Hands-on Science

Science Education-Contemplating the Future

Edited by:
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The Hand-on Science Network

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Foreword

Science Education - Contemplating the Future

By the beginning of the 21st century, at the dawn of a new millennia, the recognition of the fundamental importance of science to the humankind was widely established. The crucial role of the school and science education to the development of science and technology was accepted by most scientists and all using the scientific knowledge on their master in technology and engineering. However, there was a renewed sense of the need to improve school science education and its effectiveness and to improve and generalize scientific literacy in today' societies. At the Hands-on Science Network, we actively promote the incorporation of hands-on investigative experiments-based activities in the classroom, and in non-formal and informal contexts, as the key driving element of the science teaching/learning process at all school levels and in society. Although we focus on active learning of science, we are open to all pedagogic and methodological approaches embracing all committed to the development and improvement of science education in an open and mutually supporting environment. Stating the critical role of the school, we also recognize and adjust to the evolution of our societies including the challenges and opportunities raised by the recent developments on artificial intelligence.

The book herein aims to contribute to further the improvement of Science Education in our schools and to an effective implementation of a sound widespread scientific literacy at all levels of society. Its chapters reunite a variety of diverse works presented in this line of thought at the 22nd International Conference on Hands-on Science held in Cairo, Egypt, December 14 to 18, 2025.

Vila Verde, Portugal, December 10, 2025.

Manuel Filipe Pereira da Cunha Martins Costa
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Two Decades of Hands-on Science. Looking Ahead

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Abstract. The impact of the rapid development of science and its applications over last century, and the ever-increasing expectations and pressure the society, and human' innate curiosity, places on scientists, brought science and technology education to very high level of importance among the modern educational system, at all levels.

Back in 2003 the Hands-on Science Network project1 was launched aiming to contribute to the development and improvement of science education at schools and science literacy in our societies.

With a broad open understanding of the meaning and importance of Science to the development of our societies, each individual and of the humankind, the main goal of the Hands-on Science Network is the development improvement and generalization of science education and scientific literacy by an extended use of investigative hands-on experiments based active learning of Science and its applications, while fostering cooperation and mutual support understanding and respect among teachers, researchers, educators, students and all involved and committed to science education at all levels and contexts.

In this communication we will give a brief overview of the past activities and intervention of the Hands-on Science Network and prospect for the future.

Keywords. Science Education, Scientific Literacy, Investigative Hands-on Experiments, Active Learning, Scientific Method, Hands-on Science Network.

1. Introduction

When the Hands-on Science Network project [1] was designed at the beginning of the 21st century, a main goal and focus was clear: to improve in-school science education by promoting the incorporation of hands-on investigative experiments-based activities in the classroom as the key driving element of the science teaching/learning process at all school levels and at lifelong learning [2]. The Hands-on Science Network, stands for promoting the development of science education and scientific literacy in our societies. HSCI embraces a wide membership of teachers and educators from all school levels from pre-school to adult education and also in non-formal contexts, managers and policy makers, academics and researchers in virtually all fields of Science and STEM, from a large number of countries of the five continents. In an open-minded tolerant and friendly atmosphere, we support each other with our diverse ideas and experiences and join our committed efforts towards a better improved and generalized Science Education.

With an open and wide understanding of the importance of Science Education and of the ways to effectively implement it as a crucial factor to the sustainable development of our societies and of human kind, we encourage the use of innovative hands-on experimental approaches to Science and STEM in-school teaching and learning and to the promotion of a widespread Scientific Literacy in our societies. As well in raising the profile and attractiveness of Science in Education, we also aim to increase the desirability of a career in Science for all [3].

2. Main activities of the Hands-on Science Network

Along the years a large number of diverse activities were organized in different countries enrolling several thousand teachers and possibly over one hundred thousand students in different countries and grades or age levels from adulthood to pre-school children. Countless lectures and dissemination activities, in more or less formal ways, several dozen teacher training course in different subjects, science fairs (Figure 1) and science contests, and a large number of meetings, workshops and conferences were organized. Several books were published and a remarkable open access repository is available at the HSCI' website [1].

The annual Hands-on Science international conference series was launched in 2004 by the Hands-on Science Network and is now in its 22st edition. Organized every year in different countries across Europe and the World (Portugal, Spain, Greece, Brazil, Slovenia,

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Turkey, Slovakia, Czech Republic, India, Ukraine, and this year in Egypt) the HSCI conferences are focused in supporting and helping teachers in their task and promote the development of Science Education and scientific literacy.

Figure 1. The lovely and remarkably detailed work of basic school students' members of the Turkish S.O.S. (Saving Our Species) initiative participating in one of the exciting science fairs

Each year an average of 200 teachers, educators, academics, researchers, students and all sort of persons interested or involved in science education, at all grades and levels, meet in a friendly mutually supportive and open-minded way to present learn and discuss current trends challenges and opportunities in science education at all age levels and contexts respecting and integrating all different perspectives and diverse and innovative proposals of solution to the problems science education is facing.

A wide range of main topics was chosen from environmental education, at all grades and ages levels from pre-school to life-long-learning (Figure 1), and sustainability (Figure 2) [4,5] to informal and non-formal education or the use and development of IT or the diversity and inclusion problems [6] always celebrating science and science education [7]. This year, for the first time in Africa, we will honor the Egyptian people and culture and their remarkable contribution to the development of science and humanity, projecting the future evolution in scientific education [8].

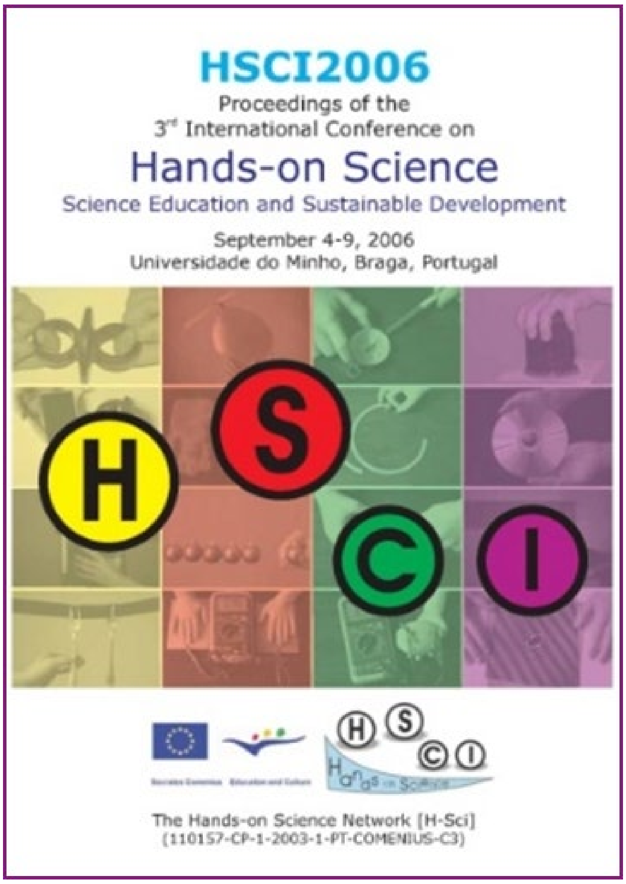

Figure 2. The cover (by José Benito Vázquez Dorrío) of the HSCI2006 conference that had as main subject the contribution of science to a sustainable development

3. Investigative experiments and the scientific method

The Hands-on Science network aim to contribute to the generalization innovation and improvement of Science and Science & Technology education at basic vocational training secondary and higher education schools by hands-on experimental investigative practice in the classroom, bring hands-on active learning of Science into the classroom and into the soul and spirit of the school and making it the core of Science Education, promote the development of Scientific Literacy at all levels of our Societies... "Educating for Science and through Science".

Well before the scientific method was defined and put into written words becoming the essential and pivotal guideline to scientific research, Greeks, Babylonians, Egyptians and many others followed, in different and flexible ways, its steps in the process of understanding and explaining the world they, and we, live in. Aristotle one of the greatest sages of humanity

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gave us moto of the Hands-on Science Network "We learn how to do by doing the things we are learning to do" and help setting the basis of critical reasoning fundamental to science and the development of humankind.

Observing, seeing critically, is the first and fundamental step in the process of establishing scientific knowledge but also of science' learning. Always in an active and committed way, the student must, like a scientist, to define predict and construct new scenarios raising doubts and problems, critically analysing the situations and proposing explanations and solutions to the questions and problems identified. Students must to able to observe, establish hypothesis, express discuss and criticize their own conclusions and establish/decide, themselves what to do in order to establish and acquire new knowledge.

4. New challenges and opportunities

Science Education is not just about conveying or leading the learner to acquire knowledge about Science, the current Scientific Knowledge, to be able to better understand and "explain" the World we live in. As well as important, if not even more (interesting discussion to have in another occasion…), are the competencies, "mastering" the method and procedures that one needs to use in other to acquire more knowledge, better understanding, about the World that surround us (from the still hidden mysteries of the human mind, of the word of virus, of the interaction of light and electromagnetic waves with matter, of the *infinite* universe and its "origin"…), to create more, new, knowledge, to advance Science and in doing so allowing the future development of our societies and human kind.

The school and the teacher played a crucial role on the amazing development of science and science and technology over last couple centuries. And its paramount importance remains today not only as global factor of development by allowing and promoting the dissemination of knowledge, and key competencies, among our youngsters, but also by supporting and creating conditions, often in challenging environments, for a sound healthy growth of the children and students as human being. This human element must never to be forgotten specially on these days of civilizational regression we are witnessing. Human interaction is fundamental to the man as living being. It is key to have children, students, citizens, able to listen and communicate, to feel empathy, to be able to help and accept to be helped by others, to work together on common or personal goals, to share joy and aspirations.

The role of the school raises today to a level of unprecedented importance helping the family and the community in raising our youngsters to become good citizens and human beings better understanding nature and the impact we have in the world we live in.

Not only the school must resist to any attempt to minor its place in society. It should also adapt to the new times yet not refraining itself to use well established and progressive tools and pedagogical strategies, diverse and varied to cope with the huge range of situations it encounters. Provided that the student/human being is placed in the centre of an active volunteer and committed learning process. The hands-on inquiry approach proved not only to be valid in science technology and engineering but in any other field. The vast majority of students do learn in a concrete manner by experiencing or feeling, and process the information actively by experimenting doing or acting upon. However, many prefer an introspective way creating their own reasoning worlds before stepping down to the real world, and they should be integrated. So many examples could be given… who does not remember the tales and stories told by the grandparents, mother and dad or even older siblings or friends in slower running times…? Diversity is paramount. Being open minded also. To accept use and integrate different ideas and approaches is very important and may guarantee that "all" will be successful. Please do be careful with the definition of success…

New times, new challenges and new opportunities. Have your eyes and mind wide open to find them. The scientific method may help…

Unless someone comes up with a new and "better" method to replace the scientific method (in its flexibility and proven credits) in the establishment of scientific knowledge, the "man" and its role, the human factor…, is and will be irreplaceable. The readily availability of that information, proven and established (ignoring the perversity of “fake science” and the intentional forgery of “facts”), will never be enough to ensure an effective development of science, even with the most advanced, human, Artificial Intelligence, AI, in within or with a computer without the effective involvement of Nature (itself, and the one that someone/”thing” may feel or say to have replicate, even within the limits of the Heisenberg uncertainty principle…).

AI can be, as in fact is of extreme usefulness in scientific research. It has been so for many decades. And recent and promising advances will further raise its importance… unless we leave money greed and power to guide and control its development and use, as it looks like it tends to be happening now...

5. Conclusion

The Hands-on Science Network exists to promote the development of science education and scientific literacy. It encourages a generalized use of innovative active hands-on experimental investigative approaches to science and technology education, in an open minded and inclusive way. In raising the profile and attractiveness of Science in Education, we aim also to increase the desirability of a career in Science for all.

6. Acknowledgements

To all teachers, students, researchers and scholars, parents, officials and policy makers and all those others that with commitment and enthusiasm contributed and or attended the initiatives we promoted a sincere word of appreciation and congratulation by your contribution towards an improved science education.

This work was supported by the Portuguese Foundation for Science and Technology (FCT) in the framework of the Strategic Funding UID/04650/2025.

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[7] http://hsci.info/hsci2023/

[8] http://hsci.info/hsci2025/

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Hands-on Physics: The Pathway to Pleasure in Teaching and Learning Process

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Abstract. First I'm going to address the statement implicit in the question: Could the hands-on physics be the pathway to pleasure in teaching and learning process? Then how do you measure happiness depending on the progress in teaching and learning science/physics? It is well established that emotions play a key role in the teaching-learning process and cognitive [1]. In this paper I introduce a brief history of situations like that which leads to a conclusion: "Hands-on science/physics can be considered as a pathway to pleasure in teaching and learning process". A survey model was utilized to indicate satisfaction and the study was carried out on a limited number of students (18 students of Gr.10) in a particular class at the last school two years ago.

Keywords. Hands-on Physics, Hands-on Activities, Inquiry-Based Learning, Science Process Skills.

1. Introduction

One of my hopes is to see teaching Science /Physics in National and International schools based on Hands-on activities, and to see each student has got both (Science text book and Science Kit) altogether. Hence each student would has the chance to study the concept and access the required tasks by doing experiments/ hands-on activities and acquire skills; to record data, to observe changes with variables, to write the conclusion and to enjoy exploration! Subsequently, the student behaves as a junior researcher or an explorer.

Two years ago I have been asked to teach physics to Gr.10 students in Queen of Peace School (a Private language school). In the 1st meeting with the school principal, he informed me that I'll teach physics to a particular class - as a part time - which has some passive students who don't care about studying and dislike science, and some others are slow achievers. I said no problem! But in fact it was a problem, it seemed to me as a challenge!

To identify such passive and slow achiever students, I introduced myself in the first session, then asked every student to introduce himself/ herself and to tell me which subject he/she likes?

Figure 1. Hands-on Physics with kids and a pathway to Pleasure!

2. Classification of the students: who like /who dislike Physics!

I classified the students into two categories; (who like /who dislike Physics). I discovered that most of the class (about 20 students) dislike science generally except four students who like it.

With this in mind, I started to teach them physics according to the syllabus using Inquiry-based learning, hands-on activities and a weekly experiment in the school Physics lab. I divided the class to 4 groups, each group named by a

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great physicist, Newton Group, Faraday Group, Einstein group and Tesla Group. Everyone in the group has a role; who set up the apparatus, who record data, who write the results, and who write the conclusion.

In the short term, I noticed that all of them started to be alert and good observers. The high achiever students expressed their pleasure, and the students who were classified as passive and slow achievers started to be more interested. And both of them expressed their good feelings and happiness.

In light of that, I wished to have a happiness-meter (has not invented yet), or a pleasure indicator to measure the level of their pleasure.

3. Hands-on Physics is a pathway to pleasure!

As a matter of fact, it's well known that dopamine is a pathway to pleasure [2]. I discovered that hands-on physics might be a pathway to pleasure as well! I recorded a lot of notes like that once teaching Science/physics in the schools where I have been teaching, and later in Tesla Academy. In fact, Science Process Skills (SPS) is very important for every individual because, every individual uses (SPS) at some stages of their daily life.

Figure 2. Hands-on Physics: The Pathway to Pleasure

In science / physics education literacy, SPS can be divided into two groups as “Basic” and “Integrated”.

Science process skills refer to the following six actions, in no particular order: observation, communication, classification, measurement, inference, and prediction.

4. The Situ-emotions Monetarization

A small sample size of 18 students (Gr.10 class A) was considered and a questionnaire was employed for in situ-emotions monetarization. I noticed a decrease from 30% to 12% in negative emotions and an increase from 82% to 91% in positive emotions was detected when considering the transition from instructional approach 1 (classroom approach), to instructional approach 2 (Hands-on Physics approach).

Figure 3. A great pleasure in teaching talent students and give them the chance to introduce presentations

The dataset was analyzed by means of principal component analysis (PCA). It reveals the importance of emotions’ valence, but also their activating/deactivating character. An approach to epistemic emotions is achieved from this perspective.

It has been demonstrated that the implementation of inquiry-based hand-on activities (Hands-on Physics) results in increased occurrence of security and trust among the students, in comparison with occurring emotions after receiving more theoretical interventions.

5. Taxonomy of epistemic emotions

The expression of emotions constitutes a human dimension inherent to its own existence. The heritage inherited from Ancient Greece is full of references to the human affective domain. Since then, emotions and reason have been confronted and placed in opposite poles, with the subsequent creation of the "body-soul" duality, with emotions being almost considered like a threat that hinder the human's path to pleasure/ happiness "Eudaimonia".

Regarding the type of emotions expected to be generated in a classroom, a taxonomy based on the epistemological affective dimension constitutes the best choice, considering emotions, feelings and experiences, generated during the construction of scientific knowledge. In that scenario it is important not only to detect if emotions experienced by students are positive or negative, but also to analyze if students possess the predisposition that leads them to be active and attentive, allowing them to develop features related to the construction of the scientific knowledge, like curiosity, rationality, uncertainty, perseverance or skepticism. [3]

6. Research question, objectives and result

The current piece of research constitutes a concrete study focused on physics contents with the aim of contributing to the improvement of instructions, from the emotional point of view. Namely, it is addressed the following research question:

Does the implementation of manipulative Hands-on Physics activities imply an improvement of the emotional performance of Gr10 students (in particular of this class) towards physics curricular content?

Considering the addressed problem, the main objectives of the current research could be enounced as follows:

1. To report two instructional approaches with increasing experimentality degree and implication of students to address a physical problem consisting on determination of some topics / concepts in the curriculum.
2. To monitor students' emotions when receiving both interventions for further analysis of the affective domain.

Percentages for both groups of emotions in the classroom-approach and in the practical-one were directly calculated. A decrease from 30% to 12% in negative emotions and an increase from 82% to 91% in positive emotions was detected when considering the transition from instructional approach 1 (classroom approach) to instructional approach 2 (inquiry-based hands-on approach).

Figure 4. Hands-on Science course for kids in Tesla Academy

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7. Dimension of Hands-on physics teaching - learning process

The study of affective dimension of the sciences teaching-learning process is nowadays a well-established research line in science education.

It is important to make the creative physics teachers aware of their emotions in order to induce changes in their students' attitudes to make them feel responsible of the scientific and human development through the implementation in their future.

The emotional benefits of the implementation of active methodologies in physics/science education of undergraduates is reported in the literature. Studies are also reported stating emotional improvements in both students and physics teachers, after the implementation of active methodologies, highlighting the employed methodology [4].

Figure 5. My team before participating in the National Physics Olympiad contest

Figure 6. A student who be awarded with a "physics book" as she was the "Top Achiever" in Physics Exam in Queen of Peace School

8. Conclusions

The first is that can be obtained from the presented study is that consideration should be given to the taxonomy of emotions and, according to the physiological effect produced by emotions, overcome the classical and simple positive/negative dichotomy and move closer to a taxonomy of epistemic emotions related to the reaction of students during the development science teaching-learning processes.

Figure 7. Teachers have a pleasure in the professional development workshops

Secondly, it has been demonstrated that the implementation of inquiry-based learning using hand-on activities (Hands-on physics) results in increased occurrence of curiosity and interest among such limited students.

As a physics teacher, I usually get pleasure in teaching kids /students using Inquiry- based learning, using hands-on activities /experiments, and in attending professional development workshops with multinational colleagues, and in

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attending hands-on science conferences as well. Furthermore, I get more pleasure when teaching talent and highly interested students in science.

Figure 8. School visits give us a pleasure tool

At last, if I can borrow a quote from Richard Feynman (The greatest physics teacher and Noble Prize winner in Physics):

"I have a friend who's an artist, and he sometimes takes a view which I don't agree with. He'll hold up a flower and say, "Look how beautiful it is," and I'll agree. But then he'll say, "I- as an artist- can see how beautiful a flower is. But you, as a scientist, take it all apart and it becomes dull." I think he's kind of nutty. … There are all kinds of interesting questions that come from knowledge of science, which only adds to the excitement and mystery and awe of a flower. It only adds. I don't understand how it subtracts". [5]

Figure 9. Professional development (Conferences & Workshops) give Sc. teachers a pleasure as well

The use of a still in ancient Babylon is

9. Acknowledgements

I deeply appreciate Dr. Manuel Filipe (Chairperson of Hands-on Science Network) and the HSCI committee for the acceptance of hosting and organizing the annual conference this period HSCI2025 in Cairo. I appreciate too Dr. Medhat Ibrahim (National Research Centre) and his team in Science Café for the great support. I appreciate my colleagues in Tesla Academy for efforts, and the significant role of Eng. Mohamed Sabry for the technical support.

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Education and Artificial Intelligence in Ukraine: Prospects, Challenges and Strategic Directions

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Abstract. Artificial intelligence (AI) is increasingly heralded as a transformative force in education, enabling personalised learning, adaptive tutoring, predictive analytics and automation of administrative tasks. In Ukraine, where the educational system is undergoing deep structural reforms in the context of digitalisation, conflict and socio-economic shifts, the adoption of AI represents both a significant opportunity and a formidable challenge. Recent research demonstrates a growing awareness among Ukrainian higher education stakeholders of AI-tools, yet also flags concerns about content quality, equity and educator readiness. This article aims to synthesise current knowledge, chart the landscape of AI adoption in Ukraine's education system, identify key enablers and barriers, and propose strategic directions for integrating AI in a way that supports educational quality, equity and resilience.

Keywords. Artificial Intelligence, Digital Transformation, Adaptive Learning, Higher Education, Armed Conflict.

1. Introduction

Ukraine has committed to enhancing digital infrastructure in education and aligning with global "Education 4.0/5.0" paradigms. For instance, a study [1] shows Ukrainian educators framing the transition from Education 4.0 to Education 5.0 in the AI-era. Digital transformation is inherently complicated by the ongoing war, socio-economic instability and disparities in access. Yet these very challenges underscore the importance of resilient, adaptive educational systems. AI thus emerges not simply as an innovation option, but potentially as a capacity-booster for education in a crisis-affected environment [2-3]. Measures have already been taken to develop the infrastructure. For example, the Ministry of Education and Science and the Ministry of Digital Transformation of Ukraine, together with experts, have developed recommendations for the responsible use of artificial intelligence in higher education institutions. The document (https://bit.ly/44CiuhR) contains advice for faculty, students, higher education institution administrators, and researchers on how to effectively integrate AI into the educational and scientific process. The recommendations pay special attention to the security component of integrating AI tools—the principles of human control, confidentiality, data management, transparency, and non-discrimination.

