had improved during the activities, which were presented to the other classes and published on the school's Instagram account.

Throughout the activities, it was possible to see the gradual development of participation. At the storytelling stage, in both classes, the students were attentive to the storyline, participating in the reading and accompanying their classmates. This was different to what was observed in the dialogic lecture.

After the story was finished in the 6th grade class, the students commented on how their understanding of the creation of the microscope, the discovery of the cell and the importance of Cell Theory in understanding the formation of living beings had become clearer.

As for the 8th grade class, since the story involved a situation of danger and discovery in the middle of the forest, they were enthusiastic about listening and, above all, reading and interpreting the plot, reflecting their interest in taking part in the activity.

In this way, we consider the relevance of storytelling in approaching curriculum content, being a dynamic and didactic way of making lessons more interesting, as well as stimulating orality and writing. We therefore agree with Silva and Bernardino (2011, p. 237) who consider that storytelling is a strategy that can make a positive contribution to teaching practice. According to the authors, listening to stories stimulates the imagination, educates, instructs, develops cognitive skills and streamlines the reading and writing process.

During the making of the parody in the 6th grade class, the development of a collaborative spirit was noted, as well as an improvement in student-student relations, especially since it was a single parody, which favored interaction between the groups when choosing the rhythm, musicalization and establishing the connection between the parts of the parody. When observing the parody created, we noticed an approach to cell organelles and their respective functions, as well as a historical contextualization of the discovery of the cell and its two characteristics. This resulted in the content being assimilated in a more natural way and allowed for a better understanding of content that was considered abstract.

This allows us to agree with Barros, Zanella and Araújo-Jorge (2013), who point out that music can contribute to the educational process, because through the construction of parodies the student can express the knowledge they obtain about a certain subject in a natural way. The authors also point out that parodies are easily assimilated and understood by listeners who appreciate them, so it becomes a favorable medium for learning to take place.

The use of playful activities is a way of providing the individual with a pleasant, motivating, enjoyable, planned and enriched environment, which enables the learning of various skills. In addition, developing these activities has a great tendency to motivate students to participate spontaneously in class (Katon, Towata & Saito, 2013).

In the 8th grade class, we found that the stages of collecting and observing flowers and the culinary activity of classifying fruits and pseudo-fruits created a climate of enthusiasm about the content covered, in a motivating and integrating way.

We therefore conclude that the fun activities proposed were important methodological tools in the acquisition of scientific knowledge, in addition to the social attitudes of respect for colleagues, the rules of the game, cooperation and personal initiative.

Keywords. Playfulness, Active Participation, Angiosperms, Cytology.

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Tatu Ecological Trail: Popularizing Scientific Knowledge about the Biodiversity of The Cerrado

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Abstract. The objective of this study was to survey and identify the plant species and to characterize the associated entomogenous gall morphotypes, occurring on the Tatu Ecological Trail, in a stricto sensu cerrado area, on the Central campus: CET-Anápolis, of the State University of Goiás. Over 12 months, the occurrence of 27 gall morphotypes distributed in 23 plant species belonging to 15 botanical families was recorded. Leaf galls were more common, with discoid and globoid shapes being the most frequent gall morphologies. It is intended to identify the gall species, and thus contribute to the advancement of scientific knowledge and the popularization of this knowledge.

Galls are anatomical structures that provide shelter, food and protection for inducers [1], developing in plants as a result of complex interactions between the host and the inducing organism. Galls can manifest themselves in different ways, such as bumps, swellings, and deformations in the leaves, stems, and roots of plants.

The diversity of shapes, sizes and colors of galls reflects the diversity of inducing organisms, among which insects stand out, and the adaptive strategies involved in this co-evolutionary relationship. The interactions between galls and plants are quite specific, and generally, gall insect species use a single species of host plant [2].

Understanding gall ecology in the Cerrado can provide valuable information about the dynamics of plant-insect interactions and the coevolutionary processes that shape biological diversity in this biome. For the state of Goiás, there is still little information on the occurrence of galling insects and their respective host plants [3].

This work aims to investigate and contribute to the discussion on the occurrence and morphological diversity of galls in the Cerrado, aiming to contribute to the advancement of scientific knowledge and to the popularization of this knowledge, expanding the discussion on the importance of conservation of this important Brazilian biome.

The inventory of plant species and associated gall morphotypes that occur along the route of the Tatu Ecological Trail and its vicinity was carried out monthly through an active search, in a cerrado area stricto sensu, from August 2023 to July 2024. In the active search, trunks and branches, leaves and other organs were observed in search of galls.

The gall morphotypes were recorded by means of photography and collected in paper bags for observation in the laboratory, using a magnifying glass and optical microscope. The morphotype terminology was used to distinguish the galls, since the identification of the inducer was not always possible. The categorization of the morphotypes was performed by the characterization of the galls, such as color, hairiness, distribution and host organ [4,5,6]. The fresh samples of the galls were sectioned under a stereomicroscope to access the inductor and describe some characteristics of the gall. The inductors were preserved in 70% ethanol and will be sent to specialists for identification.

In the survey carried out, 27 morphotypes of galls were found distributed in 23 plant species of 15 botanical families. The five plant families with the highest abundance of gall host species were: Erythroxylaceae (3), Malpighiaceae (3), Myrtaceae (2), Fabaceae (2) and Melastomataceae (2). Four of these families were cited as being the richest in galls in a survey carried out in 2001 [4], in different physiognomies of the Cerrado, in Minas Gerais. Three species had two gall morphotypes each: *Ouratea hexasperma* (leaf/stem), *Byrsonima pachyphylla* (leaf/stem) and *Qualea parviflora* (leaf/leaf).

Almost all of the gall host plants observed in this study had arboreal habit (91%), and only two had subshrub size. Galls occurred in the following plant organs: leaf, leaf vein, stem and ovary/fruit. Of these, the greatest richness occurred in the leaves, where 17 gall morphotypes were observed, distributed along the entire leaf blade. In *Erytrhoxyllum* *suberosum*, *E. tortuosum, E. campestre* and *Eremanthus glomerulatus*, a type of leaf gall was observed that only occurs along the central vein, a fact that was also reported for *Inga cylindrica* in a study carried out in semideciduous seasonal forest in Goiânia [3]. The stem galls were represented by four morphotypes, and in two species galls were recorded in the ovaries and/or fruits. The most frequent gall formats were discoid (48.2%) and globoid (44.4%), respectively. The color of the galls varied between green, yellow, brown, red and rusty. The galls were isolated or grouped and were glabrous or pilose.

Gall-inducing insects are very abundant, but ecologically and taxonomically little known [7]. So far, the Cecidomiids have been responsible for the induction of galls in most of the plants studied in the literature. It is noteworthy that most of the galls caused by this group of galling insects are observed in the leaf, as in the present study.

Fabaceae, Asteraceae, Myrtaceae, Malpighiaceae, Rubiaceae and Bignoniaceae were indicated as the richest families in gall insect fauna in South America [8], which corroborates the results found, considering that in the present study the families Fabaceae, Myrtaceae and Malpighiaceae were the richest.

The present study provides relevant information on the occurrence of galls in host plants in a cerrado area stricto sensu, which can contribute to the knowledge of the richness and distribution of gall insects and associated flora in the Cerrado. In addition, in future stages, it is intended to use the data obtained for the construction of didactic resources and the planning of activities aimed at the dissemination and popularization of knowledge about this important guild of insects and their coevolution with plants.

Keywords. Non-Formal Teaching Space, Cerrado Flora, Entomogenous Galls.

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Socioscientific Issues in Science Teaching: An Analysis in Four Brazilian Journals

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Abstract. Socioscientific issues (SSI) are social problems that involve the intersection of scientific knowledge with complex social and cultural considerations [1]. Examples include climate change, genetically modified food and organ transplants [2]. Thus, SSI have aroused interest as their inclusion in science teaching and learning environments can help develop students' argumentation, opinion formation and decision-making when faced with controversial issues [3].

From this perspective, this paper aims to investigate how the subject has been presented in four Brazilian journals related to science teaching. A qualitative approach and bibliographical research were used [4]. Articles published between 2014 and 2023 in four national journals were selected: *Química Nova na Escola, Revista de Ensino de Biologia da SBEnBio, Revista Brasileira de Ensino de Física* and *Revista Brasileira de Pesquisa em Educação em Ciências*.

The articles selected were those with the following terms in the title, abstract and/or keywords: socioscientific issues, SSI, socioscientific controversies, controversial and/or socioscientific topics, socioscientific discussions and socioscientific aspects. These were analyzed in terms of their distribution over time; the type of research carried out; the level of education covered; the area of knowledge and topics covered; and the teaching strategies used.

A total of 45 articles relevant to the topic were selected in the period investigated, in which 2016 and 2021 showed the greatest predominance of publications (Fig. 1). This is because in 2016 a special issue was published, which included papers presented at the VI National Meeting on Biology Teaching (ENEBIO) and the VIII Regional Meeting on Biology Teaching. Of the 11 works recorded in 2016, 9 came from this edition. Similarly, in 2021, the *Revista Química Nova na Escola* published a special issue on Argumentation in Chemistry Teaching. Eight papers were published that year, 5 of which came from that issue. In the other periods explored, the number of papers varies from 6 to 2, with a decrease between 2014 and 2023.

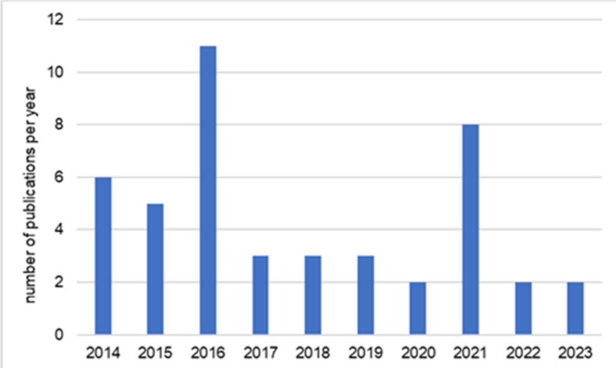

Figure 1. Temporal evolution of the topic of socioscientific issues in the journals analyzed

Regarding the type of research, 3 of the articles are not characterized as such, presenting only didactic proposals. Thirteen articles report theoretical research, 7 of which are documentary in nature, analyzing magazine articles, folders, curriculum documents, lesson plans and science teaching activities. In addition, 4 theoretical articles in essay format on SSI were located, as well as 2 articles on the development and application of analytical tools: one aimed at developing a tool for the study of science communication texts that address SSI [5] and the other related to a model that addresses relationships between epistemic practices and socioscientific issues in science education [6]. Most of the studies were therefore related to empirical research (29 articles), and the majority (18 articles) were characterized as case studies [4].

Concerning the level of education, 8 articles did not identify it. In contrast, 25 were aimed at basic education and 12 at higher education. This data suggests the relevance of SSI and the privileged place it has taken on at all levels of education.

As far as the area of knowledge is concerned, the areas of Chemistry (16 articles) and Biology (11 articles) stand out, while there is only one article on the area of physics in the *Revista*

Brasileira de Ensino de Física. In relation to the subjects covered in each area, there is a prevalence of environmental issues, with 19 occurrences, 8 of which are associated with issues of a social nature (6 articles), ethics (1 article) and health (1 article). It is worth mentioning the prominence of works in the field of chemistry that deal with environmental issues (8 articles), such as: water pollution, the use of pesticides, insecticides, fuels, agrotoxins, toxic substances and the construction of thermoelectric plant construction. On the other hand, in the area of biology, there was a concentration of works with a health focus (6 articles), such as: Sexually Transmitted Diseases (STDs), Dengue, Zika, Chikungunya Fever, the birth of babies, diet and drug use. It is notable that SSI related themes are broad and will continue to emerge or evolve over time.

Regarding the didactic strategies most commonly used to address SSI, a variety of means can be observed, focusing on the use of case studies (10 articles), classroom discussions (5 articles), group work (3 articles), readings of science communication materials (2 articles) and mock juries (2 articles). The case study strategy was the most frequent in the investigations, and eight of the ten were focused on the principle of argumentation [7]. It is worth noting that their inclusion can make a significant contribution to the formation of critical citizens who are more participative in society.

In view of the above, it can be concluded that there was a consistency in the number of publications in the period investigated, except for 2016 and 2021, due to the reasons already discussed. In other words, educators' interest in addressing SSI has continued over the years. Another relevant point is the predominance of empirical research in relation to theoretical research, suggesting that researchers perceive that the topic is already well founded in the literature and, therefore, research with the character of didactic intervention is currently necessary. The variety of SSI addressed is also noteworthy, in which environmental and health related issues prevail. The wide-ranging possibilities of using SSI to discuss topics that are relevant to students' scientific and social education are evident, as they can help promote argumentation, critical thinking and scientific literacy. It also makes science lessons more attractive and dynamic.

Keywords. Brazilian Journals, Science Teaching, Socioscientific Issues.

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Investigative Experimentation on Milk Fraud: Knowledge and Scientific Dissemination from a Science-Technology-Society Perspective

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Abstract. This proposal presents an investigative and practical approach to examining milk frauds., aiming to spark curiosity and reflection among young people and children about the health, economic, and environmental impacts of such fraud. Through characterized as a Problematized Experimental Activity (AEP) the propose emphasizes the importance of science, and how it needs to be used to help humanitie. The dissemination of interdisciplinary scientific knowledge, and the role of society in understand and take sustainable decisions in a Science-Thecnology-Society/STS' perspective. So we believe that knowlegde the principles and theories and to how they are applying them in real situations of this fraud type could help us to live better.

The activities begin with the presentation of milk samples, in a proposal to investigate [1] that could it be analized? If they are adulterated or unaltered, alongside real news cases highlighting major instances of milk fraud [2] in our country. These cases will be used to discuss the types of frauds frequently used, health risks, economic losses, and environmental damage associated with adulterated milk.

The initial focus is on problematizing these situations, encouraging participants to think critically about the broader societal implications and introduce some theories to understand experimentions that we can develop to know the quality of this material basic in our alimentation in most kide of milkfoods and drink.

The more important in this propose is a dialogical process, interactive and dynamic investigative process with the participants of this workshop. Participants will work through secure experimental activities designed to engage them in identifying and understanding common fraudulent practices in milk. Using basic lab reagents such as 1% iodine solution, phenolphthalein, and a diluted sodium hydroxide solution, participants will analyze milk samples to detect potential adulterants. The materials used in the experiments will be simple and readily available, allowing for easy replication in educational settings [1].

Beyond the experimentais procedures, the project includes a range of additional activities aimed at fostering deeper engagement and criticals' thinking. For this we will propose to participants will engage in reading little texts and educational/scientifique activites designed to facilitate understanding of how adulterants are used to mask the quality of milk. The participants will observe and participate too in experiments demonstrating how certain chemical reactions reveal the presence of adulterants in milk. These experiments will highlight the differences between altered and unaltered's milk samples.

We will presents a “news clothesline” will display headlines and stories related to milk fraud, prompting participants to discuss these cases in a dramatized and dialogic format. The goal is to explore how scientific knowledge is applied (or misapplied) in society and the consequences of these actions for us. We can make inscriptions for two or tree sections during 45 minutes each.

After analyzing the milk samples, participants will be asked to compile and present their findings in the form of a report. The report will include conclusions on the types of fraud identified and which samples were not adulterated. This process encourages participants to apply scientific reasoning, draw evidence-based conclusions, and communicate their results based in chemistry science.

We will use Basic lab tools such as beakers, test tubes, pipettes, and pipettes will be used, alongside reagents like iodine, phenolphthalein, and dilute sodium hydroxide solution for safe use. A banner will be displayed to explain the chemical reactions involved in detecting adulterants. This will help participants better understand both the fraudulent techniques used in the dairy industry and the scientific methods used to identify them. The experiments will be conducted on two tables where the necessary equipment and materials are arranged. The setup will allow to make easy Moving among different adifferent milk samples that wil be analyzed.

The first objective is to promote scientific literacy and awareness of fraudulent practices in everyday products, using milk in a case study. Participants will learn not only how to detect fraud but also why such practices are harmful to consumers and society [5]. The activities are designed to be accessible and engaging for a wide audience, from young children until young and adults education, professor's training in initial or continued formation that could think this thema like strategies in a contexte making complex scientific concepts understandable and relatable.

Our proposal also aims to highlight the importance of integrating scientific and thecnological knowledge with social awareness promolting. By combining experimental activities with discussions on the ethical, economic, and environmental impacts of fraud, participants will gain a more holistic understanding of the role of science in society. The inclusion of interactive and dramatized elements further enriches the experience in experimental learn in chemistry/STS [4], making it both dialogical, informative and enjoyable.

The exploration of milk fraud is not only a scientific investigation but also a reflection on the intersection of science, technology, and society (STS) [4] The project emphasizes how scientific advancements can be both a tool for progress and a means of perpetuating harmful practices when misused. By examining the societal and environmental consequences of fraudulent activities, the project encourages participants to think critically about the role of science in addressing real-world challenges [5].

In summary, this experimentation activity offers an engaging, hands-on approach to understanding milk fraud and its broader implications. Through problem-based experimental activities/PEA, participants will explore the intersection of science, ethics, and society, gaining valuable insights into how scientific knowledge can be applied to promote scientific knowledge can be applied to promote public health, protect consumer rights, and foster sustainable practices. By aligning these educational activities with accessible materials and interactive methods, this propolse seeks to inspire a new generation of informed, responsible, and critically thinking citizens [1].

Keywords. STS Education, Sustainability, PEA.

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Investigative Teaching Sequence on Ecological Interactions Using the Series “The Last of Us”

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Abstract. Historically, learning has been viewed as a passive process that relies on sensory engagement and repetition to demonstrate understanding. However, several educational theories advocate a constructivist approach that emphasizes contextualizing information and applying it to real-world problems [1].

The shift to this paradigm requires redefining the role of the educator through the use of research-based methodologies that foster scientific thinking and critical skills, such as inquirative teaching sequence (ITS). These methodologies promote student autonomy and meaningful learning by encouraging hypothesis formulation, data analysis, and problem solving [2].

This research investigates the impact of inquiry-based learning on students’ understanding of ecological interactions, using the HBO series “The Last of Us” as an educational resource. The study focuses on enhancing critical thinking and analytical skills, particularly in relation to ecological frameworks. Focusing on the second episode, which introduces the Cordyceps fungus and its effects on humanity, the narrative provides a context for exploring ecological relationships, thereby deepening students’ understanding of ecological concepts.

The series was chosen because it is an audiovisual production that is very popular among young people, and is based on Carl Rogers' idea that learning is the result of the interaction between the student and the environment, involving cognitive, sociocultural, affective-emotional and experiential processes, as discussed above [3]. It is a drama, adventure and horror series based on the game franchise of the same name. The series follows Joel and Ellie, two survivors of a post-apocalyptic world devastated by a fungus that turns people into zombies (undead creatures that feed on humans). Together, they face dangers, enemies and moral dilemmas on a journey that could change the fate of humanity.

The ITS, focusing on ecosystem analysis and environmental conservation, was conducted in the 1st grade of a public high school in Anápolis, Goiás, involving 92 participants. The ITS began with an assessment of students’ prior knowledge of ecology, followed by the screening of an episode of “The Last of Us,” which was segmented into two lessons. Students were tasked with writing a critical review linking the events of the episode to ecological interactions. Subsequent lessons involved a dialogued lecture on ecological concepts, revisiting examples from the series. Students then worked in groups to analyze a terrarium design, identifying trophic levels and interactions. The ITS concluded with a review of ecological knowledge and an assessment activity, which included questions connecting the series to the content studied and evaluating the role of media in the learning process.

The concept of ecosystem was explored, revealing that most students associated it primarily with animals and plants, with only a minority recognizing microorganisms. Practical examples provided included aquariums and anthills, while the notion of the human body as an ecosystem elicited surprise. The prior knowledge check emphasizes the importance of integrating students’ existing knowledge into learning [4].

In the interaction-centered activity, students were tasked with analyzing the episode and constructing critical reviews. Reviews indicated that students understood the objectives of the activity, looking for evidence of ecological interactions, although they did not explicitly categorize these interactions. Inquiry-based learning facilitated argumentation, allowing students to connect data with statements and explore relationships between variables.

Notably, students demonstrated prior knowledge of biological concepts, such as mutations and symbiosis, while some reviews highlighted misconceptions about ecological interactions, particularly the lack of representation of interactions between animals in the series. This reflects the notion of knowledge as a social construction, emphasizing the importance of students’ pre-existing knowledge in shaping their understanding of ecological concepts [1].

The second phase of ITS involved a dialogued presentation and a terrarium activity, where students identified ecological roles, such as producers (plants), primary consumers (insects, arthropods and mollusks) and decomposers (fungi, bacteria and protozoa). The classification of mushrooms and earthworms generated debate, with students divided on their roles as consumers or decomposers. Interactions between species in the terrarium were classified as harmonious interspecific interactions, as no damage was observed. The teacher reinforced that, in this case, predation exists, as it involves damage to at least one species.

The final phase of ITS involved an individual activity where students analyzed ecological interactions portrayed in the episode. The responses predominantly highlighted disharmonious interactions between humans and nature that make survival difficult amid environmental challenges. In addition, students explored the concepts of parasitism and mutualism in relation to infection. While mutualism was minimally acknowledged, parasitism was unanimously exemplified through the fungus infecting humans, illustrating detrimental effects such as nutrient exploitation and serious health consequences.

Analysis of student answers regarding competition for resources in the series illustrates the principles of ecological competition, emphasizing the disharmonious interactions that arise from struggles over resources essential for survival. Food scarcity served as a significant catalyst for violence among survivors.

Furthermore, students expressed that familiarity with the series or its source game increases engagement in learning, and many of them noticed the interactive and enjoyable nature of the content. This aligns with Rogers [3], who posits that effective teaching transcends the mere transmission of knowledge by fostering student engagement and interaction.

The research findings demonstrate that the inquiry-based teaching approach, through designed activities, significantly improves students' critical and reflective thinking. This pedagogical strategy not only fosters interest in real-world situations but also encourages active participation in knowledge construction.

Consequently, the approach makes lessons more engaging and relevant, equipping students with essential scientific vocabulary and critical thinking skills. The activities align with core teaching-learning processes, emphasizing the importance of questioning, reflection, and environmental interpretation in contemporary education.

Keywords. Following Teaching, Science Teaching, Teaching by Inquiry.

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Exploring Sign Terminology in Environmental Education for Promoting Deaf Students' Citizenship

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Abstract. This work is being developed as part of the ENEB postgraduate program at the Federal Institute at Goias, within the Professional Master's in Basic Education at the Urutaí Campus. The aim is to investigate the terminologies proposed in a bilingual approach, using LIBRAS as the first language (L1) and Portuguese as the second language (L2) of deaf. We intend to create a glossary for both deaf and hearing individuals interested in LIBRAS and Environmental Education (EE), and its inclusion in high school with environmental education themes.

This qualitative research encompasses understanding the laws and documents related to the education of deaf students within the environmental context, as well as expectations for their inclusion and the promotion of their citizenship in our society. We seek frameworks that can enhance the learning of deaf students, who may not fully comprehend the content if instruction is provided solely in Portuguese.

Therefore, we need to discuss specific methodologies and theories that can address the unique ways in which deaf students understand and conceptualize terminologies and concepts [1]. This involves respecting the process of sign language and sign terms to improve their learning.

Another aspect highlighted in this research is the scarcity of studies and educational resources that can assist teachers and trainers working with environmental topics for deaf students. Searches conducted from August 2023 to May 2024 in the Digital Library of Theses and Dissertations (DLTD) and on the CAPES journals website yielded fewer than 10 works that involved the three descriptors we selected: "Brazilian Sign Language (LIBRAS) teaching," "environmental education," and "deaf" [2-3].

The idea of a bilingual digital glossary, presented in video format with contextual descriptions in Portuguese as L2, can enhance the accessibility and adaptation of environmental content for deaf students for a social mediation of learning. This approach also supports the pedagogical training of teachers who need to addressenvironmentalthemes, fostering inclusive teaching practices and deaf citizenship.

Our studies suggest that increased interaction for deaf students in the school environment promotes better conceptual understanding through more dialogic and visual communication. In addition to improving communication and boosting the self-esteem of deaf students, the use of technological resources can enhance the study of environmental topics. Tools such as YouTube videos in LIBRAS, QR codes, and other technologies facilitate access to information and support learning. These tools are based on visual pedagogy and other resources that assist both deaf and hearing students in interacting with concepts and peers in ways beyond simply transmitting or receiving pre-defined information.

An important aspect to highlight is the possibility of new communication processes and meaningful content relationships. To address this, we created the "Girassol de Libras" website, where we organized some environmental education concepts. This organization was based on the analysis of the textbook from Editora Moderna Plus, Volume 4 of the National Textbook Program (NTP) 2021, specifically chapters 7 and 12, which cover terms related to chemical pollution and recycling.

We selected 16 terms of this textbook, we organized them using Canva resources, and presented them in alphabetical order in "Flor de girassol" site. The site includes sign language concepts linked to YouTube videos we created, along with video summaries and related images to foster interaction for social constructions [4] of the selected terms for environmental education. This is so important for the learning and to participate deaf in societe decisions.

We aim to make this resource available to deaf students, teachers, and even undergraduate students who will be teachers and are interested in working with environmental education themes. This will help include all students, increase engagement, and promote participation through visual resources on a website that we have named "Flor de Girassol" [5]. There everybody can know somethings about environment We explain the meaning of them and we presents and explain their sens and people can let a message and interact avec deaf that interest for this theme. This site will soon be disponible for everybody that be interested in fostering education for citizenship and planetary sustainability, whether they are deaf or hearing can use this [6].

Keywords. Deaf Education, Sustainability, Visual Pedagogy.

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Tatu Ecological Trail: Promoting Teaching, Research and Extension beyond Scientific and Environmental Education about The Cerrado

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Abstract. This work aims to describe the actions carried out and the results achieved with the extension project of the Tatu Ecological Trail, a non-formal teaching space located at the Central Campus of the State University of Goiás. In this space, guided tours are carried out with basic education students, monitored by undergraduate and graduate students from UEG. The trail passes through three phytophysiognomies where elements of biodiversity, seasonality, edaphic conditions and climate are explored. In addition to these elements, it seeks to promote in visitors feelings of belonging and appreciation of the Cerrado. Thousands of students have already visited the trail, as well as dozens of monitors have been trained.

Practical activities carried out in non-formal spaces, such as parks and ecological trails, can promote meaningful experiences with the local biome, as is the case of the Cerrado in the Midwest region [1]. The Cerrado biome constitutes a mosaic of plant physiognomies, ranging from grassland formations to forest ecosystems, with high species richness and a large number of endemic species [2].