A significant amount of statistical data has been accumulated. For example, according to the results of the international study "Education as a Tool for Developing Personal Resilience, Social Capital, and a Culture of Peace," 22% of students and 24% of teachers frequently use artificial intelligence in their teaching. Students, parents, and teachers surveyed for the aforementioned international study consider critical thinking and information evaluation to be the most useful skills acquired in future education (36% of students, 48% of teachers, and 41% of parents) (https: // summitflg. org/study/osvita-yak-instrument-formuvannya-osobistoyi-stijkosti-socialnogo-kapitalu-krayini-ta-kulturi-miru/). Among Ukrainian respondents, this figure is 54%.

2. Opportunities of AI in Ukrainian Education

AI is integrated into education in Ukraine in different ways:

- Personalised and adaptive learning. AI-driven tools can tailor content, pacing and feedback to individual learners, supporting diverse needs (including inclusive education). Ukrainian research highlights positive attitudes among stakeholders toward AI-tools for personalised learning and real-time feedback.
- Automation and administrative efficiency. Routine tasks (scheduling, assessment, tutoring chatbots) can be streamlined, freeing educators for higher-order pedagogical work. For example,

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Ukrainian studies reflect on chatbot use in higher education institutions.

- Supporting inclusive education. AI has potential to support students with special educational needs via adaptive interfaces, immersive technologies and accessibility features. A Ukrainian inclusive-education study emphasises both promise and necessity of careful integration.
- Data-driven decision-making and institutional management. AI analytics can inform institutional strategies, monitor learning trajectories, predict drop-out risk and support quality assurance

3. Key Challenges and Risks

The integration of AI into education has revealed the following challenges:

- Infrastructure, connectivity and digital divide. Reliable internet, hardware, cloud services and institutional support remain uneven across Ukraine, especially in conflict-affected regions.
- Teacher readiness, motivation and professional development. Studies show that teacher motivation and self-development in AI technologies are critical yet under-addressed. Without targeted training and support, AI tools risk being under-utilised or mis-used.
- Data quality, bias and content accuracy. AI systems depend on high-quality data and pedagogically sound design. Ukrainian inclusive study warns of uncritical adoption of “radically new technologies” without age-appropriateness, cultural fit and methodical integration.
- Ethical, legal and governance issues. AI in education raises issues of privacy, algorithmic transparency, academic integrity (especially relevant in Ukrainian context with generative AI use), and regulatory frameworks are still evolving.
- Equity and inclusion risks. Uneven access may deepen existing educational inequalities; AI must be implemented with equity-awareness.
- Conflict and resilience context. Ukraine’s ongoing war amplifies the importance of resilient digital systems, yet also makes implementation more complex due to displacement, infrastructure damage and staff stress. AI deployment must be aligned with crisis-sensitive educational strategies.

4. Strategic Directions for Ukraine

Drawing on the Ukrainian context and international best-practice, we propose three interlinked strategic pillars.

4.1. Infrastructural & environmental readiness

- Develop national AI-in-education infrastructure: connectivity, cloud platforms, secure data management, resilient systems in conflict zones.
- Establish partnerships between government, universities, EdTech firms and international donors to resource AI initiatives.
- Ensure open-platforms and interoperable systems facilitating scalability.

4.2. Pedagogy & human-centred AI integration

- Promote teacher professional development programmes focused on AI literacy, pedagogical adaptation and ethical use of AI.
- Embed learner-centred AI tools (adaptive tutoring, chatbots, VR/AR) aligned with Ukrainian curricula and language/cultural context.
- Foster inclusive AI design that involves students, teachers and communities in tool development (co-design).
- Maintain human-in-loop approaches: AI supports rather than replaces educators, particularly vital in contexts of trauma and disruption.

4.3. Governance, ethics & inclusion

- Develop national policy framework for AI in education: data governance, algorithm transparency, academic integrity guidelines, privacy protections.
- Monitor and evaluate AI implementation outcomes with a focus on equity: ensure

that students in rural, displaced or conflict-affected areas receive access and benefit.

- Encourage research and feedback loops: universities to conduct evaluative studies of AI impact, adaptives to Ukrainian realities (e.g., war-affected learners).
- Align AI integration with resilience-oriented education: designing for continuity under disruption, leveraging AI to support remote/hybrid learning during crises.

5. Proposed Integrative Model for Ukraine

We offer a conceptual model — "AI-Enabled Resilient Education System (AI-RES)" for Ukraine. The model posits three layers: (a) foundational layer (infrastructure, policy, digital access); (b) operational layer (pedagogical practices, AI-tools, teacher training); and (c) outcome layer (learning quality, inclusion, resilience, well-being). Feedback loops link outcome data back to infrastructure refinement and practice improvement. The model emphasises that AI adoption must be systemic, not piecemeal, and must integrate with Ukraine's specific socio-political context (including war, displacement, need for psychosocial support.

6. Discussion

While the potential of AI in Ukrainian education is compelling, the strategic focus must shift from technology-push to people-centred, context-aware implementation. The war-affected environment amplifies the need for educational systems that are adaptable, inclusive and emotionally supportive; AI can contribute but cannot substitute human connection, pedagogical sensitivity and institutional resilience. Ukrainian case studies suggest positive stakeholder attitudes toward AI but simultaneously highlight readiness gaps and ethical concerns. The success of AI in Ukrainian education will ultimately depend on aligning digital innovation with educator capacity, learner needs and systemic equity.

7. Conclusion

In Ukraine, integrating AI into education presents a pivotal moment: if done strategically, it can support personalised, inclusive and resilient learning systems; if done poorly, it risks amplifying inequality and undermining trust. The transition to an "Education 5.0" paradigm — where AI, human pedagogy and resilient infrastructure converge — offers hope for a post-conflict recovery and future-oriented educational ecosystem [4-5]. The recommendations offered in this paper provide a roadmap for policymakers, educators and technologists alike. Further empirical research is needed on longitudinal impacts, equity outcomes and conflict-sensitive AI deployment in Ukrainian education.

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Experimental Explanation of a Challenging Geometrical Optics Phenomenon

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Abstract. When using a reflective telescope, observers notice a secondary mirror positioned in front of the main mirror. Yet, when looking through the eyepiece at a distant target, this secondary mirror appears to have little or no effect on the observation. In this talk, I will present several engaging experiments and my innovative statements of principles to explain this phenomenon—showing that while it can be explained by my approach, it cannot be adequately analyzed using concepts from most standard textbooks.

Keywords. Reflective Telescope, Converging Point, Point Source of Light.

1. Introduction

In the teaching of geometric optics, particularly regarding image formation by lenses or mirrors, there are obvious shortcomings. As many experienced teachers have concluded, textbooks are not incorrect, but they omit important aspects. For example, in geometric optics, objects are composed of point light sources, and the human eye can only resolve these points. Similarly, real images are also formed from point light sources, just like actual objects, and they can be observed directly or magnified with a magnifying glass. However, almost all textbooks neither recommend experiments to observe real images directly nor provide photographs of them. Due to these omissions, students struggle to connect textbook content with actual optical phenomena. As a result, they often answer exam questions based solely on textbook logic and are unable to explain, in practice, even simple principles of telescopes or microscopes.

This makes it even more challenging to explain why the secondary mirror in a reflective telescope appears to have no influence when observing through the eyepiece. The following experiments and devices are employed to elucidate this intriguing optical phenomenon.

2. Interesting Experiments

Main Components of the Teaching Device (see Figure 1)**:**A. Concave mirror with obstacles. B. Translucent screen – to display converging points of light and how each behaves as a point light source. C. Magnifying glass. D. Eye model. E. Fish-shaped object made of multiple tiny LEDs – each LED represents a point light source.

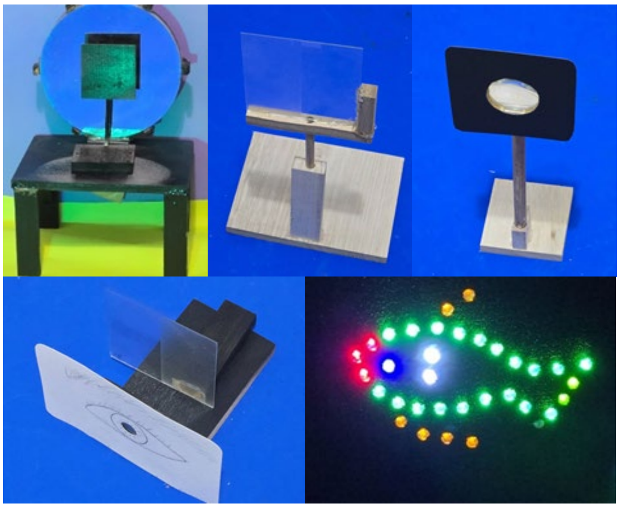

Figure1. Main Components of the Teaching Device

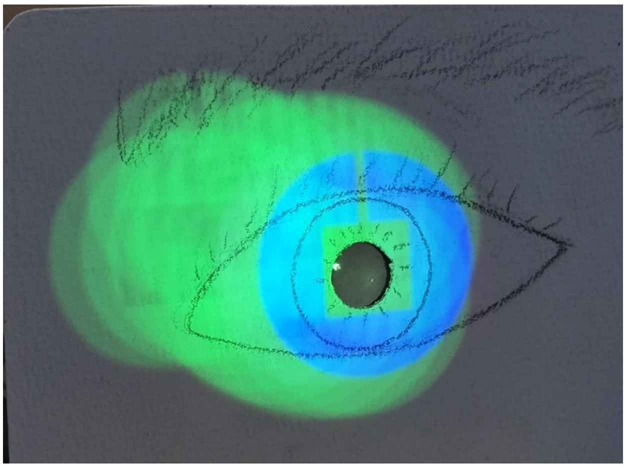

Figure 2. Light from the blue point light source (the fish's eye) on the real image does not enter the pupil

This demonstrates that some converging points on a real image may be invisible. Using a phone to capture the real image seen directly by the eye confirms that the blue fish eye is indeed not visible (see Figure 3-1-18).

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A rectangular obstacle was placed in front of the concave mirror, blocking about one-third of its surface (see the top of the left image in Figure 3-1-23). The fish-shaped object was positioned on the left side, not shown in the figure. For the experiment, a frosted glass screen was first placed approximately 150 cm from the concave mirror and slightly adjusted so that the fish-shaped real image appeared clearly on the screen (see the middle of the left image in Figure 3-1-23). The fish's image then appeared on the frosted-glass "retina" of the eye model (i.e., it is a real image of the real image on the frosted glass screen). The image on the frosted-glass retina could also be magnified (see the right image in Figure 3-1-23). According to optical principles, this fish-shaped image is clearly unaffected by the obstacle.

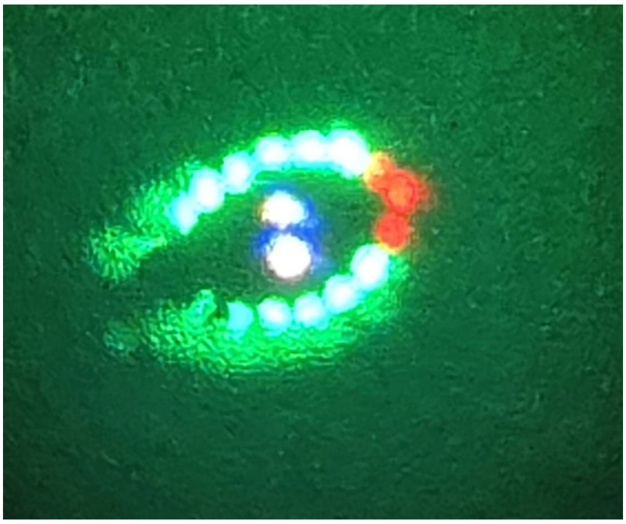

Figure 3. The blue fish eye no longer appears on the retina of the eye model. In other words, when observing this real image directly, the fish's eye cannot be seen

The fish-shaped image on the eye model's retina lost the middle portion of the fish's body. The orange-red belly fin and the two white spots disappeared; in other words, the middle section of the fish body was missing on the retina. This occurs because the point light sources in the middle of the fish-shaped real image emitted light, but these rays did not enter the pupil (see the left image in Figure 5). Using a phone to photograph the real image formed by the obstructed concave mirror confirmed that the middle section of the real image had a shadow (see the middle image in Figure 6).

If the frosted-glass screen is inserted into the shadowed area, the previously missing portion of the real image reappears on the screen (see the right image in Figure 6). This demonstrates that the shadowed part of the real image still has converging points of light; however, because the rays from these point sources do not enter the pupil, the middle section of the fish-shaped real image is invisible to the eye.

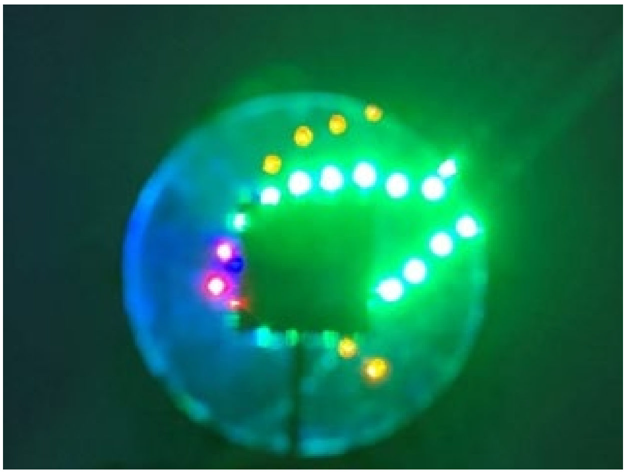

Figure 4. When observing the real image with the naked eye, the blue fish eye is not visible due to the shadow caused by the obstacle. Using a phone to capture the real image produces the same result – the fish eye is not seen

On the retina of the eye model, the fish-shaped image lost the middle portion of the fish's body—the orange-red belly fin and the two white spots disappeared. In other words, the middle section of the fish body was missing on the retina because the point light sources in that portion of the real image emitted light, but the rays did not enter the pupil (see the left image in Figure 6).

Photographing the real image formed by the obstructed concave mirror with a phone confirmed that the middle section of the real image had a shadow (see the middle image in Figure 6). However, if a frosted-glass screen is placed into the shadowed region, the missing portion of the real image reappears on the screen (see the right image in Figure 3-1-24). This shows that the shadowed part of the real image still contains converging points of light; the reason it is not visible to the eye is that the rays from these point sources do not enter the pupil.

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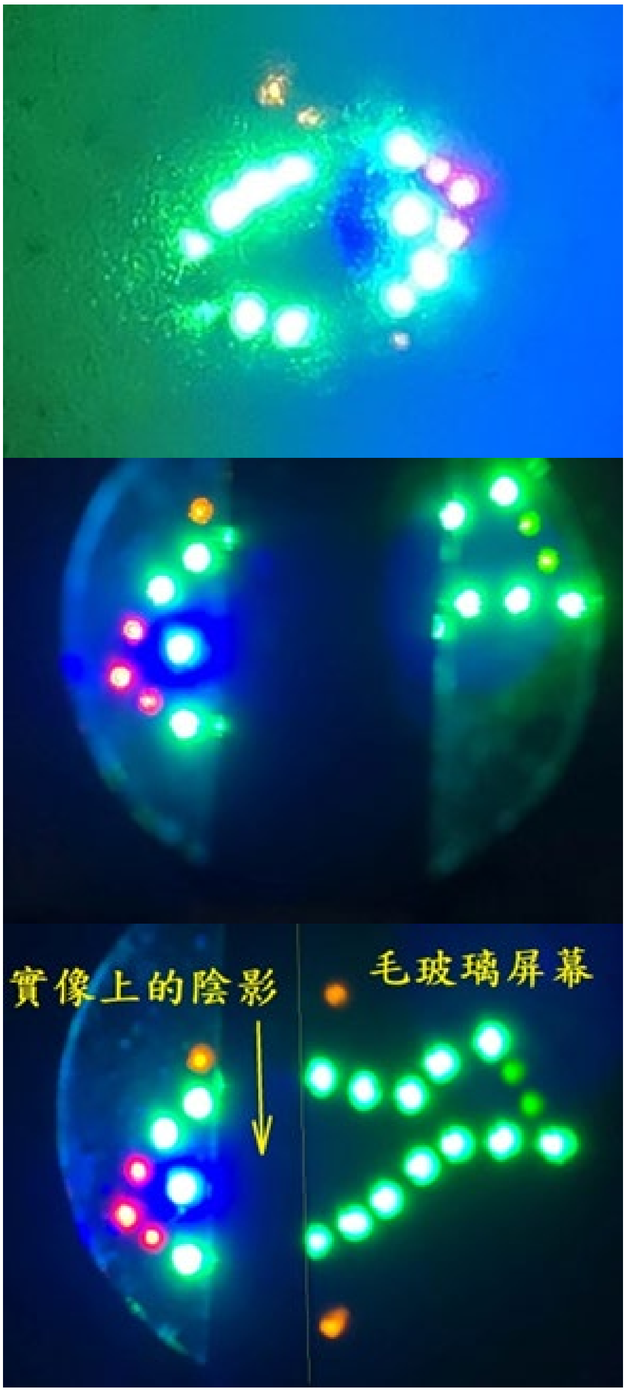

Figure 6. When the frosted-glass screen in front of the eye model is removed, the fish-shaped image on the eye model's precise frosted-glass retina loses the two white spots in the middle of the fish's body and the orange-red belly fin. Observing the real image formed by the obstructed concave mirror with the naked eye also shows that the middle section of the fish's body, including the two white spots and the orange-red belly fin, is not visible

When observing the fish-shaped real image formed by the obstructed concave mirror through a magnifying glass (see the left image in Figure 3-1-25), the image is located approximately 4 cm in front of the magnifying glass. Using the face of the eye model as a white screen, we can see how the light rays emitted from each point light source (converging point) on the real image are distributed in space.

When the face-screen is positioned farther from the magnifying glass, the light beams from each point source are more dispersed, and their cross-sections are larger (see the middle image in the top row). As the screen is moved closer to the magnifying glass (see the three rightmost images in the top row of Figure 3-1-25), the cross-sections of the beams shrink and come closer together, eventually converging entirely (see the rightmost image in the top row), with the gaps in the cross-section corresponding to the obstacle in front of the concave mirror.

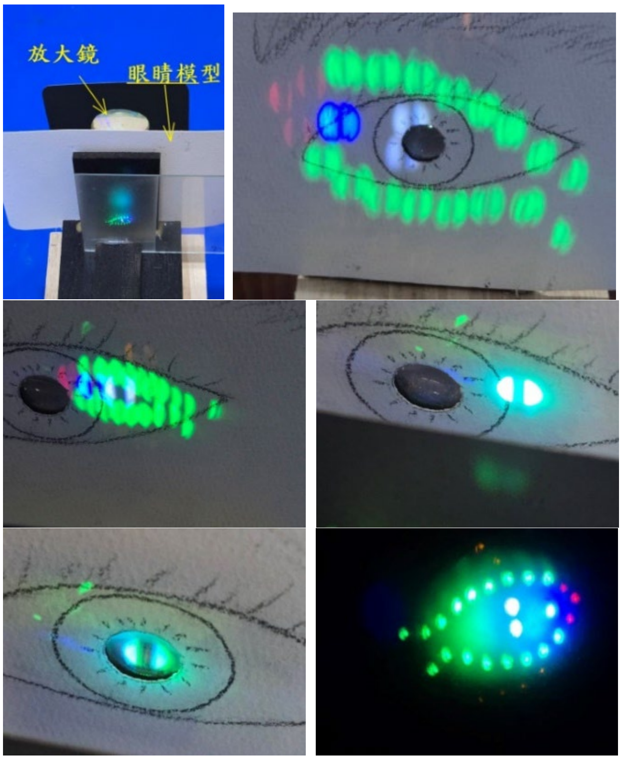

Figure 7: The eye model observing the fish-shaped real image through a magnifying glass. The face-screen shows how light rays from each point source (converging point) on the fish-shaped image are distributed. As the eye model moves closer to the magnifying glass, the spread of each light beam narrows and the beams come closer together. All rays from the point sources on the fish-shaped image enter the pupil, resulting in a complete fish image on the precise frosted-glass retina, including the belly fin

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By adjusting the eye position (as we do when using a reflecting telescope) so that the beams from all point sources enter the pupil (see the left image in the bottom row of Figure 7), the complete fish-shaped image appears on the retina (see the right image in the bottom row). Consequently, when the human eye observes the real image formed by a concave mirror with an obstacle (and hence with a secondary mirror, as in a reflecting telescope) through a magnifying glass, the shadow in the real image disappears (see Figure 7).

7. Acknowledgements

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6th National Science and Environmental Education Festival and 7th International Children's Summit

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Abstract. The 6th National Festival on Science and Environmental Education took place at Beykoz Doğa Schools in Istanbul on Saturday, October 4, 2025. Another joint event that was held as parallel on the same day and at the same venue was the 7th International Children's Summit.

The Festival and Children's Summit were both organized by the EXPEDU-Expedition to Education Association. EXPEDU organizes these joint events periodically in collaboration with four international organizations: The International Hands on Science Network, Science on Stage Europe (National Representative; Science on Stage Türkiye), NASE-IAU, (National Representative; NASE Türkiye) and the Global S.O.S. Network. Within this framework, the 6th National Festival on Science and Environmental Education along with the 7th International Children's Summit featured national and international participants from kindergarten to adult teacher levels. The program included a variety of science demonstrations, STEAM workshops, science competitions, and project exhibitions, as well as modern dance and folk dance performances, piano recitals, and nature games for children in the unique natural settings of Beykoz Doğa College.

Academicians, teachers, and students from Spain, Bulgaria, Romania, and Georgia participated in the Festival and Summit, with their original presentations and performances.

Awards were presented to the schools that won the competitions at the Gala held in the evening. Additionally, the ten delegate teachers who will represent our country with their STEAM projects at the Science on Stage Europe Festival, which will be held in Lithuania in May 2026, exhibited those projects at their stands and gave their preparatory presentations at the festival. This paper presents the outlines of the 6th National Festival on Science and Environmental Education along with 7th Children Summit.

Keywords. 7th Children's Summit, 6th Festival on Science and Environmental Education, Global S.O.S. Project.

1.Introduction

The idea of organizing a science festival along with a children summit at Antalya Akdeniz University in 2012 was based on the Global S.O.S. Project. The project has been carried out with student groups on a voluntary basis world wide since 2005 [1,2].

The Global S.O.S. Project focused primarily on endangered species and their habitats [3,4] It adopted STEAM approach and used hands-on science activities to explore nature. The core subjects were studied as extracurricular activities by the groups of volunteer students and their teachers from around the world throughout each academic year [5]. The project continued to lead the festivals and summits in subsequent years.

The 1st Science Festival along with Children's Summit was organized as a one-day event and hosted by Akdeniz University in collaboration with the Hands on Science Network [6,7]. It was realized in response to the need for sharing all research and experimental studies conducted by students within the scope of the Project in an interactive environment through presentations and exhibitions.

The event's framework and scope continued to expand in the following years. It was held in Bursa in 2014, Ankara in 2016 and 2018, as an online event in 2021, Ankara in 2023 and in Istanbul this year. Science on Stage Türkiye [8], National Representative of Science on Stage Europe [9], joined among the festival and summit stakeholders in 2016. In 2022, SOS Project Coordination established the EXPEDU (Expedition to Education) Association [10], bringing together all festival stakeholders.

This year NASE Türkiye, National Representative of NASE-IAU [11], was invited in the festival community and the 6th Festival on Science and Environmental Education along with 7th International Children Summit was held at Beykoz College in İstanbul on October 4,

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2025.

These two events, held in the same day at the same venue, brought together children, teachers, researchers, field experts and public. An informal learning environment which supported scientific thinking processes and developed problem-solving as well as innovation skills was created. The program included STEM workshops, environmentally-based hands-on activities, Global S.O.S. Project stands, Science on Stage teacher projects, scientific presentations from field experts and knowledge-sharing sessions with international participants. Children's active participation in science and environmental issues on a global scale was encouraged.

The program objectives of the Festival and Summit have been jointly addressed and determined across a broad spectrum to encompass the educational goals of all stakeholders. These objectives can be summarized as to; create an interdisciplinary learning and sharing environment for scientific literacy; promote STEAM based learning culture; motivate teachers to present their projects on a global scale; encourage young people to choose a career in science and to take actions for protecting natural environments thus contribute to the development of qualified, environmentally conscious and productive individuals of the future.

2. Methodological Path

This paper was written as an experience report, mainly based on the strategies carried out through the process of realizing a science festival along with a summit, presenting the outlines of the event, portraying impressions of the participants.

2.1. Planning works for the festival

Planning initiative began with a meeting of four authors, who have been involved in Global S.O.S. Project and are at the same time members of EXPEDU (Expedition to Education) Association, one year prior to the festival and summit. A festival planning committee of five teachers, one of which was the coordinator of Global S.O.S. Project, the other was the coordinator in host school and the rest were the members of EXPEDU Association, was constructed.

The project was announced, like each year, nationally and internationally informing teachers about the Global S.O.S. project and encouraging them to participate into the project alongside their students. It's educational program was launched in October 2024 with these groups in online format and lasted for one academic year until June 2025.

Project partners were Türkiye, Bulgaria, Romania, Georgia, England, Jordan and Kazakhstan. Groups from Türkiye were paired with the groups from these countries. Research topics and hands-on activities included in the project's annual plan were shared with the groups online. Group-pairs made research about endangered local species and conducted monitoring tests in the vicinity of their schools and shared their findings in reports with each other. In addition to these reports as outcomes of the project, the group-pairs constructed the products of Global S.O.S. Project by carrying out several joint sub-projects with a STEAM approach and improved them throughout the academic year.

2.2. Evaluation and integration of festival content proposals

A certification and awards program for the event was established in honour of Prof. Dr. James Westgate from Lamar University U.S.A. Faculty members from universities across Türkiye were contacted to receive volunteer support for the evaluation of Global S.O.S. sub-projects and Science on Stage Türkiye teacher STEAM projects. Furthermore, workshop calls for the festival and summit were published widely, incoming proposals were collected, evaluated and grouped into lists.

The academicians and teachers from Spain, Romania and Türkiye were invited for key note speeches and workshop presentations to draw attention for STEAM work and environmental science.

2.3. Involving further presenters and publishing calls for public participants

Contacts were made with companies and non-governmental organizations working on STEAM applications and stand lists were prepared for them to exhibit their sample

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experiments and model designs. Correspondence was established with local municipalities. Social media channels were used to ensure public participation of all ages and levels of education.

2.4. Addressing logistical issues

2.4.1. Determining festival venue

For the festival venue, proposals from schools that had worked with Global S.O.S. project in previous years were reviewed and as a result of the discussions in meetings, Beykoz Doğa College, located in the heart of Beykoz forest, was chosen as the venue for the festival and summit in 2025 (Fig.1).

This venue and it's location offered numerous advantages, such as providing an ideal environment for the festival groups, who were mainly consisted on teachers and students, numerous classrooms and open spaces in surrounding natural areas for workshops and a large sports center capable of hosting exhibition stands.

On the otherhand the long distance from the city center to the college created a disadvantage in terms of transporting the participant groups.

The meals for the festival and summit participants were provided by the host school at no cost.

Figure 1. Beykoz Doğa College

2.4.2. Setting the festival date

The festival committee decided to exclude winter period to avoid transportation difficulties. They also carefully reviewed scheduled school holidays and mandatory exam dates within the school curriculum to ensure a festival date that would not overlap with the breaks and exams. Festival date was stated by the committee as 4 October, Saturday, 2025.

2.4.3. Making arrangements for presenters

Funding for the festival and summit was extremely limited and despite best efforts, sponsorship proved difficult to secure. In spite of these challenges, the festival along with the summit was organized entirely as a volunteer event by the EXPEDU Association, and most presenters volunteered to participate at their own expense.

Participants, consisting of a presenter and two students from abroad, were hosted as guests by a teacher from the Global S.O.S. Project community. Other presenters, project groups and participants coming from abroad and various provinces of our country covered their travel expenses through the institutions they work for, municipalities or their own means. The urban transportations of the two presenters coming from abroad were provided by other volunteer teachers using their own vehicles.

The festival committee rented a house near the event venue for a group of sixteen people consisting of teachers and students from Bulgaria for two days. Following the festival, a group of thirty festival members were hosted for dinner at the same house.

An informative text containing urban transportation options from the city center to the college was provided and conveyed to the participating groups. In various meetings the festival committee continued to regularly share details about the preparation of the materials and equipment, that all presenters would need at their stands and workshops during the festival, with the host school coordinator until the festival date. Presenter name lists were shared with the college and name badges were prepared.

In meetings, the locations of the indoor and outdoor classrooms, conference hall and sports center were also shared with the festival committee online through visuals by the host school. Using the plans and maps, the festival committee arranged the workshops in indoor and outdoor classrooms and numbered them. These numbers and classroom plans were shared with the workshop owners online.

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A similar process was implemented for the exhibition stands of Global S.O.S. Schools, Science on Stage Türkiye delegates and the layout was based on the Sports Center's plan. These plans were distributed to presenters before and on the day of the Festival and Summit.

Presentation contents and visuals were requested from the participants who would make oral presentations in the conference hall and the necessary arrangements for transferring these contents to the stage were made with the host school coordinator thus included in the opening program.

Once all workshops and other presentations were finalized in the lists, invitation letters were written to workshop owners, presenters and visitor schools. Finally the program was published and shared with the community.

Correspondence continued with the science companies regarding the science gifts to be given to the student groups who won the competitions at the Gala award ceremony that would be realised in the summit evening.

2.4.4. Providing facilitation in directing attendees to stands and workshops

A registration and information desk would be needed in order to facilitate access to workshops or exhibition stands and navigation within the festival venue. The location maps and other guiding documents would be presented at this desk to direct participants to stands, indoor and outdoor workshops and the cafeteria throughout the day (Fig.2).

These issues were also studied in the meetings together with the host school and the relevant documents for the registration and information desk were prepared together.

2.4.5. Advertising the festival and summit

Advertising the festival was realized through mainly social media and in school communities by using posters, flyers and texts.

2.4.6. Funding

Funding options were very limited. The sponsorship secured was not enough to cover the entire festival budget. However, the greatest strength of our festival and summit was the very high level of volunteer motivation among the entire festival community.

Our main sponsor for this festival and summit was Beykoz Doğa College who donated the festival venue and facilities, provided breakfast and lunch for the participants during the day and created festival badges.

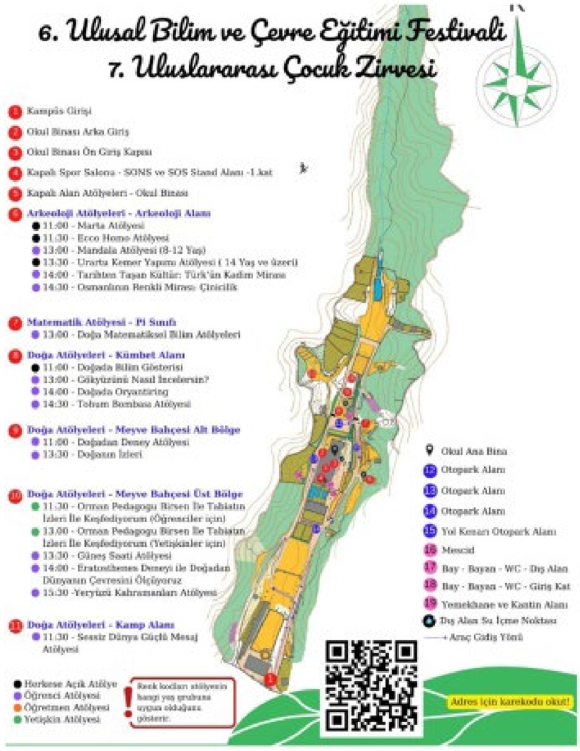

Figure 2. Location map for workshops

Companies operating in the field of STEAM education donated science gifts to be given to students as competition prizes.

Some of our teachers within our Global S.O.S. Project community made voluntary contributions by hosting guests and providing support with their own vehicles for city transportation. Besides, there was volunteer time among in-kind contributions.

3.Results

3.1. Overview of the festival and summit

The daylong festival and summit, with the motto "A Happy Universe for a Sustainable Existence" brought children, teachers, researchers and field experts together. An informal learning environment was created to

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support scientific thinking processes, problem-solving, innovation skills and environmental awareness with the inclusion of STEAM (Science, Technology, Engineering, Art, Mathematics) based projects.

The content included fourty STEAM workshops conducted indoor and outdoor. Global S.O.S. Project was represented by fifteen exhibition stands. The students conducted environmentally-based hands on activities at their stands in sports centre of the venue (Fig.3). These presentations were accompanied by Science on Stage Türkiye delegate teachers with ten project stands (Fig. 7, 8), the host school with three project stands and EXPEDU (Expedition to Education) Association with one stand at the same location. Some presentations were delivered at the stage by pre-schoolers (Fig.4).

Figure 3. Global SOS Exhibits

Figure 4. Presentation from Preschoolers

Three companies operating in the field of science education; Stemistbox, Rentech-Renko and MKU Technology met the visitors at the entrance hall of the venue with six exhibition stands where they introduced technology based science implications and opened a space for students design and experiment their own ideas.

Three oral presentations were delivered by academicians in the conference hall along with ten project presentations by the Science on Stage Türkiye delegation.

Figure 5. Opening Speech - STEAM Education in Schools through Astronomy

Certificate and award ceremonies were accompanied by piano recitals and dance performances at the Gala that was programmed in the evening (Fig.11,12).

One of the features attracted attention at the event was the inclusion of astronomy, history, archaeology and art subjects in the festival content (Fig. 5, 6, 9, 10).

Figure 6. Urartian Belt Making and Ecco Homo - Outdoor Workshops

Lists of workshop titles and exhibits were presented in Tables 1,2,3,4.

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Table 1. History and Archeology Workshops

1	Marta: Developing Life Skills
2	Mandala: An Ancient Wisdom of Arts and Science
3	Ecco Homo: Following Our Traces
4	Honouring Our Ancestors: Urartian Belt Making
5	Culture Overflowing from History: The Ancient Heritage of the Turks
6	The Colorful Heritage of the Ottoman Empire: Tile Making

Table 2. Outdoor Nature and Math Workshops

1	Science in Nature Demonstration
2	Exploring Nature's Traces with Forest Pedagogue Birsen (Play-Learning Session
3	Orienteering in Nature
4	Traces of Nature
5	Seed Bomb Workshop
6	Chemistry of Nature
7	Heroes of the Earth
8	Experiments from Nature
9	How Do You Analyze the Sky?
10	Silent World: A Powerful Message
11	Sundial Workshop
12	Measuring the Earth's Circumference from Nature with the Eratosthenes Experiment
13	Nature Science with Mathematics

Table 3. Indoor Nature Workshops

1	The Birds Came to Speak
2	"Eco Game": Where is the Species?
3	Balancing Bird Workshop
4	Discover the Power of the Wind: A Renewable Energy Experience with STEM
5	Children's Book Writing Workshop
6	May the Cranes Always Fly - Origami Workshop
7	Modern Science Education with Vernier Sensors
8	The Mystery of the Hologram: Discover Science and Optics with the MKU-S-60 STEM 3D Projection Box
9	STEM Design with Artificial Intelligence
10	Design-Focused Thinking Education Application
11	Comics Book Workshop
12	Astronomy Activities
13	A Quadrantto Navigate and Determine the School Altitude
14	A Touch of Blue from Flora to Marmara
15	Origami Workshop
16	A Planisphere to Discover Our Sky
17	Climate Games Workshop
18	Air Quality in Our Life
19	Biomimicry Workshop
20	Water Activities for Children Using Everyday Materials
21	Earth Workshop: Nature and Scientific Curiosity in the Reggio Approach

Table 4. Science on Stage Türkiye Presentations

1	STEM Escape Room
2	Plant Aquarium

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3	The Effects of Natural and Chemical Food Preservatives: Safe Food Preservation Methods for a Healthy Life
4	Orange Pyramid
5	Investigation of the Effects of Waste Ceramics on Soil and Art: A STEM and Visual Arts Integration Project
6	STEM for Clean Water
7	Meta Archery
8	Recycling
9	Green Building Design for a Sustainable Future
10	The Artificial Intelligence Code: How Machines Learn

3.2. Feedbacks from the participants

Some feedbacks received in the forms of written anecdotes and observation notes from teachers after the event, are as follows:

‘‘The festival and summit increased students’ desire to learn about science and the environment and motivated them to take part in scientific studies.”

“We were happy to meet and exchange ideas with other teachers who were willing to work on science and the environment through the festival and summit and were sensitive to this issue.”

“The event was compatible with our curriculum, provided ideas for classroom practices, and provided an experience that could inspire our future work."

“We were very pleased with the knowledge sharing and material diversity between the stands.”

“The event was planned on a strong foundation in terms of creativity, academic depth and technological awareness.”

“We found the festival and summit very useful in terms of establishing science communication on national and global scale"

“The festival and summit were wonderfully organized thanks to the intense efforts of the coordinators and the contributions of all stakeholders. We, along with our parents and students, participated with a team of 24 from the city of Bolu and we were so pleased. Everything was meticulously planned down to the smallest detail. We thank you very much. The dedicated work of the workshop instructors was also commendable; it was an event that brought science to both children and adults. "

“Our students expressed that they thoroughly enjoyed the workshops and had a fulfilling day. They were also delighted by the science gifts received. Overall, the entire organization was wonderful. It was an inspiring and enjoyable event for all of us.”

“Thanks to workshops and presentations designed for different age groups, children adapted more easily to topics specific to their age levels and exhibited their work with confidence.”

“Open-space workshops were extremely effective in channeling children's natural curiosity and physical energy toward science. The spirit of free exploration outside the classroom made learning tangible and fun.”

“Awards given at the end of the festival immediately boosted the children's motivation. They reinforced the message that effort is not just about winning, but also about being recognized.”

“This comprehensive organization, centered on science, environmental awareness, sustainability and the active participation of children, has provided our students with both educational and inspiring experiences.”

“Despite the large number of school groups, the impact of the stands made by family groups like ours was significant. This demonstrated once again how informal learning environments like families can make valuable and unique contributions to science education. ”

“Particularly, the children in our family group gave personal answers based on their experiences to questions from both school groups and foreign participants, demonstrating that they had internalized science not only as a subject but as a life practice.”

Faculty members who also observed project presentations remarked that the students'

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motivation for science and the environment, as well as their scientific thinking skills, were notable and they were very willing to learn and share.

They also indicated that the festival was inspiring, boosted students' self-confidence and encouraged them to develop scientific projects.

Figure 7. Meta Archery

Figure 8. A Science on Stage Türkiye stand

Some of the impressions obtained from the students were presented below:

"*It was great fun to exhibit our own work at our own stand and explain the project to other young children like us, adults and those from abroad. The open-air workshops were especially great; we tried things we couldn't do in the classroom."*

"It was incredible to receive an award! We realized how valuable our project was. We were so happy when we were returning home and we want to do better next time."

"It was interesting to see that children from other schools were also looking for solutions to the same problems, such as environmental pollution."

"The presentations, organization, and overall atmosphere throughout the event were truly impressive. Overall, I was very satisfied with the experience."

4. Remarks

Particularly noteworthy aspects of the festival and summit, as stated by the participants, were:

- wide range of participants (students, teachers, academics, parents, NGOs) from Türkiye and abroad
- The exhibition and workshop areas being always full due to the high interest, curiosity and motivation of the participants
- Scientists coming together with students and teachers to exchange knowledge,
- The awards given to projects and students being motivating,
- Workshop organizations for different age groups empowering the inclusiveness of the festival,
- Presentations through projects, hands on activities and workshops making learning enjoyable and permanent,
- Participations from Türkiye and abroad and peer presentations among different age groups encouraging science communication.

4.1. Strengths

The host instution is a private school located within a forest, thus surrounded by extensive natural areas. It's physical conditions, layout and interior design are well capable to serve the purposes of the festival and summit. In addition to this, a well-planned logistics and space utilization was realized during the planning period. Many workshops were held in the natural environment as outdoor activities. The combination of in-class experimental spaces and open-field workshops offered rich experience that appealed to different learning styles.

Also weather conditions on the day of the event made it possible to hold some of the workshops outside in nature without any inconvenience. Beykoz Doğa College's extensive facilities and diverse learning spaces, including classrooms, gardens, a conference hall and a large sports centre enhanced the festival's diversity and richness. "*The 6th Science*

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and Environmental Education Festival and the 7th International Children's Summit offered a rich and inclusive experience for the participants by effectively utilizing Beykoz Doğa College's extensive facilities and versatile learning areas (in-classroom and outdoor workshops). It was clear that the physical environment directly impacted the quality of the event" as noted by a festival participant.

Figure 9. The Colorful Heritage of the Ottoman Empire: Tile Making

Figure 10. Marta Outdoor Workshop

The availability of technical equipment in each classroom facilitated the indoor workshops. Active cooperation, positive approach of the host institution and the availability of a team specifically assigned to this event at the school were another crucial aspects in reaching the goals.

The diversity at the event stood out on some fronts such as participation and age group levels. It included presenters participating from both various cities of Türkiye and abroad, besides a wide range of age groups from preschool through university level. In addition, by opening exhibition stands and donating student awards, the support of NGOs and private organizations operating in the field of science contributed to the scope and motivation of the festival and summit.

Figure 11. A View from the Gala Ceremony

Participants were not just listeners; all participants were given the opportunity to gain experience at project stands and workshops. Awards given in different categories increased students' sense of self-efficacy and increased their motivation to participate in the next project.

Some other strengths that contributed to the success of the event were the numerous regular online meetings held between the members of EXPEDU Association who volunteered in the planning committee and the host school coordinator during the year-long festival preparation process and the effective collaboration that was developed through these meetings.

4.2. Challenges and areas to be improved

"Securing financial support was among the biggest challenges faced during the process. However, the festival venue was donated by Beykoz Doğa College. The host school also volunteered to help overcome financial difficulties and limitations by assigning some of its staff for the festival day and providing the necessary equipment for interior design, workshops, and presentations.

Since the school was far from the city center, transporting the groups to the venue was another factor that could limit participation in the event. To overcome this problem, informative texts and road maps detailing school routes and travel options were shared in written announcements with public and with potential attendee groups.

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The festival attracted 500 participants. While this participation is not low, it appears that there is room for improvement in increasing participation by making announcements more widely so that as many people as possible can benefit from such a comprehensive informal science learning environment.

Weather, as a potential limiter for outdoor activities, is a factor to be taken into consideration during the event planning process. The unpredictability of weather conditions and the fact that many nature workshops were planned as outdoor activities required an alternative arrangement for indoor classrooms in rainy weather. Since there was not a much detailed alternative plan for such a scenario and because the weather was a little rainy for a short period of time on the festival day, a few workshops were bound to start with short delays.

In terms of arranging project exhibition stands, *"it would be more effective to position similar age groups side by side, especially when younger age groups were involved"* as stated by a participant.

Figure 12. A View from the Opening

Due to the diversity of the content and the high number of workshop applications, the event program was quite extensive. On the otherhand, the event was limited to a single day and even to hours. Each workshop could only be visited by a single group. Furthermore, because the opening presentations exceeded the scheduled timeframe, some workshop presentations overlapped with conference presentations. Consequently, some workshop hosts missed some presentations. Optimizing the program planning will increase attendance rates for workshops and other presentations and ensure visitors can benefit from all the content.

Although family participation in the festival and summit was quite low, as stated by a family group presenting a project at this event:

"To maintain the uniqueness of family-involved projects and increase their number, special registration or mentoring support can be provided to these groups."

5. Final Considerations

As far as the authors' own observations and the informal feedback from the participants were concerned, educational goals were determined to be relatively achieved on the other hand highly positive impact was obtained. It can be considered that this collaborative and inclusive event contributed to the development of science communication to some degree and created an inspiring learning environment where STEAM was celebrated.

Despite limited financial resources and a small planning team of five members, high level of volunteerism and motivation among the entire festival community were some key factors to the success of this event.

It is hoped by the authors that these efforts and experience will inspire, in proceeding years, the Global S.O.S. community and other educational communities wishing to undertake similar initiatives by taking these steps much further with educational research and practices thus contribute to the creation of ideal environments for science communication by improving the areas open to development.