However, the Cerrado is the most threatened savannah on the planet and one of the 25 global hotspots [3]. This accelerated degradation of the biome is the result of anthropogenic manipulation that has consequences for human society that is generally not perceived as part of the environment.

In this context, ecological and interpretive trails have proven to be efficient tools with the population, including schools, to promote feelings of belonging and appreciation of the environment in which they are inserted [4].

Located in the Cerrado Ecological Reserve of the Central Campus of the State University of Goiás (UEG), in Anápolis, the Tatu Ecological Trail was inaugurated in 2001, and since then permanent environmental and scientific education activities have been developed. In 2023, the actions on the trail were registered with the Dean of Extension of UEG.

The Trail is 1,500 meters long and runs through three phytophysiognomic formations inserted in the Cerrado biome: cerrado stricto sensu, semi-deciduous mesophilic forest and gallery forest. The activities carried out on the trail are mediated by professors and students of the Biological Sciences course at the UEG Central campus, with the aim of bringing visitors closer to topics related to the Cerrado and its biodiversity. In addition to the scientific and environmental education work developed, research is carried out on the track by undergraduate and graduate students at the master's and doctoral levels, producing new knowledge.

Dozens of students from the Biological Sciences Course, many of them scholarship holders for extension, permanence and scientific initiation, as well as graduate students from the Professional Master's Programs in Science Teaching (PPEC) and Master's and Doctorate in Natural Resources of the Cerrado (RENAC), have participated in the actions carried out, including activities of guidance on the trail (monitoring), offering workshops and lectures, in addition to the preparation of didactic resources.

For the undergraduate, the track works as a laboratory, providing learning and teaching experiences, especially to students who participate in the project as monitors. The execution of the project and the involvement with basic education schools favors initial professional training, bringing engagement, experiences and learning beyond what is experienced in the undergraduate course. For the graduate students, the work in the project involves participation in a co-training process.

The project also offers educational opportunities to basic education students. Thousands of students from the public and private school system in Anápolis and region have already taken guided tours of the trail, in addition to participating in workshops, such as the production of exsiccates, assembly of paper entomological boxes, footprint molds of typical

Cerrado animals, soil collection and pH analysis, experiments on bioactive compounds of plant species from the Cerrado, collection and observation of fungi, aquatic insects, termites, among other organisms. Thus, the project has generated a series of positive and lasting results, among which the following stand out:

1. Scientific and Environmental Education: Visits to the Tatu Ecological Trail provided basic education students with access to scientific concepts about the Cerrado, its ecological importance and unique biodiversity. This experience has contributed to greater environmental awareness and the development of sustainable attitudes among participants.

2. Appreciation of Natural Heritage: Direct contact with the natural environment of the Cerrado allows students to develop a deeper appreciation for the local natural heritage. By understanding the importance of preserving this ecosystem, participants are sensitized and encouraged to become active defenders of this biome and its natural resources.

3. Stimulation of Curiosity and Learning: The experience provided by the project arouses the curiosity of students and stimulates their interest in scientific knowledge. By experiencing practical and interactive activities, participants are motivated to explore new concepts and deepen their understanding of the topics covered.

4. Inclusion and Access to Quality Education: The project provides enriching learning opportunities for students from different schools in the region, promoting the democratization of access to quality education. In addition, by receiving information about the Cerrado biome, participants have the chance to broaden their horizons and acquire knowledge outside the traditional school environment.
5. Impact on the Local Community: The benefits of the project extend beyond the students, also reaching their families and school community. By sharing their experiences and learnings, participants are expected to positively influence the attitudes and behaviors of their social circles, disseminating values of environmental preservation and collective responsibility.

It is therefore concluded that the Extension Project developed in the Tatu Ecological Trail has positively and significantly impacted the training of the participating undergraduate and graduate students, as well as the external community involved, promoting environmental awareness, appreciation of natural heritage, stimulation of learning, educational inclusion and popularization of scientific knowledge produced about the Cerrado [5]. These results highlight the essential role of teaching, research and university extension in promoting sustainable development and building a more conscious and engaged Society.

Keywords. Non-Formal Space, Cerrado, Tripod Teaching-Research-Extension.

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Experimenters in Action: A Didactic Guide for Natural Sciences Teachers

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Abstract. This work aims to describe the educational product developed in the form of an experiment notebook, designed to assist Science teachers in the Final Years of Elementary Education in developing experimental activities with an investigative approach, with the goal of achieving meaningful learning, where students play an active role in the process. Thus, the activities proposed in the notebook not only meet curricular demands but also contribute to the holistic development of students within the context of the thematic unit Matter and Energy.

According to the changes that occurred in the Science curriculum in Brazil and the creation of the Base Nacional Comum Curricular (BNCC) [1] and the Curricular Document for Goiás (DC-GO) [2], we have the Thematic Axis Matter and Energy, which is now included in the Final Years of Elementary Education, incorporating content related to Chemistry and Physics in all grades. Both documents encourage student protagonism and Scientific Literacy, emphasizing the importance of experimental activities in the learning of Natural Sciences.

Therefore, to assist teachers in this new curricular structure, this educational product linked to the master's dissertation, titled "Experimenters in Action," aims to support Science teachers by expanding their resources for conducting investigative experimental activities, where students seek answers based on prior knowledge [3-4], highlighting the importance of placing students as protagonists in the learning process, stimulating their curiosity and creativity [5-6].

The material is structured as a guide notebook for teachers, containing reports for students. It includes eight investigative experimental activities, with two for each grade in the Final Years of Elementary Education. Experimental activities from previously selected didactic and complementary books were restructured according to the skills present in the BNCC and DC-GO, making them investigative in nature.

For the 6th grade, the considered skills are EF06CI01 (BNCC) and EF06CI01-C (DC-GO) with the experimental activity "What is the importance of drinking water that has gone through a filter or purifier?"; EF06CI02 (BNCC) and EF06CI02-B (DC-GO) with the experimental activity "If the milk doesn't go on the fire and only a substance needs to be added, what happens for it to turn into cheese?".

For the 7th grade, the skills addressed are EF07CI02 (BNCC and DC-GO) with the experimental activity "Why does the tongue stick easily to a frozen metal bar?"; EF07CI04 (BNCC) and EF07CI04-A (DC-GO) with the experimental activity "How does our body temperature remain stable even when the environment is cold or hot?".

For the 8th grade, the considered skills are EF08CI02 (BNCC) and EF08CI02-C (DC-GO) with the experimental activity "I will make a simple electric circuit for the science fair; what materials will I need?"; EF08CI02 (BNCC) and EF08CI02-D (DC-GO) with the experimental activity "Why do the lights on a string of lights stop working when one breaks?"

For the 9th grade, the addressed skills are EF09CI04 (BNCC) and EF09CI04-E (DC-GO) with the experimental activity "How does sound manage to be transmitted through a string?"; EF09CI05 (BNCC) and EF09CI05-B (DC-GO) with the experimental activity "Does light influence the color of an object?"

Each of the 8 experimental activities contains the topics listed below:

1. Checking Prior Knowledge: Refers to the questions for initiating discussion and identifying the knowledge that students already possess, aiming for meaningful learning. It is suggested that students' responses be presented orally to the class.
2. Skills Addressed: Comprises the skills present in the BNCC and DC-GO, respectively.

3. Teacher's Note: Contains important information and guidelines for the teacher.
4. We Will Need: Presents the list of all materials necessary for conducting the proposed experiments.
5. Experimenting: Refers to the basic instructions for carrying out the experiments, and when necessary, includes questions for recording essential notes needed for the development of the experiment.
6. Investigating and Recording: Contains questions for students to reflect on and respond to, allowing them to systematically record their knowledge and the results of the experimentation.
7. Important: Presents important information for the teacher about the proposed topic and may include supporting images for content explanation.
8. Restructuring My Knowledge: Composed of questions that may have been asked at the beginning of the activity or other questions that allow students to review and verify the knowledge they have restructured from the practice conducted. It is suggested that the new responses from students be presented orally and discussed with the class.
9. Going Further: Provides suggestions for the teacher to deepen or further explore the topic with students. It includes suggestions for videos that help reinforce and/or deepen the proposed skills.

The reports for student completion do not include the answers to the questions, which are only found in the teacher's guide, nor do they contain the items “Skills Addressed,” “Teacher's Note,” and “Important,” as their content is specific to teachers.

This material was validated by applying one of the proposed experiments in a 9th grade class with 22 students, showing satisfactory results based on student engagement and active participation during the implementation. The results highlight student protagonism and meaningful learning, meeting the demand for which the proposed material was developed.

Keywords. Investigative Approach, Science Education, Experiments.

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Learning with Woman Scientists. Card Game to Promote Science Education

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Abstract. In 2015, the United Nations (UN) published the 2030 Agenda, which includes the 17 Sustainable Development Goals (SDGs) as a global action plan [1]. The SDGs are aimed at eliminating extreme poverty and hunger, providing lifelong quality education for all, protecting the planet and promoting peaceful and inclusive societies.

In this context, it is worth highlighting SDG 05, which deals with gender equality. If this is a global action target, it is clear that gender inequality exists and is present in many parts of the world.

According to the report "An unbalanced equation: increasing women's participation in STEM in Latin America and the Caribbean", globally only 29% of university researchers are women [2]. In higher education, women have less progression beyond master's level [3] and another alarming statistic refers to the awarding of Nobel Prizes in Science, where only 3% went to women [3].

The lower female participation in the sciences discourages and makes it even more difficult for women to get involved in scientific activities, such as those related to STEM (Science, Technology, Engineering and Mathematics) [4]. According to the report "Cracking the code: educating girls and women in Science, Technology, Engineering and Mathematics (STEM)" [4], there are huge disparities and profound inequalities when we analyze the presence of men and women in STEM fields. In higher education, women represent only 35% of all students enrolled in STEM-related fields [4].

According to this report, this does not happen by chance and is related to various factors, including cultural factors such as discrimination, social norms and expectations that influence the quality of education received by girls, as well as the subjects they study [4].

In order to achieve the aims of the 2030 Agenda, according to UNESCO, "it is necessary to cultivate transformative, innovative and creative thinking and skills and, likewise, competent and empowered citizens" [4, p.14]. In this context, schools, universities and educational systems play an extremely important role [4]. These spaces can promote actions aimed at increasing girls' interest in STEM areas, working to form a culture of respect and equity, as well as promoting students' scientific education.

Mastering scientific and technological knowledge (scientific literacy) is essential for full citizenship in today's world. Science Education and Scientific Literacy are essential for the development of "key competences", as the [5] document points out.

Science Education as an educational process [6] can foster scientific literacy in students. When students learn to deal with the method, to plan and carry out research, to argue and counter-argue, to reflect and substantiate with the authority of the argument, they are building citizenship that knows how to think, as well as how to do science. Citizenship that knows how to think involves knowing how to build and use science and technology for ethical, civic and sustainable social ends.

Scientific Literacy can be understood as "training the subject to understand the knowledge, practices and values of an area of knowledge in order to analyze situations and make decisions on different occasions in their lives" [7, p.5]. Scientific Literacy, from a formative perspective, encourages students to come into contact with elements of scientific culture, enabling them to incorporate the social norms and practices of science in order to evaluate, make decisions and solve problems in their daily lives.

In view of the above, the aim of this work is to present possibilities for working on science education and scientific literacy among students in the final years of elementary school through investigative and playful activities. To this end, a card game entitled "Learning with Women Scientists" was created. This is an educational product linked to the first author's professional master's thesis (under construction).

The game includes cards with data on important

female scientists worldwide, and cards with problem situations contextualized in the interrelationships between Science, Technology, Society and the Environment (CTSA). The problem situations cover topics such as space exploration of the universe, waste generation, the use of natural resources, the impact of chemical products, energy sources, the subatomic world, the energy crisis, the chemical composition of matter, ocean diversity, seismic activity, genetics and diseases, agricultural production, health and language.

The auxiliary cards were created to help students/players understand unfamiliar terms or words. These cards were divided into two groups: cards with scientific questions and cards with the professions that appear throughout the game. In the process of playing, the proposal is to involve the participation of two groups, each with a maximum of five participants. The winning group randomly chooses a card from the problem situation. One participant must read the problem situation out loud. If they have any doubts, they can consult the auxiliary cards. Then each group will receive the block with the scientist's cards. Through analysis, debate and argumentation, the participants in each group should select which scientist(s) can help solve the problem situation, according to their skills and contributions to science.

The dynamics of the game encourage active participation and debate among students, facilitating a learning experience that values collaboration and dialog. The game aims not only to promote knowledge about notable female scientists; it incorporates STEM education by addressing complex issues such as sustainability, recycling, safety, energy sources, material properties, health and heredity, as well as social and environmental problems including hunger, resource scarcity and communication and technology challenges.

This pedagogical resource has emerged as a strategic tool for developing students' investigation and argumentation skills in an active and entertaining way. In addition, it can help achieve the SDGs proposed by the UN and foster Global Citizenship Education (GCE), preparing students for active and informed involvement in the globalized world.

It is believed that the game could be an important tool for working with students on key competencies, namely: 1) Systems thinking competence; 2) Anticipatory competence; 3) Normative competence; 4) Strategic competence; 5) Collaboration competence; 6) Critical thinking competence; 7) Self-knowledge competence; 8) Integrated problem-solving competence.

Keywords. Basic Education, Gender Equality, Scientific Literacy.

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Teaching Science and Maker Education in the Supervised Curricular Internship

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Abstract. This experience report aims to describe a scientific initiation research carried out in the context of a Supervised Curricular Internship (ECS) and Pedagogical Residency Program (PRP), with the objective of exploring didactic-pedagogical strategies and materials in the teaching of Science in Basic Education.

ECS offers undergraduate students the opportunity to engage in experiences that foster deep reflection on their future teaching profession. The purpose of the internship is to promote the training of pre-service teachers through immersion in the school environment, allowing them to experience pedagogical practices, analyze, and understand the spaces in which they will operate.[1]

In this context, it is crucial that the pedagogical experience within ECS includes innovative teaching practices based on theoretical approaches and educational technologies. Among the various innovative technologies in the educational field, the Maker education and culture movement can serve as a theoretical approach that helps teachers create new knowledge. The biggest challenge of the Maker Movement is to transform education[2]. Given these new theoretical approaches, teachers must be open to change, embracing new ideas, and understanding that not everything learned during training and teaching practice needs to be repeated.

With a qualitative approach, we employed data collection methods in the development process that included detailed observation and meticulous field journal entries. Initially, a diagnostic was conducted to identify the main difficulties faced by students regarding Science content. Based on the results, various materials were developed using a 3D printer, focusing on the contents of Earth and Universe, Genetics, and Cell Organization, which were identified as challenging. The Science curriculum content was taught to the final years of elementary school students through Maker Education, allowing them to engage hands-on and become "creators," aligning with the "Maker" concept".

In addition to participating in activities at school, students had the chance to visit the IFGoiano LabMaker and the Rosa de Saberes Education Center during the research. These technical visits provided students with a comprehensive view of the material production process, from modeling to printing. The students' participation in exhibitions and technical visits helped integrate different areas of knowledge, offering them the opportunity to experience and observe real-world situations related to the studied content[3]. These experiences allowed students to gain a broader understanding of the production process and the scientific concepts involved, enriching their learning in a creative, collaborative, and interactive manner.

For example, to address Genetics and Cell Organization, classes included interactive lectures, dynamics, experiments, and the use of didactic materials produced by the 3D printer. To facilitate the understanding of concepts, students were collaboratively guided in groups to paint 3D-printed cells with gouache paint. As specific colors were assigned to each cell component, one student would paint it, then pass the cell to another student in the group, ensuring everyone's participation. At the end of the activity, students were able to understand the differences between eukaryotic (animal and plant) and prokaryotic cells.

In another instance, students were introduced to a chromosome chart and a buildable DNA model. They were divided into groups to share these materials. By handling the models, observing their three-dimensional forms, and feeling the texture and divisions of each structure, students discussed among themselves to share ideas and clarify doubts. This approach encouraged active participation and collaborative knowledge construction, as per the principles of Maker Education. Indeed, Maker Education fosters creative expression, collaboration, autonomy, and interdisciplinary work [4].

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To allow students to engage hands-on and solidify their understanding of the presented content, interactive activities with modeling clay were proposed for constructing cells and an individual's karyotype, highlighting the differences and characteristics of each chromosome. At this moment, students were able to relate theory to didactic materials to produce a product that enhances their understanding of Science content. This reflection reveals how Maker Education encourages students to build artifacts and objects, understand their function, and appropriate techniques, transforming them into producers rather than mere consumers [5].

Another topic covered was the Earth's Layers, taught to a 7th-grade class. These classes were conducted not only in the classroom but also in different school environments, such as the science laboratory and library, in addition to a visit to the IFGoiano LabMaker to experience the prototyping process. Students were encouraged to reflect on the proposed topics and actively participate in knowledge construction by producing prototypes of the Earth's layers using 3D printing and styrofoam.

These practices were not only productive for our teacher training but also enriching for the elementary school students, as we sought to engage them actively as protagonists in their learning process. "The classroom can be a privileged space for co-creation, a Maker space, for seeking entrepreneurial solutions at all levels (...), the important thing is to stimulate each student's creativity." Therefore, these experiences contributed to both the students and us, future teachers.

Keywords. Maker Education, Supervised Curricular Internship, Teacher Learning.

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Validation of the Didactic Resource "Entomological Box" in Investigative Activities Developed in a Non-Formal Teaching Space

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Abstract. The objective of this study is to describe the use of the "Entomological Box" resource in investigative activities developed in a non-formal teaching space, located at the Central Campus of the State University of Goiás, in Anápolis, GO. The entomological box is a low-cost resource and was used with basic education students visiting the Tatu Ecological Trail. The resource was used in the construction of concepts about biological diversity, scientific collections, morphological and taxonomic characterization of insects, and the importance of bees. The results showed that the resource has the potential to arouse curiosity, bring engagement and promote the active construction of scientific concepts, and can be used in various teaching contexts and for different age groups.

The realization of practical activities, especially investigative ones, in Science Teaching, whether in formal or non-formal teaching spaces, still presents some precariousness, especially with regard to the lack of didactic material. In teaching about insects, for example, it is common to use entomological boxes, and for this purpose, it is necessary to collect the specimens that will make up the collection, which requires time and sacrifice of the specimens collected.

Several authors [1,2] report the use of this resource as being able to actively assist in the teaching-learning process of students, increasing interest and curiosity about the contents. The authors also reinforce that the contact between theory and practice places the student within a perception of experience, thus being an important didactic-pedagogical resource in Science classes.

The use of these resources should preferably be combined with the performance of practical activities, conceptualized as educational tasks in which the student has direct experience with the physical material, in which action must be taken, either by developing the task manually, or by observing the teacher in a demonstration, provided that, in the task, the object is presented materially [3].

Practical activities are developed on the Tatu Ecological Trail, a non-formal teaching space, located on the Central Campus of the State University of Goiás, in Anápolis. These scientific and environmental education activities have been developed since 2001 and are aimed at Basic Education students from the public and private education networks of Anápolis and region. The activities range from the guided descent to the trail that cuts through three phytophysiognomies of the Cerrado, to the use of investigative and playful activities in which various resources are used.

One of these resources is the entomological box, a low-cost resource acquired commercially [4] and which is made from the model printed on A4 sheet, both of the box and of the insect specimens. To assemble the material, in addition to the printed sheets of paper, glue and colored pencils are used. The use of the resource was adapted to the activities carried out at the Ecology and Science Education Laboratory – LabEduc, a space attached to the Tatu Ecological Trail. The validation of this resource took place with both elementary school and early childhood education students. For each stage of teaching, the activities were adapted, adapting to the language and contents worked.

In general, the activity consists of three moments: 1. Presentation of the empty entomological box, questioning the purpose of the box called "entomological". In this context, the etymology of the word and the meaning of this resource that represents an important scientific collection in sampling and recording the diversity of insects are discussed. 2. Next, an investigation is carried out with the students about which animals should be placed inside the box. Different arthropods are presented, all made as paper models. The investigation continues to ask which of the arthropods are insects and why? That is, which morphological characteristics could be used as a criterion for classifying the group of insects. Examples of insects known to students are requested. This moment is used to discuss the ecological importance of insects. 3. At the last moment of the activity, students receive printed sheets and colored pencils so that they can assemble their own entomological boxes. The observation of the differences found between the colored insects by the students also produces an opportune moment to explore the concept of species diversity. Other concepts such as aposematisms, camouflage, mimicry can still be explored, depending on the stage of teaching and the purpose of the visit.

We conclude that the "Entomological Box" resource is a low-cost, easy-to-apply resource, capable of arousing the curiosity and engagement of students. In addition, the resource makes it possible to approach various scientific concepts, such as scientific collections and their importance for the recording of biodiversity, the morphological and taxonomic characterization of arthropods and insects, among other contents. Another advantage of the material is the possibility of producing several boxes, so that each student can prepare his own, which reinforces the concept of practical activity in which the student has direct experience with the physical material, developing the task manually. The practical activity can be of the investigative type, in which previous knowledge, hypothesis raising, argumentation and systematization of ideas are worked on. It is also possible to develop playful activities, such as the one carried out with early childhood education classes, in which the insects were made with modeling clay.

Keywords. Non-Formal Space, Didactic Resource, Science Teaching, Entomological Box.

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The Use of the Investigative Approach to the Promotion of Scientific Literacy

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Abstract. In the teaching of Science, the lack of interest of students in school activities may be associated with the decontextualized approach to scientific concepts. In this context, this research sought to identify the contributions of the investigative approach to the promotion of Scientific Literacy of Elementary School students. For this, we used, as a tool to induce scientific culture, an Investigative Teaching Sequence (ITS) with the theme "Reproductive Mechanisms". 144 students were impacted with a didactic approach that aims to bring curricular scientific concepts closer to the innate curiosity of students about the object of knowledge "Reproduction", causing greater engagement and enchantment for "doing Science".

In the teaching of Science, the lack of interest and motivation of students in the construction of their knowledge may be associated with the difficulty in relating the curricular scientific concepts to the situations experienced by them in their daily lives [1]. That is, they do not see meaning in what is taught to them, since the object of knowledge is not sensitive to the context of its learning or origin [2]. Thus, the great challenge arises to bring scientific knowledge closer to the students' context, making learning meaningful.

Meaningful Learning (ML), according to Ausubel, is the result of the integration of new information with the learner's previous knowledge [3]. In this context, the student is a non-neutral subject, and his location in space, time and culture influences his interaction with the object of knowledge in a broader way than only within the school environment [4].

By providing activities that arouse curiosity, questioning and investigation – through methodologies that value the practical use of knowledge and develop "competencies, skills, attitudes and values" [5] - educators create an environment conducive to the development of critical, autonomous thinking and the student's capacity for analysis [6].

In this perspective, from the theoretical references that support the Teaching of Science by Investigation (TSI) and Meaningful Learning (ML), this research proposed to investigate the contributions of TSI and ML to the promotion of Scientific Literacy (SL) of Elementary School students.

The research data were collected in four classes of the 8th grade of Elementary School of a public school of the state network, in Anápolis-GO. We used as a tool an Investigative Teaching Sequence (ITS) composed of interconnected activities that were developed during eleven classes.

Regarding the Theme, the ITS contemplated the object of knowledge "Reproductive Mechanisms" and covered diversified methodologies guided by the problem: "How do organisms perpetuate themselves? What are the structures and mechanisms involved in this process?"

In the end, the collected data were organized and analyzed qualitatively, seeking to find evidence of the Scientific Literacy achieved, according to the SL indicators proposed by Sasseron and Carvalho [7].

Among the activities developed during the ITS, we highlight the initial instrument applied in the first and second class, which met the objective of surveying previous knowledge; and the final instrument, which was the repetition of the initial activity, with the objective of producing comparative material for the identification of SL in development.

Having been carried out within the scope of the Professional Master's Program in Science Teaching at the State University of Goiás (PPG PEC/UEG), the results presented here are part of the dissertation entitled "Perspectives of investigative practices for the promotion of Scientific Literacy in Elementary Education".

In the initial instrument, the students produced a cloud of ideas, a mind map and a text. The analysis of the "idea cloud" revealed that the students presented a reasonable repertoire of spontaneous terms related to reproduction/reproductive mechanisms. This analysis corroborates the idea that students are not empty boxes. This is the general principle of the constructivist theories that revolutionized the planning of the teaching-learning. The mind map aimed to organize ideas for more efficient writing. Analyzing the texts produced by the students, it was possible to identify in each of them the SL indicators. A total of 71 SL indicators, 42 of which were related to the work obtained in an investigation; 09 related to the structure of thought and 20 related to the understanding of the analyzed situation.

In the final instrument, a mind map and a text were produced. Although the mind map was not used with an evaluative character, it was possible to observe an expansion in the students' repertoire, evidenced by the increase in the number of scientific terms related to the theme studied. The final text was thoroughly analyzed in order to identify signs of Scientific Literacy (SL) in development, using the indicators proposed by Sasseron and Carvalho [7].

We observed an increase from 71 to 324 SL indicators, which represents a growth of approximately 356%. The indicators related to working with data obtained in an investigation increased by about 198%, from 42 to 125. The indicators associated with the structuring of thought had a significant increase of 1300%, going from 9 to 126. In addition, the indicators related to the understanding of the analyzed situation increased by 265%, from 20 to 73.

Considering that for the production of the final text the students did not have any motivating text or source of consultation, having to seek only their constructed knowledge, we understand that the activities of the ITS favored a Meaningful Learning. Given that the students were able to remember the situations experienced, as well as the concepts and meanings constructed.

This result is in line with the objective of this research, which is to promote the Scientific Literacy of students using the ITS as a tool to induce situations favorable to the construction of knowledge for the consolidation of Meaningful Learning.

In addition, we observed a significant advance in SL indicators, as well as in the students' ability to express their ideas in verbal and written language. This allows us to conclude that the ITS contributed to the construction of a more scientific perspective among the students.

Keywords. Scientific Literacy, Meaningful Learning, Reproductive Mechanisms, Investigative Teaching Sequence.

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An Intercultural Proposal between the Astronomy of Indigenous Peoples of Oiapoque and the Popularization of Traditional Knowledge

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Abstract. In accordance with the latest census by the IBGE – Brazilian Institute of Geography and Statistics, there are 305 indigenous ethnicities in Brazil, which speak 274 native languages. In particular, in the Northern region of Brazil, the state of Amapá is home to the Palikur, Karipuna, Galibi, Galibi-Marworno, Waiãpi, and Tiriyó ethnicities.

From north to south of the country, each community possesses distinct characteristics and particularities related to their cultures, cuisines, histories, agricultural practices, and traditional knowledge. Indigenous knowledge represents historical legacies of great cultural value for the native peoples and the entire social construction of the national territory. Among the diversity of traditional knowledge, Indigenous Astronomy influences the daily practices of various indigenous communities throughout Brazil to this day.

Indigenous Astronomy is a branch of Ethnoastronomy, one of the areas of astronomical knowledge that studies a people's astronomical understanding through their customs. Indigenous constellations are traditional knowledge closely linked to scientific understanding, as they are related to natural phenomena and can be integrated interculturally with Basic Education.

Although Brazil has a plurality of indigenous ethnicities, records of astronomy from only a few indigenous groups, such as the Guarani and Tukano, have been documented, with none of them in the state of Amapá. Cataloging these constellations is of great importance for the appreciation, dissemination, and spread of indigenous knowledge throughout Brazil.

In this light, this is an excerpt from a doctoral research project currently under development, which seeks to catalog the constellations of the indigenous peoples of Amapá, with a focus on the Karipuna ethnicity, predominantly found in the municipality of Oiapoque, on the northern border of the state. This effort will contribute to a significant educational resource, as Astronomy is included in the National Curriculum Parameters (PCN) and expanded upon in the National Common Curricular Base (BNCC). The guiding documents suggest that traditional indigenous knowledge, as well as their histories and cultures, should be worked on interculturally in the school environment and are grounded in Law No. 11,645, of March 10, 2008.

Interculturality is fundamental in the educational context, aiming to promote understanding, respect, and appreciation of the different cultures and identities present in society. Its integration with Basic Education allows students to develop skills for coexistence, dialogue, and appreciation of cultural diversity, contributing to an education that fosters understanding and respect for different cultures. Indeed, working interculturally with Indigenous Astronomy contributes comprehensively to the promotion of indigenous culture and to an astronomy education aligned with the principles of the BNCC.

The BNCC recognizes the diversity and cultural plurality of Brazil and suggests that themes be addressed transversally, incorporating interculturality. In the context of Astronomy, interculturality is highlighted through Ethnoastronomy, which has great potential to be explored within Brazil, as the country is home to various indigenous and traditional communities with vast cultural wealth. The cataloging of constellations from traditional peoples becomes crucial for linking basic education learning with Brazilian culture.

Given the scientific and cultural importance of disseminating indigenous culture and traditional knowledge, the primary objective of this research is to catalog the constellations of the Karipuna indigenous people residing in the state of Amapá. From this initial premise, the aim is to investigate how we can use intercultural approaches to catalog the constellations of the Karipuna indigenous people, highlighting their cosmological, historical, cultural, and scientific

aspects, and thus develop educational materials to promote the dissemination of indigenous culture, contributing to the teaching of ethnoastronomy and the appreciation of traditional knowledge.

This entire proposal has qualitative characteristics, underpinned by an ethnographic methodology with participant observation. Data collection will be conducted over a long period and will require living within the indigenous villages to identify which constellations exist in the communities and validate them through astronomical observations.

This research is divided into four stages: planning and meetings with project partner organizations to develop a schedule for living in the villages; development of the proposals and validation of data; reflection and writing about the experiences and educational products resulting from the research; and the organization of an event to disseminate the research and the developed products.

Data collection will be carried out through oral histories, image and video production, interviews, group discussions, and a field journal. Throughout the development process, in addition to respecting all ethical research principles, the researchers will adopt a stance of empathy and respect for indigenous culture. It will be a collaborative effort, with all participating indigenous individuals receiving authorship credit for the products derived from this research.

The development of this project is committed to the preservation of traditional knowledge. This proposal seeks not only to disseminate knowledge but also to strengthen ties of respect and mutual understanding of indigenous traditions. This project has the potential to impact education, research, and the preservation of indigenous cultural heritage, contributing to a more just, inclusive, and culturally aware society.

Keywords. BNCC, Interculturality, Indigenous Astronomy, Ethnoastronomy, Oiapoque.

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Initial Training of Science Teachers for the Mobilization of STSA Education and Science Education in the School Context

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Abstract. This text reports the development of a training proposal that aimed to contribute to the initial training of science teachers, aiming at the mobilization of CTSA (Science, Technology, Society and Environment) education and Science Education in the school context. These perspectives aim to promote the scientific and technological literacy of students, a movement that goes beyond the simple transmission of scientific concepts. There is, therefore, a concern with unveiling the nature of Science and Technology, highlighting them as social and human enterprises. In addition, it emphasizes the relationships that are established between Science, Technology, Society and Environment, with the objective of equipping citizens so that they can participate in decision-making based on scientific and technological issues.

The motivation for the development of this action arose from concerns related to my professional practice, especially when observing the formative itinerary experienced by teachers in initial training within the scope of the Pedagogical Residency Program (PRP). This program, which was a public policy created with the objective of improving the initial training of basic education teachers, fostered institutional projects of pedagogical residency in licentiate courses.

In the context of the Pedagogical Residency Program, as a professional who accompanied the residents in the basic education school, and by observing the regencies developed by them in the curricular component Natural Sciences, in the final years of Elementary School, it was possible to observe the existence of formative needs that are essential for a science teaching that goes beyond the mere transmission of scientific concepts.

The motivation is also justified in consideration of several studies, such as those by Vieira (2003), Vázquez *et al.* (2011) and Deconto, Cavalcanti and Ostermann (2017), which point to the existence of simplistic perceptions about the nature of Science (NoC) and Technology among many teachers who teach Science. In addition, in an initial diagnosis carried out with the residents, we found the existence of naïve perceptions about the nature of science and technology, as well as the lack of knowledge of the STSA relationships. This finding is in line with the studies cited, indicating training needs.

In this context, the proposal was developed with five undergraduate students in Biological Sciences, participants in the Pedagogical Residency Program (PRP), linked to the Federal University of Mato Grosso (UFMT), Araguaia Campus, and the Senador Filinto Muller State School, institutions located in the city of Barra do Garças, state of Mato Grosso.

For the elaboration of the proposal, it was necessary to select authors from the CTSA field and their respective works (books, articles) to support the process. Based on this, we proceeded to create a didactic material composed of PDF content and video lessons. The video classes were hosted on Instagram, in a profile created for this purpose. The didactic material aimed to provide theoretical and practical knowledge about the nature of science and technology, as well as their interrelations with society, supporting science teachers in the elaboration of didactic proposals in this perspective, in order to promote scientific education in the school context.

The didactic material was organized into five modules: the first module presents the CTSA field, the second offers reflections on the nature of science, the third addresses aspects of the nature of Technology, the fourth discusses the interrelations between Science, Technology, Society and Environment, and, finally, the fifth module deals with Education and CTSA Teaching.

For the development of the didactic material, a course with a total duration of 40 hours was planned, of which 5 hours were carried out synchronously and 35 hours asynchronously. The synchronous moments took place in two meetings, using the Google Meet platform, chosen because it is familiar to the participants. The asynchronous moments included readings of texts related to the theme and video classes prepared by us, research professors responsible for the action.

The synchronous moments consisted of opportunities to discuss the syntheses and narratives elaborated by the students during the asynchronous studies of the content. These moments were fundamental, as they allowed to expand knowledge about the topics addressed, especially in relation to latent aspects about the emergence of the CTSA field, the nature of Science and Technology, their interrelations with Society, as well as issues related to Education and CTSA Teaching.

As a final work, it was suggested to the students the elaboration of a didactic proposal with a CTSA approach. We suggest the theme "Pesticides" due to its relevance to the social and economic context of the state of Mato Grosso. The students, divided into groups, used Google Docs. to, collaboratively and under the guidance of the research professors, plan and produce a didactic proposal for the curricular component Natural Sciences. The proposal was aimed at high school students, with the objective of developing the skills (EM13CNT304) and (EM13CNT104) of the National Common Curriculum Base (BNCC).

In addition to the development of the training proposal, we seek to understand the contributions of this experience in the training of future Science teachers for the mobilization of CTSA education in the school context. For this, the data obtained through observations recorded in a field diary were analyzed, as well as the syntheses/narratives prepared by the students during the training course, in addition to the didactic proposal that they developed as a final work. Data analysis was conducted using Bardin's Content Analysis (2016).

The analysis revealed that the development of the proposal allowed teachers to acquire a more realistic view of the nature of science, technology and STSA relations. In addition, the teachers found directions that allowed/allow the mobilization of the knowledge acquired in the elaboration of didactic proposals with a CTSA approach. The analysis of the didactic proposal, which addresses the theme of pesticides from a CTSA perspective, evidenced the teachers' understanding of the importance of integrating science, technology, society and environment in teaching, in addition to demonstrating their ability to apply theoretical knowledge in a practical context.

In fact, the didactic proposal not only demonstrated the appropriation of the concepts and principles of the CTSA field, but also evidenced the ability of teachers to translate this knowledge into activities and pedagogical strategies that stimulate critical thinking, reflection and student participation. This is evidence of the effectiveness of the training process, indicating that teachers have not only assimilated theoretical knowledge, but have also developed the ability to implement it in the school context. This mobilization of knowledge is essential for the promotion of scientific education in the school context.

Keywords. CTSA, Science Education, Science Teaching, Pedagogical Residency.

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Science Education Beyond University Walls

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Abstract. Human beings use five ways of Human beings use five ways of approaching the universe: science, philosophy, religion, art and madness [1]. The main characteristics of science are that it is explanatory, logical, provisional and empirical [1]. Generally speaking, science produces generalizations about the universe based on empirical grounds, using a more or less variable method, logical discourse and accepts that generalizations are provisional, as an exemple, they can be overturned and/or challenged in the future [1].

In modern times, citizens need to understand the products/processes that come from science and how they impact on their lives, otherwise they will find it difficult to understand common everyday situations, such as the news, and they will also find it difficult to enter the world of work. Dealing with technology requires a critical eye, avoiding prejudice against innovation and, at the same time, passive acceptance of technological novelties [2].

Still in this context, two main factors have changed the process of transferring knowledge in contemporary times: i) the exponential growth of knowledge produced, which means that it is no longer possible to teach everything to everyone, so the quality of the knowledge to be taught has become more important; ii) the influence of the work of scholars (epistemologists and psychologists) who have elucidated that knowledge is constructed at both an individual and a social level [3].

Science and technology are part of our daily lives; today the world is connected. Understanding, interacting, reflecting on, discussing and forming an informed opinion are the actions of an emancipated citizen. The popularization of internet access has facilitated the availability and circulation of information, but there is a need to filter, analyze and process this information so that it can become knowledge.

In this context, the popularization of science involves the act of disseminating and publicizing science to the various sectors of society [4]. Nowadays, the popularization of science is essential, because with scientific and technological development, new research topics must be put on the agenda for social debate [4]. The democratization of scientific knowledge plays a fundamental role in citizens' right to information and social participation [4]. It is therefore necessary for scientific and technological results to be disseminated beyond the walls of the university, strengthening formal and non-formal education, as well as training for citizenship.

Demo [5] argues that Science Education (SE) promotes citizenship that knows how to think, which involves knowing how to build and use science and technology for ethical social and citizen purposes. Thus, SE is an educational process. When you learn to deal with the method, to plan and carry out research, to argue and counter-argue, to base your argument on authority, you are building a citizenry that knows how to think, as well as how to do science.

SE means knowing how to deal with the science that is impregnated in today's society and taking advantage of scientific knowledge to improve the quality of life of citizens, in terms of health, food, housing, sanitation, etc., as well as working on the urgent environmental issue [5]. It should be noted that Science Education, Popularization and Scientific Dissemination must be allied in the process of democratizing and socializing the knowledge produced by the sciences.

This work aimed to present strategies for the didactic transposition of technical-scientific research topics for a wider audience, including students, educators, rural producers and others. Therefore, the aim is to consolidate strategies for the propagation of Science Education, popularization and dissemination of science, beyond the walls of the university.

The work involved the participation of university professors, undergraduate students and post-doctoral students. The different actors took part in all stages of the process of creating and disseminating the digital products.

The products for dissemination on social

networks were prepared based on an analysis of at least two scientific articles. In selecting and curating the scientific texts, priority was given to socially relevant topics related to the conservation of the Cerrado's biodiversity, sustainable agricultural production, impacts, mitigation and adaptation to climate change published in qualified and impactful journals (Qualis Periódicos classification - Capes).

The articles choice was based on their importance in the context of elucidating critical environmental issues for the general population, with a special focus on local communities, farmers, students and educators. This population includes those directly affected by environmental issues and who could benefit from a more didactic understanding of current challenges and possible solutions. The selected works were analyzed in order to understand their interrelationships, as well as to identify the most relevant and significant information for a clear understanding of the topics covered.

The technical information in the articles was translated and transformed so that it could be understood by a wider audience, but always taking care not to mischaracterize the content of the selected articles. To create the digital products, Google Drive was used to organize the materials; Canva to create attractive designs; Unsplash and Pexels: high-quality free image banks to add visual elements to the content; Lightroom: to edit photos for the media. The digital products generated included didactic and strategic visual elements to facilitate understanding by the general public.

To reach as many people as possible, we used Instagram, a platform that allows non-formal communication with the potential to reach various sectors of society. The products were published on two profiles @loveplantscerrado and @Mykocosmos. Both profiles also have websites dedicated to the dissemination of science and the popularization of science, https://www.loveplantscerrado.com.br/ and https://www.mykocosmos.com/ respectively.

It is believed that making scientific content available in an accessible and didactic way can enable individuals from different social groups to understand scientific issues, leading to citizen science education. It is hoped that scientifically educated citizens will be able to adopt better practices in the face of environmental challenges.

This form of dissemination provides greater visibility for scientific studies and the work of scientists, demystifying the “scientist” profession and bringing the university closer to society.

Keywords. Popularization, Citizenship, Science, Dissemination.

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Cienciar: Teaching Action Focused on Active Methodologies and Meaningful Learning

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Abstract. The aim of this work is to describe actions that relate active methodologies and critical significant learning in the process of (initial and continuing) teacher training. As well as demonstrating how such actions can enhance the Science Education of the subjects involved in the process.

We understand methodologies as guidelines for teaching and learning processes. These are consolidated through strategies, approaches and techniques [1]. Active methodologies are strategies aimed at the effective participation of students in learning and the construction of knowledge [1]. These include the inverted classroom in which the student studies beforehand and the classroom becomes a fertile space for questions, discussions and practical activities [2].According to Moran [1, p. 37] "learning is active and meaningful when we advance in a spiral, from simpler to more complex levels of knowledge (...)". For Moreira [3], meaningful learning involves non-literal and non-arbitrary cognitive interaction between new knowledge and prior knowledge (subsumers). The new knowledge gains meaning and the learner's prior knowledge becomes richer, more differentiated and more elaborate.

Meaningful learning is a process, meanings are gradually grasped and internalized and language and interaction are indispensable in the process [3].

Critical Meaningful Learning is an anthropological perspective that allows the subject to be part of their culture without being subjugated by it [3]. Through the critical perspective, students will be able to "work with uncertainty, relativity, non-causality, probability, the non-dichotomization of differences, with the idea that knowledge is a construction (...)" [3, p.7].

Nowadays, we stress the importance of solid teacher training. This training must include knowledge of the subject to be taught (content, construction processes and Science, Technology, Society and Environment – in portuguese CTSA - relationships); knowledge and questioning of spontaneous teaching thinking; mastery of theoretical knowledge about learning; knowing how to criticize the usual teaching; knowing how to design activities and guide the activity with students; knowing how to evaluate, research and use the results of research [4].

Based on the above, we will now describe the actions that were carried out in the context of initial and continuing teacher training at the University of Goiás State (UEG), Palmeiras de Goiás University Unit. The subjects of the actions were professors working in Higher Education linked to the Professional Master's Degree Program in Science Teaching (PPEC-UEG), Basic Education teachers enrolled in and graduating from PPEC-UEG, teachers working in Basic Education and undergraduates on the Biological Sciences Course at UEG-Palmeiras de Goiás.

The actions took place under the Pedagogical Residency Program (Capes/UEG) over 18 months. Google classroom was used as the environment for hosting the virtual classroom. In this space, the actors/subjects were integrated and were able to share knowledge, expertise and experiences.

The flipped classroom was used as a strategy for the active involvement of the subjects. In the virtual classroom, text files (scientific articles, book chapters, booklets, etc.), activities, videos and links (to access other environments) were shared, always in advance of the face-to-face meeting/action. It should be noted that the actions developed in Basic Education used textual materials and educational products generated by PPEC-UEG master's students and teachers, as well as educational products deposited on the EduCapes Platform [5]. The texts selected sought to enhance the development of the subjects' scientific education.

The face-to-face meetings involved discussions / discussions of texts on the processes of constructing scientific knowledge, CTSA

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relations, approaches in the teaching-learning process (e.g. Teaching Science by Investigation), as well as the evaluation process and the use of research results in teaching-learning. These meetings were also spaces for socializing and exchanging knowledge and experiences between the undergraduates and the teachers already working (in continuing education).

Practical activities were planned, designed, adapted and developed collaboratively with students in the final years of primary and secondary school at the project's partner schools. The proposed activities were conducted by the undergraduates, under the supervision of the preceptor teachers, and involved active methodologies. Thus, they worked with experimentation, investigation, didactic-pedagogical games and other playful activities, such as theater and storytelling [6].

After each action carried out in the partner schools, the trainees met with the teacher trainers to analyze and evaluate the strengths and weaknesses of the teaching-learning process and teaching performance.

In this way, the undergraduates were able to consolidate essential knowledge for their future teaching career. In addition, teachers in continuing education were able to rethink their classroom practice, incorporate active methodologies and theoretical elements that can enhance the critical and meaningful learning of students in basic education.

It is believed that this way of integrating subjects enhances teacher training, making it more meaningful for teachers.

Keywords. School, Science Education, Integration, Teacher Training.

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Essential Oils as an Alternative to Antimicrobials for *Salmonella sp.* Strains

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Abstract. Microbial resistance, exacerbated by the indiscriminate use of antimicrobials, poses a global threat to public health, highlighting the need for alternatives to conventional antibiotics [1-2]. In this context, essential oils (EOs) from plants emerge as a promising ecological solution, aligned with Brazil's National Policy on Medicinal Plants and Phytotherapics (PNPMF), which aims to promote sustainable use of biodiversity and ensure the quality and safety of phytotherapeutics [3-4].

Studies indicate that EOs possess effective biological properties, including antimicrobial, antioxidant, and anti-inflammatory activities, offering an alternative with lower toxicity and environmental impact [5]. This study explored the antimicrobial activity of EOs from *Pimenta dioica* against *Salmonella sp.*, contributing to the development of sustainable solutions in the fight against antimicrobial resistance. Leaves and fruits of *P. dioica* were collected in Iporá – GO and subjected to hydrodistillation using a Clevenger apparatus to obtain the EOs. Antimicrobial activity was tested using the agar diffusion method with *Salmonella enteritidis* and *Salmonella typhimurium* strains.

The strains were spread on agar plates that had been autoclaved and solidified. Subsequently, different concentrations of EOs (25, 50, and 100 μg/mL) were applied to 3 mm filter paper discs placed on the agar medium in various positions. Water, ethanol, and amoxicillin antibiotic were used as controls, and all experiments were performed in triplicate. To determine the antimicrobial efficacy of the EOs, inhibition zones were measured and statistically analyzed using Tukey's test at a 5% significance level, and ANOVA was performed using the SISVAR® software [6]. EOs from the leaves and fruits of *P. dioica* exhibited significant antimicrobial activity against *Salmonella sp.*, especially at a concentration of 100 μg/mL.

Analysis of EOs from the leaves of *P. dioica* revealed inhibition zones of 14.2, 15.9, and 21.6 mm against *S. enteritidis*, while EOs from the fruits showed inhibition zones of 15.7, 15.1, and 23.7 mm (at concentrations of 25, 50, and 100 μg/mL, respectively). At a concentration of 100 μg/mL, the efficacy was statistically superior compared to the antibiotic control (zone of 20 mm). In assays with *P. dioica* EOs on *S. typhimurium*, inhibition zones at 100 μg/mL were 16.3 and 16.6 mm, respectively, though other concentrations showed no inhibition.

These results indicate that *P. dioica* EOs have significant potential as antimicrobial agents, particularly against *S. enteritidis* and *S. typhimurium*. This study suggests that these oils could be an effective alternative to traditional antibiotics, offering not only a promising solution to antimicrobial resistance but also an option with a favorable ecological profile, representing a sustainable and environmentally friendly choice that aligns with biodiversity conservation and public health promotion principles.

Keywords. Microbial Resistance, Essential Oils, Phytotherapy, Environmental Sustainability.

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Tessituras Project: Reading and the Act of Reading as a Principle for Living

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Abstract. We are faced with a life characterized by fluidity, spectacle, performance, and, above all, the mediation of capital, which crushes all humanity in a process of reification that impacts human lives, especially the poorest, the socially vulnerable, and, above all, the incarcerated population. Given this reality of precariousness, fragility, and invisibility of those deprived of freedom, who do not fit societal expectations but will eventually return to society in a process of reintegration, we see this project as fundamental for the changes we aim for in our community. Why not give these reeducators an opportunity to be transformed through education? Thus, this project can be the primary action in a trajectory of change for many prisoners who may benefit intellectually, symbolically, and socially from the act of reading as a redemptive action for building and rebuilding human humanity. This occurs through guided reading practices in the process of reading therapy [3], an action that mobilizes access to texts, reading of the world [2], words, and understanding of text and human life.

Encouraging reading and establishing the habit of reading create symbolic, imagistic, cultural, linguistic, and cognitive relationships in the construction of the reading space and the formation of the reader [3], activating human subjectivity in a movement to reclaim one's own humanity. This project aims to establish these important elements for reading within the context of education for the act of reading and for life, addressing illiteracy, limited reading opportunities, exclusion, the erosion of humanity, and the barriers that the world of literary texts (the very decoding of signs) might represent for this incarcerated community.

However, this assertive action regarding education and the necessary human reclamation in these prison spaces faces many challenges, such as the lack of awareness about the sentence reduction program and, above all, the low educational level of most of the incarcerated population, which represents preliminary difficulties in reading and benefiting from it, as noted by members of the group Education in Prisons. When we consider that humans live constantly in a humanized world and sometimes find themselves in a condition of complete dehumanization, we might regard talking about the "humanization of the human" as a pleonastic concept, or redundant, as humanity is expected to be humanized. In this movement of returning humanity to the human, literature is seen as a tool capable of expressing the human being and consequently influencing the formation of the person [1].

The act of narrating and self-narrating is a universal necessity in organizing the symbolic and subjective dimension of life. Thus, we understand reading, as access to literary art, as fundamental to humanized life and capable of reshaping life and the processes that compose it, whether anguished or not, but important for the formation of individuals integrated into life. For this reason, it is very important that it is present and that we can perceive this symbolic dimension, provided here by literary art, as an integral part of our social adjustment, which, amidst many concerns and unrests, allows us to see that the act of narrating is crucial for the formulation of human subjectivity, for giving meaning to existence, finding solutions to anxieties and human suffering.

The processes of exclusion faced by people are diverse. The marginalization and precarization affecting Brazilians range from the lack of material resources to the exclusion from access to knowledge. There is already a wealth of research seeking to develop strategies to provide people with deep knowledge and ensure that education reaches everyone equally, offering conditions for life and living. From these considerations, we conceive a project for training and supporting readers, capable of including reading in the set of relevant knowledge for exercising citizenship and for forming autonomous individuals prepared to face the adversities of human life.

Additionally, as reading is considered therapeutic [3] and how this relates to the formation of incarcerated individuals for reading various texts of classical literature, organized into relevant themes appropriate to their reality, in an exercise of reading, interpretation, and production of reflections that also include elements of personal, social, and historical memory of our existence. In the construction of literate knowledge of all kinds, reading as an exercise to read the world and read words to understand the world and insert oneself into it in an autonomous and critical manner is essential. For this, in professional training and beyond, reading mediation as a fundamental practice for the formation of individuals in life and their production is necessary. This project allows for important reflections on the practice of reading in the prison environment, on the formation of a taste for reading, on possible reading practices, and, especially, how reading opens “doors” to the world of deeper ideas about living and being in the world. A conception of reading in the literary realm and its configurations with reality.

Keywords. Reading, Prison, Remission, Reeducators, Readers.

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The Leadership of Xakriabá Women: Protagonism, Resistance, and Transformation

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Abstract. This article aims to explore the role of Xakriabá women as fundamental leaders in the fight for rights, cultural preservation, and community strengthening. The Xakriabá, are identified by the Handbook of South American Indians (1946) as part of the Jê ethnic group, reside in the mid-São Francisco region, in the municipality of São João das Missões, in northern Minas Gerais.

According to the document "Povos Indígenas no Brasil" (PIB, 2014), the Xakriabá have survived intense contact with bandeirantes and later with cattle and mining fronts, but today, they are experiencing a process of cultural valorization and an attempt to reclaim their space. Originally, this group was hunter-gatherers with a complex social organization (Almeida, 2006, p. 9 – 16). The protagonism of indigenous women manifests itself in a multifaceted way, reflecting their ability to balance multiple roles both inside and outside their communities.

The Xakriabá indigenous woman acts as a mother, wife, community leader, teacher, artisan, and political representative, being fundamental to the cultural and social survival of their people. By simultaneously playing the roles of mother, wife, teacher, and politician, she embodies the strength and resilience of her culture. As a mother, she is the guardian of ancestral knowledge, transmitting traditions and values that sustain the identity of her people. In the role of wife, she shares responsibility for managing community life, strengthening family and social ties. As a teacher, she contributes to the formation of new generations, ensuring that education respects and values her culture. As a politician, she breaks historical barriers, defending her community's rights and addressing gender and ethnic issues in positions of power, promoting changes that resonate both within and outside their villages.

The goal is to highlight how these women take on leading roles both within their communities and in broader political arenas, challenging the patriarchal and colonial structures that have historically marginalized them. The methodology used combines a qualitative analysis based on interviews with two Xakriabá indigenous women, a bibliographic review on indigenous feminism, and participant observation in community events.

This approach allows for a deep understanding of these women's life trajectories, their resistance strategies, and how they articulate their ethnic identity with gender issues. The results reveal that Xakriabá women, by occupying leadership positions, promote not only the defense of their territories but also the maintenance and revitalization of their cultural traditions. They stand out in leading movements that seek social justice, recognition of rights, and the amplification of their voices in the Brazilian political and academic scene.

In their struggles, Xakriabá female leaders have achieved significant gains, such as access to specific public policies and the strengthening of interethnic and intergenerational support networks. We conclude that Xakriabá women, by confronting the challenges of gender and ethnic discrimination, emerge as central figures in building a more equitable and sustainable future for their people, serving as examples of resistance and transformation in the ongoing fight for rights and recognition.