6. Acknowledgements

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We would like to thank Doğa College in Beykoz, Istanbul, for hosting the 6th Science and Environmental Education Festival and the 7th International Children's Summit; Rahşan

Tekinarslan and Kadim Can for their valuable collaboration; the administration of the EXPEDU-Expedition to Education Association for organizing the event; our festival and summit partners, International Hands on Science Network, Science on Stage Türkiye, and NASE Astronomy Türkiye. Thanks to the science companies Renko, STEMISTBOX, Bilim Kubbesi (Science Dome), Ankara Robotics Coding Academy, and MTU Technology for their support.

Many thanks to the academicians and educators, schools, students, and parents from Spain, Romania, Bulgaria, Georgia, and Türkiye who contributed to the realization of this national festival and international children's summit with their workshops, presentations, and exhibitions. Finally, we would like to express gratitude to the Global S.O.S. Project, which is currently run by EXPEDU Association and is the foundation for the 6th National Festival on Science and Environmental Education along with 7th International Children's Summit.

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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) [1] 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 [2]. The BRT, updated by Benjamin Bloom, organizes educational objectives into levels of increasing complexity: remember, understand, apply, analyze, evaluate and create [1]. 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. Minecraft, Cognitive Flexibility Theory, Bloom's Revised Taxonomy.

1. Introduction

The theory of cognitive flexibility [2] proposed by Rand Spiro et al. studies learning in complex and poorly structured domains. The theory postulates that the fundamental characteristic that defines specialists in this type of domain is the ability to restructure their knowledge in very different ways in response to the highly changing and unique characteristics of the situations and problems they face. To achieve this "cognitive flexibility", teaching must provide multiple representations of the contents and be based on the presentation of multiple cases for the same concept in different contexts.

Bloom's Revised Taxonomy is an update of the original, created by Benjamin Bloom in the 1950s. It organizes educational objectives into hierarchical levels of increasing complexity, helping to structure core curriculum and evaluation.

In the revised version, the six levels of the cognitive domain were renamed and transformed into verbs to reflect actions. The levels are remember, understand, apply, analyze, evaluate, and create. This structure helps educators plan and assess learning more effectively [1].

Minecraft is a digital game that allows players to create and explore virtual worlds built from blocks. Rated as a sandbox-style first-person game. With its engaging dynamics and flexibility, the game has the potential to be an educational tool, stimulating interaction, exploration, and appropriation of scientific knowledge [3].

Considering the above, it is possible to consider the Minecraft game environment as a complex and poorly structured domain, as is foreseen in CFT.

Analyzing the structure of CFT and BRT, we can see that they can complement each other so that we can structure educational activities using the Minecraft game as a teaching-learning tool, CFT brings a theoretical basis that is complemented with the methodology brought by BRT.

2. The relationships between cognitive flexibility theory (CFT), Bloom's revised taxonomy (BRT), and the game Minecraft

The Cognitive Flexibility Theory is a constructivist theory of teaching and learning developed by Rand Spiro and collaborators. It is based on the idea that the acquisition of knowledge in complex and poorly structured domains requires a flexible and multidimensional approach. The theory proposes that learners should be able to analyze

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the same information from different angles and perspectives, allowing for a deeper and more multifaceted understanding of the subject. Cognitive flexibility involves the ability to restructure knowledge adaptively to suit new situations, promoting effective knowledge transfer [2].

The acquisition of advanced knowledge in complex and poorly structured domains, according to the Theory of Cognitive Flexibility, involves the need to demonstrate the complexity and irregularity of these domains. This is done using multiple representations of knowledge, centering the study on concrete situations (mini cases) to apply conceptual knowledge. It is important to emphasize knowledge applied to real situations rather than abstract knowledge, allowing the construction of flexible schemes through the presentation of specific situations. In addition, it is crucial to highlight multiple connections between concepts and mini cases, avoiding compartmentalizing knowledge. The active participation of the student in the process also plays a fundamental role in the acquisition of advanced level knowledge in complex and poorly structured domains.

Within the game Minecraft, we have situations of complexity and irregularity available, as players are often faced with complex and unstructured environments, where they must deal with different elements and challenges. This reflects the need to demonstrate the complexity and irregularity of knowledge domains.

From the nature of the game with several construction possibilities we have the multiple representations, which arise when players represent knowledge in various ways, whether building structures, solving problems or creating systems within the game. In addition, by exploring and interacting with different scenarios and situations within the world of Minecraft, applying your knowledge in a practical and concrete way, we have the study in the case (mini cases).

We also see the knowledge applied within the Minecraft game when players need to apply their knowledge to survive, build, solve problems and achieve goals within the game, emphasizing the practical application of knowledge, flexible schemes can also be observed, from the construction and problem solving, which require the creation of flexible schemes, adaptable to different situations and challenges that arise in the game.

Multiple connections arise when players establish connections between different concepts, structures, and mechanics within the game, promoting a deeper and more comprehensive understanding. Finally, we see the use of Minecraft allows active participation in the players' knowledge building, problem-solving, and exploring complex concepts in a practical and engaging way.

Thus, the use of Minecraft as an educational tool can provide an immersive and interactive learning experience, aligned with the principles of cognitive flexibility theory for the acquisition of advanced knowledge in complex and poorly structured domains.

To structure the activities within the CFT, we can make use of Bloom's Revised Taxonomy [4], as it serves as a methodological basis for the development of the proposed activities, serving as a guide for the development of the activities, ensuring a logical progression in learning and in the application of the concepts in a practical and interactive way. It consists of six stages: remember, understand, apply, analyze, evaluate, and create.

In the remember stage, students are challenged to recall and recognize previously learned information, while in the understanding stage, they are encouraged to demonstrate understanding of the information, interpreting and explaining it in their own words.

The application stage indicates that students are challenged to apply the information learned in new situations or context, then moving on to the analysis stage where they are encouraged to analyze the information, identifying patterns, relationships and essential components.

The fifth stage, evaluate, we have a moment in which students are challenged to make judgments and evaluations based on specific criteria and finally create, where they are encouraged to create something new, using the knowledge acquired in an original and creative way.

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As in CFT, we can observe the stages of BRT within the game Minecraft, the remember level can be identified when players need to recall fundamental details of the game or associate previous knowledge with the dynamics of the game. The understanding step, on the other hand, can be seen when the players explain how certain game mechanisms work.

The apply and analyze steps arise when players apply their skills and knowledge to solve problems or create constructs and mechanisms within the game, in the case of the former, and when players analyze different aspects of the game, such as biomes or survival strategies, and make detailed comparisons.

Next, the evaluation stage can be seen when players evaluate the effectiveness of different strategies or methods, making critical judgments about what works best in certain situations. Finally, the create stage, which involves producing something new or original in Minecraft, this manifests itself when players use their creativity and knowledge to design and build complex structures, systems, or even entire worlds.

Therefore, we can use a combination of the Cognitive Flexibility Theory (CFT) and the Revised Bloom Taxonomy (BRT) for teaching and learning, let's list some reasons for this:

Regarding the improvement in the understanding of concepts, CFT encourages students to restructure their knowledge to solve new and complex problems and by applying this theory, students can go beyond simple memorization and understand concepts in depth, while BRT offers different levels of learning, from basic understanding to critical evaluation. The combination of these levels allows students to broaden their understanding and achieve broader goals.

We also have a flexibility in the approach to the contents, as CFT allows educators to adapt their teaching approach based on the needs of the students. This is especially useful in a diverse learning environment, while BRT offers a flexible framework for setting specific goals. Educators can choose activities and assessments that cater to students' different cognitive levels.

The use of CFT and BRT can be done with practical activities and reflection, in the first, when students participate in practical activities, these concrete experiences promote a deeper understanding, while in the case of the second we have an incentive to reflection. Students can analyze their own solutions, synthesize new ideas, and evaluate their own progress.

In brief, CFT and BRT complement each other, creating a comprehensive and adaptable approach to teaching. Educators can customize their strategies according to the learning objectives and needs of the students, making the teaching process more engaging.

3. A proposal for a connection between CFT, BRT and Minecraft for teaching

Considering the theory of cognitive flexibility, Bloom's revised taxonomy, and the use of the Minecraft game for teaching and learning, we have elaborated a basic framework for the activities within the Minecraft game in four steps:

1. Remember (BRT) and Prior Knowledge (CFT): Starting from an example or examples of structures built in the game so that students can see the blocks being used, but without showing how they work, in this part a tour is made so that they can see what is in the game and make mental associations with what they already know.
2. Understanding (BRT) and deconstruction (CFT): Students' access to environments that contain explanations of how the blocks work in the game and what their relationship is to physical concepts
3. Apply, analyze and evaluate (BRT) and mini cases and tests (CFT): Environment with proposed activities so that students can interact/solve problem situations involving the related blocks and from this think of possibilities and uses for the blocks.
4. Create (BRT) and Assessments (CFT): Free creation environment where students must use the related blocks to

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build new uses and possibilities, from the constructions, evaluate learning.

To exemplify, we show below a proposal for the use of this structure within the game with environments for the study of the physical concepts of horizontal and vertical movement, friction, thrust, free fall, gravity, among others.

For stage 1, we have an environment with several structures built for student interaction, the first of which is an elevator made with magma and soul sand blocks (Fig. 1), the magma block (right) when it is submerged in water generates a downdraft, which pulls the player down with constant speed, and the sand block of souls (left) creates an updraft that lifts the player with constant speed.

At the top of the elevator a platform was built (Fig. 2) for free fall with slime blocks at the end of the fall (green blocks in Figs. 1 and 2), these blocks produce thrust like a trampoline, here we can observe the physical magnitude impulse.

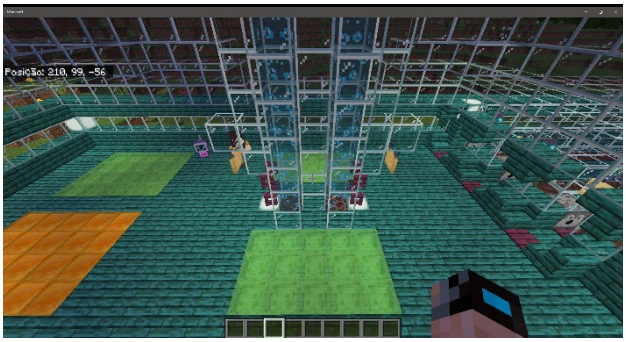

Figure 1. Magma and soul sand block elevator

Figure 2. Free-fall platform and slime block

Still on vertical movements, a structure was built with soft snow (white) and spider web (white web shape), shown in Fig. 3, when falling vertically on these blocks, we have a reduction in the speed of fall, representing a resistance to movement.

To observe the movement horizontally, we have platforms with blocks of slime (green), blocks of honey (orange) and soft snow (white), shown in Fig. 4 and blocks of soul sand (brown) and spider web (white web), shown in Fig. 5. When walking and running on these blocks, the player experiences a reduction in their speed, and the concepts of friction in movement can be studied.

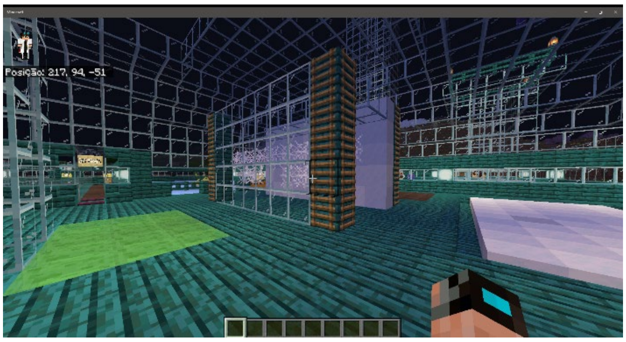

Figure 3. Structure for studying vertical motion with soft snow and spider web

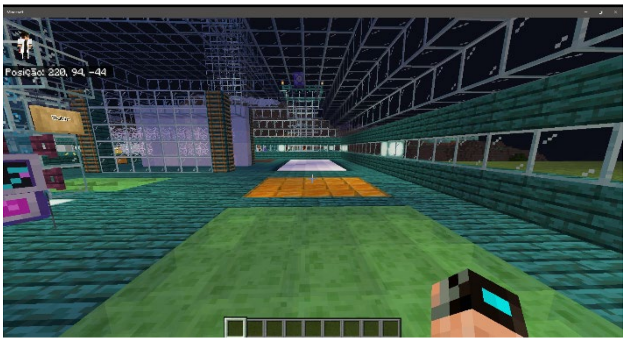

Figure 4. Platforms for horizontal motion study (slime, honey, and soft snow)

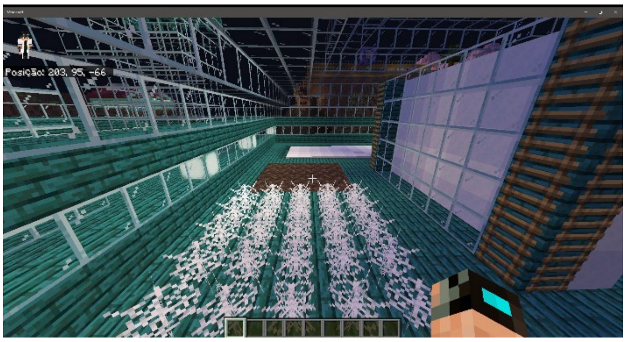

Figure 5. Platforms for the study of horizontal movement (spider web, soul sand)

For frictionless movement, we use ice blocks (blue) and boats (yellow) in an environment that

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resembles an ice rink (Fig. 6), in this environment the player's speed is increased when moving with the boat on the ice.

To finish stage 1, a racetrack was built (Fig. 7) in which the player runs with boots that increase speed, there are 3 levels (soul speed 1, 2 and 3). With these boots, when walking on the block of sand of souls, the student experiences movements with different speeds.

Figure 6. Frictionless motion study ice rink

Figure 7. Test track for soul sand race (different speeds)

The interaction with all these structures and blocks will make the student make associations of the physical concepts involved and their previous knowledge with each of the blocks worked within the game.

After this interaction, we move on to step 2, where students will understand and receive information about the blocks and physical concepts involved, for this step, a room was built, whereby pressing buttons (purple on the floor), students will receive information about the blocks on the screen when walking through the room, shown in Figure 8.

After this stage and already understanding the functioning of the block, we move on to the third, which contains proposed activities so that students can, through observation, apply and analyze physical concepts, for this stage, some activities were built, which we detail below.

Figure 8. Step 2 Study environment

The first is a race in the sand of souls, here students will work on the concepts of speed (Fig. 9)

Figure 9. Environment for racing activity on the sand block of souls

The second activity is for the study of free fall, we have an elevated platform for free fall (Fig. 10), to study the gravity of the game, and through a slow fall effect, simulate gravity on another planet (Fig. 11)

Figure 10. Environment for free fall activity

The third activity consists of a boat race on a frozen lake in the game, here two types of ice blocks were used, which leave the boat with different speed when passing over them, we have acceleration and deceleration can be observed (Fig. 12).

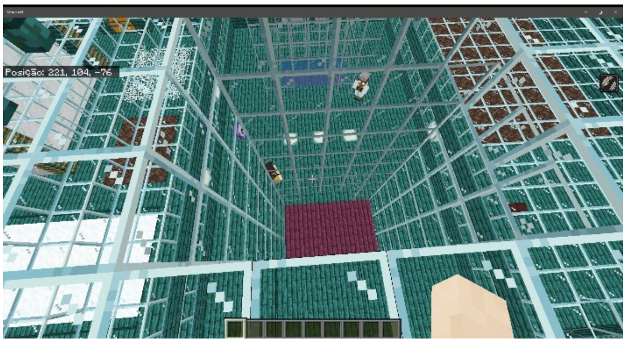

Figure 11. Environment for Slow fall activity

Figure 12. Environment for Boat Racing Activity

Finally, the last activity consists of a race on the blocks (Fig. 13), where students will be able to measure the speed in each of them and observe the friction behavior.

Figure 13. Environment for block running activity

After carrying out the proposed activities, students will be led (stage 4) to an environment where they can build (create), having access to the blocks of the game and using the blocks studied, something that shows what was learned, from this construction, we can carry out the learning assessment, according to the assumptions of CFT and BRT.

4. Conclusions

In this work we saw the relationships between the theory of cognitive flexibility, Bloom's revised taxonomy and the use of the game Minecraft for the teaching and learning of Physics, we brought an essay demonstrating the relationships between them and from this, we propose a structure of four stages for its use in the game, as a way to exemplify and show in practice this structure in operation, environments were created within the game for studies of some physical concepts, such as speed, friction, free fall, among others. We hope to soon be able to use this environment with a group of students and from this verify the potential for teaching and learning Physics. In addition, we also hope that this study serves as an inspiration and basis for other studies that involve the use of Minecraft games for teaching.

5. Acknowledgements

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The Science Education Journey. What Next?

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Abstract. The teaching and learning of science.is, in developed countries, an established subject on the curriculum for children during statutory school age attendance. However, science was not always part of what was considered an appropriate education. This paper traces the development and emergence of science in the formal curriculum. It poses the question, ”What next?”. It also recognises the importance of everyday hands-on experiences in the community, based in the culture where children are growing up as an important part of their learning about science in action in their everyday, which is not always compatible with the theoretical aspects that they are taught in some school curricula. Lastly, whilst the paper refers to the development in a Western developed country we ask are there similar tracks that can be identified in other societies?.What is the journey of science? Where you come from? Is it an important issue in the present technological advancing but climate changing times?

Keywords. STEM, Holistic, Early-Years, History, Play, Education Learning.

1. Introduction

We humans belong to the group of boned animals with fur and teeth whose females give birth to live young then fed on milk derived from the mother’s blood plasma, called mammals. Young mammals play. In play the young learn essential life skills such as food hunting, alertness to danger, essential skills for adult hood. Societies still encourage their young to learn. Essential skills for adult hood, be it re-enacting in their play with smaller visons of adult tools and associated activities as happens in home in early years settings where children. Reenact adult’s activities, such as cooking, cleaning, and also adult activities and emotions witnessed or learning to use a bow and arrow for hunting as in that case play corners for example [1]. Toys and other everyday objects with which our young interact are in science education terms models in the same sense of models, such as of the human body, atomic structures which are used in science learning educators models [2].

Learning in an establishment for all children in a society is a relatively recent phenomenon. In. the Medieval centuries in the Western world there were four m main routes of education [3]. The Church was the main provider of an education which was theological, the Latin language and reasoning skills, grammar, logic and rhetoric and subjects focused on aspects of mathematics, arithmetic, geometry, music theory and practice and astronomy. Calligraphy was a skill learnt in monasteries and the medieval manuscripts that survive are evidence of this. Practical skills were also learnt of agricultures, basic medicine and healing. Aspects of botanical sciences developed through then study of herbs and other plants found to have medicinal properties. certain plants were used to the cloth woven on looms [4]. Hence engineering and technology for such tasks was learnt from parents whose trade it was. Learning ‘on the job’, an apprenticeship, was how many trades, doctors, blacksmiths, farmers and barrel makers for example, were learnt. Grammar schools were established for c boys form the local area particularly to focus on Latin grammar and a small fee was charged for attendance, The British Public schools originated in often charitable foundations for pupils from a wide area Eton College was founded by King Henry Sixth in 1440 as a charity school for seventy poor boys, but other boys whose families could pay could also attend. The King envisaged that the pupils would go on to study mostly theology at Kings College Cambridge which he also founded.

2. Science Education emerges as a curriculum subject

Science education, as we recognise it today, embracing the classic subjects of Biology, physics, chemistry and geology now embraces additional subjects such as Psychology, environmental science, ecology, has developed through distinct stages from the specific focus on Astronomy alongside arithmetic and geometry which are essential in. learning and practicing sciences. The recognition of the importance of the physical sciences in the industrial world in the second half of the

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nineteenth century grew and hence the need for education for more than the elite. Indeed, hitherto there had been no universal mandated education in England. Learning had been conducted by the Chistian church and in the secular world by the grammar and public schools. However, with the move of agricultural workers into the cities seeking work in the newly established manufacturing factories owners for universal basic, elementary, education to provide workers with a basic level of language literacy and arithmetic.

The passing of the 1870 Education act, known as the Forster Education act 1880 [5] dealt with provision of free education for children, partly to prevent child labour by compulsory school attendance. The schools were run by a School Board. However, the voluntary Church schools which had been established were allowed to continue, as they still do but within the State system. Science became a subject taught particularly in the grammar schools whose pupils were selected by various test, at aged 11, and trade skills more so in the other state schools for pupils not selected popularly referred to as having failed the 11+ exam.

The grammar schools were the main drivers of secondary science education, largely physics, chemistry and biology, which in the last twp. years of schooling, 16-18 years was often botany and Zoology of grammar school education, leading to a \university education for a very few. Geology was sometimes offered. With the emergence of more and more comprehensive schools this tended to be the pattern in comprehensive schools with the less academic classes taking different level leaving exams. With the passing of the 1944 Education Act [6] three types secondary school were established of which only two really survived until the Labour Government in 1965 onwards merged all state funded secondary schools into Comprehensive schools with a common curriculum including the sciences.

The introduction of the English National Curriculum. In 1988 applied to all schools and was introduced into the primary schools for whom science learning was a new area, often implemented by teams of advisory teachers providing professional development. One of the authors set up and ran one of these. The Early Years Foundation Stage (EYFS) was introduced after a consultation in 2017 for children from birth to five years and set learning goals against which children were assessed. Maths was a specified area whilst 'science' was embraced in the Understanding the World area.

3. Paradigm shifts in Science learning and Teaching

A breakthrough in attitudes from the academic focus of science studies in secondary school began in the early Seventies. In the 1970s. primary science became gradually established replacing what had sometimes been taught as Nature Study in some schools. Practitioners gradually through experience understood that the former traditional, approach of didactic instruction was not suitable. A non-Governmental body, the Schools Council, which was disbanded in 2007, produced a series of books of science situations such as how to keep a teapot warm effectively, the solution for which children designed and made to see if their ideas worked.

The introduction of the English National Curriculum [6] by an Act of Parliament in 1988 and first implemented in schools with science, and Design and Technology, which is basic engineering and design and making, for children. from 5 to 16 years. It was gradually introduced into particularly primary schools. This led to a surge of primary science publications and training course for primary teachers in training having to study primary science. This was a paradigm shift.

An important milestone as the National Curriculum was being written in the teaching and learning of science occurred in the early 19 80s when Professor Ros Driver published her book, The Pupil as Scientist [7] in which she pointed out that the secondary pupils coming to science classes already held ideas and experiences about much of the science concepts that were being taught.