Keywords. Cultural Preservation, Female Protagonism, Resistance, Xakriabá Women, Indigenous Leadership.

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share and celebrate this knowledge in such a significant space for exchange and learning.

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Between Reading and Literacy: A Literacy Project in Prison

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Abstract. The processes of exclusion to which people are exposed are diverse. Marginalization and precarization affecting Brazilians range from a lack of material resources to exclusion from access to knowledge. Today, there are numerous studies aimed at developing strategies that provide people with profound knowledge and ensure that education reaches everyone equally, thereby offering better living conditions. Believing in these possibilities, the extension project "Tessituras: Weaving Life, Narratives, and Books: The Materialization of Reading and the Body in Prison," which supports this research, aims to be an experience of training and supporting readers. It seeks to incorporate reading into a body of knowledge relevant for exercising citizenship and for developing autonomous individuals prepared to face life's adversities.

Thus, it explores how reading functions as therapy and how this relates to the education of people deprived of freedom through the reading of diverse texts from classical literature, organized around relevant themes suited to their reality. This involves an exercise in reading, interpretation, and reflection that includes personal, social, and historical memory elements of our lives. In the construction of literacy knowledge of all kinds, reading practice involves reading the world and reading words to understand the world and engage with it autonomously and critically. For this, both professional training and beyond, reading mediation is necessary as a foundational and fundamental practice for personal development in life and its production.

Thus, it is possible to develop important reflections on reading practices in the prison environment, on cultivating a taste for reading, on possible reading practices, and, particularly, on how reading opens "doors" to the world of deeper ideas about living and being in the world - i.e., a conception of reading in the literary realm and its configurations with the prison reality in Brazil and its legal reverberations. However, in this context, how can we promote reading among adult individuals deprived of freedom who are illiterate? Why not provide these reeducators with mechanisms to be transformed through education? Moreover, basic literacy. Before they can reflect on texts or make connections linking their lives through literary analysis, they must first "read" at a basic level, recognizing the signs of words and understanding their role in life. This is the major challenge: literacy as an essential element for achieving citizenship.

Literacy is a fundamental right for achieving citizenship and a powerful tool for social transformation. In environments such as prisons, deprivation of freedom leaves marks that exacerbate social exclusion and limit opportunities for reintegration into society after serving a sentence. Illiteracy among individuals deprived of freedom deprives them of a basic right, deepening marginalization and limiting participation in resocialization programs. It is worth noting that many imprisoned individuals did not have access to formal education during their lives, which may have contributed to their life trajectories and involvement in crime. By promoting literacy, we offer these individuals a new perspective on life by achieving a minimal dimension of citizenship that can transform them into subjects of their own history.

Literacy can help incarcerated individuals understand their rights and duties, communicate more coherently, and comprehend their surroundings, even within the prison environment. The project aims to foster individual skills, critical thinking, and autonomy in decision-making through writing, reading texts, and life experiences. By investing in the literacy of individuals deprived of freedom, IFGoiano/Urutai demonstrates a commitment to human dignity and a concept of justice that goes beyond mere compassion. If education is the fundamental pillar in building a more just and equitable society, it becomes even more crucial in a reeducation environment where prisons serve as a means of social reordering through educational practices rather than merely a refuge for socially undesirable individuals. Therefore, we understand that a literacy project in the Pires do Rio prison (which has 15 illiterate individuals) is not only a necessity but also an investment in the future of incarcerated

individuals and in society at large.

Keywords. Education, Literacy Prison Environments.

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Advances and Challenges in Teacher Training for Inclusive Education: The Role of Educational Policies and Teaching Initiation Programs

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Abstract. Educational policies and teaching initiation programs have played fundamental roles in the evolution of teacher training, especially in the context of inclusive education. Educational inclusion seeks to ensure that all students, regardless of their socioeconomic conditions, abilities or special needs, have access to quality education in an environment that values diversity and promotes equity.

Educational policies that promote inclusion have evolved significantly in recent decades. In Brazil, the National Policy on Special Education from the Perspective of Inclusive Education, established by the Brazilian Inclusion Law (LBI), and the National Guidelines for Special Education in Basic Education, are examples of regulatory frameworks that guide the integration of students with special needs. special needs in the regular educational system. These policies emphasize the importance of curricular adjustments, physical and pedagogical accessibility, and ongoing teacher training to ensure that all students can fully participate in the educational process.

Furthermore, the National Common Curricular Base (BNCC) establishes guidelines for inclusive education, promoting pedagogical practices that respond to diversity. The policies also encourage the creation of multifunctional resource rooms and the use of assistive technologies, contributing to the elimination of barriers and the promotion of meaningful learning for all students.

Teaching initiation programs are essential for preparing teachers capable of facing the challenges of inclusive education. These programs generally include theoretical and practical components that cover everything from the theory of inclusion to the application of different pedagogical strategies. Initial training often encompasses courses in diversity, special education, and assistive teaching methodologies, providing future educators with a solid foundation for dealing with the variety of needs and learning styles found in classrooms. Internships and practical experiences are crucial components of these programs, allowing pre-service teachers to engage directly with the reality of schools and develop practical skills for inclusion. These internships are designed to expose prospective teachers to diverse contexts, promoting a deeper understanding of inclusive practices and helping to develop empathy and problem-solving skills.

The impacts of educational policies and teaching initiation programs on inclusive education are significant. Firstly, the integration of inclusive guidelines into the curriculum and teaching practice has contributed to the creation of more equitable learning environments. Schools have become more suitable to meet the needs of all students, providing a space where each student can develop and learn according to their specific skills and needs.

Inclusion-oriented teacher training has led to greater awareness and competence among educators. Teachers who are well prepared to deal with diversity are better able to implement strategies that accommodate different learning styles and paces, resulting in a richer and more effective educational experience for all students.

Furthermore, the focus on inclusive practices has helped to reduce the stigma associated with special needs and promoted a culture of respect and appreciation of diversity. Inclusive education not only benefits students with special needs, but also enriches the educational experience of all students, preparing them to live and work in a diverse society.

Educational policies and teaching initiation programs are essential pillars for promoting inclusive education. They ensure that teachers are equipped with the knowledge and skills needed to create learning environments that serve all students, contributing to a more just and equitable society. The continuous evolution and implementation of these policies and programs are fundamental to the advancement of education that truly respects and values diversity.

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Keywords. Continuing Training, Educational Policies, Inclusive Education, Teacher Training, Teaching Initiation Programs.

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Strategies for Teaching Botany in Elementary School: Narrative of a Graduate Student during the Pedagogical Residency Program

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Abstract. This experience report aims to detail a pedagogical practice implemented with Basic Education students, with the purpose of improving their understanding of botany, an area in which the students demonstrated greater difficulties. The adopted methodology was based on the use of didactic strategies from active teaching-learning methodologies [1], inserted within the context of the initiatives of the Pedagogical Residency Program (PRP) of the Federal Institute of Education, Science and Technology Goiano, Rio Verde Campus (IF Goiano), specifically within the scope of the Biology subproject.

Qualitatively, observation was adopted as the method, with detailed records in a field diary of the activities conducted by PRP residents at the partner school, as well as the narratives documented in the portfolios of those involved [2]. The activities began with an expository lesson, enhanced by a slide presentation, which introduced the students to the main plant groups in a visual and engaging manner.

During this exhibition, physical specimens were presented to illustrate each group, allowing students to directly and concretely observe the morphological and structural differences between them. To represent Bryophytes, a piece of moss was brought into the room, exemplifying the characteristics of these avascular plants that grow in humid environments. Pteridophytes were illustrated with a fern leaf, highlighting the presence of vascular tissues and reproduction by spores. For Gymnosperms, a pine cone was used, symbolizing the naked seeds typical of this group, which are not enclosed by fruits. Finally, for Angiosperms, flowers and fruits were presented, highlighting the distinctive characteristics of this group, such as the production of flowers and fruits that protect the seeds [3].

This approach combined theoretical and practical elements, providing students with a deeper understanding of the peculiarities of each plant group, thereby facilitating learning and the retention of botanical concepts. As a result, students were able to observe the characteristics of each group in a practical manner.

In the next stage, students were organized into groups, with each team receiving a topic related to one of the plant groups studied. Each group was responsible for creating teaching materials aimed at consolidating and deepening their understanding of their respective plant group. This process involved the creation of presentations, posters, and other educational resources that helped reinforce the characteristics and importance of each plant group.

The activity not only enabled a practical application of the concepts learned but also encouraged student collaboration and creativity, fostering a more solid and integrated understanding of botanical content. After presenting the materials, the Gamification¹ strategy was used as an evaluation method, with the goal of making the review process more interactive and engaging. This approach not only assessed students' mastery of the content but also fostered a more dynamic and participatory learning environment.

The pedagogical actions developed, based on active methodologies, demonstrate that applying these methods in Basic Education effectively enhances the teaching-learning process in Botany. By using innovative practices, we were able to stimulate students' interest and facilitate a deeper and more engaged understanding of the proposed topic. Thus, incorporating active methodologies and creative strategies allows us to explore the topic in a comprehensive and accessible manner, promoting a more enriching and meaningful learning experience.

Keywords. Botany, Elementary Education, Active methodologies, Gamification.

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Building Playful Resilience in Chemistry Students

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Abstract. Playfulness is a concept that describes an internal state derived from various human activities, capable of evoking pleasure, joy, and fun [1]. Therefore, playfulness represents a state of wholeness, where one is fully engaged in an activity with pleasure; however, this experience varies from person to person and can permeate many situations we encounter. For undergraduate students, especially in the aftermath of COVID-19, intervention programs aimed at promoting resilience are continually being expanded [2]. In this context, playful resilience is increasingly understood as a quality of individuals who intentionally leverage their experiences of playfulness to relate, react, and act in overcoming mental stress. Considering the points discussed, this study seeks to document the application of an educational activity designed for first-year chemistry undergraduates, following the four theorems proposed by Heljakka [3], which are summarized later in the text and aimed at fostering playful resilience in higher education. This account may offer guidance to educators interested in adopting similar approaches, emphasizing the importance of playful experiences in chemistry education to cultivate key student skills such as resilience.

The teaching activity detailed here was conducted as part of a scientific communication course in the Bachelor's program in Chemistry at the University of São Paulo, Brazil, which had 59 students enrolled at the time. The course aims to improve students' abilities to communicate scientific knowledge to the general public. In this context, students were assigned the task of creating digital narratives on chemical waste that would be accessible and understandable to a broad audience. To achieve this, the support provided to the students included both guidelines for writing in this genre and instructions for using the block-based programming platform, Scratch [4], as a creation tool, resulting in the production of audiovisual media similar to videos.

Students gained the knowledge required to develop their narrative plots by reading, interpreting, and giving oral presentations on original research articles (ORA) to the class.

Initially, the students were divided into fourteen groups, with four ORA assigned among them. Subsequently, activities more closely related to developing digital narratives began, conducted over six successive classes. These classes focused on the following stages: basic instruction on using the Scratch platform; theoretical grounding for narrative construction using Bell's model [2]; creating textual narratives; adaptation of narratives into Scratch; and presenting the narratives created in Scratch.

Our methodology for analyzing the narratives draws from Heljakka's [3] research, which explored educational activities that cultivate playful resilience in higher education students. Heljakka identified four essential theorems for fostering playful resilience through playful learning. The first theorem (1) asserts that play is inherently joyful and entertaining, creating a risk-free environment that stimulates creativity. The second theorem (2) highlights the diverse aspects of play, including creative and imaginative activities, object manipulation, and role-playing. The third theorem (3) focuses on structured play within educational settings, emphasizing collaboration, co-creation, and co-construction among students. The fourth theorem (4) integrates these concepts, connecting them to developing playful resilience as a key element of higher education.

In total, fourteen narratives were created and analyzed through the four theorems in developing playful resilience through playful learning into higher education. Related to the first theorem (1), the use of the online platform Scratch enables students to utilize various characters and scenarios, such as rivers, ocean shores, forests, and classrooms, either by accessing its internal library or by adding their own files, personalized characters, and custom scenarios. Additionally, two narratives present a fantastical scenario featuring anthropomorphized animals that interact with humans and their contaminated environment to

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seek a solution. This example demonstrates the extensive range of creative possibilities offered by the Scratch platform. Creativity is also involved in the process of transcribing information and scientific knowledge from original articles into a narrative format aimed at a broad audience.

The second theorem (2) emphasizes incorporating object play and role play into educational playful activities. The Scratch platform features an interface inspired by LEGO, consisting of colorful blocks that represent lines of code. By connecting these blocks, users can animate characters, adjust their expressions, create dialogues, and change scenes, effectively translating tangible play into a digital format. Additionally, some groups recorded their own voices to create dramatic role plays for their characters, demonstrating the use of a popular media format to frame their interactions and reshape the way of interacting with narratives (6).

According to the third theorem (3), students advanced through several stages, from the initial phases to the final product required by the educator. This progression involved various activities, including group work, discussions within their own group, interactions between different groups, and exchanges with educators. The classroom environment can be understood as a space for constructing and materializing ideas, requiring collaboration and co-creation from multiple individuals throughout the process of story-making. Considering the previously established connections between the educational activity reported here and Heljakka's [3] theorems 1 to 3, it is also reasonable to conclude its alignment with premise 4. Indeed, the professor incorporated characteristics into the activity that created a space in higher education chemistry lessons where students had the freedom to act and create collaboratively, without consequences or oppression, bringing entertainment, creativity, and enjoyment to the learning process. This fostered a sense of accomplishment among students, as well as motivation and understanding of scientific knowledge and how it integrates with the world.

The potential of the educational activity described in this abstract for promoting playful resilience has been recognized as a successful implementation, based on the discussions in this abstract. However, additional nuances are worth noting, such as its contributions to enhancing the understanding of chemistry content, which is essential for the coherent and grounded creation of digital narratives. Using the Scratch platform as a didactic tool, which requires no prior knowledge and offers numerous options for creation and innovation, also supports the development of media and information literacy. This literacy encompasses skills for receiving and producing messages by converging languages and communication media.

Keywords. Education, Scratch, Narratives.

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Institutional Program "Project Knowing the IFG" as a Scientific Dissemination Tool

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Abstract. The Federal Institute of Education, Science and Technology of Goiás (IFG) is a centennial institution that started as the School of Artificers Apprentices in 1909, with the creation of the former state capital, Vila Boa, currently the city of Goiás. In 1942, it was transferred to the new capital of the state of Goiás, the city of Goiânia, and was renamed the Technical School of Goiânia. During this period, it offered educational levels corresponding to high school. In 1956, it was renamed again to the Technical Federal School of Goiás, and in 1999, it began to offer technological courses. With this change in status, it became the Federal Center of Technological Education of Goiás (CEFET-GO). In 2008, it assumed its current name, the Federal Institute of Education, Science and Technology of Goiás, or, in its shortened form, the Federal Institute of Goiás (IFG), which is composed of 14 campuses.

IFG is an educational institution that offers secondary, undergraduate, and postgraduate degrees. It is multicurricular and multicampus, offering courses in different teaching modalities, such as technological and professional programs. According to its statute, IFG's guiding principles include a commitment to human rights, social justice, equity, diversity, citizenship, and ethics, aiming to train and qualify citizens for professional performance in various sectors of the economy, prominently local, regional, and national socioeconomic development.

Thus, the research was developed at the IFG Campus Goiânia, with the objective of analysing the project Knowing the IFG at the Goiânia Campus and its importance for students to be able to enrol in one of the institution's courses.

This project is structured as a guided visit, which consists of receiving elementary and high school students from public municipal and state schools of Goiânia. The aim is to present them with the courses offered by the Goiânia Campus and provide as much information as possible about these courses, their entrance process, and the infrastructure the campus has for the development of the courses. It has been developed at IFG's Goiânia Campus since 2007, where the researchers involved in this action are permanent staff members.

Annually, IFG receives visits from students ranging from the last year of elementary school to the last year of high school. The visits are scheduled by the originating school according to the availability of the visiting school staff and the students, and transportation is under IFG's responsibility, whose bus takes and returns the visitors to their originating school.

"Knowing IFG" promotes knowledge about the institution to students and their teachers, starting with a welcoming speech in an auditorium, where they receive general information about the IFG educational institution, including its historical trajectory, course admissions, research and extension activities, how to engage in projects, and how to receive student support, including financial aid. All these details are reinforced by an institutional video presentation. At the end of the welcoming session, visitors receive printed material about the campus and are guided around the campus to see the physical structure of the institution, such as the theatre, library, gymnasium, and laboratories for Biology, Civil Construction, Electricity/Electronics, Environment, Mining, and Chemistry.

Therefore, there is significant intersectoral involvement within the campus, which reflects the importance of the project undertaken by the institution and its staff, who mobilise according to their sectors to welcome students, for example, with presentations and demonstrations of experiments in some labs.

In 2022, the IFG Goiânia Campus received 34 visits, accommodating 1,700 students. In 2023, there were 60 visits with a total of 2,100 students. Thus, the project, more than just opening the institution's doors to primary and secondary school students, allows them to glimpse the possibilities of becoming IFG students and to share these possibilities with their family members and friends, as they become promoters of IFG's educational

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opportunities.

Since 2017, the “Knowing IFG” project has been part of the program for IFG's Science, Technology, and Culture Education Week (SECITEC), which is part of the National Science and Technology Week, an initiative developed annually by the Ministry of Science, Technology, and Innovation to mobilise the population on the importance of science as a tool for generating value, innovation, wealth, solutions to national challenges, social inclusion, and improving the quality of life. During SECITEC, IFG staff and students exhibit their teaching, research, and extension projects in the campus's external yard so that both internal and external communities can glimpse what has been developed at the institution. Consequently, it is the period when the volume of guided visits in the “Knowing IFG” project increases, mainly because visitors are encouraged to participate in many of the proposed activities at SECITEC.

In addition to the guided visits, the “Knowing IFG” project includes an itinerant action, where the IFG research team visits municipal and state schools to share some project actions and results and allow them to engage with IFG’s lab equipment. In this format, the staff not only promotes lectures but also engages the students so that they can be involved in practical experiments and interact with lab equipment.

For 2024, the visits are ongoing, and during the SECITEC event this year, it is expected to receive many students from municipal and state public schools. The staff has been preparing to better welcome the visitors and meet their expectations about IFG. This is the essence of this project: to open the doors of a public federal institution to welcome more and more people, fulfilling the aim of returning.

Keywords. Communication, Extension, Project Knowing the IFG.

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Evaluation of Mental Health, Food Consumption and Dietary and Nutritional Insecurity in IFG Integrated Technical High School Students

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Abstract. Inadequate food consumption can be associated with the development of depression and anxiety, among other mental health illnesses. Given the context in which they live, full-time integrated secondary school students may face food and nutritional insecurity, with inadequate eating habits, mainly due to the consumption of processed and ultra-processed foods. The aim of this study was to assess the mental health and food consumption of integrated secondary school students. This is a quantitative and descriptive study, using an online questionnaire to collect data.

A total of 149 students took part, of whom 54.6% were aged between 14 and 16; 76.5% were female; and 90% said they were white or brown. Regarding psychological well-being and individual mental health, 96.6% of the students had already experienced some feeling of psychological malaise, caused by discouragement, lack of desire to carry out daily activities, irritability, sadness, loneliness, a desire to isolate oneself, lack of energy, insomnia or excess sleep, with frequent symptoms (56.4%). Among the participants: 15.4% use medication to sleep, improve mood and/or relieve anxiety; 16.1% feel comfortable talking about their mental health with other people; 26.2% practice or have engaged in risky behaviors that may have affected their mental health (such as smoking cigarettes, marijuana, drinking alcohol or using other substances, hurting themselves on purpose, etc.); 77.9% have reported witnessing, practicing or being the victim of bullying, prejudice, discrimination, persecution or harassment in the school environment.

The impact of social media on mental health was felt in different ways. They highlighted positive and negative impact (65.8%), no impact (14.1%), negative impact (10.7%) and positive impact (9.4%). In terms of support or advice for mental health issues at the IFG, 30.2% received it from a psychologist and 12.1% only from teachers, with 32.2% considering it very useful.

Regarding food consumption and mental health, according to the students' perception, 80.5% noticed a change in their body weight over the last 6 months: 42.3% increased their weight and 26.8% decreased it; 60.4% said they ate a lot when anxious and 50.1% sought food as an emotional comfort. Irregular eating habits were also highlighted by the interviewees, such as eating a large amount of food in a short space of time (79.2%); and not eating for a whole day (59.1%). Methods for losing weight were highlighted by 16.8% of the participants who said they used them. After joining a full-time course, 85.9% said that there had been some change in their daily eating habits, with an increase in the consumption of industrialized foods, such as: sweets and treats (78.5%); soft drinks (68.5%); ice cream (63.8%).

The literature already robustly documents prospective associations between the dietary contribution of ultra-processed foods and chronic diseases, including mental disorders. A study with Brazilians concluded that the consumption of these foods increased the risk of developing depressed mood, lack of pleasure or energy for daily activities by 42%, highlighting the importance of a healthy diet associated with emotional well-being [1].

In adolescence, there is a high consumption of processed and ultra-processed foods, which are high in saturated and trans fats, sugars, artificial additives and low in dietary fiber [2-4]. This practice is motivated by convenience within a busy routine, which can reduce food consumption from meals that require more time to prepare [5]. It should be noted that adolescents are prone to poor eating habits and a sedentary lifestyle, which can affect their quality of life and contribute to the onset or worsening of mental health problems.

The results of this study show that the school environment had an influence on the eating and behavioral habits of the students who took part

in the research. The results are intended to support public policies and interventions to promote a healthy and inclusive educational environment, considering the impact of mental health on adolescents' learning and development.

Keywords. Mental Health, Ultra-processed foods Adolescents, Students, Comprehensive Education.

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Health Education with an Emphasis on Food and Nutrition Security

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Abstract. The "Viva o Centro" project aims to revitalize and develop the central region of Goiânia through the integration of art, culture, health and leisure, which contributes to the sustainable development of the region. Regarding health promotion, the project, in partnership with the Extension Program "*Minha Marmita, Nossa Saúde - IFG" (*My lunchbox, our health - IFG)", aims to carry out nutritional education and promote food security by addressing relevant topics to improving the quality of life and the prevention of Chronic Non-Communicable Diseases (NCDs). NCDs represent the group of diseases of greatest magnitude in the world and affect especially the most vulnerable populations, such as those with medium and low income and education, due to greater exposure to risk factors or restricted access to information and health services [1-2].

It is worth highlighting that the incidence of NCDs is related to modifiable risk factors, namely: obesity, inadequate eating habits, physical inactivity, smoking, consumption of alcoholic beverages, environmental pollution and mental health [3]. Therefore, the adoption of health promotion strategies creates favorable environments for developing autonomy in making appropriate food choices and are essential for motivating people to adopt healthier lifestyles [4].

Therefore, teachers and students from the Integrated Technical Course in Nutrition and Dietetics at the Federal Institute of Goiás, representatives of the Extension Program "*Minha Marmita, Nossa Saúde*", promoted activities to disseminate information and practices that aim to prevent and control NCDs. Through the exhibition of educational materials on a *stand* located at the central fair, workshops were held to raise awareness about the importance of a balanced diet, food preparation practices and the conscious use of food.

The first workshop aimed to raise awareness among the community about the adequate consumption of sugar and salt, with a view to reducing consumption, as they are critical factors for the incidence of diabetes and hypertension, respectively. By showcasing educational materials and food labels, the public was encouraged to explore the nutritional content of the foods they commonly consume in their daily lives. Also, the negative impacts of excessive sugar and salt consumption were discussed, which are directly associated with increased blood glucose and blood pressure.

Strategies were introduced to replace traditional ingredients with healthier alternatives. These included using spices and herbs to season food in a flavorful way without relying on excessive salt. Additionally, the importance of critically reading labels to identify and avoid products high in harmful ingredients was emphasized, along with the distribution and discussion of the "Ten Steps to a Healthy Diet." [5].

The second workshop offered a practical approach to the preparation and use of "herbal salt", a healthier alternative to common salt. Participants were guided on how to create spice blends that can enhance the flavor of foods without adding sodium. In addition to recipes and preparation methods, the workshop included a discussion on the importance of reducing salt consumption for cardiovascular health and disease prevention.

In this workshop, the new food classification was introduced using felt food replicas, which encouraged greater interaction with the audience. These strategies are aligned with the principles of the Brazilian food guide, mainly because they encourage autonomy in food choices through qualitative approaches, that is, the nutrient is an important part of nutritional education. However, the approach to adequate and healthy eating derives from a food system socially and environmentally sustainable.

These activities not only provided participants with practical skills to make healthier food choices, but also strengthened their understanding of how small dietary changes can have a relevant impact on NCDs prevention. Implementing these strategies promotes a more conscious approach to eating and contributes to improve health and well-being.

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Moreover, creating this dialogue with the community not only fostered positive interactions between students and professional practice environments, but also helped guide the public in making informed food choices, reading labels correctly, and promoting greater autonomy through healthier decision-making.

Keywords. Food and Nutrition Education, Health Education Food Safety, Non-Communicable Diseases.

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NEPeTI: A Decade of Encouraging Computing in the Saint Patrick's Valley-GO

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Abstract. The area of Information Technology (IT) is experiencing exponential growth, but there is a shortage of qualified professionals to work in the sector [1], making it necessary to promote initiatives that can corroborate this scenario. This paper presents strategies developed at the Ceres Campus of the IF Goiano to attract new talent in Computing and ensure the permanence and success of students through institutional actions linked to the Federal Institutes' tripod of teaching, research and extension. In this context, the Nucleus for Studies and Research in Information Technology (NEPeTI) was created in 2014, and is the group responsible for bringing together projects focused on the area of Computing. One of its first pioneering actions at the Institution was the development of preparatory training for the Brazilian Computer Olympics (OBI), with the Ceres Campus of IF Goiano standing out in the State of Goiás since its first participation in 2015. These actions include a variety of projects, with the aim of preparing students for this competition with knowledge of logic and solving algorithms. The activities are carried out with technical and higher education students in the Programming Mode, as well as other primary school students from the external community in the Initiation Mode. These training and olympiad preparation activities, known as the "Dragonflies" project, have proven to be a way of attracting and inspiring talent for Computing, and have encouraged students to enter the Ceres Campus or to continue their studies through the verticalization of education, in which a student can continue their studies at the same institution. Another high-profile project that is part of NEPeTI is the "Digital Girls in the Cerrado" initiative. Faced with a shortage of IT professionals, this number is even lower when female professionals are considered. Studies show that the inclusion of women in technological areas is essential for the creation of more diverse technologies and, consequently, for a fairer society [2]. As advocated by the United Nations (UN), one of the sustainable development goals is to promote gender equality through initiatives aimed at the community and social activism [3]. In this sense, this project emerged as an extension initiative created in 2016 [4], mirroring actions underway nationally and internationally, as a partner project of the Digital Girls Program (PMD) of the Brazilian Computer Society (SBC). Thus, the Digital Girls in the Cerrado project aims to empower women in technological areas, encouraging girls in science, technology, engineering and mathematics (STEM). The students have the opportunity to give and take part in workshops, lectures and debates, with the aim of becoming protagonists in the history of technology. All the activities carried out aim to strengthen the students' self-confidence, as well as providing opportunities for activities aimed at the external community, especially in basic education. Furthermore, over the last 10 years, NEPeTI has expanded its lines of action. Among the most recent actions is the extension project "Computational Thinking in the Cerrado", which provides technological training for primary and secondary school students through a programming course, applied in various public schools in the Saint Patrick's Valley-GO region. Another initiative is a teaching and extension project aimed at students from the Ceres Campus and other educational institutions in the region, with activities aimed at encouraging the Maker Culture with robotics, 3D printing and virtual reality activities, which are emerging themes in the IT area. The workshops are held in a maker lab at the Ceres Campus so that participants can develop technical and cognitive skills to promote creative solutions to real problems. In addition to carrying out the projects already mentioned, NEPeTI as a research group also carries out research in Computing in line with the actions underway with a view to investigating their impact and contributing to the advancement of the state of the art. PIt is therefore evident that NEPeTI is proving to be an agent for encouraging careers in Computing through its work in the teaching, research and extension tripod, while the projects linked to it make it possible to demystify the IT area and promote technological training and inclusion from basic education to higher education, working on various fronts that contribute to the expansion of Computing education on the Ceres Campus and surrounding regions.

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Keywords. Education, Digital Inclusion, Projects, Training, Technology.

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Characterization of Annatto Seeds from the Center-West and Southeast of Brazil

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Abstract. In Brazil, annatto (*Bixa orellana*) has been found as a plant native to the States of North and Northeast, mainly Amazon, Pará, Paraíba, Piauí, Maranhão, Ceará and Bahia. The fruit of the annatto tree are flat ovoid, hemispherical ellipsoid or conical capsules, containing numerous seeds, surrounded by a soft, red pulp. They are densely covered with flexible spines and contain, on average, 54 seeds that contain the pigment.

Bixin is the pigment present in the highest concentration in seeds, representing more than 80% of total carotenoids. Annatto seeds are also rich in proteins and can be used in forage farming, being used in the composition of poultry feed, especially layers. Depending on the producer, the harvested fruits may remain between the plants for a few days, depending on local rainfall conditions. Then, the fruits are placed on canvas, in terraces, or in masonry dryers for drying and better use of the dried fruit.

Annatto seeds can be dried in both artificial nd natural dryers, such as the sun, with the main objective of reducing the moisture content of the fruits. Fruit peeling can be done manually or mechanically. The subsequent seed processing operations are sieving and drying the seeds. Drying is generally carried out using heat from the sun, as low temperatures are needed to prevent the degradation of the bixin in the seeds. The ideal moisture content for good storage and subsequent distribution is 14%. Moisture levels above 14% are conducive to fungal growth and should be avoided.

Considering the high nutritional power of annatto seeds in terms of Vitamin A, which places it in the category of functional food, even as an enriching ingredient in food formulations, the objective of the present work was to evaluate the physical-chemical composition of annatto seeds of different Brazilian regions – Triângulo Mineiro, Goiás, North of São Paulo and North of Minas Gerais.

The seeds were obtained from local stores and stored in dark-colored polyethylene bags at – 18 °C. The analyzes were carried out in the physical chemistry laboratory at IFTM – Campus Uberlândia. 07 samples were obtained.

Seed moisture was determined in quintuplicate using the oven method at 105 °C, according to the Official AOAC method [1]. The oil content of the seeds was determined in a Soxhlet extractor using petroleum ether as a solvent, according to the official AOCS method [2]. The bixin content of the seeds was determined using a spectrophotometric method recommended by the FAO [3]. The protein content was determined by the Kjedhal method and the ash content by incineration of the samples; crude fiber was determined by acid and basic digestion of the samples. All these methods are recommended by the AOAC [1].

The moisture content of all seeds ranged between 6 and 9%, an adequate value for storage and distribution. The fat content was quite similar between the samples, varying between 2.5 and 3.2%. The protein content of all samples was greater than 13%, with emphasis on a sample from the north of Minas Gerais, whose protein content was 23.8%. The fiber content varies between 15.1 and 22%. And the bixin content of the seeds, which effectively increases their commercial value, varies from 2.4 (a low value, which indicates probable degradation) to 4.75% (again from the northern region of MG). These results showed that the same batch of seeds from the northern region of Minas Gerais had great potential to be used as a food ingredient, bringing protein enrichment and transforming formulations into sources of vitamin A.

Keywords. Functional Foods, bixin, characterization, annatto.

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Sucupira Opinion: A Milestone for Brazilian Graduate Course

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Abstract. Opinion nº. 977, dated December 3, 1965, was drafted in response to a request from the then Minister of Education and Culture of Brazil. The opinion addressed the need to define graduate courses and establish general guidelines for the organization and operation of such programs. In fulfilling the mandate of the Federal Higher Education Teaching Statute, the opinion sought to define the nature and objectives of graduate programs and outline their fundamental characteristics as required by law. Also known as the Sucupira Opinion, this document facilitated the implementation of various graduate courses. It allowed the formalization of many already functioning without clearly defining their purposes, objectives, and structure. In this context, the opinion played a crucial role in regulating these programs and resolving uncertainties regarding their nature.

Structurally, the Report begins with a brief introduction explaining the reasons for its creation. It is divided into seven sections: the historical origins of graduate courses, the necessity of graduate courses, the concept of graduate courses, an example of graduate courses: the American model, graduate courses in the Law of Guidelines and Bases, graduate courses and the Teaching Statute, and the definition and characteristics of masters and doctoral programs.

Regarding its content, the Opinion highlights that the name and system of graduate courses in Brazil were inspired by American universities' organizational model. According to Saviani (2008), the American model served as a reference for the implementation of graduate courses in Brazil, although European influence was also significant.

The Sucupira Opinion argues that an efficient graduate program is essential to confer a true university character to Brazilian higher education, transforming universities from mere institutions for professional training into centers for the creation of science and culture.

To present the concept of graduate courses, the Report distinguishes between stricto sensu and lato sensu graduate programs. Lato sensu graduate courses refer to programs following undergraduate education with a specific technical-professional focus, not covering the entire field of knowledge within the specialty. Stricto sensu graduate courses are of an academic and research-oriented nature, with a primarily scientific objective, even when applied to professional sectors (Brazil, 2005).

Regarding the differences between these two types of education, lato sensu graduate courses comprise courses designed for training in specific areas of a professional or scientific field, aiming at the scientific and technical mastery of a specific and limited area of knowledge or profession, leading to the formation of specialized professionals. Additionally, these programs offer certificates of proficiency or completion, which may be obtained even in non-university institutions.

On the other hand, stricto sensu graduate courses are academic and research-oriented, with a primarily scientific objective, conferring an academic degree that attests to a high level of scientific competence in a specific field of knowledge.

Reflecting on these differences, the Sucupira Opinion presents the concept of stricto sensu graduate courses as a cycle of regular courses following undergraduate education, systematically organized to develop and deepen the knowledge acquired at the undergraduate level, leading to the attainment of an academic degree (Brazil, 1965).

The Opinion also reflects on graduate courses in light of the Law of Guidelines and Bases of Education in force at the time, Law nº. 4,024/1961, and the Federal Higher Education Teaching Statute.

The 1961 Law of Guidelines and Bases of Education places special emphasis on graduate courses by classifying different types of higher education programs: undergraduate, graduate, specialization, improvement, and extension courses. However, the law only classifies these programs and does not define their nature or provide guidelines for the organization of graduate programs. At that time, the intention

seemed to be to confer special status to graduate courses, distinguishing them from specialization courses.

The Federal Higher Education Teaching Statute grants the Federal Education Council the authority to regulate graduate programs, as it assigns this Council the power to define and set the characteristics of these programs.

In the final section of the Report, the definition and characteristics of master's and doctoral programs are presented, emphasizing that the aim is to outline the fundamental aspects of these programs rather than establish rigid standards that could hinder the essential flexibility of any stricto sensu graduate program (Brazil, 1965).

The stricto sensu graduate model adopted in Brazil defined its organizational structure, centered on two levels: the master's and the doctorate. According to the Sucupira Opinion, a master's degree requires the defense of a dissertation, which should demonstrate the candidate's ability to systematize and master a specific topic. The doctorate aims to develop broad research capabilities, where the candidate must defend a thesis that makes a real contribution to knowledge in a particular field.

Additional characteristics are presented in the Report, highlighted as follows:

- The study program will include a variety of subjects to allow students to choose, guided by the director of studies;
- Following a criterion of greater flexibility, a minimum duration of one year for the master's degree and two years for the doctorate is determined, in terms of the academic year, instead of a uniform and unvarying duration;
- The total amount of studies required to complete the program can be assessed in credits or equivalent units;
- A time allowance for individual studies and research work estimated at a total of 360 to 450 hours is provided;
- The first phase of studies will include attendance at lectures, seminars, and evaluation of the student's ability and performance. The second phase will be dedicated to investigating a special topic and preparing the dissertation or thesis.

In conclusion, we emphasize that the Sucupira Opinion marked the establishment of graduate programs in Brazil, their regulation, and control by official government agencies. According to Cury (2005), no other document has articulated doctrine and regulation on the subject with as much impact on this level of higher education in Brazil. He argues that the Opinion was and continues to be the systematic reference for the organization and implementation of Brazilian graduate courses.

It was this Statement that first established the basic institutional framework for graduate courses in the country, differentiating two levels of education, the master's and the doctorate, and establishing a continuum between them. Until then, graduate courses had been considered at a minimum level, only to ensure their existence in educational institutions, but there were no standards to regulate and guarantee the quality of this education. Moreover, the Opinion spurred the creation of numerous graduate programs, now following the guidelines and regulations stipulated therein, leading to a considerable expansion of graduate courses in Brazil.

Keywords. Graduate Course, Legislation, Sucupira Opinion.

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Formation of the Ecological Subject from a Racialized Perspective: Challenges and Contradictions in the Context of Capitalism

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Abstract. Since the Industrial Revolution, capitalism has intensified anthropogenic impacts on the environment, reinforcing the socio-environmental crisis [1]. This historical process of colonization and imperialism has influenced and shaped societies molded by economic liberalism, characterized by systemic violence that perpetuates the exclusion of specific ethnic-racial groups. Structural racism is one of these systems that disproportionately affects non-hegemonic people and groups, with a particular focus here on anti-Black racism. This research aimed to investigate academic productions that correlate the construction of the ecological subject [2] from a racialized perspective. The research question was: "How to form ecological subjects from a racialized perspective, considering the contradictions arising from life within capitalism?" For this, education is highlighted as a crucial field for identifying, problematizing, and acting on contemporary issues, especially regarding racism, socio-environmental interferences and impacts, and the promotion of ecological subjects who seek alternative modes of interaction with the environment and the people around them. In this sense, three theoretical axes constituted this research: the notion of racism from a structural perspective [3], understanding that racism is characterized as a historical and political process, with institutional and ideological dimensions. Another theoretical axis is scientific education and the perception of the environment and subjects. To imprint a racialized perspective, it was possible to seek out works that emphasize the school's responsibility in combating racism [4]. Finally, the last theoretical axis dealt with the concept of the ecological subject [2] to reflect on the interferences and articulations when trying to form an ecological subject from a racialized perspective. The research methodology was a state-of-the-art review aiming to map academic production based on the indicated theoretical framework [5]. The chosen platform was Google Scholar. The keywords used were: "ethnic-racial relations" AND "structural racism" AND "ecological subject." Based on this, 5,240 works were identified. The established analysis criteria were: i) the racial issue as a central element of analysis, ii) mention of issues related to capitalism, iii) the approach to educational topics related to the formation of the ecological subject and socio-environmental issues. Based on these criteria, it was possible to select 10 works that emerged in the research. After analysis, we concluded that most of the reviewed works place the racial issue as a central axis of their analyses. Furthermore, it is observed that many works integrate discussions on the formation of the ecological subject from a racialized perspective. The research continues by analyzing the evidence of contradictions considering the capitalist system. In this way, it will be possible to reflect on and propose teaching practices that consider the formation of the ecological subject from a racialized perspective, given the challenges and contradictions we face today within this political and economic system.

Keywords. Capitalism, Scientific Education, Ecological Subject, Structural Racism.

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Karajá Craftsmanship from the Perspective of Socio-Environmental Valuation

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Abstract. Indigenous crafts are a rich cultural expression and means of (r)existence [5]. The life of the Iny Karajá people, even in urban environments, is closely linked to the natural resources and biodiversity of the Cerrado [2]. The practice of handicraft reproduction has become synonymous with ethnogenesis (ethnic-cultural resistance), economic sustainability, intergenerational education/social integration [3]. This work aimed to verify people's willingness to pay for the continuity of epistemic services provided by the Iny Karajá community in the municipality of Aruanã, state of Goiás. Data were collected through a semi-structured questionnaire from a sample group composed of 100 participants, men and randomly selected women between 18 and 60 years old, tourists and residents of Aruanã who were in the vicinity of the Maurehi Museum.

The Maurehi Museum - Indigenous Cultural Center of Aruanã, is located at the main entrance of Aldeia Buridina, in the center of the city of Aruanã-GO. Today it is divided into two rooms, one is intended solely for displaying the Museum's private pieces open to visitors and the other is intended for families to display their productions that are intended for sale. Each production stand belongs to a family in the community. The caretaker and person responsible for the Museum is the Chief of Aldeia Buridina, Mr. Raul Hawakati. The choice of the Contingent Valuation Method (MVC) and Willingness to Pay (DAP) for this research was to have an economic approach used to evaluate the monetary value of environmental goods or services that do not have an established market price. This is a method frequently applied in environmental economic valuation studies to estimate the value that people attribute to natural resources, ecosystem services or conservation measures, whether for direct or indirect use, where the value is basically linked to the satisfaction in ensuring the existence of the resource [1]. MVC involves conducting interviews or questionnaires with X sample of the target population. Respondents are presented with hypothetical scenarios that describe changes in the state of the environment, culture or environmental policies, and are then asked about the value they attribute to these changes through the DAP Willingness to Pay [4]. In this method, the value is not specific to the good or service, but is something given to that good or service according to the subject's perception [1]. Data analysis indicated that among the participants, 30% people visited the Museum and among these, 90% cited that they were driven by the virtue of curiosity in learning about indigenous culture and history, adding that, at the end of the visit, they stated that it was an educational and informative experience.

Regarding the results of the DAP, the participants who were willing to pay for epistemic services (represented by handicrafts), 80% were willing to pay the estimated amount of R$ 36.25 per month, 15% declared they were not willing to pay, Among these, 10% responded that the responsibility for preserving this cultural asset should lie with the Federal Public Power through the Ministry of Traditional Peoples. 5% chose not to express their opinion. When participants willing to pay were asked which body should be responsible for managing the amounts collected through DAP, 90% responded that they would indicate the Municipal Public Power, through the Department of Culture, as this body has the opportunity to get to know the reality of the communities in the municipality. Another relevant result was realizing that the 80% of participants who were willing to pay the DAP understand that it is important to preserve the knowledge that refers to indigenous artifacts, because they are part of the historical and cultural heritage of society, not only local, but represent the diversity of the country.

And each piece made is based on traditional/ancestral knowledge, which can significantly contribute to the conservation of biodiversity in the Cerrado.Therefore, we concluded that, when participants were willing to pay, understand how important the art of the Iny Karajá people is as a material asset, since indigenous crafts are a vital source of economic sustenance, contributing significantly to family and intangible income as it uses ancestral

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techniques with a wealth of meanings, stories/memories and traditions transmitted over generations, expressing through each piece the identity of the culture of the Iny people. However, participants who were not willing to pay claimed that this is the responsibility of the public authorities to promote public policies that encourage, value and continue indigenous art.

The participants who refused to give their opinion made it clear that they did not understand and were not interested in this discussion. Another notable fact was that 85% of the participants were unaware of the fact that the Ritixocó ceramic dolls, made by the Iny Karajá people, are listed by the National Historical and Artistic Heritage Institute (IPHAN) as National Humanity Heritage. This situation makes it clear that there should be implementations of public policies, Federal, State or Municipal, that encourage perspectives that value Iny Karajá art as cultural resistance, corroborating society's awareness of indigenous culture. These results highlight the importance of valuing indigenous artisanal production as an epistemic service. Actions like this could contribute to popularizing the discussion about the permanence of the traditions and cultural identities of the Iny Karajá people, regardless of where they live.

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Children's Literature and Environmental Education: Thematic Analysis of the Work Tainá A Guardiã Das Flores, by Ayana Sobral and Cristiane Sobral

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Abstract. In this work we aim to understand the concept of Environmental Education (EA) in the work Tainá a guardian of flowers. We developed a qualitative study, aligned with literary analysis (concept of quality), emerging two reading keys: 1) aesthetic conception of the work and 2) thematic quality: EA conception. The work is consistent with elements that configure the textual, thematic and graphic quality. As for the thematic nature, it tells the story of Tainá and her passion for flowers, which leads her to protect her country, moving from an EA perspective that involves a conservative, pragmatic and critical conception. Like this. demonstrates a movement that in the activity of reflection subsidizes action, lacking a trajectory that (re)thinks attitudes as critical EA presupposes.

Keywords. Children's literature. Environmental education. Thematic Analysis.

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Challenges for the Development of Sustainable and Smart Cities

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Abstract. The development and organization of urban environments are fundamental for the evolution of society, especially in the context of sustainability. Urban growth brings significant challenges that compromise the environmental, economic and social sustainability of cities. To address these challenges, a paradigm shift is needed that involves new ways of urban thinking, focusing on the design, planning and development of more sustainable built environments and infrastructures. Smart cities, which must integrate their environmental, economic, social and cultural dimensions, require essential elements such as sustainable education, renewable energy and efficient waste management.

The role of government is crucial in the transition to urban sustainability, creating a new social attitude of shared responsibility. Urban indicators are essential tools for assessing and monitoring cities progress towards sustainability, enabling the formulation and evaluation of public policies. Characterizing the specific indicators and methods employed to assess existing mechanisms in sustainable and smart cities contributes to sustainable urban planning and interdisciplinary development. The environmental issue is associated with the difficulty of identifying and replicating successful mechanisms in the transition process towards sustainability. Monitoring these processes is a major challenge, that is, although it is not possible to use a universal indicator for sustainability, it is possible to understand the main concepts and models associated with the development of sustainable cities.

It is worth noting that the United Nations (UN) 2030 Sustainable Development Agenda mentions cities as key actors for an active evolution towards greater sustainability [1]. In addition to the challenges, there are some gaps regarding the topic: there is a shortage of publications that consolidate the fundamental sustainability principles required by sustainable cities; How to evaluate the performance of sustainable cities? there is a lack of systematic quantitative and visual research and multidisciplinary scrutiny of the structure and evolution of the field of sustainable cities; data available for cities around the world are patchy and insufficient to differentiate the diversity of urban areas with regard to access to essential services and specific infrastructure needs. And, existing approaches used to map deprived areas are often siloed and, individually, often lack transferability and scalability and do not include the views of different interest groups; How is urban infrastructure in developing countries? How will these countries meet SDG-11?; How to plan urban expansion in cities without compromising sustainability?; How to include greater social participation? Digital citizen?

There is no mapping of literature and indicators for the SDG-11 objectives. Sustainable urban development is a complex challenge that requires an integrated and holistic approach, considering the environmental, economic, social and cultural dimensions of cities. The transition to sustainable and smart cities requires collaboration between researchers, planners, policymakers and decision-makers, as well as the use of effective urban indicators to monitor and evaluate progress.

Understanding urban sustainability as a concept under construction is essential for the development of methodologies and tools that can guide sustainable practices and promote urbanization that respects environmental limits and improves the quality of life in cities. Thus, this study contributes to the advancement of knowledge in the field of sustainable and smart cities, offering a critical analysis of existing indicators and methods, essential for sustainable urban planning and development.

Keywords. Urban Planning, Public Policies, Urban Sustainability, Transition to Sustainability.

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Interfaces of Racial Equity in Health and Education: Training Professionals for the Unified Health System in Brazil

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Abstract. This work aims to contextualize the relevance of implementing racial equity in health education through the systematization of the state of the art on the subject, presenting the predominant approaches of ongoing initiatives, such as decoloniality, knowledge dialogues, and intersectionality. This is a work derived from a master's thesis in public health.

The practices of reorienting health education are urgent, especially considering that these education and work relationships should aim at social transformation.

In this context, the creation of the Secretariat for Work and Education Management in Health (SGTES) and the National Policy for Continuing Education in Health (PNEPS), both linked to the Ministry of Health in Brazil, are important for consolidating this process.

It is also noticeable that there have been movements to reformulate the curriculum in the Brazilian scenario, challenging traditional health education focused on the biomedical model.

Some of the identified experiences analyzed, within the Brazilian context, the development of courses on the health of the Black population in undergraduate and graduate programs, involving students from medical, social work, and psychology courses in the Northeast region. The topics addressed were: "Race, Racism, Institutional, Education, and Practices in Health." The courses were collaboratively developed through discussions with the Black movement, quilombola communities, faculty, and students.

Another experience described the implementation of the Specialization Course in Black Women's Health (CESMN), which was conducted in partnership with the Postgraduate Program in Health and Environment at the Federal University of Maranhão (UFMA). Also at the same university, two courses were offered in the Master's Program in Health and Environment: "Health of Indigenous Populations and Communities" and "Health of the Black Population." The introduction of these courses resulted from the efforts of individuals who fought to ensure that this knowledge occupied epistemological and political spaces, particularly through interdisciplinary work with the Extension and Research Center for Rural, Quilombola, and Indigenous Populations and Communities (NUruNI).

At the University of Brasília, the course "Indigenous Health" has been offered through a collaborative process with Indigenous students at the university. Adopting the theoretical-methodological perspective of Popular Education in Health, the course is structured around interculturality in health education.

An international experience contextualized the recent need for and benefits of cultural competency training in Public Health, Social Work, Medicine, Nursing, Dentistry, and other programs, highlighting the challenges that are still encountered in implementing this competency in education. They described a workshop conducted with Master's students in Public Health to explore issues related to culture, power, privilege, and social justice. Based on the perspective of intersectionality, the intervention considered systems of power and oppression and their impacts on the social determinants of health.

Finally, the editorial of the American Journal of Community Psychology addressed the theme: "Teaching for Decoloniality in Community Psychology and Allied Disciplines." The published issue contextualizes the global sociopolitical oppressive environment and the rise of the radical right, highlighting the deepening inequities related to race, gender, sexuality, and class. While colonial projects deny humanity and dignity, the editorial engages with interdisciplinarity to rethink what it means to be human. Additionally, the issue introduces the concept of decoloniality, discussing the coloniality of power and how it is present in curricula.

Keywords. Curriculum, Equity, Health Human Resource Training, Health of Black People.

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Hands-on Science. Science Education for Sustainability

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Abstract. The sustainable development of our society demands a constant improvement and generalization of science education and the establishment of a sound widespread scientific literacy at all levels of modern societies. Since 2003 the Hands-on Science Network, innitialy established as an EU' Socrates Comenius 3 network, developed a large range of diverse activities of promotion of active learning of science and scientific literacy [1].

With a broad open understanding of the meaning and importance of Science [2] to the sustainable development of our societies, each individual and of the humankind, the main goal of the Hands-on Science Network [3] is the development improvement and generalization of science education and scientific literacy by advising and promoting an extended use of investigative hands-on experiments based active learning of Science and its applications, while promoting extend cooperation and mutual understanding and respect among its members and all those involve in science education at school and I non-formal and informal context encompassing all age levels from pre-school to adult education and lifelong learning.

We are well aware of the diversity of situations, cultural economic social and at individual level [4], we face when dealing with the teaching/learning process and we do value and welcome all positive inclusive and humanistic, framed by the UN's Universal Declaration of Human Rights, pedagogic and educational approaches to science education. However, we do promote and advise the extensive use of the scientific method that drives the pursuit of scientific knowledge as the driving and guiding basis of all processes of in-school teaching/learning of science, leading the students towards an active volunteer commitment to hands-on experimental science learning activities: observing, analysing critically, deducing, reasoning, defining, discussing, experimenting… and, as such, "making" (learning) science as scientists do.

In this presentation our approach will be presented as well as a brief overview of our main activites.

Keywords. Hands-on Science, Hands-on Science Network, Science Education, Sustainability Awareness.

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Hands-on Physics: Everywhere and for Everyone

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Abstract. Almost all reports on education, learning, dissemination and vocation in Physics learning indicate that there is a need to establish links between formal learning content and the inherent experiential learning related to the physical scientific method [1-2]. One obstacle to making this necessary connection lies in the tendency of teachers to replicate in the classroom the teaching they have received as students, sometimes focusing on theoretical foundations and in most situations far removed from an active, practical, experiential approach. The ability to learn by doing, using hands-on/manipulative/practical/experimental/material -centred activities [3-4], should therefore be a possible objective of teacher training and should be offered the possibility to develop competences in this field. This paper presents an updated review of possible resources that teachers can use in this constructivist context, different possibilities of use outside and inside the classroom [5-7], as well as the recent results of various in-service teacher training courses using this methodology [8]. The purpose of this plenary lecture is to provide with an overview of the advantages and possibilities of using experimental activities in formal education, inducing, if possible, their use in their daily teaching work, so that students 'do' science instead of being simply 'exposed' to it.

Keywords. Hands-on, Physics, Formal Education, Informal Education, Non-Formal Education, Training of Teachers.

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Making Crystals at Home

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Abstract. The experiment presented here allows you to grow single crystals at home. Crystal is the term used to describe solids that have a three-dimensional ordered arrangement of atoms, ions, or molecules [1]. This form of matter organization can be observed in its macroscopic structure, which, due to the existing symmetry, can generate perfect geometric shapes, showcasing the beauty found in nature.