Thus, in the closing decades of the last century it was recognised that children had ideas and experiences of much science. Much research was published related to such understanding and the correction through teaching of the leaner's alternative ideas. However, most of such work focused on

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physical sciences. There was also a move towards trying to present science as relevant in everyday society and the development of more hands-on science.

4. Recognition of Informal learning

Developing particularly in the last quarter of the last century there began a recognition that children learn much of their understanding out of school where they spend more of their hours than they did in schools. The increasingly discussed place-based learning in the early years of the 21st Century recognises such but place is a wider concept than just geographical [8], which is a pedagogical approach considering where learners and facilitators, if present, are located. We identify the following categories of learning outside a classroom, child or children only or with another as facilitator. We assert that, in observing and exploring about Science out of school, Everyday Science, may occur in six distinct locations:

1. In the Home, its environmental location and its cultural heritage.
2. Other venues either purpose built for dissemination of information- science museums, cultural museums, botanical gardens, zoos and aquaria.
3. In formal education settings which are implementing governmental policies and practice.
4. In urban settings, built st[reets, urban. Plants and animals, gardens, parks.
5. In 'Nature' non cultivated settings such as woods, river banks., lakes, moors, beaches
6. Various media.

The importance of museums, zoos, gardens and field centres as well as the rise in Science centres became established and recognised as effective and importance places of learning which complemented the school based work. Research on where pupils learn about phenomena showed that the source was frequently out of school from observations, books and other media [9, 10].

Children spend more of their waking hours in ' informal' settings, particularly the home environment inside and outside where several of the above categories overlap. This understanding means that observations and experiences in these environs are an important part of developing science capital and complementing school learning.

Research carried out analysing the interactions and interpretations of children in zoos, museums, field centres reveals a pattern which develops with the age of children of their interpretation of biological phenomena and objects. Indeed, Natural History dioramas, considered old fashioned by some establishments who have dismantled such have been shown to be valuable educational resources [11].

Whilst formal learning is delivered in purpose-built schools, incidental observations are made by learners inside and outside the building in then environs by the children. Playgrounds with equipment are sites of experiential STEM learning for example in primary schools, swings, slides and climbing frames provide hands on experiences of physical science in action [12]. As are Children's playgrounds in parks and other leisure venues within school including within auspices of the school as part of the curriculum but out of school on activities in the grounds around the school, outside the classroom. There had been a debate they are conscripts led by educators [13], hence such is not free choice learning but directed.

However, whilst the 'conscripts' attend to the work and experiences arranged they also notice in our experiences working with such groups the free choice observations. Children taken to a museum by parents or carers during leisure and holiday time or in the case of preformal school learners, in playgroups or childcare situations are also conscripts too because they are taken, although on occasion a young child asks to be taken, often a repeat visit go for example a pond or zoo.

5. The emergence of Early years Science learning

5.1. Free choice interest interactions

Free science by the learner interest interactions primary children fr0m the eeriest years interact with objects Gelman and Brennerman [14] acknowledged children's construction of

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understanding as they interact with objects. Such Hands-on- experiences enable children to build on knowledge and skills across other learning and construct understanding as they interact with objects). The objects in their everyday are of household items but often include toys. In science education terms toys are models in the sense that are models are used in science learning such as atomic models, those showing an atomical organs, but which can be dismantled and constructed again as their structure related to function is learnt [2]. Secondly researchers have identified patterns in young school children's learning [15] and, particularly that of inquiry when following the inquiry-based science approach. Researcher identified four categories of they named small science when observing Bangladeshi heritage preschoolers at home in Australia. These were multiple possibilities for science; discrete science; embedded science and counter intuitive science. Observed in the children's activities. However, play interactions follow a sequence.

5.2. The Play sequence

Observations of pre-school and early primary children showed researchers that children in playing for example, on standard playground equipment such as swings led to an understanding of hands-on physical science in [12].

Subsequent observations on children from 9 months old to 4 years playing with toys that they chose from items available ina play groups over seen years lead to the identification of the play Cycle [16]. The interactions follow a Play Cycle like the one that occurs in inquiry science investigation in school. Tunnicliffe noticed that the interaction of the young preschool children in play interactions with toys and objects followed a sequence reminiscent of the theory of situational interest [17] and that this applies to children's free choice play. A child engages with that which caught their interest. Reviewing the observation revealed a sequence of interactions. identification of a sequence of play and this was represented cyclically (Fig. 1).

Such observations also led to the identification of STEM bytes, single interactions of cause and effect which children use to interrogate objects particularly toys. At about two years of age, if they have had these early experiences, the learning coalesces into STEM play [18] Furthermore, the individual actions made are identifiable these bytes have become known as STEM-bytes. With experience in usage these individual action contributes to the developing understanding of a STEM concept such as a force or pattern.

Figure 1

6. Holistic. STEM

We now accept that children playing is not 'messing about' and that their play is different from the adult being involved in things of their choice which are not their normal work or carrying out duties actions that are recreational for adults. In their own, that is non paid, time [19]. The youngest children, after the first days of independent life when they have experienced moving their bodies and focusing on what they see, begin interacting with objects, materials and phenomena from their earliest years. Learning starts pre-birth, the first 1000 days from conception to the second birthday are regarded as the crucial years [20].

The children interact in a sequence, beginning with what interacts the, comes to their attention. They interrogate whatever exploring what they can 'do' to it but finding out what 'it' does in response. These experiences, such as touching something with a small push to something which then moves, or their fingers go into it, for example. water or a soft material such as mud. These basic actions are a part or 'byte

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component part' of a concept, particular with toys of a force.

These individual observations and experiences gradually come together in the child's mind to understanding a concept. For example, in pushing a toy on a smooth surface the child is using force, the push, but also not experiencing resistance to move through friction on this smooth surface., in particular a force in this case. Moreover, children, whilst thinking and problem solving do not know of the adult inflicted silos of STEM science, technology engineering but are laying the foundations for the development of scientific method which is one of the goals of particularly secondary science teaching which, as and Tippett and Mifford [15]. consider, it is enhanced scientific literacy is an outcome of STEM education scientific literacy is a formal goal of education as early as kindergarten the recognition of the play sequence and the stages in concept development in STEM, which is an integral part of this hands on investigative play of the earliest year children, providing opportunities for these children students to participate in STEM activities from their earliest year before entering formal school system," seems a worthy endeavour".

Each small action constitutes small part of a concept, in this case of forces, these small parts are STEM phonics and the experience is thus a STEM-E, a STEM experience. Such early pre formal instruction experiences in informal learning environments are named HOLISTIC STEM. In these 'play' interactions children are problem solving, progressively building their experiences and understanding, progressively in small incremental instalments. Moreover, everyday STEM is all around. In a child's life as well as in playgroups and nursery. Others and other adult with the children are often unaware of such, oncoming they realise they are in the most important situation to be a blessing to recognise the STEM in action and encourage the children, providing the action verbs of what they are doing, pushing, pulling, dropping, throwing. Thus, language literacy is an essential integral part of developing STEM capital in the youngest learners as well as hearing their spoken languages in using pictorial fiction books (PFB) to recognise items and actions, STEM inaction and developing problem solving skills.

7. What is next?

Science learning, or more realistically in the crucial earliest years where children have a right to quality care and education As is stated in the 2024 Global report on Early Childhood and Education [21]. The acceptance and development of realistic child cantered play opportunities with culturally relevant objects and toys as models of STEM in action. Moreover, UNESCO affirm that a child Should have at least two such toys of their own. Such a development in understanding of politics and policy makers that for curricula should start from the child's inherent inquiry approach and be built upon as opposed to the long-held practice of starting with the advanced concept and teaching it from that starting point rather than building up the understanding gradually from the child's intuitive explorations. Such means the relinquishing of the silo mode traditional in STEM teaching.

The associated understanding that learning occurs in many venues and Communication through various aspects of language such as signs, symbols, gesturers, vocabulary, speech patterns written words and oral ones are the central to STEM learning, hitherto a largely unrecognised area. The recognition that practitioners working with children in the first years of life particularly the 0-3 years have the most important adult role in facilitating the development of STEM and language of all later practitioners.

The use of various media is important for children to learn about, especially online content and effective developmental and recreational use is important but the safe use and the additional emphasis on a child using their own hands in manipulative movements so they can pick up and hold implements, like a pencil, other tools is important to recognise and develop.

Finally, we have to recognise that AI will play an ever-increasing role in all aspects of our lives. How can we use it to help the earliest of children learn and develop their own skills and understanding frm their initiative?

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Can Science Be Taught to Children?

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Abstract. Can science be taught to children from 3 to 6 years old (Nursery) and 6 to 12 years old (Primary school)? This is a controversial question because there are ones who would deny, in principle that in nursery and primary school, any kind of teaching and/or serious learning of the experimental sciences can be done and those who would say that it is time to consider this question seriously, because today, our society in general and the high school students when they reach the high school know close to nothing in chemistry or science, and maybe if they earlier begin to do science they will improve their science knowledge. Finally, the answer may obviously yes, and obviously not, depending on what we imagine is science. We will dive into both positions and we will defend the "yes" answer.

Keywords. Scientific Tools, Sensory Exploration, Simple Experiments, Teaching Experimental Science Early.

1. Introduction

Can science be taught to children from 3 to 6 years old (nursery) and 6 to 12 years old (Primary school)? This is a fascinating and complex question. At the heart of it, there's a tension between two perspectives: one that doubts the efficacy or appropriateness of teaching experimental science at such an early age (3-6 years for Nursery, 6-12 years for Primary school), and another that sees potential benefits in introducing science concepts earlier, in a way that might be more engaging and effective for younger children.

Let's break down the arguments on both sides. The Official College of Catalan Chemists (COQC, acronyms in Catalan) [1] focus on defending the "yes" position arguing that science can and should be introduced to children in these early age groups.

Chemistry education is a vital aspect of the science curriculum that helps students understand the composition, structure, properties, and changes of matter.

2. Arguments against Teaching Experimental Science Early

2.1. Cognitive development

Children aged 3 to 6 are still developing basic cognitive skills such as attention, memory, and language. Critics argue that abstract scientific concepts, chemical reactions or biological processes, are advanced for their level of cognitive development. Piaget's theory of cognitive development [2, 3], for instance, suggests that young children are in the "preoperational" stage, which involves concrete thinking rather than abstract reasoning.

Early childhood education often emphasizes play as a primary mode of learning [4, 5]. Critics believe that introducing structured science lessons could hinder natural curiosity and exploration.

What do they mean by "Structured Science Lessons"? When we talk about these young and tender ages, play, curiosity and exploration are the most important but, it is not against science.

2.2. Conceptual complexity

Science, especially experimental science, involves complex concepts like cause and effect, observation, and hypothesis testing. Critics argue that children in these early stages might not be able to grasp such abstract notions. Instead, they might be better served by focusing on foundational skills such as language, social interaction, and early numeracy. Children may not yet understand cause and effect, making it difficult to engage with scientific principles meaningfully.

Critics believe that children cannot understand the cause-effect relationship. Maybe for the little ones it's true but 8-year-olds already know that their actions always have an effect around them and they can relate this to science.

Younger children have shorter attention spans and may struggle to stay engaged with

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activities that require sustained focus or abstract thinking. Experimental science often involves longer, more structured activities (e.g., setting up experiments, making predictions, analyzing results), which may not hold their interest or fit into their natural developmental patterns.

It is clear that for younger children the approach to science cannot be with these parameters.

2.3. Developmental preparation

Critics argue that introducing science at a very young age could result in oversimplification or even misunderstanding of core scientific principles. For instance, if children are taught science using overly simplified or inaccurate explanations, they could develop misconceptions that might hinder their understanding later on. There is a concern that the complexity of scientific concepts is inappropriate for young children, potentially leading to confusion rather than understanding.

Many educators may not feel equipped to teach science effectively to young children, which could result in poorly delivered content.

It is not acceptable be understood that science is taught in Primary with incorrect explanations. If the fault lies with the teachers, who are not prepared, maybe they need to be properly prepared in science.

3. Arguments supporting teaching Science Early

3.1. Science is Everywhere

Science is not just a subject in school; it's part of the world around us. Children have to incorporate science into daily activities. From observing the weather to noticing how plants grow or how objects fall, young children are constantly exposed to scientific phenomena. Teaching them to observe, question, and explore these phenomena scientifically can be an enriching part of their natural curiosity. Even at a young age, children can engage in basic scientific activities like observing changes in water, watching seeds grow, or experimenting with simple cause-and-effect relationships.

3.2. Fostering Curiosity and Problem-Solving

One of the key aspects of science is curiosity. Young children are naturally inquisitive, constantly asking "Why?" and "How?". If we nurture this curiosity by introducing them to science, we can help them develop critical thinking skills early on. Simple experiments, hands-on activities, and exploration can teach children how to ask questions, make observations, and seek answers. These skills are valuable not just for science but for problem-solving in everyday life.

Children are naturally curious about the world around them. Introducing science concepts can harness this curiosity, encouraging exploration and inquiry from an early age.

3.3. Building a Foundation for Future Learning

Early exposure to science can build a foundation for more advanced learning later. Just as children learn basic math skills early on, they can also begin to grasp fundamental scientific concepts. Early science education doesn’t need to involve complex concepts like the periodic table or advanced physics. It can be about learning how to classify objects, noticing patterns, experimenting with materials, and understanding simple cause-and-effect relationships. This foundation can help children approach more formal scientific learning in later years with greater ease and interest.

Introducing basic scientific concepts like the scientific method, observation, and categorization in nursery and primary school can lay the groundwork for more complex learning in later years.

3.4. Hands-on Learning Experiments

Experimental science is not just about abstract theories; it’s about hands-on learning, which is crucial for children in the 3-12 age range. Children at this age thrive in environments where they can engage physically with their learning. Teachers have to conduct simple, safe and engaging experiments, like mixing colors, observing plants grow, or watching ice melt, help children develop an

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understanding of the world through sensory experience. These types of activities are engaging and allow children to learn in a concrete way that aligns with their developmental stage. Young children benefit from experiential learning. Simple experiments and observations [6] such as exploring colors through mixing or studying properties of Light and measuring ingredients in cooking can provide foundational scientific skills, such as asking questions, making predictions and promoting a holistic learning experience.

3.5. Improving Science Literacy

The argument that high school students often have little understanding of science is a strong one. By introducing science earlier, we can help improve science literacy across the population. Early exposure to science might inspire future interest in the subject and reduce the fear or anxiety that many students have when they encounter science in later years. Moreover, when children engage with science early, they are less likely to develop the notion that science is a subject reserved only for "gifted" students or "smart" people. We need to make our society scientifically literate. Early science education can help prevent the knowledge gaps observed in high school students. By fostering a strong foundation, students may be better prepared for advanced scientific coursework.

Finally, as we defend the position that science can and should be introduced early, the initial question becomes: “How should it be taught to children in the 3-6 and 6-12 age groups?”

4. How Can Science Be Taught to Young Children?

4.1. For Nursery (3-6 years old)

At this age, children can learn about science by engaging their senses. Activities like feeling different textures, watching water flow, observing plants or animals, and hearing the sounds of nature are foundational scientific experiences.

Basic experiments, like mixing water with different substances (flour, sand, sugar), can help children observe changes and form basic conclusions about the properties of matter. Figure 1 shows the children drawing and painting their own reflected in a spoon, on the concave side and on the convex side.

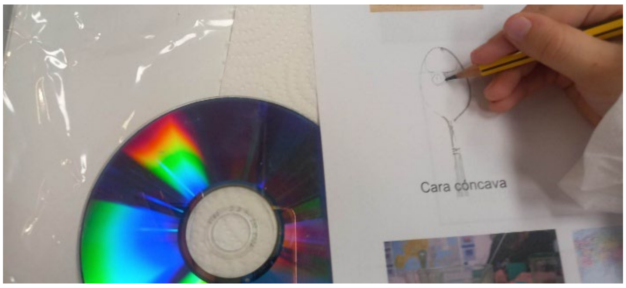

Figure 1

Storytelling and Science: Stories and books can be used to introduce science concepts. For instance, books about the lifecycle of butterflies or the water cycle can lay the groundwork for more formal science later.

Questioning and Exploration: Encouraging children to ask questions like "What happens when we add more water?" or "What do you think will happen if we mix these colors?" can foster critical thinking.

4.2. For Primary School (6-12 years old)

Hands-On Activities: At this age, children can engage in more structured experiments, such as growing plants, building simple machines, or conducting basic chemistry experiments. Figure 2 shows, on the left, a glove inflated by the gas produceds in the reaction of baking soda and vinegar. On the right are some examples of geodes from last year.

Figure 2

These activities can teach them about hypotheses, observations, and conclusions. An example is making geodes, following the

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Scientific Method, without the children knowing, as explained at Hands-on Science 2024 in Brazil [7].

Scientific Tools: Introduce them to simple tools like magnifying glasses, thermometers, or even microscopes, so they can start to understand how scientists explore the world.

Figure 3

Real-World Connections: Use everyday situations—like cooking, weather patterns, or playground dynamics—to show how science works in the real world. For example, cooking can be used to explain chemical changes, while observing the weather can teach them about meteorology.

Inquiry-Based Learning: Let students drive their own questions and experiments. Instead of simply teaching facts, encourage students to ask questions like "Why do things float?" or "What happens if we heat this?" and then guide them through the process of finding answers.

And then, still, come the mutual influences. What happens if we drop a glass cup on the floor from different heights? And what happens if we try the same with a plastic cup?

What happens if we put a metal pan on the fire — and what happens if we put a plastic plate there instead?

What happens if we give a sardine to a cat, or if we give that same sardine to a pigeon?

What happens if we add salt to water, or flour to water?

What happens if we eat a piece of chocolate — or an entire bar?

What happens if we heat butter? Or wood? Or water?

This is the second stage: we witness things happening.

We observe events, transformations, processes — phenomena — and we give them names like: Combustion, dissolution, decay, eruption, expansion, reaction, respiration, evolution, and pollution.

5. Examples and Practical Strategies

Use Everyday Experiences: Incorporate science into daily activities, like observing nature during a walk or cooking to explore chemical reactions.

Terrassa launches an analemic clock [8]: "You are the needle and your shadow tells the time" an analemic clock, with the help of the Astronomical Group and the Green Spaces Service. The work is located on the ground floor of Plaça dels Drets Humans, on the edge of Vallparadís Park and shows the universal time adjusted to the position of the city

"The correct name is analematic clock, of universal time. The analema is the curve that corrects the difference between solar time and official time, because the solar day does not have exactly the same length throughout the year" In this clock, it is the person who acts as the needle, standing on the central plate to project its shadow on the hours.

Figure 4

It is "a perfect tool for the dissemination of astronomy", especially among the young audience: "Children ask why they have to stand in a specific place and this allows us to explain

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the Earth's orbit and the movement of the Sun. It is a great excuse to talk about science".

In addition, the clock is adjusted to universal time, and its orientation takes into account Terrassa's position with respect to the Greenwich meridian—only eight minutes apart—. For this reason, as Calaf points out, "the hours are turned slightly to the left, to correct this lag".

In this clock, the person acts as the needle: it must be placed on the central plate, at the point corresponding to the number of the month of the year in which it is located. In this way, its shadow will indicate the solar time on the curved line of the ground, in one of the circles listed from 4 in the morning to 8 in the evening.

However, two hours must always be subtracted, if we are on summer time, or one if we are on winter time. Thus, the clock shows the universal time adjusted to the position of Terrassa.

Simple Experiments: Teachers have to conduct simple experiments which must be safe and engaging most children, the future scientists of our society. Some simple experiments are growing plants, making slime, or mixing baking soda and vinegar to demonstrate chemical reactions.

Color Mixing with Water:

Objective: To explore color theory.

Activity: Provide clear cups of water and food coloring. Let children mix primary colors to create secondary colors, discussing what happens when they mix different colors.

Figure 5

Figure 5 shows the mixture of the colors blue and yellow, which move through the paper by capillarity and both form the color green.

Water Filtration Experiment:

Objective: To learn about water purification and environmental science.

Materials: Different types of soil, sand, gravel, coffee filters, dirty water.

Activity: Create a simple water filter and observe how well it cleans dirty water. Discuss the importance of clean water and the science behind filtration.

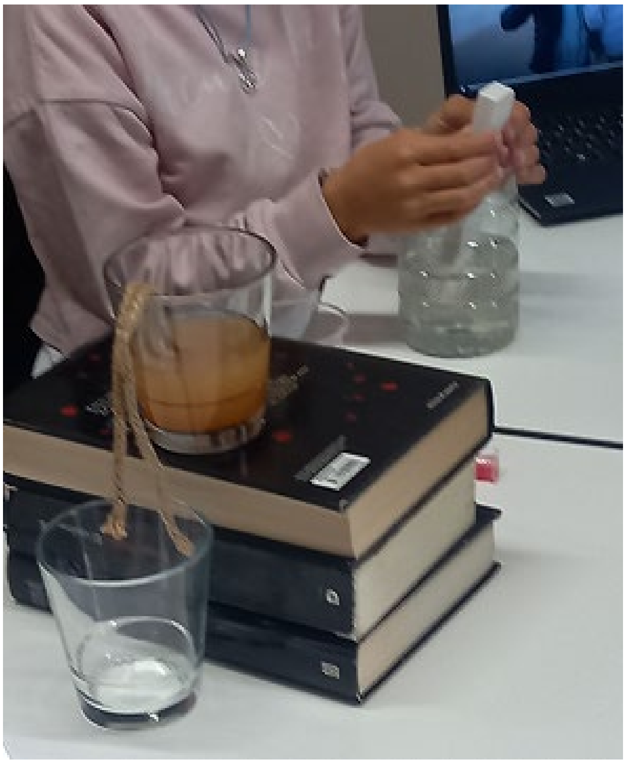

Figure 6

Storytelling and Themes: Use storytelling to introduce scientific concepts. Themes around seasons, animals, and the environment can be both entertaining and educational.Once

Once upon a Time deep inside the forest there were three little pigs brothers like anyone else in the forest the tree pigs were scared of the big wolf which have been trying to hit them all the time.

One day they decide the best way to protect themselves from that big wolf was building a house for a each one. The youngest one of them

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which wanted to finish as soon as possible for going to play, he build a house made of straw. Then, his brother the middle one saw his brother playing so he immediately finished his house which was made of wood. The big brother was working very hard to build himself a house made of bricks and advised them for better protecting their houses but the two younger brothers ignored him and keeps it playing happily.