Due to its structural perfection, it is possible to determine how the atoms are arranged in space, the bond distances and angles, and which symmetry elements generate the macroscopic shape. Thus, crystallization plays a fundamental role in the unequivocal determination of structures, with the major limitation of the technique being the need to obtain a single crystal.[2] Thus, the objective of this project was to use an easy method for the crystallization and obtainment of single crystals of the inorganic salt $KAl(SO_4)_2$, in order to present to the students of IF Goiano – campus Ceres what a crystal is and what characteristics are perceptible in a way macroscopic.

Alum crystals, also known as potassium alum or potassium aluminum sulfate ($KAl(SO_4)_2$), are commonly used in various applications including water purification, cosmetics, and as a mordant in dyeing. They typically form octahedral crystals that are clear and colorless.

To conduct the experiment, you need a package of “pedra hume“ or alum, a glass, and water. The solid from the alum package sold at the pharmacy was dissolved in water in a glass, using the smallest amount of water possible for dissolution. The prepared saturated solution is then left to rest for the slow evaporation of the solvent, allowing crystals to form. All the solid from the package (approximately 30 grams) was dissolved in the minimum amount of water needed and left to rest. After a few days, alum crystals began to form, as shown in Fig. 1.

Figure 1. Obtained alum crystal

The proposed activity is simple, affordable, and therefore highly feasible for implementation in high school classrooms with limited budgets.

Keywords. Monocrystal, Solid State, Solubility.

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Nutritional Properties and Culture of Ora-Pro-Nobis. An Unconventional Vegetable

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Abstract. Ora-pro-nóbis is a Non-Conventional Food Plant (NCFP) of the Pereskia species and aculeata genus, also characterized by being a climbing cactus, which contains many proteins in its leaves, in addition to having medicinal effects in combating anemia. Despite this, people who are predisposed to the formation of kidney stones cannot consume ora-pro-nóbis due to the concentration of oxalate present [1], which is a substance that is harmful to them. These plants used as food could have a nutritional value that could be enriched with various nutrients, dietary fiber and also ascorbic acid (vitamin C). For this reason, we are seeking various contributions to nutrition and health. We believe that people need to know more about this and cultivate this plant to have a better diet. The combination of nutrients present in the plants and their conservation also needs to be scientific and known. Therefore, based on our bibliographic review study, we are proposing ways to prepare and cultivate this plant, so that more people can learn about and enjoy its benefits, whether in the preparation of beverages or food.

To this end, we are aligning our study with the United Nations' 2015 Sustainable Development Goals as part of the 2030 Agenda [2], aiming to contribute to several of these goals by promoting quality education, environmental preservation, and safer food practices. Therefore, it is essential to disseminate accurate and reliable information about this plant so that more people can benefit from it in a healthy and sustainable way.

We conducted a search in CAPES journals to determine what researchers have been studying regarding this plant over the past 10 years. This search was carried out between February and May 2024. We identified 37 articles, four dissertations, two book chapters, and one review article, totaling 44 works. However, only seven of these were peer-reviewed. We also observed that most of the authors were Brazilian. It is crucial to encourage further studies and promote the dissemination of information about the plant's nutritional properties and antioxidative, as well as explore additional ways to prepare it as a healthy food option [3]. More studies on nutrition and its elements need to be conducted and disseminated to society. This can help people better utilize our resources and explore the potential of our flora. Techniques that enhance yield and production should also be developed and promoted for the benefit of all. We consider it essential to promote effective communication about better nutrition and a higher quality of life, starting with basic education to introduce Ora-pro-nobis a unconventional plants in yours diet [4].

To achieve this, we should prepare an e-book with the participation of high school students and agricultural engineering undergraduates. This e-book will aim to teach people how to prepare seedlings and organize knowledge about the nutritional potential of ora-pro-nóbis for safe foods and more sustentabilite produtions.

Keywords. NCFP, Safe foods, Sustentabilite produtions.

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Reading Comprehension of Scientific Articles in Integrated High School

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Abstract. Reading comprehension of scientific articles in Integrated High School is an essential skill for the academic and professional development of students. Thus, we see the need to understand and study this topic. Therefore, this study aimed to conduct a bibliographic review on the reading comprehension of scientific articles in Integrated High School. The literature review was carried out by searching for articles and books that contained "reading comprehension," "scientific articles," and "Integrated High School" in their titles during the period between 2017 and 2019.

The results reveal that Integrated High School seeks the integral formation of the human being and should include in its curriculum knowledge that prepares students for the world of work and offers technical training. In this educational context, critical reading and interpretation of scientific texts allow students to develop in-depth skills on a given subject, question information, and construct knowledge autonomously. According to Kleiman (2022), reading practices should be integrated at all educational moments and phases in different and engaging ways for students, as reading directly contributes to their educational process.

Thus, it was possible to understand that reading comprehension of scientific articles helps students become familiar with scientific language, the structure of articles, and research methods, facilitating the understanding of complex concepts. According to Cunha (2019), the interpretation of scientific information can promote critical thinking, argumentation skills, and the competencies necessary for the formation of informed and conscious citizens.

Therefore, in Integrated High School, which combines general education with professional technical training, reading comprehension of scientific articles is even more relevant, as it prepares students to face challenges in the world of work and higher education. Implementing pedagogical strategies that encourage the reading and analysis of scientific articles can help improve these skills, promoting more meaningful and integrative learning.

Keywods. Reading comprehension, Scientific articles, Integrated High School.

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Note

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Knowledge of High School Students in a Technical Integrated Education Program in Goiás Regarding Institutional Actions and Public Policies on Mental Health

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Abstract. This study examines the awareness of institutional actions and public mental health policies among high school students enrolled in a technical integrated program at the Federal Institute of Goiás (IFG). Approved by the IFG Research Ethics Committee, the observational study utilised an electronic questionnaire developed by the authors. Involving 149 students aged 14-19 from the Goiânia Oeste campus, the study found that 92.6% of students were aware of the institution's mental health resources, with 87.2% recognizing the presence of an on-campus psychologist. Despite this, 42.3% reported not receiving any mental health support. Although most IFG campuses have a school psychologist, many Brazilian public schools lack this professional. As of 2023, only 85 out of 5,568 Brazilian municipalities have complied with Law 13.935/2019, which requires hiring Psychology and Social Work professionals in basic education. When asked about emotional support, most students reported receiving it from the campus psychologist (30.2%) and teachers (12.1%). This underscores the importance of training teachers to identify mental health issues and refer students for appropriate care. Additionally, 75.8% of students were unaware of mental health services provided by the public health system (SUS). These findings emphasise the need for increased awareness and access to mental health support in educational settings to enhance student well-being. This study was approved by the IFG Ethics Committee (number: 6.197.347).

Keywords. Mental Health, Public Policies, High School Students, Institutional Actions, Educational Environment.

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Construction of a Sustainable Greenhouse for Teaching Agricultural Engineering

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Abstract. Sustainability has increasingly become a global priority, highlighting the urgent need to replace industrialized materials, such as iron and cement, with more sustainable and reusable alternatives. To foster environmental preservation, it is essential to promote sustainable practices through the dissemination of information and ideas in various contexts, such as classrooms, lectures, and field activities. Addressing environmental issues and Environmental Education from multidisciplinary, interdisciplinary, and transdisciplinary perspectives is fundamental to achieving sustainable and balanced development [1].

Commercial greenhouse projects generally use galvanized steel structures, which, although more expensive, ensure greater stability and durability, as well as allowing for more effective control of the internal environment, especially when associated with climate control equipment and sensors [2]. However, the total cost of a greenhouse can be reduced if the producer opts to use available alternative materials, such as bamboo and shade nets, which, as demonstrated by the Bio-Structures project carried out at IF Goiano – Campus Urutaí, are viable. Nevertheless, two and a half years after the project's construction, the greenhouse already shows signs of degradation due to climatic and biological factors.

The present study aimed to build a sustainable greenhouse for plant production, aligned with the United Nations' 2015 Sustainable Development Goals, within the scope of the 2030 Agenda [3].

The greenhouse project was designed by students from the Agricultural Engineering Study and Research Group, using the computer-aided design software SOLIDWORKS, version 2021. For construction, sustainable and recycled materials were chosen, such as wood from demolitions, treated eucalyptus, PVC (Polyvinyl Chloride) pipes, transparent plastic sheeting, and fastening elements.

The structure, measuring 4 meters wide, 7 meters long, and 2.5 meters high, was built on land provided by the Production Department of the IF Goiano – Campus Urutaí, specifically to meet the needs of the Institution's seed laboratory.

This initiative demonstrates our commitment to sustainable innovation in rural constructions and the promotion of practices that contribute to responsible agricultural development.

Keywords. Eucalyptus, PVC Structure, Rural Constructions.

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Insect Oil as an Alternative for the Oleochemical and Animal Industry

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Abstract. Tenébrio molitor has potential as a protein ingredient for the non-ruminant nutrition industry, with satisfactory results, as well as the approval of Tenébrio molitor larvae as the first safe insect for human consumption in Europe. Therefore, the proposed project addresses both aspects: quantitative and qualitative potential of the Tenébrio molitor insect in oil production, with possible future tests in the oleochemical and animal industries. In this context, the objective of the project will be to determine the chemical composition of the oil extracted from Tenébrio molitor larvae and the bromatological composition of the defatted flour, to assess its viability as an alternative for the oleochemical and animal nutrition industries. The breeding of Tenébrio molitor will be carried out at the Entomoculture Laboratory of the Federal Institute of Goiano (IFGoiano), Campus Campos Belos.

The experimental beetles will be acquired from the Laboratory's own creation, coming from the same batch, population and age. The insects will be kept in plastic laying trays, fed with a standard diet consisting of 75% wheat bran and 25% corn bran, and chayote fractions will be made available every 3 days as a source of moisture.

After slaughter and drying, the T. molitor larvae will be subjected to oil extraction methods: solvents with Soxhlet extraction and cold pressing extraction, to obtain the oil and defatted flour. To characterize the oil, the following variables will be determined: density, viscosity and chromatographic profile.

In silico exploration of the biological potential of the components of the oil from T. molitor larvae will be carried out. To evaluate the bromatological composition of the defatted flour, MS, MM, PB, EE, FB and EB will be determined. The data will be analyzed by the SAS statistical program. Interaction calculations will be done using the AutoDock Tools suite of tools. The expected results are to understand the potential of insect larvae oil, using different extraction methods, as well as to evaluate the nutritional value of defatted flour.

Keywords. Insect Oil, Tenebrium Molitor, Oleochemical Industry, Animal Industry.

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Usage of 3D Pen in Chemistry Teaching for Visually Impaired Students

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Abstract: The inclusion of visually impaired students in The inclusion of visually impaired students in the educational context requires the implementation of effective teaching and learning strategies. In this regard, the application of emerging technologies, such as 3D printing, has gained significant traction and success in this area.

Technologies that allow the creation of objects from a virtual model are referred to as additive manufacturing, where items are created by adding materials (such as polymers or metals) in layers. This model is becoming increasingly present in the educational scenario, playing a crucial role in supporting inclusive pedagogical practices [1].

The 3D pen represents a significant innovation aimed at enhancing the learning experience for blind individuals. While it resembles a conventional pen in form, the 3D pen operates similarly to a 3D printer, albeit with greater simplicity and practicality. This tool enables the creation of various molecular structures, which will aid in understanding how these molecules are spatially arranged [2].

Furthermore, the 3D pen, being an affordable and accessible resource, can be utilized in various social contexts, thereby promoting the inclusion of more public school students in the learning of Chemistry. Through this approach, it is possible to create tactile and adaptable three-dimensional objects, facilitating the transmission of information.

Students with visual impairments encounter numerous obstacles while pursuing studies in the fields of science, technology, engineering, and mathematics (STEM). Chemistry courses can be particularly demanding due to the visual nature of the subject. As a result, visually impaired students may struggle to develop spatial skills, a concept that is extensively studied and closely correlated successfully with learning chemistry content [3].

Therefore, we will use a 3D pen to draw molecules related to organic chemistry, with the aim that handling and touching the printed objects will facilitate the understanding of the content.

Keywords. Chemistry Teaching, 3D Pen, Visual Impairment.

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Investigative Teaching in Elementary School (Final Years): A Challenge for Science Teachers in the Context of a Public School in Iporá

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Abstract. Investigative Teaching or Inquiry-based learning [1] can help introduce elementary school students to scientific concepts through the processes established during a scientific investigation. When dealing with children in the early stages of elementary school, some people may question their ability to understand scientific theories. However, it is argued that science education is essential for children's development, and that practical and contextualized activities can broaden reflection on everyday life and the possibility of learning about other ways of understanding and intervening socially, in addition to encouraging classroom discussions. Inquiry-based learning can not only increase students' interest and understanding, but also facilitate problem-solving, argument development, critical understanding of content, and greater authorship and clarity of the ideas presented [1]. In legal documents [2], the objectives of the Natural Sciences include learning about oneself, about the diversity of processes of evolution and maintenance of life, as well as understanding, explaining, and intervening in the world. Pedagogical methodologies that do not consider the active positioning of students, focusing on the teacher and the transmission of knowledge, can limit the achievement of these objectives and the understanding of Natural Sciences as described in the curricular bases. Some authors [3] emphasize the need for diversification in pedagogical methodologies. They emphasize that practical activities, such as experimentation and observation, are crucial to establish a solid foundation in Science teaching and develop a comprehensive scientific vision. In summary, it is believed that learning from inquiry-based teaching can contribute to greater meaning in the content learned and favor student engagement. Thus, this study aims to identify and describe the difficulties reported by a group of Science teachers in Iporá, also seeking to understand the educators' perception of the importance of proposals that consider the active stance of students. This research is ongoing. The methodology considered here is related to a qualitative approach, using the questionnaire as a research instrument. Data analysis will be based on Lüdke and André [4]. This research is expected to start from an understanding of school contexts and the challenges faced by teachers, and contribute to science classes that favor student protagonism. This research is developed within the scope of the supervised internship in science, a mandatory subject in the Biological Sciences course in Iporá. Reaffirming the importance of the teacher as an intellectual [5], this research is related to the initial training process of the first author. Therefore, it is believed that researching teacher training during the internship also involves reflecting on how to be in the classroom in a way that makes sense and is coherent with the way education and teaching and learning processes are thought about.

Keywords. Science Education, Teaching Methodologies, Active Methodologies, Investigative Teaching.

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Perceptions and Challenges of Teacher Education Students in Iporá, Goiás: A Preliminary Study

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Abstract. Education in Brazil is recognized as a universal right and a duty of the State and the family, as established by the Brazilian Constitution [1] and the Law of Guidelines and Bases of National Education (LDB) [2]. These legislations emphasize the value of education professionals as a central element. Complementing this framework, Decree No. 3.276/1999 [3] and Resolution CNE/CP No. 2/2019 [4] provide specific guidelines for the initial and continuing training of teachers, promoting the alignment between theory and practice and emphasizing the importance of multidisciplinary education. Despite these guidelines, the teaching profession in Brazil faces significant challenges, such as low salaries, adverse working conditions, and social devaluation. These factors contribute to the attrition of new professionals and result in a shortage of qualified teachers in the country [5] [6]. In this context, this study aims to explore the perceptions and expectations of teacher education students in the 3rd and 7th semesters in Iporá, Goiás, regarding the teaching career, focusing on understanding their motivations, the challenges they face, and their views on the role and future of the teaching profession. The research, still ongoing, uses a mixed-methods approach, combining qualitative and quantitative methods. A structured questionnaire was administered to 114 students in these semesters across three Higher Education Institutions (HEIs) in Iporá: Universidade Estadual de Goiás (UEG), Instituto Federal Goiano (IF Goiano), and Centro Universitário de Iporá (UnIPORÁ), which offer courses such as Biological Sciences, Languages, History, Geography, Mathematics, Chemistry, and Pedagogy. Preliminary results reveal a female predominance of 72% in teacher education courses, reflecting social and cultural patterns. The age range of students varies, with most students in the 3rd semester aged 18-20, while in the 7th semester, the predominant age group is 21-24 years. These demographic trends suggest the need for educational policies that consider gender and age to promote inclusion, as well as academic interventions to improve retention and course completion. The diversity of courses and the specialization of the HEIs highlight the importance of coordinated educational planning to meet local demands and strengthen teacher training in the region.

Keywords. Education, Teacher Training, Perceptions, Challenges.

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A Problematizing Experimental Activity on the Use of Essential Oils to Combat *Aedes Aegypti*

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Summary. During the teaching of organic chemistry school subject, high school students frequently report difficulties for differentiating oxygenated organic functions and understanding their physicochemical properties. Then, one way to streamline teaching is the use of experimentation with investigative approach. Considering the alarming increase in dengue [1] cases in Brazil and with the aim of facilitating learning in a contextualized manner, this investigation aimed to develop an experimental [2] activity focused on the production of a handmade candle with essential oils to address organic chemistry concepts and the prevention of *Aedes Aegypti*. The research, characterized as qualitative and exploratory [3], was conducted with a class of 3rd-year high school students and was anchored in the three pedagogical moments (3M) [4]: initial problem-posing, knowledge organization, and knowledge application. For data analysis, the classes were recorded in audio and video and subsequently transcribed. Following this teaching methodology, the data revealed that the experimental activity with a problematizing approach provided students with dialogic and interactive moments, encouraging active participation, raising questions and hypotheses, and enabling the understanding of chemical concepts, especially related to polarity and the identification of organic functions in the analyzed chemical structures. Thus, we concluded that the activity contributed, firstly, to student learning, advancing in terms of scientific concepts and understanding of the theme, and secondly, to the initial training process of the teachers.

Keywords. Aedes Aegypti, Essential Oils, Experimental Activity, Organic Chemistry.

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Reading in Prison: A Reading Therapy Experience with Incarcerated Women

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Abstract. The issue of the Brazilian prison system is indeed very complex and requires numerous efforts to comply with the Brazilian Penal Execution Law, Law 7.210, even in a country that sustains so many inequalities and injustices as Brazil. Ensuring human rights and the reintegration of individuals deprived of freedom is a significant challenge. This reality becomes even more specific when we consider women deprived of liberty, that is, the reality of female prisons and the lives of women who undergo short or long periods of incarceration. One of the most profound and effective activities in the work of reintegrating individuals deprived of liberty is reading, including for sentence reduction, as provided by the Brazilian Penal Execution Law. The greatest advantage of reading lies in its capacity to comprehend, analyze, mobilize knowledge, and produce not only new texts but also a new understanding of human life itself. The “Tessituras: Reading, Women, and Incarceration” project aims to bring literary readings into the prison environment, specifically for women, through guided activities and a schedule of texts, mainly short stories, that address gender issues and the multiplicity of femininities. The objective of our project is to promote “reading therapy” [1], that is, the reclamation of humanity through literary art, capable of accessing the symbolic universe and touching the deepest and most emotional dimension of the human being, filling what has been emptied by the dehumanizing conditions of incarceration. We believe in Literature as an essential good for human life, a fundamental right for humanity [2]. Art allows us to access the symbolic dimension of being, ensuring fundamental conditions for living with dignity and rights. We acknowledge that some lives are more precarious than others [3], and that we are in a perverse system of human life precariousness, in a logic where some are valued more than others and where “bodies and faces” are framed by the complex power relations in society. Based on this premise, we proposed a reading schedule over ten meetings, with texts, mostly short stories from Brazilian classic literature, carefully selected for group readings. The goal is to reflect on this literature in its aesthetic and ethical conception, mobilizing ideas and knowledge that challenge stereotypes and crystallized perceptions about life and the world, especially human life, influenced by class, race, and gender issues. The task is also to demystify classic literature as difficult and inaccessible texts, and to view reading as a feasible practice within the perspective of literacy, which mobilizes resources to generate reflections that provoke human anxieties and afflictions, leading to the search for more questions rather than answers.

Keywords. Literature, Prison, Reading, Precarious Life, Sentence Reduction.

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Estimation of Carbon Sequestration and Storage in Plant Biomass in a Permanent Preservation Area during the Rehabilitation Process in the Municipality of Rio Verde, GO

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Abstract. The study aimed to estimate carbon sequestration and storage in plant biomass of a Permanent Preservation Area (APP) undergoing rehabilitation in the municipality of Rio Verde, GO. APPs play a crucial role in environmental preservation, but are often degraded due to economic and urban pressure. The study area, located in the Goiano IF, was fenced and subjected to several interventions to promote the recovery of native vegetation. Using the Continuous Floristic Inventory, 164 trees belonging to 16 native species of the cerrado were identified. The total aboveground biomass was estimated at 46,241.48 kg, resulting in a carbon stock of 23,120.74 kg and sequestration of 84,853.11 kg of CO_2 equivalent. Species such as Anadenanthera colubrina and Inga vera showed greater carbon sequestration potential, representing 62.9% of the stored carbon. The results indicate that, despite the low diversity, the rehabilitation of APPs can contribute significantly to the mitigation of climate change, reinforcing the importance of continuous actions to recover and monitor these areas. The introduction of species with high carbon storage capacity is recommended to increase the effectiveness of APPs in mitigating environmental impacts.

Keywords. Carbon Sequestration and Storage, Climate Change, Rehabilitation of Permanent Preservation Areas.

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Enhancing the Use of ICTs by Approaching the Topic of Racism with Undergraduate Students from UEG-UnU Iporá

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Abstract. This research emerged from an internship experience, based on a perception that was observed regarding the inadequate use of information and communication technologies (ICT) in Natural Sciences classes. It is an ongoing research that articulates the themes of initial teacher training, ICTs and racism as a generating theme [1]. The hypothesis is that ICTs are underutilized due to the lack of preparation of teachers and students, in addition to the precariousness of teaching work. The research question posed here is related to “what are the main challenges encountered by teachers in training to use ICTs”? To identify the challenges, a focus group [2] will be organized with undergraduate students from UEG Unidade Iporá. This group will address the theme of racism, based on the concept of structural racism [3]. Understanding the importance of addressing such aspects during basic education classes, as well as an element established in the law of guidelines and bases of national education, amended by law 10.639/2003, ethnic-racial relations and racism are themes that should be addressed by different curricular components and on an ongoing basis. Therefore, based on the notion of teacher as intellectual [4], considering that it is essential to address racial aspects and to be up to date with regard to ICTs, this research is based on. The methodology considers a qualitative approach [5] with a participatory research design. At the present time, the research structure includes the consolidation of the theoretical framework and the elaboration of state-of-the-art research that considers these thematic axes. Based on the descriptors "teacher training" AND "racism" AND "information and communication technology", it was possible to find 470 works in the Google Scholar database. These are in the analysis phase to identify how ICTs have been used during teacher training. This is expected to contribute to teacher training, in a way that allows them to take advantage of the benefits of ICTs and adapt them to their daily classroom routine.

Keywords. Education for Ethnic-Racial Relations, Information and Communication Technologies, Science Education.

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The Development, Participation and Completion of a Game for the Science Classroom: Playfulness in the Construction of Student Protagonism

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Abstract. One of the biggest challenges for teachers working in science classrooms is to get students to actively participate in the pursuit of their protagonism. Student protagonism encompasses active participation in learning, the ability to make decisions and the ability to solve problems autonomously. It is also related to the quality of their interactions with classmates and teachers, teamwork and taking responsibility[1]. Although the pursuit of this protagonism is not easy, some didactic strategies make it possible in the classroom environment, among them the educational game. The idea of the educational game aims to bring the playful nature of the game closer to the possibility of improving cognitive development2. For these reasons, this paper discusses the proposition of a game in which the student is the protagonist from its conception, application and conclusion in the science classroom.

The activity is divided into three different stages, all of which involve the participation of the students. First, they are put into a conversation circle to come up with a text, key words or a list of concepts that they can remember from their science lessons. Then, in the conversation circle, the students share their writings, which can be supplemented by other students. At this point, the teacher writes down the students speeches, highlighting the concepts and content. After organizing the students speeches, the teacher proposes another moment to build concepts on the topics they have discussed. The construction of the concepts will be in the form of questions, all related to the students speeches during the conversation circle. The students construct the concepts and the the teacher, together with the students, turns them into questions. In this game you can list 25, 28, 30 or as many questions as the teacher and students decide.

After listing the questions, bingo is played. In bingo, the teacher lists the words on the board or projector so that the students can choose nine to make up their cards. The numbers drawn are not the numbers themselves or the words provided, but the concepts in the form of a question. The teacher speaks the concept drawn that is related to the word listed and the students relate it to the word on the list, this moment can occur through autonomous or shared speech.

In general, we can consider that the game proposal described contributes to student participation at all stages, from conception to completion, and this leads to a greater degree of engagement in the teaching and learning process. Valuing their knowledge, expressing themselves and sharing ideas is provided by the environment created by the game, which offers a place of lightness and no pressure[3] which makes it easier for the students to play a leading role. It's important to note that the activity described also includes a level of interaction, which in short, is the level at which the material or toy is manipulated. This level includes collective construction activities related to[2]

Keywords. Game, Participation, Protagonism, Science Classroom.

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How to Visualize Chemical Equilibrium in a Simple Way

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Abstract. The experiment presented here allows you to visualize how the chemical balance can be manipulated or shifted visually as the balance of chromate and dichromate ions. A chemical reaction is a process in which one or more substances (reactants) undergo transformations in their structures and form new species (products). However, some chemical reactions can occur both in the forward direction (reactants → products) and in the reverse direction (products → reactants). When the rate of the forward reaction is equal to the rate of the reverse reaction, the concentrations of reactants and products remain constant (at equilibrium).[1]

The objective of this project is to present a chemical equilibrium system in a simple and quick way, which can be analyzed by the color difference of the reactants and products, and to evaluate how chemical equilibrium is shifted by changes in the concentration of reactants and products.

For this experiment we use 50 mL of a 0.1 mol/L aqueous solution of potassium chromate (CrO_4^{2}); 50 mL of a 0.1 mol/L aqueous solution of potassium dichromate ($Cr_2O_7^{2-}$), 20 mL of 0.1 mol/L NaOH, and 20 mL of 0.1 mol/L HCl. 20 drops of the potassium chromate solution (yellow) were added to one test tube, and 20 drops of the potassium dichromate solution (orange) were added to another test tube. Then, 5 drops of NaOH were added to each tube, and the resulting color was recorded. Next, 5 drops of HCl were added to each tube, and the resulting color in each tube was recorded. The reaction used is Potassium chromate and potassium dichromate can exist in chemical equilibrium:

$$\underset{\text{(yellow)}}{2\,CrO_4^{2-}+2H^+} \Leftrightarrow \underset{\text{(orange)}}{Cr_2O_7^{2-}+H_2O}$$

Le Châtelier's principle predicts that any disturbance to the equilibrium will cause the system to act in a way that minimizes that disturbance. When HCl is added, the concentration of H+ ions increases, and the system reduces the excess by shifting the equilibrium toward the formation of products (orange), turning the yellow solution orange. When NaOH is added, the concentration of OH- ions increases, which react with H^+ ions, decreasing the concentration of H^+, and the system shifts the equilibrium toward the formation of reactants (yellow), turning the solution yellow.[1-2] The experiment allows practical observation of the equilibrium shift and can be used in teaching chemistry to 2nd-year high school students.

Keywords. Reaction, chemical equlibrium, acid-base.

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The Didactic Use of the PhET Simple Pendulum Simulator

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Abstract. The simple pendulum is a physical system that involves a mass suspended by an inextensible thread of negligible mass, which oscillates due to gravitational force. This system is one of the classic examples of a simple harmonic oscillator, and studying its behavior is a way of understanding the laws of physics. Using a simple pendulum simulator is a valuable tool for visualizing and exploring simple harmonic motion in an interactive way, as well as promoting critical thinking and improving analytical skills.

In this study, a simple pendulum experiment is proposed using a PhET simulator. The aim is to study the simple pendulum, with quantitative analyses of period and frequency, in different situations.

The interactive simulation, a visual representation of a pendulum is presented, where it is possible to modify several parameters of the experiment, such as the length of the thread, gravity, mass and friction. The simulation also features a stopwatch, a ruler and a goniometer, the latter used to determine the angle corresponding to the desired amplitude. Furthermore, the simulator also provides speed and acceleration data.

In our experimental proposal, detailed instructions are presented so that students and teachers can access and use the simulator, making it easier to carry out the virtual experiment.

Additionally, procedures are proposed to investigate the connection between the pendulum period and variables such as length, mass, oscillation angle and gravity. The work also contains questions for the analysis and discussion of the results achieved in the simulations.

Keywords. Experimentation, Simple Pendulum, Simulator.

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What Is an Atom? Building an Educational Atomic Model for Classroom Use

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Abstract. In most Brazilian public schools, the approach to teaching Natural Sciences still lacks pedagogical resources that spark greater interest and facilitate the understanding of abstract concepts that are more distant from students' everyday lives. This is due to a combination of factors, such as the absence of laboratories and physical infrastructure, the high costs of acquiring specific teaching materials, and limitations in the initial and ongoing training of teachers.

In this context, the process of scientific literacy among students is compromised, making it difficult to provide an education that enables them to learn, connect, and use scientific knowledge to demystify and reinterpret their worldviews and reality. Proposing and developing alternative pedagogical strategies that make the teaching and learning of Science more meaningful is increasingly necessary. For example, in the study of atoms, there are few teaching materials designed for everyday classroom use that differ from traditional theoretical models. As a result, the understanding of the basic characteristics of this component of matter is limited.

This work aims to characterize a three-dimensional atomic model designed to facilitate the study of atoms in the classroom.

The three-dimensional atomic model was made using cutouts from cardboard boxes, plastic balls, and wires, all repurposed from discarded materials. The balls were colored to represent protons and neutrons in the atomic nucleus and electrons in the electron cloud. They were suspended using metal wires and a cardboard tube, both attached to a base made of cardboard gears and pulleys with ligatures. To simulate the movement of electrons in the electron cloud, a crank connected to the pulleys allows this property to be simulated without the use of electricity or batteries. It is lightweight and portable, making it easy to transport and use in classrooms. A cardboard legend was also created to facilitate the identification and differentiation of the represented regions and particles.

The model represents the quantities of particles of the element oxygen (O), which is abundant on our planet and in the composition of living beings. It will facilitate the discussion of abstract concepts in chemistry, physics, and biology that many students struggle to understand through traditional lectures.

Made with recyclable and low-cost materials, it can be replicated and adjusted to represent other elements and used in various educational and academic contexts.

Keywords. Scientific Literacy, Teaching, Atom.

Capillarity in Plants: A Practical Experiment

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Abstract. The use of experiments in science education is essential for promoting active and practical understanding of theoretical concepts [1]. Experiments allow students to visualize and experience scientific phenomena, making learning more engaging and meaningful [2-3]. It also develops critical skills such as observation, analysis, and problem-solving, which are essential for scientific thinking. This study aims to explore the concept of capillarity in plants through a practical lesson developed for high school students [4-5]. Using simple materials, such as water, food coloring, and flowers, the activity allows students to observe how water is transported through plants. The methodology involves adding coloring to the water, preparing the flowers, and observing the changes in the color of the petals. The objective is to demonstrate the process of capillarity and its importance in the conduction of water and nutrients in plants. The project integrates practice and theory, promoting a deeper understanding of fundamental biological processes.

Keywords. Botany, Capillarity, Experimental Teaching, Natural Sciences.

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Analysis of the Relationships between the Cognitive Flexibility Theory, Bloom's Revised Taxonomy and the Minecraft Game for Teaching and Learning Physics Concepts

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Abstract. This work discusses the relationship between the Cognitive Flexibility Theory (CFT), Bloom's Revised Taxonomy (BRT) [2] and the use of the game Minecraft as an educational tool. CFT, proposed by Rand Spiro, emphasizes the importance of restructuring knowledge in complex domains, promoting multiple representations and the practical application of knowledge [1]. The BRT, updated by Benjamin Bloom, organizes educational objectives into levels of increasing complexity: remember, understand, apply, analyze, evaluate and create [2]. The use of Minecraft is introduced as a digital game, an environment that allows you to explore physical concepts in an interactive and practical way, aligning with the principles of CFT and BRT. Based on the analysis of these principles, we propose a four-step structure for elaboration in-game activities. Each stage is detailed with examples of activities that involve concepts such as speed, friction, free fall, among others. Finally, we observed that the combination of CFT and BRT can enrich the teaching-learning process, offering an adaptable and engaging approach. We hope that we will soon be able to apply this methodology with students to verify its potential in physics teaching.

Keywords. Bloom's Revised Taxonomy, Cognitive Flexibility Theory, Minecraft.

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The Tensegrity Stool

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Abstract. Tensegrity, or tensional integrity, is a term used in architecture to describe systems or structures that maintain their shape under a balance of compressive and tensile forces. The term was coined in the 1960s by American architect Richard Fuller, who used it to describe structures that combined functionality with futuristic design. A practical architectural example is the Needle Tower by American Kenneth Snelson, which relies entirely on the combination of tension and compression to support an eighteen-meter tower built entirely of aluminum tubes and stainless steel cables. Although the architectural application of the concept is relatively new, this type of structure is found in nature, such as bone and muscle structure, where bones are responsible for compression while muscles are responsible for tension.

We presented a stool whose structure is based on the concept of tensegrity, which in turn is full of physics. The materials used are described below:

1. 40 cm steel chain (15 mm thick),
2. 1.90 m of 30 mm x 20 mm rectangular steel bar, 0.9 mm thick,
3. 2.5 E6013 welding electrodes,
4. spray paint

The stool consists of two inverted L-shaped structures connected by the middle of the opposite sides of two square bases, one upper and one lower. The L-shaped parts are directly connected by a flexible chain, and the bases are directly connected at two vertices on the same side by two flexible chains. The design gives the impression of being unsustainable, given the flexibility of the chains. But physics explains it:

1. The short chain connecting the L's is responsible for the compressive force resulting from the weight of the upper base itself and/or any objects supported by that base, such as a book. In this way, the chain transmits the compression to the lower base, which rests on a surface such as a floor or table.
2. The two chains at the vertices provide the tensile forces that keep the stool balanced and prevent it from wobbling and collapsing.

On this occasion, we showed the directions and sensations of the forces of pressure and tension that support our structure, bringing physics to an architecture that refers to an illusion explained by mechanics.

Keywords. Tensegrity, Stool, Physics, Tension.

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Occurrence of Insects in Agroecological Cabbage Cultivation Using Natural Extracts

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Abstract. Vegetable production in agro-ecological systems is a promising alternative for meeting the demands of society, sustainability, environmental conservation and human well-being. However, regardless of the production system adopted, problems with insects and pest mites are recurrent. The use of bio-inputs, such as natural products extracted from plants, is a source of bioactive substances compatible with agro-ecological production, maintaining environmental balance without leaving chemical residues and without toxic action for animals and humans, as well as reducing the negative effects caused by the uncontrolled application of organosynthetic insecticides. Interest in the use of microorganisms in agricultural practices has increased significantly in recent years, both in promoting plant growth and in the biological control of pests and plant diseases, among other applications. The aim of this work was to evaluate the performance of different doses of microorganisms (Effective Microorganisms, EM) on the germination of two soybean genotypes (C258 and C248), under laboratory conditions. The germination test was carried out 7 days after the experiment was set up, assessing the number of normal, abnormal and dead seedlings. The soybean seeds were evaluated according to the different concentrations of MS. The experimental design was randomized, with 4 treatments (control, 15%, 25% and 50%) and 4 replications, containing 40 seeds of each soybean variety, making a total of 320 experimental units. According to each treatment, the seeds were soaked with the MS for 5 minutes, 10 seeds at a time in 15ml of the inoculant, at concentrations of 15%, 25% and 50%, and the control treatment was soaked only in water.The seeds were then placed on two sheets of Germitest paper, which had previously been moistened with distilled water (2.5 times their weight). After setting up the treatments, they were placed in the germination chamber at 20°C, without photoperiod. Soybean seeds of the C258 genotype, inoculated with efficient microorganisms (EM), showed no significant results compared to the control treatment. In contrast, soybean seeds of the C248 genotype, bioconditioned with EM, showed a higher germination rate (68%) compared to the control (45%). There was a significant difference compared to the control, with more satisfactory results for the two highest concentrations, 25% and 50%, which did not differ from each other. It can be concluded that the higher concentrations of MS contributed to better results in the germination of normal seedlings of soybean seeds of the C248 genotype.In view of this, the aim of this study was to verify the influence of natural extracts used in agroecological cabbage cultivation areas on the occurrence of insect pests and predators. The experiment was carried out in an area located at the IF Goiano, Hidrolândia Campus, in Hidrolândia, GO. A randomized block design was used, with five blocks (beds) and five plots (one for each treatment), each plot consisting of six plants, making a total of 30 plants per treatment. The treatments used were tobacco syrup, rue syrup, neem oil, basil oil and control. The plants were transplanted on August 21, 2024. Evaluations will be carried out weekly for 30 days after transplanting, and fortnightly between 45 and 60 days after transplanting, totaling six evaluations. It is hoped that this work will contribute to the dissemination of the use of natural products in the control of agriculturally important pests, to the sustainability of the agro-ecosystem and to increasing the environmental awareness of producers and technicians, through the use of control measures that are less aggressive to the environment.

Keywords. Bioinputs, Plant Extracts, Insects, Sustainability.

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To IF Goiano, Campus Hidrolândia.

Memory in Cards: Unveiling the Solar System through Active Methodologies

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Abstract. The solar system consists of celestial bodies orbiting the Sun, including eight planets, moons, asteroids, and comets. From rocky planets to gas giants, studying the solar system reveals planetary formation and our place in the universe, highlighting the complexity and beauty of the cosmos. The project "Memory in Cards: Unveiling the Solar System" aims to provide a dynamic and fun approach to studying the solar system for 8^{th}-grade students. The primary goal is to facilitate students' understanding of the composition and functioning of the solar system in an engaging way.

The project Methodology considers the folllowing stages:

- Development of the Memory Game: A memory game using solar system-themed cards will be created.
- Production of Interactive Cards: The cards will be designed so that each complements the other, encouraging learning through information association.
- Initial Theoretical Lesson: In the first lesson, students will receive a detailed theoretical introduction to the solar system, covering its structure and functioning.
- Alternative to the Model: Instead of the traditional model, the project proposes an innovative and interactive approach with the card game.
- Group Competition: In the second lesson, students will be divided into groups of six to participate in a competition. Each group will have one minute to find matching pairs of cards, totaling 14 cards.
- Time-Based Reward: The time taken by the group members will be added up, and the group with the shortest time will receive a prize, promoting teamwork and effective learning.

This method not only stimulates practical and collaborative learning but also makes studying the solar system more accessible and interesting for students.

Keywords. Solar System, Interactive Learning, Educational Game, Group Dynamics.

Acknowledgements

I would like to express my sincere gratitude to the researchers and authors whose works have significantly contributed to this project. Special thanks to Moran for his insights into active methodologies, which have been instrumental in shaping our approach to integrating physical education with chemistry. Additionally, I appreciate Valente's contributions on active learning strategies, which have guided the development of our interactive game-based activities. Your research has provided valuable frameworks and inspiration for creating engaging and effective educational experiences. Thank you for your dedication to advancing educational practices and for your impact on our teaching strategies.

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Prevalence of Psychological Well-Being and Mental Health Issues Among Students in Technical High School Programs at an Institution in Goiás

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Abstract. This study investigates the prevalence of psychological well-being and mental health issues among students enrolled in technical courses integrated with high school at the Instituto Federal de Goiás (IFG). Over a 12-month period, 149 students participated in an online survey assessing their psychological well-being and mental health. The results reveal that 96.6% of participants experienced psychological distress, with frequent symptoms including irritability, sadness, and insomnia. Notably, 34.9% reported frequent distress, and 21.5% experienced symptoms almost daily. While 71.8% reported no engagement in risky behaviours, 77.9% had faced bullying or discrimination, which significantly affected their mental health. Mental disorders in adolescents can negatively impact learning and increase the risk of school dropout. These disorders are associated with academic and behavioural difficulties, whereas good mental balance can enhance both educational and psychosocial performance. Our findings highlight the need for targeted mental health support and intervention strategies within educational settings to address and mitigate these issues. This study was approved by the IFG Ethics Committee (number: 6.197.347).

Keywords. Psychological Well-Being, Mental Health, Technical Education, Student Distress.

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The Science Truck: A Mobile Scientific Exploration of Physics, Chemistry, Biology, and Computer Science

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Abstract. This paper presents the 'Science Truck', an extension project of the Instituto Federal Goiano - Campus Ceres, which aims to disseminate scientific knowledge in the fields of Physics, Chemistry, Biology and Computer Science, using simplified and technological experiments and equipment, in an itinerant way in a truck with trailer. To carry out the project's activities, the expositors present a brief history of the subject, its relationship to everyday phenomena and technologies, and propose provocative approaches that arouse curiosity about the subject. Right at the entrance to the trailer one finds the physics area, which features demonstrations of electrostatic, electrodynamic and thermal phenomena. Lightning, electric shocks, materials engineering, heat engines, efficiency, and energy conversion are discussed. Next is the chemistry area, which features acid-base reactions and mixtures of substances, with each experiment named after something from everyday life, such as 'Chemical Tornado', 'Magic Blow' and 'Chemical Chameleon'. In this environment, the types of reactions that occur in each experiment are discussed, such as the formation of acids and other substances that we can see by the change in color of the solutions, covering knowledge of biology and chemistry as well as applications in industry and many types of laboratories. Two steps further, the visitor finds the Biology area, with microscopes and models, where the phases of the cycle of the *Aedes aegypti* mosquito, vector of famous tropical diseases, are discussed. There one can see the structures of the mosquito in its larval, pupal and adult stages, extending the discussion to the possibilities of prevention. The last area is the IT area, where visitors have the opportunity to explore the fascinating world of technology and automation. This environment is equipped with a variety of technological resources, including small automated systems built with free hardware, such as Arduino boards. Visitors can interact with robots designed and built to demonstrate basic programming and control principles, as well as see the functionality of a 3D printer in action and a 3D pen that can be used to create volume structures. A special highlight must be given to the drone, which can be used to demonstrate concepts of aerodynamics and sensors. The importance of robotics, sensors and programming in industry and everyday life are discussed. In addition to the interactive exhibitions, the "Science Truck" project carries out comprehensive digital dissemination via social networks, broadening the reach of scientific dissemination and reaching a more diverse audience. The project also offers visitors information about academic opportunities at the Instituto Federal Goiano - Campus Ceres, a member of the Federal Network for Professional, Scientific and Technological Education. The goal is to promote a better understanding of basic science and technology, to demonstrate their practical applications, their relevance to everyday life, and to encourage the appreciation of scientific knowledge, academic career opportunities, and the job market.

Keywords. Science Dissemination, Mobile Laboratory, Extension Project, Meaningful Learning.

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Chemical Burns in 9th Grade and 1st Year of High School: Exploring the Elements of the Periodic Table through Active Methodologies

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Abstract. As students enter 9th grade, they begin studying basic chemistry with a focus on the periodic table. The proposal is to integrate physical education with chemistry to make learning more enjoyable and interactive. The project will use active methodologies to engage students in practical and collaborative activities, fostering a deeper understanding of concepts and developing skills such as critical thinking and collaboration.

The aim is to turn passive learning into an active experience using the game "Chemical Dodgeball" to apply knowledge in a practical way. In this game, students guess elements from the periodic table based on clues given by their peers, making the learning process more dynamic and engaging.

The project includes administering questionnaires and observations to diagnose difficulties and assess the effectiveness of teaching strategies. Activities will consist of theoretical lessons on the periodic table and the execution of the game on the court. The goal is to enhance understanding of the periodic table and improve the quality of teaching by offering a more interactive and enjoyable approach to chemistry education.

Keywords. Periodic Table, Teaching and Learning, Active Methodologies.

Acknowledgements

I would like to express my sincere gratitude to the researchers and authors whose works have significantly contributed to this project. Special thanks to Moran for his insights into active methodologies, which have been instrumental in shaping our approach to integrating physical education with chemistry. Additionally, I appreciate Valente's contributions on active learning strategies, which have guided the development of our interactive game-based activities. Your research has provided valuable frameworks and inspiration for creating engaging and effective educational experiences. Thank you for your dedication to advancing educational practices and for your impact on our teaching strategies.

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Development of an Interface for Data Management in IoT Systems

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Abstract. This paper addresses the development of a data monitoring and management system for IoT (Internet of Things), specifically focusing on the user interface, the frontend of the project. The main objective is to build a responsive interface for the visualization and management of data from connected devices and sensors, as well as users. The system interface was built using web technologies such as HTML and CSS for the general structure and styling of the pages to ensure consistent design. The Bootstrap framework was also used to guarantee responsiveness across various devices, ensuring an adaptable interface for different screen sizes and a consistent user experience. To facilitate maintenance, addition, and expansion of functionalities, a modular system architecture was employed.

The screens were designed with a focus on usability, being clear and straightforward. Their functionalities include the management of device, sensor, and user data, allowing only administrators to manage and modify this data. For users, the interface provides easy access to and visualization of data collected by their sensors and devices, with options to filter specific data, such as data types and time intervals, displayed in tables and graphs, and also offering the option to download this information.

Keywords. Monitoring, BootsTrap, CSS, HTML.

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What Is the Role of Citizen Science in the Knowledge and Conservation of Brazilian Mammal Fauna?

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Abstract. Brazil is home to one of the most diverse mammalian faunas globally, yet these species face significant threats from habitat loss, illegal hunting, and insufficient conservation knowledge. This study investigates the role of Citizen Science (CS) and scientific dissemination as tools for the conservation of Brazilian mammals. CS involves public participation in scientific research, allowing volunteers to collect data on mammal populations and distribution across various ecosystems. By utilizing platforms such as WikiAves, iNaturalist, and Sistema Urubu, citizens can contribute valuable information that enhances scientific research and conservation strategies. This research focuses on how CS platforms can be integrated with conservation efforts to monitor mammal populations more effectively, improve data quality, and raise public awareness. It also explores the impact of scientific dissemination in increasing public engagement and support for conservation initiatives. By examining the successes and challenges of existing CS projects, the study identifies key strategies for overcoming obstacles such as data validation and public participation. The study methodology includes selecting relevant CS platforms, collecting and analyzing data on mammal distribution, and evaluating the impact of scientific dissemination on public engagement.

This research emphasizes the importance of integrating citizen-generated data into formal conservation programs, ensuring that these efforts are both scientifically rigorous and broadly supported by the public. By leveraging the power of CS and effective communication, this study aims to contribute to more sustainable and informed conservation strategies for Brazilian mammals.

Several citizen science platforms were explored to gather initial data. The selection of platforms was based on the authors' prior knowledge, ease of public participation, and the list of data providers from the Brazilian Biodiversity Information System (SiBBr). The chosen platforms were INaturalist, BioFaces, and the Ocean Biodiversity Information System (OBIS):

- INaturalist: This global platform allows users worldwide to submit photographs of animals. For this research, we focused on records of Brazilian mammals. A simple search on the INaturalist site revealed 55,272 observations involving 519 identified species, contributed by 4,330 participants. A distribution map, which can be filtered by mammal class and country, shows that most postings are concentrated in the South-Central, Northeast, and Southeast regions of Brazil. This distribution may reflect biases related to internet access, smartphone availability, or awareness of citizen science initiatives.
- BioFaces: The search on this platform was more challenging due to its less intuitive interface and difficulty in obtaining statistics. However, a generated map, filtered for photographs only, indicated that most mammal observations are concentrated in the Central-South region of Brazil, with a notable hotspot in Mato Grosso state.
- OBIS: As a platform focused on ocean biodiversity, OBIS showed that only a very small percentage (0.00669%) of mammal observations were made by its users, with the majority of data (62%) coming from fish. The platform's graphs provide a detailed breakdown of these records by class and specific groups.

These initial findings highlight the potential of these platforms for gathering significant data on mammal distribution in Brazil, although there are limitations and biases that need to be considered in future analyses.

Keywords. Biodiversity, Citizen Science, Data Validation, Mammalian Conservation.

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Promoting Environmental Education through Composting at School: A Formative Experience in a Teacher Training

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Abstract. This abstract presents part of a project developed for the Supervised Internship (ECS) of the Biological Sciences Teaching Degree at IF Goiano, Rio Verde campus. Its main objective is to promote environmental education in a state school in Rio Verde, Goiás, through the implementation of composters and a school organic garden. The central motivation of the project is to raise students' awareness of the importance of proper waste separation, particularly organic waste, which is often improperly discarded, contributing to environmental pollution. Therefore, we rely on the CTSA perspective (Science, Technology, Society, and Environment) and Scientific Education, associated with the use of strategies from active methodologies and Maker culture education. The project seeks to engage students in the practice of composting, turning organic waste into fertilizer for the school's garden. This educational process not only addresses environmental issues such as reducing waste sent to landfills but also empowers students to apply this knowledge in their communities, promoting sustainable practices. The proposal also integrates an interdisciplinary approach involving concepts from Biology, Chemistry, and Geography and emphasizes the importance of education for sustainability.

The development methodology of the project was divided into four stages, utilizing active didactic strategies, as follows: Presentation of the project to the students; conducting classes that reinforce the importance of proper waste disposal, highlighting the problems that poor management can cause to the planet and society, in addition to classes on microbiology and biochemical processes that occur during the degradation of material within the composter; collection of materials and construction of the composters, and finally, the construction of the composters with the students from the Basic Education school.

Finally, the analysis will be qualitative, built throughout the development of the project through field diary records and narratives recorded in the ECS report.

Keywords. Composting, Organic Fertilizer, Environmental Education, Sustainability, Maker Culture.

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Development of an API for Monitoring IoT Sensors and Devices

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Abstract. This work aims to present the development of an API (Application Programming Interface) responsible for monitoring IoT (Internet of Things) devices and sensors. The purpose of the API is to allow users to search and view data from their sensors stored in the non-relational database InfluxDB. To build this API, FastAPI was used, a framework designed to assist in the creation of other APIs. This framework was chosen because it is one of the fastest Python frameworks, as well as reducing development time. The API also allows application administrators to register, edit, and delete new users and devices, which are stored in the relational database PostgreSQL. Users can create and edit their devices. To store user credentials in PostgreSQL, the SQLAlchemy library is responsible for this communication. This library treats database attributes as objects, allowing the application's source code to avoid the need for SQL. Alembic was used for database migrations, which is used to change the state of tables and store database versions. The communication between the API and InfluxDB is done through the InfluxDB-Client library, using Flux, a scripting language for InfluxDB that allows queries to be made along with Python. Using this tool, the user does not need to worry about the script required to perform queries to retrieve their data from the database. Access to InfluxDB is managed through tokens, which provide access to buckets and measurements.

The API interface includes a login screen, which, when authorized, creates a session for the user. On the homepage, users can view registered devices and search for sensor data related to them. The data search interface is easy to navigate, where the user must select from a dropdown box the data from the database they wish to view.

Users can view their data either in tables, with all information displayed in columns in chronological order of when the data was sent to the database, or graphically, where the evolution of the sensor values that the user searched for can be visualized. It is also possible to download the query in CSV format. As an administrator, it is possible to register, edit, and delete users, as well as create, edit, and delete devices assigned to users. The administrator also has access to system logs, as well as access to sensor data from all users in the database, through a master token provided by InfluxDB.The developed API provides a platform capable of managing the data of users and devices registered in PostgreSQL tables, and also allows users to search, filter, and view their sensor data stored in InfluxDB intuitively and simply. As future work, the API should be distributed for testing with users to uncover the main difficulties encountered when using the API. It is also necessary to deploy the application on a server so that users can access it from a domain.

Keywords. Fastapi, InfluxDB, Monitoring, PostgreSQL.

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The Role of the "Scientific Practices" Axis in the Dissemination of Science and Technology

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Abstract. The "Scientific Practices" axis, carried out as part of the "Paths of Science and Technology" extension project, promoted by the Instituto Federal Goiano - Ceres Campus and in partnership with Ceres City Hall and the Pequeno Príncipe Full-Time Municipal School, aims to stimulate learning in the natural sciences, earth sciences and technology. The project aims to stimulate scientific literacy in an attractive and playful way for elementary school students, developing their understanding of scientific concepts, not just through lectures, but in conjunction with practical activities. The "Scientific Practices" axis develops classes and activities with children from the 1st to the 5th grade who take part in the project at the Ceres Campus, planned together with the project supervisors and carried out by students from the Chemistry Licentiate and Information Systems Bachelor courses.

The lessons were developed based on the National Common Curriculum Base (BNCC) [1] and the Computing BNCC [2], using strategies that combine theory and practice, carrying out scientific experiments as a teaching method and bringing interest in the subject to the students. Different environments such as the classroom, the computer lab, the microscopy lab and the biology lab were used. Various contents were covered, involving Computing, Chemistry, Physics, Biology and Geography, through dynamic tasks, such as the "Density Tower", where students explored concepts of density and molecules through experimentation with different materials, "Volcano", which introduced geological and chemical concepts about natural phenomena by assembling a volcano and simulating its eruption.