Figure 7

Suddenly behind some brushes the big wolf jumped over the youngest pig, the little pig want to escape and ran to his house of straw and locked himself up. The wolf realized the house was too weak so the wolf said, I will blow and blow and throw the house down. When the house of straw fell down, the little pig ran across the forest followed by the wolf and he arrived to his brother wooden house the two of them locked themselves up inside.

The wolf realized the house was weak so he blew and blew and throw the house down. The house made of wood fell down and the two brothers ran away to their big brother's house.

When the two pig brothers arrived they together with their older brother locked themselves up in the house, they locked doors and windows.

The wolf blew again, blew with the maximum he can but the house didn't fell down. What can I do?, the wolf thinks and he start to walk around the house until he figured out he could just climb to the roof and enter into the house through the Chimney (fireplace), and tried to do it. However, the oldest pig which was guessed that the wolf intend to enter through the Chimney put a cooking pot full of boiling water to the chimney (fireplace) so when the wolf went down he fell into boiling water and burning himself. The wolf left there screaming so terrible such scream could be heard from everywhere in the forest and he said that he never tried to hit any other animal ever.

The story is over [9-10].

Figure 8

Teachers can introduce to the little ones the differences between straw and wood or wood and brick but also the differences between sand, salt and stone. One Thousand and One Nights is a collection of Middle Eastern folktales compiled in the Arabic language during the Islamic Golden Age, 8th century to 13th century. It is often known in English as The Arabian Nights, from the first English-language edition (c. 1706–1721), which rendered the title as The Arabian Nights' Entertainments. Some of the stories commonly associated with the Arabian Nights—particularly "Aladdin and the Wonderful Lamp" and "Ali Baba and the Forty Thieves" and "The Seven Voyages of Sinbad the Sailor" were not part of the collection in the original Arabic versions, but were instead added to the collection. Just these stories can be used to

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introduce scientific concepts to the little ones while telling the story.

So, flying with a rug and see the city from above or hide treasures, gold, silver and more or travel by sea and how to make a boat. From all these children stories everybody can extract a part of science.

Figure 9. Scholars from a library in Baghdad

6. Strategies to implement

Inquiry-Based Learning: Encourage students to ask questions and pursue their inquiries. Let them formulate their experiments based on their interests, fostering a sense of ownership over their learning.

Classroom Environment: Create a science corner in the classroom filled with books, tools, and materials for experiments. This dedicated space can encourage exploration and ongoing interest in science.

Parental Involvement: Encourage parents to participate in science-related activities at home. Provide them with simple experiments they can do with their children to reinforce learning.

By providing structured lesson plans and engaging activities, educators can effectively teach science to young children and primary school students. The goal is to foster curiosity, critical thinking, and a love for science that will benefit students as they progress through their education.

7. Conclusion

The argument for teaching science early is grounded in the belief that young children are natural scientists, constantly exploring and making sense of the world around them. Science, when appropriately adapted for their developmental stage, can be a source of wonder, curiosity, and excitement not a complex, intimidating subject [11].

Figure 10

Figure 10 shows how two little girls play in a very fun way in the Barcelona Science Museum. They play with the difficult concept of “inertia” that they cannot understand but they comprehend (because they have tested it, cause-effect) that if they open their arms or legs the speed of the turns decreases and vice versa.

By introducing science in a hands-on, inquiry-based way, we provide children with the tools they need to understand the world and develop critical thinking skills. Early science education doesn’t need to be about mastering complex theories; it can be about fostering a mindset of curiosity and exploration, which can later evolve into deeper and more formal scientific knowledge.

In an age where science literacy is more important than ever, teaching science early can help prepare children for the challenges of the future—equipping them not only with knowledge but also with the ability to think critically, solve problems, and approach the world with curiosity and creativity.

In conclusion, while there are valid concerns about teaching science to very young children, the benefits of early exposure to scientific concepts are compelling. By leveraging children's natural curiosity and providing hands-on experiences, educators can cultivate a love for science that enhances their future learning. The key is to tailor the approach to be age-appropriate, engaging, and integrated with their everyday experiences.

8. Acknoledgments

We thank the teaching staff and children from Nursery and Primary schools who have participated in these actions. This activity was supported by the Professional College of Catalan Chemists (COQC).

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Two Intriguing Parts of a Wind Power System

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Abstract. A complete wind power system can be divided into four parts: the professional wind turbine, the transmission system such as a gearbox, the electricity generator with its load, and the auto-control system. Because gearboxes sometimes malfunction and reduce electricity production, the transmission system and generator have been combined into a directly driven electricity generator, while still following the same underlying principles. In examining the basic principles of these four parts, we found that although people are familiar with generators and gearboxes, they often do not fully understand how they work. We developed an innovative electricity generator to emphasize that, rather than a driving force turning the generator, magnetic damping is the only force involved in electricity production. We also designed a special instrument to demonstrate that while a large gear can drive a small gear to rotate at high speed, this only happens when the torques applied to the large and small gears, respectively, satisfy the proper conditions.

Keywords. Producing Electricity, Magnetic Damping, Lever Principles, Gearbox.

1. Introduction

Because windmills have long been children's toys around the world, and primitive windmills have existed in many regions since ancient times, many people seriously underestimate the depth and complexity of wind power technology. In fact, wind power is a highly interdisciplinary field, involving aerospace engineering, fluid mechanics, computational fluid dynamics (CFD), mechanical and electrical engineering, and automatic control. It is highly challenging and far from the simplicity of a toy.

A complete wind power system consists of at least four major parts: the professional wind turbine, the transmission system, the generator with its load, and the control system. Each part is crucial and governed by its own underlying principles. Modern wind power systems often combine the transmission system and generator into a directly driven generator to avoid losses caused by gearbox failures, though the underlying principles remain the same.

Due to the interdisciplinary complexity, engineering specialization that obscures the big picture, and protection of commercial secrets, there is a lack of suitable educational materials on this mature technology. This is a problem both domestically and internationally. Most professional references are industrial manuals or technical data that do not explain the fundamental principles of each part of a wind power system, making them unsuitable for students or general readers. In other words, comprehensive reference materials that explain the functions and principles of the entire wind power system based on fundamental scientific concepts are extremely rare and fragmentary.

Therefore, we set out to create teaching materials that highlight the basic principles of each part of a complete wind power system, and found that the fundamental principle of the electricity generator and the intriguing principle of the gearbox are often misunderstood. To address this, we developed two instruments, which will be described below along with their correct principles, respectively, to illustrate these two misconceptions.

2. Magnetic Damping in Electricity

In most textbooks, the electricity generator is treated merely as an exercise in the chapter on Faraday's law. In such exercises, students are usually asked only to calculate the electromotive force (emf), and that is it. As a result, many students believe that producing electricity is simply equivalent to creating a potential voltage—but this is not the case. On the other hand, because an external driving force is always used to operate the generator, many people assume that the driving force is the main factor in producing electricity. Clearly, this is not true either.

In reality, while an emf is induced in the coil, an electric current simultaneously flows through the same coil. According to the definitions of current and emf, the electrical energy is thereby increased, which is why we call this phenomenon electricity generation. According to

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Lenz’s law, the induced current or the magnets exert a damping force that reduces the kinetic energy.

Electricity generation is a phenomenon of energy conversion, so it is essential to understand the details of how energy is transformed in order to truly have the ability to design a power generation system. The purpose of this teaching tool is to illustrate that, from a mechanical perspective, it is friction producing heat, magnetic resistance producing electricity.

From a thermal perspective, friction producing heat involves detailed microscopic mechanisms. From an electrical perspective, magnetic resistance producing electricity also involves electrical mechanisms, namely the induced electromotive force and current. Both occur simultaneously, and according to their definitions, the electrical (potential) energy increases. Friction and magnetic resistance are directly involved in these two energy conversion processes, both doing negative work and thereby reducing kinetic energy; the kinetic energy is converted respectively into the object’s thermal (internal) energy and electrical energy.

The innovative generator, shown in Figure 1, is designed to clarify the concept of electricity generation. Two sets of magnets, shown in Figure 2 (left), are fixed at the two ends of a rotatable bar, which remains balanced relative to its pivot. At the bottom of the structure, there is an induction coil. As the rotating bar moves, the magnet sets pass over the induction coil at a distance of approximately 0.5 cm, as shown if Figure 2 (right), inducing an electromotive force (emf) within the coil.

Figure 1. Rotation of the magnet components in this innovative generator

As shown in Figure 3, a switch is used to control the flow of electrical current, even though an electromotive force (emf) is already present in the induction coil.

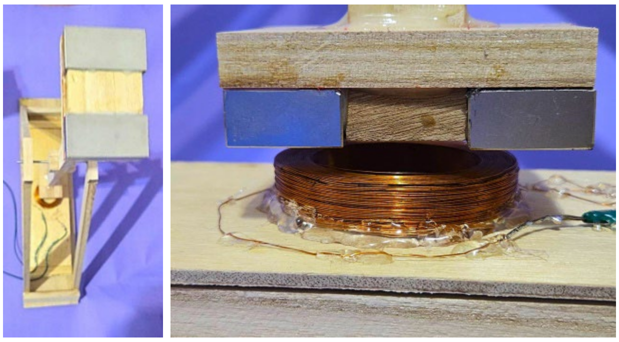

Figure. 2. the magnets (left) and the induced coil (right)

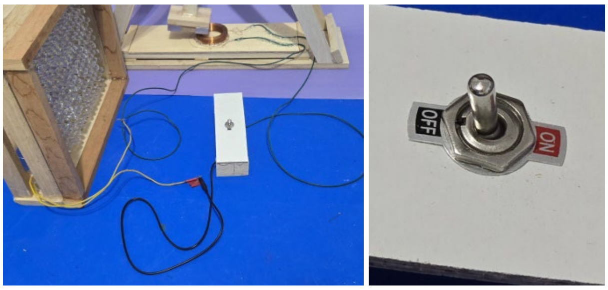

Figure 3. A switch controls whether current flows through the induction coil and external devices (e.g., LED lights)

Wen the switch is turned on, an electric current flows, lighting up LEDs of different colors, allowing students to observe the current, as shown in Figure 4.

Figure 4. A switch controls whether current flows through the induction coil and external devices (e.g., LED lights)

The experiment is very simple: by gently rotating the magnets by hand, they continuously sweep over the induction coil. If the switch is turned off, the induction coil is not connected, so no current flows in the coil (even though an emf exists). In this case, electricity generation does not occur, no magnetic damping is produced, and the kinetic energy of the magnets is not converted into electrical energy.

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When the magnet assembly rotates, it is obviously subject to gravity. However, because the magnet sets at both ends and the rotating bar are initially balanced in terms of gravitational torque, the magnets clearly do not slow down or speed up due to gravity. Under ideal conditions, friction and air resistance can be neglected; even if they are not negligible, the rotating magnets cannot increase their speed. Since the magnet assembly can continue rotating for a long time, the teacher can emphasize that, at this moment, there is no driving force present—only air resistance and friction gradually slow down the rotation.

When an induced electromotive force (emf) occurs and the switch to the induction coil is closed, allowing current to flow through any conductor or electrical device connected to the coil, the current is generated solely by the induced emf. Therefore, the current direction is always parallel to the emf. According to the definitions of current and emf, electrical energy is necessarily increased. According to Lenz's law, a magnetic damping force inevitably occurs, and the kinetic energy of the magnets is converted into electrical energy.

This confirms that only magnetic damping is directly involved in electricity generation, which is the key point this experiment demonstrates. Electricity generation is actually independent of the external driving force, just as friction is also independent of the driving force.

3. How Torques Control Gearbox Rotation

Historically, Archimedes famously claimed that given a lever long enough and a fulcrum, he could move the Earth. In reality, even if he had such a lever and fulcrum, he could not have moved the Earth. The reason is that Archimedes overlooked an important aspect of the lever principle: although the force applied at the longer end of the lever can be smaller, the point of application of this force must move a longer distance. To move the Earth, the force at Archimedes' end of the lever would have to act over an extremely long distance in order to move the Earth even slightly. To this day, this subtlety is often overlooked in teaching the lever principle.

Typically, instruction emphasizes that applying force at the longer arm allows for a smaller force, while the shorter arm requires a larger force to maintain torque balance—but it often neglects to stress that the distances moved by the points of application of these forces are also different.

When teaching about gear systems (i.e., two or more gears combined), instruction often focuses on how the system increases the rotational speed of the smaller gear, while overlooking another important phenomenon: the total torque is also crucial. When the small gear rotates faster than the large gear, the reverse torque experienced by the small gear must be much smaller than the driving torque applied to the large gear for the system to rotate. In other words, while theoretically the large gear can increase the speed of the small gear, if the torque conditions are not satisfied, this effect may not actually occur.

Considering that the forces between two gears are equal in magnitude and opposite in direction (Newton's third law), and that the velocities at the contact points are the same (because there is no slipping), the following equation of motion can be derived based on the relationship between torque and the rate of change of angular momentum:

$$\tau_t(\omega_t) - N\tau_d(\omega_t) = I_{eff}\frac{d\omega_t}{dt} \quad \text{.........(1)}$$

where τ_t is the torque driving the large gear, N is the final speed-up ratio of the small gear, τ_d is the reverse torque on the small gear (i.e., the torque the small gear can apply to a driven machine such as a generator), I_{eff} is the effective rotational inertia of the entire transmission system, and ω_t is the angular velocity of the large gear.

If τ_t and τ_d are independent of the rotational speed, this differential equation is easy to solve. If either τ_t or τ_d depend on the large gear's speed ω_t, the differential equation becomes more complex.

The equation applys to most multi-gear systems and represent the key principles underlying the true function of a transmission system. They allow one to understand how energy is transmitted through the gears.

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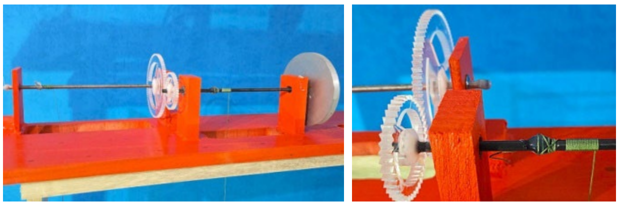

Figure 5. Gearbox Comprising Two Meshing Gears

An interesting instrument is designed to demonstrate the relationship between the torque applied to a large gear and that on a smaller gear while the gears rotate at a constant speed. First, we set up a two-gear gearbox, as shown in Figure 5.

When a lead weight is suspended from the thread wound around the large gear shaft, it applies a torque to the large gear.

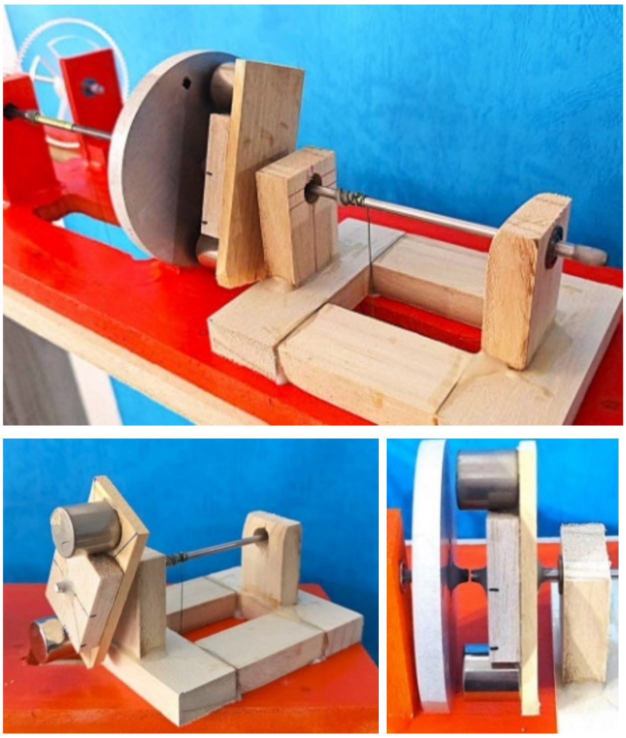

Figure 6. Instrument for Applying and Simultaneously Measuring the Reverse Torque on the Small Gear

An aluminum disk is fixed to the other end of the small gear's shaft, as shown in Figrue 6. A specialized experimental device was also created for this experiment. The device consists of two magnets fixed to a crank on an axis, as shown in Figure 6. The magnets can be positioned close to the aluminum disk, which rotates together with the small gear. The torque caused by the magnetic damping force acting on the small gear depends on its rotational speed. A weight on a scale is suspended from the thread wound around the shaft of the two magnets, and the scale reflects the variation in weight caused by the torque on the device's axis. If the axes of both the small gear and the device are aligned, the torque on the device's axis should theoretically and experimentally equal the torque on the small gear. Therefore, the torque on the small gear can be determined from the torque measured by the scale on the experimental device.

The experimental results show that, while the gearbox is rotating, the magnitude of the driving torque on the large gear is twice that of the drag torque on the small gear, which agrees with the theoretical calculation.

Figure 7. Torque on the large gear is applied via the weight suspended from the thread wound around its axis, while the torque on the small gear is measured using the special device.

4. The Equation of Motion for a Wind Power System

This article clarifies two commonly misunderstood principles in wind power systems: the torque conditions required for a gearbox to operate, and the unique role of magnetic damping in producing electricity. Wind exerts a torque on the turbine, which is transmitted through the gearbox to drive the generator. However, rotation can occur only when the driving torque on the large gear exceeds N times the reverse drag torque on the small gear—where N is the gear ratio and the

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drag torque is caused by magnetic damping during electricity generation. An increase in rotational speed alone is not enough.

Once the generator begins to rotate, electricity is produced not by the external driving force but solely by the magnetic damping force that appears when current flows through the coil. This magnetic damping force converts mechanical kinetic energy into electrical energy. Our experimental instruments clearly demonstrate these principles.

By understanding these two key ideas—torque transmission and magnetic-damping energy conversion—we can write down the equation of motion for the entire wind power system and clearly see how wind energy is transferred step by step and ultimately transformed into electrical power according to the work–energy theorem.

5. Acknowledgements

I sincerely thank the students and colleagues in the Asia-Pacific region for their feedback and inspiration in developing the teaching materials and experiments. I am also grateful to the educators and experts who shared insights on wind power systems, generation, and transmission, which greatly enhanced this work. Finally, I thank my family and friends for their continuous support and encouragement.

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The *COQC* and the Experimental Sciences

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Abstract. In this workshop, a series of experiments are presented with the goal of surprising students while applying the scientific method. Through hands-on experimentation across different scientific fields, each activity is designed to illustrate a scientific concept from the curriculum that children are expected to learn.

The main aim of the authors is to encourage science teachers to use these educational practices as pedagogical tools to consolidate and integrate the knowledge that students receive in theoretical classes.

Keywords. Chemical Experiments, Geology Experiments, Physics Experiments, Integrated Experimental Science.

1. Introduction

In this workshop, a series of experiments are presented with the aim of surprising students while guiding them through the scientific method. Through hands-on activities spanning multiple scientific fields, each experiment is designed to illustrate a curriculum based scientific concept that children are expected to learn.

Motivation, learning and attention form the three pillars of effective experimentation [1]

In physics, students explor topics such as paper and gravity, magnetism, light and the rainbow, and density. In chemistry, they investigate acid–alkaline reactions using red cabbage, prepare solutions with tea, create emulsions with milk, and examine the properties of proteins, fats, and sugars. In geology, students investigate geodes (Hands-on Science 2024 [2]), and model or observe eclipses.

Across all activities, the use of simple and inexpensive materials helps make science accessible, engaging, and enjoyable. These hands-on practices serve as valuable pedagogical tools that encourage teachers to reinforce and integrate the theoretical knowledge taught in the classroom.

The Official College of Catalan Chemists [3] (COQC, using the Catalan acronym) has designed a set of experiments using common, easily accessible materials suitable for both primary and secondary schools.

These activities are planned to integrate science into broader thematic units that connect multiple subjects. For example, when working on the theme of “Weather,” teachers can incorporate science (weather patterns), literacy (books about storms), and art (creating weather charts).

Similarly, a unit on “Acid-alkaline” can include science (acid-alkaline reactions and indicators), literacy (books on acidity and basicity), and art (students creating their own paintings).

In addition, the COQC collaborates with teachers and encourages students to keep science journals, supported by COQC’s own educational resources such as *News for Chemists* (NPQ) [4], where students document observations, questions, and experimental results. This practice promotes scientific thinking, reflection, and meaningful engagement with the scientific method.

The authors’ main objective is to encourage science teachers to incorporate these educational practices as pedagogical tools that help students consolidate and integrate the knowledge acquired in theoretical lessons. A further goal is to inspire students to pursue future studies or careers in the sciences.

Moreover, the authors include and describe several experiments that can be carried out anywhere and at any time. By implementing these hands-on activities and interdisciplinary strategies, educators can create a rich learning environment that nurtures curiosity and a love for science in young learners. Early exposure to scientific practices not only deepens their understanding of the subject but also equips

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them with critical thinking and problem-solving skills that will benefit them throughout their education.

2. Experiments

Experiments are a fundamental component of science education. A well-chosen experiment can convey concepts that students might struggle to understand through verbal explanation alone. Moreover, experiments enliven the learning process, helping maintain students' attention and, perhaps most important, motivate them to explore scientific problems autonomously.

2.1. Physics Experiments

Figure 1

This example shows our senses can deceive us. Although the two figures appear to be different in height, they are in fact the same size. This demonstrates the importance of taking measurements in scientific, and even everyday physical, observations, rather than relying solely on perception.

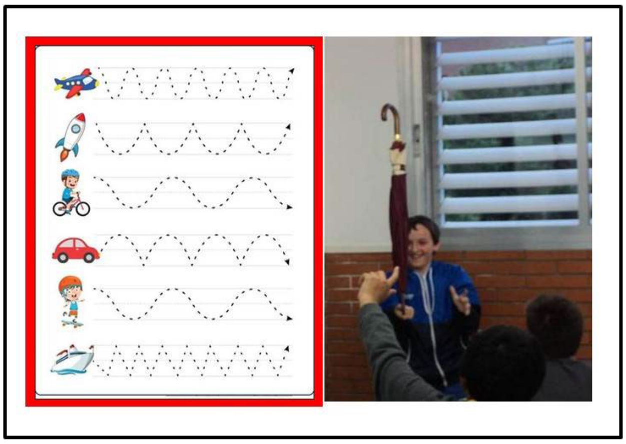

Figure 2

In this activity, students explore how magnets interact and discover the principles behind stable, unstable, and neutral equilibrium.

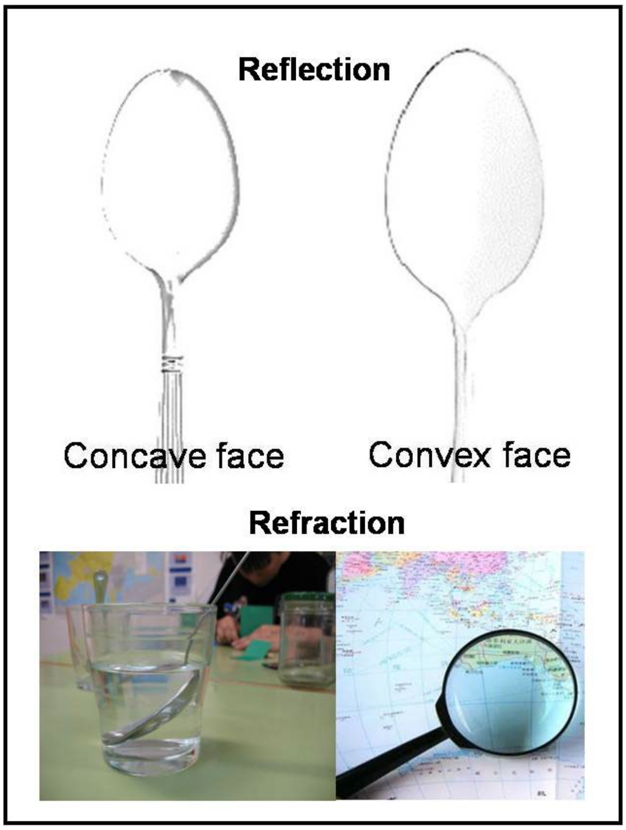

Figure 3. Reflection and Refraction

A student's face is reflected on both sides of a spoon, on the concave side and on the convex side, illustrating the principles of Reflection. In another activity, placing a spoon in water makes it appear "broken," and using a magnifying glass changes the apparent size of objects. Both effects demonstrate Refraction, the bending of light as it passes through different materials.

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Figure 4

Galileo's thermometer, one of the earliest devices for measuring temperature, operates based on the differences in density between several liquids contained within the instrument. Naturally, it can also be used to study the density of liquids and their properties

In this activity, children work with white light and colors, using the provided worksheet to record their observations and complete related tasks.

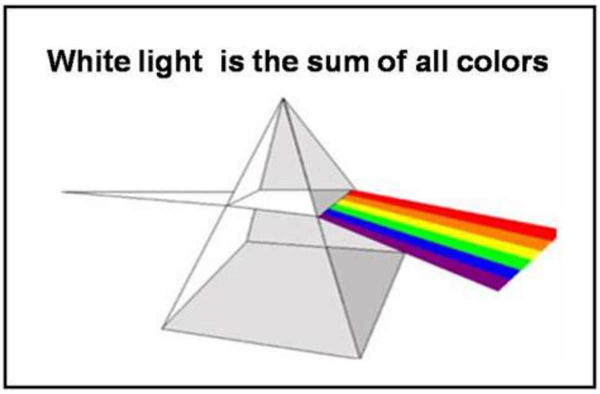
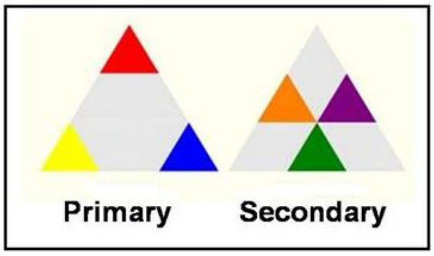


Figure 5. Light



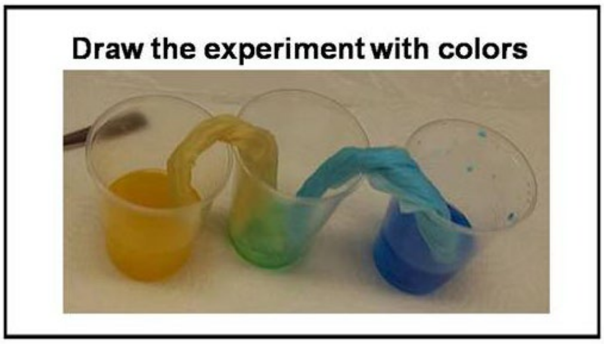


Figure 6. Colors

2.2. Chemistry and Biochemistry Experiments

Experiments are an essential part of teaching chemistry and biochemistry [5].

To introduce the concept of density, students are asked which of three liquids, syrup, water, and oil, has the highest density. Many students confidently answer that oil is the densest. The teacher then asks wheter a one euro coin has a higher density than oil o water. Students typically reply, "Yes, the coin has a higher density"

Next, the teacher asks wheter the coin floats in water. Students usually predict that it does not float. When the coin is placed in the water, it sinks to the bottom, confirming that its density is indeed greater than that of water.

The teacher then asks again what would happen if the coin were placed in the glass. Students respond that the coin would sink to the bottom. The teacher follows up by asking why this happens. Students usually reason that it is because the coin has a higher density.

The teacher confirms this explanation, explaining that objects with higher density will sink below those with lower density. This principle also explains why oil floats on top of water: water has a higher density than oil, so the oil remains on the surface.

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Figure 7

When syrup, water and oil are poured into a glass, they form distinct layers according to their densities: syrup at the bottom, water in the middle, and oil on top, as it is the least dense. Objects placed in the glass will float or sink depending on whether their density is lower or higher than that of the liquid in each layer.

A similar experiment in physics [6] investigated whether an egg would float or sink in water, demonstrating the same principle of density.

We are surrounded by chemistry, not in the negative sense that the word sometimes implies, but in the everyday reality that everything around us involves chemical processes. Many common substances can be classified as acids or bases: for example, lemon juice is acidic, while bleach is alkaline.

Red cabbage, a substance commonly found in the kitchen, can be used to test whether other substances are acidic or alkaline [7].

In school laboratories or even at home, a simple pH indicator can be prepared by boiling red cabbage leaves, alloving students to explore the acidity or basicity of different substances.

Figure 8. After boiling the leaves, the red cabbage solution is obtained by filtration

Substances are considered acidic if their pH is below 7, and alkaline if their pH is above 7. Indicators are chemicals that change colour depending on the acidity or alkalinity of a solution, allowing us to determine whether a substance is acidic or alkaline.

Red cabbage gets its colour from compounds called anthocyanins in its leaves. By boiling the leaves in water, these compounds can be extracted to create a natural pH indicator. This solution can then be added to different substances to test their acidity or alkalinity.

Vinegar is an acid, acetic acid to be precise and turs a red color when tested with red Cabbage indicator. In contrast, sodium bicarbonate is alkaline and turns green color with the same indicator.

The kitchen provides a perfect example of chemistry in every day life: the food we prepare, how ingredients are combined, and the transformations caused by heat are all practical

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demonstrations of chemical processes. Students can explore the fascinating world of chemistry by stepping into the role of cooks.

Figure 9

Figure 10. Red cabbage as a pH indicator

Through these activities, participants will:

- Identify the processes food undergoes during cooking.
- Recognize and name different cooking techniques.
- Apply the scientific method and develop problem-solving skills.
- Understand that there are chemical reactions and physical processe in the kitchen that require heat and others that require cold.

After separating the white from the yolk of the egg, a little bit of red cabbage extract is mixed with the egg white.

A fried green egg which can be perfectly eaten.

Figure 11. Modified from [8]

Figure 12

Chlorophyll plays an important role in the

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absorption of light energy of the plant. Another experiment is useful for talking about chlorophyll.

In a mortar, we can extract the chlorophyll from spinach with 96º ethanol. Then, by paper chromatography, it can be easily detected. And, finally as a special experiment, we can see its color change when illuminated with UV.

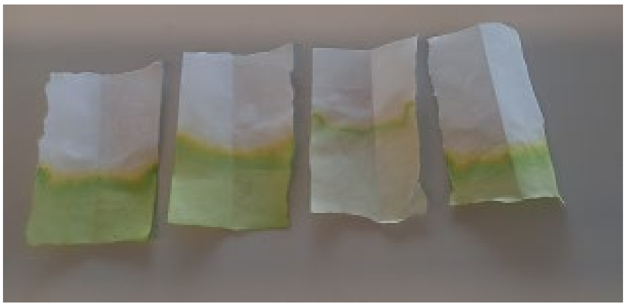

Figure 13

2.3. Geology and Astronomy Experiments

"How to make geodes and crystals?" [2]

This activity allows primary school students to grow their own crystals. Most crystals form through evaporation: for example, when water from a salt solution evaporates into the air, salt crystals are left behind.

"How to make geodes and crystals?" This activity was designed for elementary and primary schools students, particularly those under ten years old. Each experiment lasts seven to ten days, allowing young students to practice the scientific method [9], often without even realizing it, while observing the formation of crystals.knowing it.

"What are eclipses?"

An eclipse occurs when the Moon or Sun is partially or completely hidden from view. A solar eclipse happens when the sun disappears from view, either completely or partly, while the Moon is moving between the Sun and the Earth. A lunar eclipse occurs when the Moon passes into the Earth's shadow, causing it to appear darker [10].

On Friday the 14th, before sunrise, there will be a partial lunar eclipse (A in the Figure 15). Looking west, from 5:00am the Moon will begin to set, and as sunlight increases, the eclipse will become difficult to observe, so an early wake-up is necessary!

Figure 14. Pictures obtained from [2]

On Saturday the 29th between 11:00am and approximately 12:30pm, there will be a partial solar eclipse (B in the Figure 15), during which

12.8% of the Sun will be obscured by the Moon. It is important to remember that observing the Sun without proper eye protection is extremely dangerous [11].

Figure 15. Pictures: @francescpruneda @astro_emporda

Be careful!!! Viewing eclipses without special glasses can cause irreparable damage.

3. Conclusion

These experiments can be adapted according to the students' educational level. They can be performed using basic equipment and chemicals commonly found in a standard laboratory, making them ideal classroom demonstrations due to their safety, accessibility, visual appeal, and simplicity.

Science teachers recognize the value of practical experiments [5] as educational tools. By explaining experiments and guiding students through them, teachers help students strengthen their understanding of theoretical concepts while also building confidence in their scientific abilities [12, 13].

Through the implementation of these activities, the COQC has developed a comprehensive network of educational resources for science teachers, including experiment scripts and instructional videos [14].

Early exposure to science not only deepens students' understanding of the subject but also cultivates critical thinking and problem-solving skills that will benefit them throughout their education.

Finally, the COQC offers a wide collection of chemistry and science experiments suitable for all educational levels, from kindergarten and primary school to high school, which are available to anyone who requests them [3]

4. Acknowledgements

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Beach Cleaning Robotics Project: An Educational Environmental Initiative

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Abstract. This project details an innovative educational initiative, implemented within an Erasmus Programme, aimed at raising awareness and actively engaging secondary school students in coastal protection efforts through robotic technology. Situated in Elefsina, an industrial coastal city, the 3rd Gymnasium of Elefsina is keenly focused on addressing the severe challenges of marine pollution, which is often exacerbated by local industrial activities. The project successfully combined STEM and environmental education by empowering students to take practical action to protect the regional ecosystem. Students utilized robotic devices to explore and monitor the coastal zone, gaining firsthand insight into the effects of pollution, including industrial waste. Through educational robotics, small robots like Microbit Nehza and Lego EV3 were designed and programmed to effectively identify and collect litter from the beach or detect oil spills, giving students an active, hands-on role in promoting sustainable development. This fusion of programming complex robotic systems with real-world environmental stewardship demonstrated a highly effective model for fostering technological literacy and ecological responsibility among students

Keywords. STEM, Educational Robotics, Environmental Education.

1. Introduction

The increasing global challenge of marine pollution necessitates innovative educational strategies to engage future generations in environmental protection. The 3rd Gymnasium of Elefsina, located in an industrial coastal city, faces acute issues of coastal degradation and pollution from local industrial activities, making environmental stewardship a particularly relevant focus. To address this challenge, an innovative educational initiative was developed and implemented within an Erasmus Programme framework. This project strategically fused STEM education and environmental education to empower secondary school students with the technological skills and ecological awareness needed to take practical action. This paper outlines the design and implementation of this project, focusing on the use of educational robotics as a tool for both beach cleaning simulation and advanced environmental monitoring, specifically the simulation of oil spill detection. The methodology provides an effective model for fostering technological literacy and practical ecological responsibility

2. Methodology

The core methodological approach adopted in this study was hands-on and project-based, grounded in the principles of educational robotics and experiential learning. Students engaged in a comprehensive design cycle encompassing the stages of problem analysis, robotic platform selection, mechanical design, and advanced programming.

The pedagogical framework was structured around a series of interconnected phases, commencing with Contextualization and Problem Analysis. Initially, an educational session on marine pollution was conducted, aimed at fostering environmental awareness and situating the project within local ecological challenges of the Elefsina Gulf. The second phase involved an introduction to two primary educational robotics platforms, enabling participants to develop the necessary technical competencies. The third phase constituted the core practical component, during which students actively designed, constructed, and programmed robotic prototypes addressing the identified environmental issues.

2.1. Robotic Systems and Core Task

The students utilized two primary educational robotics platforms: the Microbit Nehza and Lego EV3. These small robotic devices were programmed to perform two main tasks that simulate real-world environmental response operations. The initial task involved the robots being designed and programmed to effectively identify and collect litter from a simulated beach environment. This required students to apply

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programming logic for navigation, obstacle avoidance, and simple manipulation (collection).

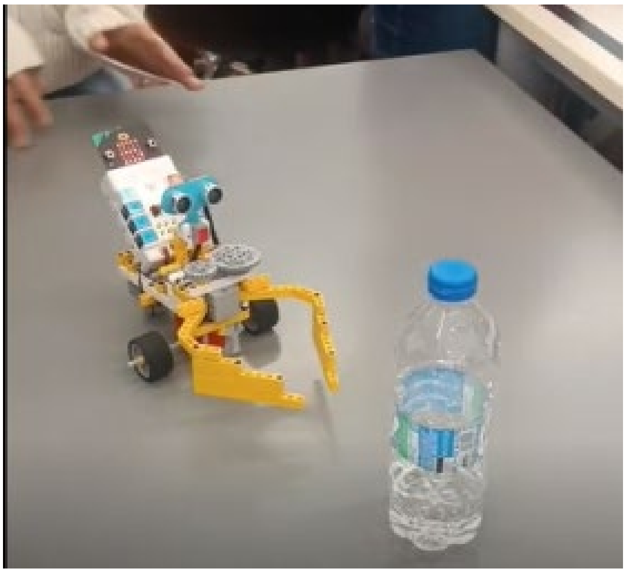

Figure 1.Gathering plastic bottles

2.2. Oil Spill Detection Simulation (Line-Following)

To introduce a more advanced concept of environmental monitoring at sea, the robotics activity was extended to include a line-following task. In this simulation, the robots were programmed to follow a black line on a light-colored surface, which is used to simulate the detection of oil spills in the sea. In a real-world application, an oil containment boom or the boundary of a detected oil slick often presents a distinct contrast that marine autonomous vehicles must follow to monitor the extent of the spill, contain it, or track its path. The line-following program provided students with an understanding of sensor-based navigation critical for autonomous environmental surveillance, such as tracking a pollution plume or a specific coastal perimeter.

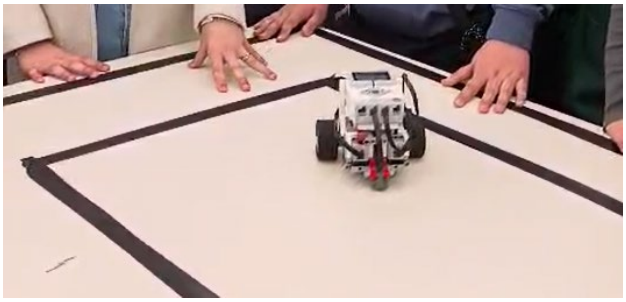

Figure 2.Detecting oil spills

3. Results and Discussion

The project yielded significant educational and environmental outcomes. By utilizing the robotic devices to explore and monitor the coastal zone, students gained direct, firsthand insight into the effects of pollution, including industrial waste. The necessity of programming the robots' detection and collection mechanisms fostered a deep understanding of complex robotic systems. The dual focus on litter collection and the oil spill line-following simulation provided a comprehensive perspective on both terrestrial and marine pollution challenges and response methods. The line-following challenge, in particular, demonstrated how abstract programming concepts can be applied to solve critical environmental problems, effectively simulating autonomous tracking and monitoring of an environmental hazard. Ultimately, the project served as a highly effective model for cultivating technological literacy and a strong sense of ecological responsibility among the participating students.

4. Conclusion

The Beach Cleaning Robotics Project successfully leveraged educational robotics platforms (Microbit Nehza and Lego EV3) to create a powerful and practical learning experience. The project’s success lies in its effective fusion of programming complex robotic systems with real-world environmental stewardship, which now includes the simulation of oil spill detection via line-following robotics. This hands-on initiative not only raised awareness of marine pollution but also equipped students with crucial STEM skills for promoting sustainable development.

7. Acknowledgements

The authors would like to thank the participating students, teachers, or their enthusiastic engagement, as well as to the Erasmus Programme for providing the funding and institutional framework that made this innovative educational initiative possible

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Social Network Analysis

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Abstract. This project applies graph theory and network analysis techniques to explore social networks using characters from the well-known fantasy book series *A Song of Ice and Fire*, which also inspired the popular television adaptation *Game of Thrones*. An undirected, weighted graph is constructed from a publicly available CSV dataset of character interactions. The analysis is conducted in R using the igraph package. Key network metrics—including degree, weighted degree, clustering coefficient, edge density, and network diameter—are used to examine structural and centrality properties. A subgraph focusing on highly connected characters reveals a denser and more interconnected network core. Centrality measures such as closeness and betweenness identify influential characters, with Jon Snow emerging as a key intermediary node. Finally, the PageRank algorithm highlights the most prominent figures, providing insights into character roles and relationships within the narrative structure.

Keywords. Network Analysis, Graph Theory, Social Network, Centrality Measures, PageRank, A Song of Ice and Fire, R Programming, igraph.

1. Introduction

The objective of this project is to model and analyze the character network of A Song of Ice and Fire using graph-based techniques. By transforming character interaction data into an undirected, weighted graph, we aim to uncover structural properties of the network and assess the relative importance of key characters. Through metrics such as centrality scores, clustering coefficients, and PageRank, the analysis provides insights into the roles, influence, and interconnectedness of individuals within the narrative. All analysis is conducted using R and the igraph package.

The dataset used in this project was sourced from a publicly available repository on GitHub, containing character interaction data from *A Song of Ice and Fire* by George R. R. Martin.

The dataset contains 796 unique characters (nodes) and 2,823 interactions (edges) in the full network. The network is undirected and weighted, meaning connections are mutual and have different interaction frequencies. The variables of the dataset include:

Table 1. Variable Description

Variable	Description
Source	Name of the first character in the interaction.
Target	Name of the second character.
Weight	A numerical value indicating the strength or frequency of the interaction.
Type	Type of graph (e.g., “Undirected”).
ID	Unique identifier for each edge.

2. Graph Construction

The dataset was imported into R, and an undirected, weighted graph was created using the igraph package. The columns Source, Target, and Weight were used to define the nodes and edges of the graph. The resulting graph includes 796 unique characters that became the nodes of the graph and 2,823 interactions that became the edges. The edge weights represent the frequency or strength of interaction between character pairs.

3. Network Properties

To explore the structure of the character network, various network-level metrics were computed using the igraph package. These metrics help describe how characters are connected and how information or influence might flow through the network.

Degree centrality identifies the characters with the highest number of direct connections in the network. Tyrion Lannister and Jon Snow rank highest, indicating they are among the most socially connected figures in the narrative.

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The top-10 characters of the network as far as their degree is concerned

Table 2. Metrics

Metric	Value
The number of vertices of the graph	796
The number of edges of the graph	2823
The diameter of the graph	9
The number of triangles in the graph	4544
The number of edges having weight>13	557

Table 3. Top 10 Degree Rank

Rank	Character	Degree
1	Tyrion annister	122
2	Jon Snow	114
3	Jaime Lannister	101
4	Cercei Lannister	97
5	Stannis Baratheon	89
6	Arya Stark	84
7	Catelyn Stark	75
8	Sansa Stark	75
9	Eddard Stark	74
10	Robb Stark	74

4. Subgraph

4.1. Full graph plot

The full network was visualized using the Fruchterman-Reingold layout for improved readability. Nodes are colored uniformly, and edge thickness is scaled according to interaction weight using a normalized formula. This allows visually distinguishing stronger character relationships from weaker ones. The result reveals a densely connected core with many peripheral characters connected by few interactions.

The full graph shows the entire character network from *A Song of Ice and Fire*, containing 796 nodes and 2,823 edges. While it provides a complete view, the visualization is dense and less interpretable due to the presence of many low-degree nodes and weakly connected characters. The graph's sparsity makes it harder to distinguish central structures.

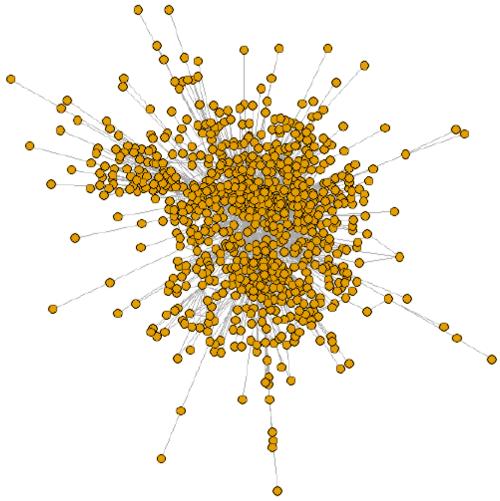

Figure 3. Full graph Plot

4.2. Subgraph plot

To better understand the core structure of the network, a subgraph was created consisting only of characters who have at least 10 connections in the full network (i.e., degree ≥ 10). This filters out minor characters and focuses the analysis on the most connected individuals.