Continuing, based on the fundamentals of Computing and the process of computational thinking, the "Computing Maze" activity was carried out, using a maze to teach spatial orientation and programming logic, where they were challenged to command a robot staged by the students themselves to pass through the maze blindfolded. Along with this practice, the "Hour of Code" activity was explored, working on algorithms through block programming in the computer lab, using the Code.org teaching platform [3]. After each science experiment, the students were encouraged to ask questions and discuss what they had been taught, resulting in mostly positive comments. In addition, the activities were evaluated by the interest shown in the class, observing student participation through questioning and interaction. Therefore, the approach of the "Scientific Practices" axis recognizes the efficient development in the teaching of scientific concepts of the natural and earth sciences and Computing in Elementary School, since it instigates the interest of the students thus providing a significant understanding carried out through practice and playfulness, contributing to the development of Scientific Literacy.

Keywords. Elementary School, Science Education, Scientific Literacy, Scientific Practices.

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Brazilian Indigenous Spices and their Use in Native and Contemporary Cuisine

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Abstract. Cuisine is a rich cultural expression, reflecting the history and traditions of peoples. In Brazil, contemporary gastronomy is influenced by Indigenous, African, and European traditions, with a particular emphasis on Indigenous knowledge of spices and natural seasonings. These native ingredients possess aromatic, medicinal, and nutritional properties and are part of an ancestral knowledge that includes sustainable management practices and cultural and therapeutic uses.

The growing appreciation for traditional practices has led chefs and cooks to reintroduce ancestral flavors into modern cuisine, seeking innovation and reconnection with cultural roots and sustainable food practices. The traditional use of spices like peppers, coriander, and herbs such as *boldo* and *carqueja* is examined in the current context to highlight the importance of biodiversity and sustainability in gastronomy. Herbs and spices like coriander, chili peppers, and lemongrass have historical culinary and medicinal uses. For instance, some Indigenous peoples already used spices like *Capsicum* peppers and prepared seasonings like "*ijuqui*" (dried pepper with salt).

The salt could be extracted from seawater as well as from the leaves of water hyacinths. From this Brazilian Indigenous food context, we seek to explore how these Indigenous culinary traditions are incorporated and adapted into modern gastronomy, valuing the cultural legacy and sustainable practices of these peoples. The aim is also to identify and compile historical and current examples of spices that have been traditionally used by indigenous peoples in their typical dishes. Additionally, the goal is to analyze how these spices and seasonings have been adapted and integrated into contemporary gastronomic practices, highlighting the evolution and innovation in the use of these ingredients over time. Another important aspect of the research is to document the properties and traditional uses of spices in Brazilian cuisine, highlighting their social, cultural, religious, medicinal, and nutritional roles.

Keywords. Brazilian Indigenous Cuisine, Indigenous Food, Indigenous Spice.

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Scientific Communication in Informal Media

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Abstract. The “Information Age” is where society lives today, with many of them available, some being reliable and others not. Currently, it is easy to access this information due to the intensity of the internet, however, with all this in the palm of your hand, attention ends up being lost, making it more difficult to feel attracted to that information.

When analyzing the lack of attention from society, especially the younger community, this work aims to promote science through social media using playfulness, thus attributing this to the verbal and non-verbal communication present on these platforms. We use games, animations, and animes to keep the receiver's attention on the publication. In these, informal language is used, including slang and language from games, both to engage the community for whom that content was made and to provide a simple understanding of the subject published.

The content posted on social media is scientific in nature, pertaining to the high school curriculum of Brazilian schools. It explains important people in the field of science and their contributions to the community, as well as content related to the subjects studied. Games are interconnected with specific content. In these, phrases familiar to young people are used, whether from songs, games, animes, movies, or memes, thus providing an understanding of that content through the cited phrase. Overall, it was interpreted that the community reached had a basic understanding of the subject presented through this medium, as shown by the post.

Analyzing data from the platform used, it is noticeable that the use of this medium led to a significant increase in the number of people following the content, mainly from posts that utilized memes and quick videos. This, in turn, generated comments expressing interest and sparked dialogues that awakened interest among these viewers.

Keywords. Information Literacy, Social Media, Scientific Literacy.

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To Universidade Estadual de Goiás

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Using of Comic Books for Teaching Topics in Environmental Chemistry

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Abstract. The Chemistry of nature's reactions, including water, soil, and air, is understood through a specific field known as Environmental Chemistry, which is not being mandatorily covered in Brazilian education. This leads to a problem caused by the lack of access to information, restricting environmental analysis and studies to students in specific fields, such as those graduating from the Integrated High School Technical Course in Environmental Studies or postgraduate students who choose to specialize in Environmental Chemistry through a master's or even a doctoral program. Chemistry, in general, is a barrier for many students, and Environmental Chemistry, more specifically, is no different. Thus, innovative and dynamic methodologies play a crucial role in captivating and encouraging learners to become more interested in these fields [1-2]. Given this context, the study proposed the development of comic books on two topics of Environmental Chemistry and applying this material to the 2nd and 3rd-year high school classes at IF Goiano Campus Ceres (Fig. 1). The use of comic in the school environment represents a playful activity that allows the approach of various topics, where the visual resource and humorous language foster a more interesting and motivating learning experience. Through the methodology of this study, it was possible to introduce the topics of "SMOG" and "Dioxins and Fullerenes" to students who voluntarily participated in the research. The study was implemented and evaluated using a mixed-method approach, utilizing a questionnaire administered after presenting the comic created during the project's execution, which gathered information regarding the opinions of the participating students. The responses were analyzed and organized to quantitatively extract, in percentage terms, the results presented by the students.

The results obtained after analyzing the responses were properly tabulated, allowing us to observe that, overall, the approach used in this project was positively received, as noted from the post-reading questionnaire responses. Thus, it was found that comic books can contribute to student learning, encourage them to read and interpret, and even assimilate the content in a light and enjoyable way. They can be included at any educational level and on any subject, opening avenues for future studies that seek to adopt this approach. The use of innovative methodological strategies in the processes of teaching Chemistry allow the students them to greater appropriation of what they learn and therefore a better command of the content.

Figure 1. Comic on the topic of SMOG

Keywords. Teaching-Learning Process, Comics, Environmental Chemistry, Educational Innovation.

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An Exploration of Radioactivity in the Universe of Scientific Cinema

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Abstract. The presentation of chemistry and physics content and concepts can present a significant challenge for students and teachers. The use of playful and welcoming teaching tools, such as scientific cinema, has been demonstrated to be an effective approach to the teaching and learning process. In light of these considerations, this study employs scientific cinema as an alternative methodology for exploring the concept of radioactivity in an integrated high school curriculum.

The film “Radioactive,” accessible on the Netflix® platform, was selected to facilitate students' comprehension of the subject on a more comprehensive level. This encompasses not only the scientific aspects of radioactivity but also its political, historical, and cultural contexts, as well as its contemporary applications [1-2].

The research was structured in four stages. The method involved four parts: 1) checking students' knowledge through writing exercises; 2) showing a movie in class; 3) using a questionnaire after the movie to see how well they understood the ideas; and 4) having a discussion with teachers from chemistry, biology, and history about new ideas [2-4].

The preliminary findings indicated that the students demonstrated a fundamental understanding of radioactivity. A post-film questionnaire administered to the students revealed that they could assimilate and deepen the concepts discussed. Furthermore, the roundtable discussion evidenced a notable engagement with social issues such as sexism, ethnic prejudice, and the challenges encountered by women in science, as explored in the film. This increase in interest and involvement demonstrates the potential of science cinema as an innovative pedagogical tool capable of promoting more contextualized and critical learning on complex scientific topics.

Keywords. Alternative Methodology, Chemistry, Radioactivity, Scientific Cinema.

Acknowledgements

We thank the IF Goiano - Ceres campus for their generous support and funding.

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arCEAGRE: Itinerant Scientific Literacy in Rural Education

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Abstract. The project aims to bring scientific knowledge and sustainable practices to rural Rio Verde - Goiás municipal schools. Through workshops and practical activities, students come into contact with topics such as ethnobotany, sustainable agriculture, soil management, organic food production and entrepreneurship.

The actions are carried out in partnership with various sectors of IF Goiano, such as postgraduate courses and specialised laboratories, as well as other institutions such as MOPORV and the Municipal Department of Education.

The workshops cover a variety of topics, from the cultivation of medicinal plants and organic food production to entomology and ecotoxicology. The aim is to stimulate students' interest in science and nature, as well as promoting the development of skills such as research and experimentation.

The project serves rural schools in Rio Verde, Goiás, where various practical workshops are held. Students can visit laboratories, learn about food cultivation and production techniques, and participate in fun and cultural activities. culturalism.

The initiative is itinerant and will continue to visit other schools in rural Rio Verde throughout the year. The project is expected to contribute to the formation of citizens who are more aware of and engaged in environmental preservation and sustainable development.

Keywords. Sustainable Agriculture, Entrepreneurship, Ethnobotany, Workshops.

Acknowledgments

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Toothpaste Production: A Practical Approach to Halitosis Prevention

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Abstract: This experiment focuses on the production of toothpaste to investigate halitosis and its underlying causes, providing a practical method for its prevention [1-2]. Participants are introduced to a formulation process involving ingredients such as calcium carbonate (abrasive agent), glycerin (moisturizer), neutral soap (surfactant), menthol (flavoring agent), methyl salicylate (aromatic compound), distilled water (solvent), and edible dye (colorant). The experiment includes detailed explanations of the role each ingredient plays in the toothpaste's efficacy. Participants then engage in the practical application of the toothpaste through a brushing session. This approach facilitates a comprehensive understanding of the formulation of dental products and the implementation of strategies to address halitosis. By integrating theoretical knowledge with hands-on experience, this experiment aims to enhance participants' awareness of effective oral hygiene practices and the scientific principles behind dental care products [3].

Keywords. Toothpaste, Halitosis, Prevention, Production.

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Money: Shall We Talk about It?

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Abstract. Money is a constant feature in our lives as it mediates exchanges via cash, PIX, or credit/debit cards. Despite its daily presence, our relationship with it is not always peaceful. In our consumer society, which is described as “liquid modernity” by Bauman (2022), it is crucial to reflect about how this relationship is shaped. Behavioral economics, as proposed by Thaler (2019), indicates how our relationship with money is shaped by the current economy, while economic psychology as studied by authors such as Ferreira (2008) and Klontz & Klontz (2011) offer insights into how our emotions influence this interaction. After all, who is in control: you or money?

Keywords. Money, Liquid Society, Behavioral Economics, Money Psychology.

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Educational Challenges and Sustainable Solutions: An Extension Project's Impact on Itumbiara-GO

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Abstract. This paper presents an extension program developed by students from IFG-Itumbiara, where active methodologies were applied at the Military School of Itumbiara-GO to address institutional challenges. The project directly involved the school community, identifying challenges and proposing sustainable solutions that ranged from infrastructure issues to pedagogical practices. The effectiveness of these solutions had a significant impact, highlighting the importance of sustainability in educational settings. These outcomes were instrumental in inspiring the NGO Engineers Without Borders to participate in a citywide recycling initiative, thereby expanding the reach of sustainable actions.

Keywords. Active Methodologies, Extension program, Institutional Challenges, Sustainability Education.

Acknowledgements

We would like to thank the Military School of Itumbiara-GO for their collaboration during the application of the active methodology. We also express our gratitude to the NGO Engineers Without Borders.

Integrating Practical Laboratory Activities into Chemistry Teaching

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Abstract. Chemistry teaching should not be restricted to theoretical exposition of content but should integrate practices that arouse interest and develop scientific skills. This study explores the introduction of laboratory activities for first-year high school students at an institution with easy access to laboratories, but where this infrastructure has not been fully utilized. During a practical lesson on electrical conductivity, the students had their first direct experience with laboratory instruments. The main experiment involved testing the electrical conductivity of various solutions, using a low-voltage lamp to check the passage of current. The activity was complemented by a reflective questionnaire, which reinforced their understanding of the concepts and encouraged critical remarks. This first practical contact demonstrated the importance of systematically integrating these activities into the curriculum early on, with a positive impact on student motivation and understanding.

Keywords. Chemistry Teaching, Conductivity, Laboratory Activities, Scientific Skills.

Acknowledgements

I would like to express my sincere gratitude to Dr. Beatriz Nogueira da Cunha for her invaluable contribution in designing and delivering the lesson. Her dedication and expertise played a key role in the success of this project. I also extend my thanks to Instituto Federal Goiano – Campus Ceres for providing the resources and academic environment necessary for conducting this study.

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Osmosis in Bell Pepper Strips: A Practical Experiment

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Abstract: This experiment aims to explore osmosis in plant cells using bell pepper strips immersed in saline solutions of different concentrations [1]. The strips are placed in three types of solutions: pure water (hypotonic), water with a small amount of salt (isotonic), and water with a higher amount of salt (hypertonic). Over 24 hours, the reactions of the bell pepper strips are observed, either bending or remaining straight, depending on the solution in which they were immersed. These visible changes result from the movement of water through cell membranes, demonstrating the effects of solutions of different concentrations on plant cells.[2-3] Students can see how water moves into or out of the cells depending on the surrounding environment, providing a more tangible understanding of the concept of osmosis and cellular transport in plants. This practical experiment helps to clearly and accessibly illustrate the importance of osmosis in the functioning of plant cells.[4]

Keywords. Plant Cells, Osmosis, Bell Pepper, Solutions.

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Environmental Education for Deaf Students: The Vowels of The Cerrado Biome from a Bilingual Perspective

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Abstract. Emancipatory and transformative environmental education encourages citizens from different social classes to reflect on the political, economic and moral scenario; individual and collective in the environment. The Cerrado Biome is the focus of the study that aims to address environmental education through bilingual educational resources (written Portuguese and visual Libras) for the acquisition of scientific literacy with Deaf students. The representatives of the fauna and flora chosen from the Cerrado Biome were: Tapir; Rhea; Ipe; Jaguar; Urucum with popular, scientific name, habitat and ecological niche. The work refers to the environmental importance of the Biome in an accessible way.

Keywords. Cerrado Biome, Environmental Education, Bilingual Education, Deaf.

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Drawing Becoming Knowledge or Knowledge Becoming Drawing?

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Abstract. Increasingly, technology has advanced in the daily lives of children and has gained the space of play, knowledge and imagination. Rescuing activities that place the child in an active way and not just as a spectator, is fundamental for the process of knowledge construction, to stimulate creativity and for the recognition of one's own self and that of the other. The choice of children's drawings aimed to instigate children, in a playful way, to get to know interesting educational resources, awakening to the search for knowledge from childhood. By proposing the reproduction of the content learned through artistic drawings, it enables the development of art, in which the student represents what he has assimilated, inserting his look and his feelings through drawing, in which this type of experience is necessary for a broader development of children. The methodology of the present work consisted of the application of children's cartoons, dialogued explanation of scientific themes present in children's drawings and subsequent application of maker education, where the children developed artistic productions on the theme. The children demonstrated engagement during the project's activities. After the exhibition of artistic productions and feedback from students and guardians, it was notorious to observe the resourcefulness in the teaching-learning process through the maker culture.

Keywords. Education Maker, Art, Children, Cartoon.

Acknowledgements

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The Third Sector as a Driver of Sustainable Cities

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Abstract. This paper examines the impact of the third sector in promoting urban sustainability, through a case study of a pilot project for solid waste recycling in Itumbiara-GO. The project, led by the Municipality and the association Estação Reciclar, involved the NGO Engineers Without Borders, which played a crucial role in community mobilization and environmental education. Initially implemented in two neighborhoods, the project demonstrated how collaboration between public entities and third-sector organizations can lead to significant social and environmental transformations. The project's expansion to other neighborhoods further emphasizes the effectiveness of this partnership in building a more sustainable city.

Keywords. Community Engagement, Third Sector, Urban Sustainability, Waste Recycling.

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Contradicting the Traditional Statement of Archimedes' Principle

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Abstract. It was verified how Archimedes' principle has been presented in high school and higher education textbooks. The analyzed corpus consists of the Natural Sciences textbooks approved by the Programa Nacional do Livro e Material Didático (PNLD) [National Program of Book and Didactic Material] 2021 as well as four Physics collections widely used in higher education. Specifically, the statement that the buoyant force always has the same magnitude as the weight of fluid displaced by the object was examined. Our investigation revealed that all the textbooks consulted still ignore the validity limit for Archimedes' principle, which emerges from Galileo’s hydrostatic paradox. In order to exemplify the dynamic nature of scientific knowledge, a simple experiment involving an unopened can of soda, water and a plastic cup can demonstrate the need to update the textbooks analyzed.

Keywords. Archimedes' Principle, Buoyant Force, Experimentation.

Elephant Toothpaste: Experimentation for Teaching Catalysts in Chemistry

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Abstract. A catalyst is a substance that has the ability to accelerate the rate of certain chemical reactions without undergoing any changes, meaning it is not consumed but is fully regenerated at the end. The use of catalysts is particularly important for industries as it makes processes feasible that would otherwise take a long time to complete. It is important to understand that catalytic substances do not increase the amount of product in the reaction; they merely speed up the process.

Catalysts increase the speed of reactions because they change the mechanism by which the reaction occurs; in other words, they create an alternative "pathway" for the reaction to take place with a lower activation energy. The lower the activation energy, the faster the reaction, and vice versa. This is how catalysts work. They can increase the speed of reactions because they allow them to occur with lower activation energy.

In Brazil, in Chemistry education, teachers cover the use of catalysts in the 2nd or 3rd year of high school. This content is fundamental for learning, as it is necessary for understanding other topics, such as chemical reactions and kinetics.

An alternative for teaching this content is to use active methodologies, such as experimentation. The "Elephant Toothpaste" experiment, in turn, effectively demonstrates the use of catalysts in chemical reactions. Traditionally, the experiment is based on hydrogen peroxide and potassium iodide and can be conducted in schools with laboratory facilities. However, it can also be carried out in the classroom using low-cost materials. The original substances can be replaced with baking powder, 3% hydrogen peroxide, and dish soap. To make it more engaging for students, it is recommended to add liquid dyes in both cases. Additionally, it is important for the teacher to provide a theoretical introduction to catalysts before moving on to the practical execution and discussion, thereby promoting content learning among students.

Keywords. Experimentation Chemistry, Catalysts.

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The Problem of Two Falling Objects: Using Inquiry-Based Teaching to Build Concepts of Air and Resistance

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Abstract. This study investigates the use of Inquiry-Based Teaching (IBT) in early elementary education to introduce the concepts of air and resistance. Through a classroom activity titled "The Problem of Two Falling Objects," third-grade students in Rondonópolis-MT were encouraged to explore how air affects the fall of different objects. The aim was to engage students in hands-on experimentation to help them construct an understanding of air and its resistance. The results showed that the students could conceptualize air as a substance that offers resistance, providing a foundation for deeper scientific inquiry in future studies.

Keywords. Inquiry-Based Teaching, Air Resistance, Elementary Science Education, Conceptual Understanding.

CEAGRE: Robotics Educational

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Abstract. The Centre of ásExcellence in Exponential Agriculture (CEAGRE) of the Federal Institute of Goiás, located in Rio Verde, Goiás, is recognized as a reference center for agricultural technology. The center promotes the development of community-integrated projects, one of which is the itinerant Robotec project, which aims to democratize digital culture and widen access to technology. The initiative organizes robotics workshops that can be applied in the classroom, enriching the teaching-learning process for primary school teachers.

The *Robotec* project aims to provide training in basic robotics, with an emphasis on practice. By means of workshops and practical activities, the aim is to introduce participants to fundamental concepts about electronic circuits and components, as well as to train them in the use of the *Tinkercad* online software for simulating electronic circuits and in the use of the *IDE Arduino* for programming. The expected results include training participants in basic robotics and digital tools, the development of practical projects that can be replicated in the classroom, as well as the integration of new technological resources into science and technology teaching.

The project's methodology is based on practical workshops. Participants will be introduced to concepts of robotics and electronics, followed by practical exercises using the *Tinkercad* and *IDE Arduino*. Each teacher will have to develop a final project using the *Blynk IoT* tool to control an irrigation system in real time, applying the knowledge acquired. At the end of the course, participants will present the projects they have developed, promoting an environment for sharing experiences and collaborative learning.

Keywords. Robotics, Teaching, Training.

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Bilateral Management and Communication of Sensors in IoT Systems with ESP32

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Abstract. This work presents the development of an algorithm for the ESP32, integrating multiple sensors with the purpose of real-time data monitoring and cloud storage using InfluxDB. Among the integrated sensors, the DHT22 stands out, responsible for measuring temperature and humidity. Communication with a sensor monitoring API enables real-time feedback of the collected information, providing an interface for data visualisation. The main goal is to create a solution that can efficiently collect, transmit, or store the data. The algorithm was developed for the ESP32 as a PlatformIO extension, using specific libraries for reading the integrated sensors, such as the DHT22. Communication with the monitoring API was established through HTTP requests, allowing the data to be sent to a remote server. InfluxDB was chosen for cloud storage due to its compatibility with microcontrollers like Arduino and ESP32. Moreover, a contingency system was implemented, so if communication with the API or the database fails, or if the WiFi connection is unstable, the ESP32 stores the data locally in its memory to be sent later once the connection is restored.

Keywords. Algoritm, FastAPI, InfluxDB.

Acknowledgements. To CEAGRE for the opportunity and support in developing the application, and to FAPEG and IFGOIANOfor their financial and structural support.

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Walking around the City, Photographing Signs of Nature and (re)Thinking the Relationship between Man and Nature: Explorations in the Pedagogy Course (FE/UFG)

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Abstract. The work aims to (re)think the trajectories of walking around the city, photographing signs of nature and (re)thinking the relationship between man and nature experienced in the class "Special topics in Early Childhood Education: children and nature" (Pedagogy - FE/UFG - 2023 /two). Thus, through narrative-analytical writing we allude to opportunized exploration (wandering around the city), through photographs produced by future teachers to problematize the Environmental Education (EE) that we aim to constitute: critical EA, with a view to their participation in discussions on the environmental issue. Therefore, taking a critical perspective as a guide, we encourage that human beings belong to the web of social, natural and cultural relationships, living in interaction, requiring reflection that subsidizes action and, then, provides opportunities for new reflection.

Keywords. Environmental Education, Photographs, Man-Nature Relationship, Teacher Training.

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Construction of Low-Cost Teaching Models for Teaching Metal Properties

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Abstract. Metals have na electronic structure with electrons delocalized in a crystal lattice, which gives them electrical and thermal conductivity. Band theory explains the properties of metals by establishing that atomic orbitals form energy bands. The free movement of electrons is permitted in a half-filled or empty band. To build a low-cost educational model, a T-shaped pedestal and two boxes were used to represent valence and conduction bands, with Styrofoam balls symbolizing electrons. The distance between the bands in metals, semiconductors and insulators is represented by moving the boxes longitudinally and checking whether there is space for the Styrofoam balls to move. This is achieved by passing a gentle air flow allowing the Styrofoam balls to be agitated in a semi-filled box or in an overlapping empty box. To represent metals, the bands overlap, allowing electron movement. In insulators, the large energy distance between bands prevents conduction; in semiconductors, this smaller distance allows the passage of few electrons. The proposed model is a useful teaching tool for dealing with abstract subjects, such as the electronic structure of metals, with the aim of overcoming learning difficulties in this subject and can be used by students at different levels.

Keywords. Band Theory, Representational Models, Conductivity, Delocalized Electrons, Semiconductors.

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Photography and Gastronomy at the *Festa do Doce* in Lagolandia

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Abstract. This work aims to document, photographically, for the purposes of dissemination and archiving, the setting of the Festa do Doce in Lagolandia, an annual and traditional gastronomic event that marks the culture of the local community. It is a religious festival in honor of the Holy Spirit, Our Lady of the Rosary, and Saint Benedict, the patron saint of the festival. Gastronomy is an important part of a culture. It highlights the habits and customs of a specific people. Through it, information about feelings and traditions is conveyed, and this festival is a memorable moment of fraternity and cooperation among the local residents, aiming to preserve and pass on the culture of this community through generations. *Santa Dica*, a religious leader and founder of the village, was the visionary behind this event, which features a wide variety of sweets made from raw materials sourced from various locations and offered free of charge.

This is made possible by the spirit of fraternity that unites the entire local community, working for the festival itself rather than for profit. As one might expect, and due to the importance of this event for the locality, the recipes are followed to the letter, just as they were by the ancestors, and families take pride in passing on this knowledge to new generations. Due to its proximity to the important tourist hub, Pirenópolis, the festival becomes more well-known and attended each year, energizing the local community and its surroundings. This work aims to recall this event, and above all, the artistic aspects involved, including the photographic documentation of the various scenes that make up the setting. Food photography is a tool to awaken people's senses and emotions that drive gastronomy.

Thus, our general objective is to demonstrate how photography can be a source of gastronomic and sociocultural information. Derived from this, our specific objective is to document the Festa do Doce in Lagolandia through photographs. In other words, we aim to present the Lagolandia festival through photographic scenes, capturing a bit of the community's history.

Keywords. Candy Festival, *Santa Dica* Lagolandia, Photography, Traditional Gastronomy.

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Virtual Learning Environment with Flipped Classroom

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Abstract. In this article, we present an experience using the flipped classroom methodology, applied to first-year high school students. Our goal was to evaluate students' perceptions of this approach. We conducted field research to collect data. Using the Virtual Learning Environment in Google Classroom with the flipped classroom methodology, students had access to various media, such as studying books, video lessons, and podcasts, allowing greater flexibility in learning. During the process of using the flipped classroom methodology, the teacher surveyed students to see if they wanted to continue with the methodology, and all three classes voted in favor of continuing. We realized that this approach allowed students to be the authors of their own learning, since they arrived at the lectures with specific questions about the content studied.

Keywords. Flipped Classroom Methodology. Learning Environment. Students. Teacher.

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A Handful of Gravel. A Quick Science Workshop for All Ages

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Abstract. It's sometimes difficult to find something easy, new and different which will appeal to all ages of learners. This workshop uses either an area of outside gravel or a handful of gravel given indoors to provide an interesting learning experience at a range of levels.

If using an area of gravel outside, ask learners to spend about five minutes sifting through the gravel to see what they can find apart from stones. Most gravels will produce sea shells, usually broken but occasionally whole. Bring these inside. and ask learners to bring a handful of gravel as well.

Initially the gravel can be used in a sorting exercise, this can be size, shape or colour. Discuss the implications of each group as well as the occurrence of the shells. What does this tell us about the gravel and its origins? How many (if any) different rock types are present? Why do the stones differ in size and shape. Much discussion and explanation can ensue from this simple exercise at all levels. Graphs can be drawn of the learners' collections either individually or as a group, and this will provoke more discussion.

Younger children can also count the number of pieces they have collected; and use them to make letters or numbers.

Keywords. Discussion, Fun, Explanation, Reasoning.

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21th International Conference on Hands-on Science

Science Education and Sustainability

23th-27th September 2024
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