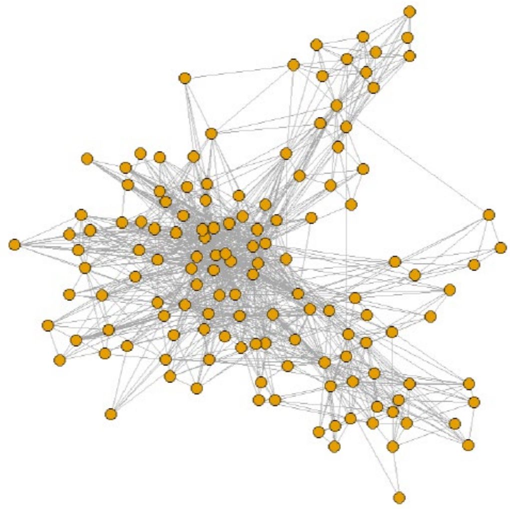

Figure 4. Subgraph Plot

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The subgraph includes only characters with at least 10 connections, significantly reducing visual clutter and highlighting the narrative core of the network. The structure is much denser, with clearly visible clusters of characters. This filtered view emphasizes key characters and interactions, making the underlying community structure more apparent.

4.3. Edge density

The edge density was computed which is defined as the proportion of actual edges to the total number of possible edges.

Table 4. Edge Density

Graph	Edge Density
Full Graph	0.0089
Subgraph(degree>10)	0.01170

Edge density measures the proportion of actual connections relative to all possible ones in a graph. The value ranges between 0 and 1. The edge density of the full graph is approximately 0.0089, indicating a sparse network with many characters only loosely connected. The subgraph, which includes only the most connected characters because of the applied condition that degree > 10, has a much higher density of 0.1170. This shows that characters with many connections tend to form a dense interaction core, with stronger and more frequent connections among them.

4.4. Centrality

Centrality measures help identify the most influential or structurally important nodes in a network. In this section, we focus on two key measures:

- Closeness centrality: how quickly a node can reach all other nodes
- Betweenness centrality: how often a node lies on the shortest path between others.

Table 5 presents the top-15 characters for each measure

Betweenness centrality reveals key characters that bridge different parts of the graph. Jon Snow, Theon Greyjoy, Jaime Lannister are the top 3 of this measure, showing they are the most critical connector in the structure.

4.5. Jon Snow's Centrality Measures

Jon Snow's centrality scores emphasize his importance in the network:

- 10th in closeness centrality: He is well-connected and reachable by others, although not in the top spots.
- 1st in betweenness centrality: He is the most influential bridge, indicating a central role in connecting otherwise separate parts of the graph.

Table 5. Betweenness Centrality

Rank	Character	Closeness
1	Jon Snow	0.13211964
2	Theon Greyjoy	0.12326573
3	Jaime Lannister	0.11677631
4	Daenerys Targaryen	0.09419228
5	Stannis Baratheon	0.09291440
6	Robert Baratheon	0.09252286
7	Tyrion Lannister	0.09162375
8	Cersei Lannister	0.07734002
9	Tywin Lannister	0.06358359
10	Robb Stark	0.06295788
11	Eddard Stark	0.05562270
12	Sansa Stark	0.05042041
13	Brienne of Tarth	0.04947298
14	Arya Stark	0.06132325
15	Barristan Selmy	0.05630053

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5. Ranking and Visualization

In this final step the PageRank algorithm was used to rank the characters regarding their relative importance in the network. PageRank considers both the number and quality of connections because it is considering how important the nodes neighbors are.

6. Conclusions and Discussion

This project explored the structure and dynamics of the A Song of Ice and Fire character network using graph theory and social network analysis techniques. By constructing an undirected, weighted graph from interaction data, a wide range of network metrics were computed to assess character prominence, connectivity, and structural roles.

The results highlight Jon Snow as a critical figure, consistently ranking at or near the top across multiple centrality measures. His top position in betweenness centrality and PageRank reflects his role as a connector between different groups and a central point of narrative influence. Interestingly, his closeness centrality was lower relative to others, indicating that while he connects major narrative arcs, he is not always directly accessible to every character.

Other prominent characters such as Tyrion Lannister, Cersei Lannister, and Daenerys Targaryen also ranked highly across various metrics, confirming their central roles in the story's social fabric. The high number of triangles and moderate global clustering coefficient suggest the presence of tightly knit groups or cliques, while the sparse overall edge density points to a broad and uneven distribution of interactions.

The use of a filtered subgraph containing only characters with a high degree provided a clearer view of the core narrative, revealing a denser and more cohesive structure. Visualizations supported these findings, allowing the central characters to stand out based on PageRank scaled node sizes.

Overall, this analysis demonstrates how graph-based approaches can be applied to literary data to expose narrative dynamics, uncover hidden structures, and quantitatively assess character importance. These findings not only align with narrative expectations but also offer a deeper perspective on how relationships shape the unfolding of complex stories.

7. Acknowledgements

The writer wants to give an acknowledgment to Dr. Aikaterini Papakonstantinopoulou professor in Athens University of Business and Economics for her guidance and support.

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Ethical Use of Artificial Intelligence in Higher Education in Ukraine

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Abstract. The rapid adoption of artificial intelligence (AI) in higher education has intensified ethical challenges related to academic integrity, data protection, fairness, and governance. In Ukraine, these issues are exacerbated by wartime disruption, unequal access to digital infrastructure, and increased reliance on online learning for institutional resilience. This paper examines ethical risks and opportunities of AI implementation in Ukrainian universities through a literature-based analysis and three guiding research questions. The study highlights integrity risks, algorithmic bias, and the need for transparent governance models aligned with EU and UNESCO guidelines.

Keywords. Artificial Intelligence, Ethics, Higher Education, Academic Integrity, Ukraine, Wartime Digitalization.

1. Introduction

The widespread integration of artificial intelligence across global education systems has launched a new era of technologically supported teaching, learning, and assessment. Universities increasingly depend on automated recommendation systems, generative AI tools, adaptive learning platforms, and algorithmic evaluation methods. While these technologies may enhance efficiency and support large-scale digital transformation, they inevitably raise ethical concerns regarding transparency, fairness, accountability, and human agency [10; 12].

For Ukraine, these challenges are uniquely shaped by the unprecedented pressures of the ongoing full-scale Russian invasion. With disrupted infrastructure, mass internal displacement, psychological stress among students and educators, and widespread reliance on remote and hybrid learning, AI tools have become not only pedagogical instruments but mechanisms for continuity, safety, and emotional resilience [6]. Thus, ensuring the ethical and responsible use of artificial intelligence is both a strategic necessity and a humanitarian imperative.

The purpose of this article is to systematize international and Ukrainian approaches to the ethical use of artificial intelligence in higher education and to examine how wartime conditions transform and intensify the associated challenges. The article addresses three key research questions concerning academic integrity, equity of access, and effective governance models for AI implementation.

2. Ethical Challenges of AI in Higher Education: Literature Review and Research Problem

Global literature highlights broad ethical issues of AI in education: opacity of algorithmic systems, bias in model training, threats to academic integrity through generative AI, and insufficient governance frameworks [8; 9]. In technologically stable environments these concerns are considerable; in crisis contexts such as Ukraine, they intensify.

Ukrainian HEIs have undergone a profound digital shift since 2022, relying on online platforms for emergency communication, learning continuity, and psychological support networks. Many universities operate under constant threat of missile attacks and electricity shortages, which affect monitoring, assessment integrity, and digital access [5; 6]. This unprecedented dependency on digital tools amplifies the ethical responsibility to implement AI systems thoughtfully, transparently, and empathetically.

Based on a synthesis of current research, this study formulates three guiding research questions:

RQ1. How do AI-driven tools affect academic integrity and assessment fairness in Ukrainian universities during wartime digitalization?

Generative AI technologies (e.g., large language models) challenge existing academic integrity frameworks by producing text, code, and problem-solving outputs that evade conventional plagiarism detection [1; 4]. International scholars warn that academic honesty policies must evolve beyond punitive enforcement toward AI literacy and compassionate assessment design [9].

In Ukraine, wartime realities increase students' reliance on AI as a coping mechanism. Students studying under air raid alarms, displacement, trauma, or unstable internet may use AI tools not with malicious intent but to survive academic overload. Thus, ethical AI use must account for the lived experiences of young people learning during war. Ukrainian researchers increasingly emphasize the need for humane, flexible, and transparent assessment policies suited to emergency digital education.

RQ2. What risks of algorithmic bias and exclusion emerge from AI-based systems in a country affected by war and displacement?

Algorithmic bias is a critical issue in AI systems globally [8]. In Ukraine, this problem is compounded by war-driven inequalities:

- internally displaced students with inconsistent access to connectivity,
- students with disabilities or injuries resulting from hostilities,
- unequal technological capacity across universities based on geographic location,
- fragmented data due to disrupted educational trajectories.

Due to shelling, Ukraine's educational infrastructure has suffered significant losses. As of 14 November 2024, four universities and seven colleges have been completely destroyed, while an additional 117 universities and 162 colleges have sustained various degrees of damage [13]. The regions most affected in terms of university damage are presented in Table 1.

AI systems trained on pre-war or foreign datasets may misinterpret learning gaps caused by air raids, power outages, or evacuations as indicators of poor performance. Digital inequality research confirms that wartime Ukraine experiences significant variation in access to devices and platforms [5]. To prevent discrimination, AI systems must be crisis-sensitive, context-aware, and designed with humanitarian considerations – consistent with UNESCO's Recommendation on the Ethics of AI [11].

Table 1. Number of Universities Damaged by Shelling in Ukraine (as of 14 November 2024)

Region / City	Number
Kharkiv	32
Odesa	14
Kherson	14
Kyiv	10
Dnipropetrovsk	7
Zhytomyr	5
Zaporizhzhia	5
Mykolaiv	5
Chernihiv	5

RQ3. How can Ukrainian universities integrate human-centered AI governance aligned with EU and UNESCO ethical frameworks during wartime transformation?

International frameworks, including the EU Ethics Guidelines for Trustworthy AI [2], UNESCO AI Ethics Recommendation [11], and ISO/IEC 42001 AI Management System Standard [3] – emphasize transparency, accountability, fairness, data minimization, and human oversight.

European research shows that universities can benefit from:

- institution-level AI governance committees [10],
- AI literacy training for educators and students [7],
- algorithmic impact assessments,
- clear disclosure of AI usage in syllabi and course policies,
- co-participatory rulemaking involving the academic community.

Ukrainian case studies demonstrate promising practices but remain fragmented: Lviv Polytechnic integrates AI literacy modules; Kyiv-Mohyla Academy updates integrity policies; Sumy State University reinforces data security in response to war-related cyber risks. Yet achieving system-wide alignment with EU and UNESCO standards requires coordinated national policies, funding, and wartime institutional resilience strategies.

3. Conclusion

The ethical use of artificial intelligence in Ukrainian higher education requires a holistic and crisis-sensitive approach. Wartime conditions amplify integrity risks, deepen social inequalities, and test the resilience of digital infrastructures. AI adoption must therefore be grounded in transparency, fairness, accessibility, and human-centered governance. Ukrainian universities need institutional guidelines aligned with EU and UNESCO frameworks, trauma-aware pedagogical strategies, and systematic AI literacy development. These measures will support both responsible innovation and the long-term strengthening of Ukraine's educational and societal resilience.

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Women in Chemistry: A Short History

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Abstract. Since the beginning of time, women had often denied access to education and their contributions in the chemistry and scientific disciplines were frequently not recognized. Now something is changing. It is essential to recognize the many women who have practiced and advanced chemistry from antiquity such as Peseshet, Tapputi, and Mary the Prophetess to the modern chemists such as Marie Curie, Al Fayyad, Dorothy Crowfoot Hodgkin, Carolyn Bertozzi, and many others. Furthermore, it is equally important to highlight the figure of Rosa Sensat, one of Catalonia's most overlooked pioneers. Our society needs to know more about the past relationship between chemistry and women, especially for our young girl students, our future scientists. This will be indispensable to increase gender equality in a few years.

Keywords. Ancient and Modern Chemistry, History of Chemistry, Rosa Sensat, Women Contributions.and Recognition.

1. Introduction

Over the past two decades, historians have increasingly examined women's roles in the development of chemistry. However, these studies often remain confined to higher education, circulating mainly among women who are already engaged in scientific fields. As a result, this knowledge rarely reaches young girls at earlier stages of their education—precisely where representation can have the greatest impact.

Throughout history, women were frequently denied access to formal education, and their contributions to chemistry and other scientific disciplines went unrecognized. Yet change is underway.

It is essential to recognize the many women who have practiced and advanced chemistry from antiquity to the present day. Important women such as Peseshet, Tapputi, and Mary the Prophetess laid early foundations through their knowledge of medicinal preparations, distillation, and proto-chemical techniques. In later centuries, women like Marie Meurdrac, Anne M. Pierrette Paulze, Marie Curie, and Rosalind Franklin expanded the scope of chemical and scientific understanding, often overcoming significant social and institutional barriers.

Today, contemporary women chemists such as Al Fayyad, Dorothy Crowfoot Hodgkin, Carolyn Bertozzi, and many others continue to drive innovation in fields ranging from crystallography to bioorthogonal chemistry. Their work forms part of a long, often under-recognized continuum of female contributions to scientific progress. Learning on the historical and contemporary relationship between women and chemistry is essential to understand women importance in this field.

Furthermore, it is equally important to highlight the figure of Rosa Sensat, one of Catalan woman most overlooked pioneers. Although not a laboratory chemist, her transformative work in education, promoting scientific literacy, hands-on learning, and equal access for girls. Rosa work reflects the contributions of many women whose influence on science has been indirect yet profound. Her life stands as a reminder that behind every visible scientific achievement, there are educators, thinkers, and organizers whose impact deserves recognition across all countries.

Showing and sharing all these stories with young students, especially girls, is a powerful step toward inspiring future scientists and advancing gender equality in the years to come.

2. Ancient women as chemists

Peseshet: The pioneer

Peseshet lived in Ancient Egypt around 2400 BC during Egypt Fourth Dynasty (though a date in the Fifth Dynasty is also possible). She practiced at the time of the building of the great pyramids in Egypt.

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Lady Peseshet is the first known woman physician & practiced in the 4th dynasty of Ancient Egypt [1, 2]. She is the earliest known female physician in history, the first female physician in Africa and likely the first known in history. Development of medicines involves many complicated chemistry processes; there is a significant relationship between chemistry and medicine.

Figure 1. Picture from #BlackHistoryMonth

She practiced medicine. Peseshet served as the director of a medical group of nearly one hundred practitioners, earning titles such as “Supervisor of Female Healers” and “Director of the Priestesses,” which highlight her leadership and influence within Egyptian medical practice.

Tapputi Belatekallim: A Perfumer of the Palace

Tapputi Belatekallim, a perfumer who worked in the royal palace of Babylon, ("Belatekallim" refers to a female overseer of a palace) is the first recorded practitioner of chemistry [1, 2]. In her time, perfume production was closely linked to religious rituals, and those who mastered the art held significant power and social prestige.

She refined stills, used to distill substances and developed some of the earliest known distillation methods. Her work represents one of the very first documented examples of experimental chemistry.

Knowledge of Tapputi’s work comes from a cuneiform tablet that describes her method for producing perfumes. She worked with a range of natural ingredients, flowers, oils, calamus (a type of aromatic reed), cyperus (a fragrant plant), myrrh (a tree resin), and balsam (another aromatic resin). These ingredients, mixed with water or other solvents, create an initial combination. This mixture was distilled multiple times and a more refined product were obtain. Tapputi distillation process, heating a liquid to form vapor and then cooling that vapor to collect a purified substance, is one of the earliest known examples in history of chemical procedure. Her process also incorporated filtration, another key chemical method, to remove impurities from the mixture. Figure shows one of the scent formulas written in Akkadian on clay tablets by Tapputi, the world's first female perfumer and the first female chemist in Mesopotamia.

Figure 2

The use of a still in ancient Babylon is remarkable, as it demonstrates an early understanding of fundamental chemical principles. Tapputi’s ability to manipulate substances through controlled heating and cooling reflects a sophisticated grasp of the transformation between liquid and vapor, concepts central to both chemistry and physics. By adding water or other solvents, then repeatedly distilling and filtering the mixture, she was able to refine her perfumes to achieve greater purity and fragrance. Distillation remains a fundamental technique in modern chemistry, essential in fields such as perfumery, pharmaceuticals, essential oil extraction, and alcohol production.

Mary the Prophetess: The mother of alchemy

Mary lived in Alexandria between the 1st and 3rd centuries CE. Unfortunately, almost all of her writings were lost, possibly during the destruction of the Library of Alexandria in 273 CE. References to her work were in later Greek and Arabic alchemical texts.

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She invented the kerotakis, with this device; she obtained essences extracted from plants to produce perfumes, pigments and early chemical preparations. Mary the Prophetess related, sometimes directly and sometimes indirectly, with several early alchemical instruments:

- the **tribikos**
- the **kerotakis**
- the **bain-marie**

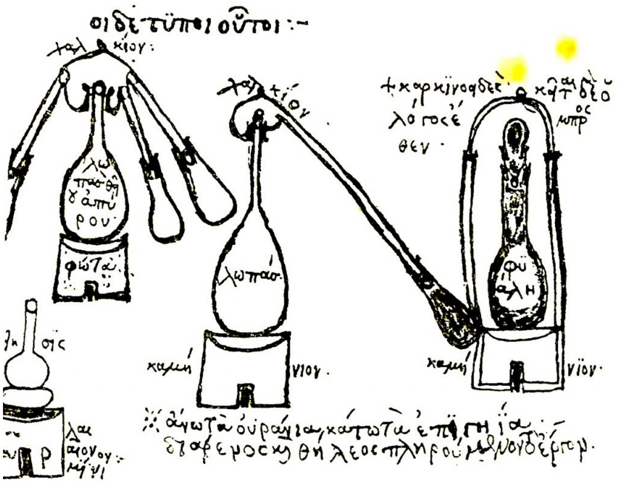

Figure 3. Distillation equipment of Zosimos from the 15th century Byzantine Greek Manuscript *Codex Parisinus 2327* as reproduced by Marcelin Berthelot in 1887

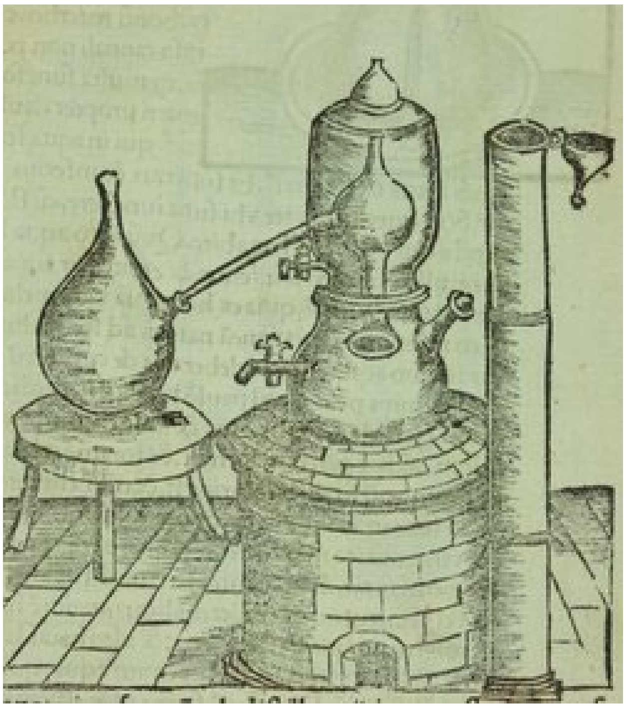

Figure 4. An alchemical *balneum Mariae*, or Maria's bath, from *Coelum philosophorum*, Philip Ulstad, 1528, Science History Institute

According to passages preserved by Zosimos, Mary advised that:

- the tubes should be made of copper or bronze,
- the metal should be roughly the thickness of a frying pan,
- the joints between the tubes and the still-head should be sealed with flour paste.

This technique is especially useful in chemical processes that require slow, controlled, and uniform heating preventing overheating, burning, or rapid temperature changes. Its importance was recognized throughout the medieval alchemical tradition. Arnold of Villanova introduced the term bain-marie in the 14th century.

Today, the term is still widely used in both laboratory settings and cooking, where a double boiler ensures delicate materials, such as extracts, emulsions, sauces, or chocolate, are heated safely and evenly.

3. Early women as chemists

Moving on to slightly more modern times [3], the most important (woman) chemists were:

3.1. Before the eighteenth century

Isabella Cortese an Italian alchemist who wrote “The Secrets of Lady Isabella Cortese”. In it were medical and cosmetic remedies, advice for how to run a household and discussion of how to turn metal into gold, she introduced alchemy to a wider readership. She developed a variety of facial cosmetics, alchemical transformations and medical remedies and other contributions to science during the 16th century.

Marie Meurdrac (1610-1680) a Frech chemist who wrote a book on chemistry for women, *La Chymie Charitable et Facile, en Faveur des Dames* [Easy Chemistry for Women] she was the first woman to publish a book on early chemistry. Meurdrac was self-taught and had her own laboratory where she experimented on remedies and cosmetics.

3.2. Eighteenth and nineteenth centuries

Elizabeth Fulhame (1759-1810) was an early British chemist who invented the concept

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of catalysis and discovered the photoreduction. She was described as 'the first solo woman researcher of modern chemistry'.

Marie-Anne Paulze Lavoisier (1758-1836). Married chemist Antoine Lavoisier and received traning in chemistry. She worked with Lavoisier editing and drewing his methods and experiments so they could be understood.

Jane Marcet (1769–1858) was an English innovative writer of popular, explanatory science books. She was married in 1799 to Alexander John Gaspard Marcet, Alexander was strongly interested in chemistry, and became a lecturer at Guy's Hospital in London and a Fellow of the Royal Society. When Jane became interested in learning more about chemistry, they conducted experiments together in a home laboratory, discussing the scientific principles involved. She wrote a book “Conversations in Chemistry”. It consisted of 26 lessons or “conversations” between “Mrs. B.”, who is teaching two young girls, Emily and Caroline. Emily asks smart questions, whereas Caroline is very critical and more interested in explosions than in basic science.

4. Women as chemists

Perhaps the most famous female chemist is Maria Skłodowska, she was awarded two Nobel Prizes in Chemistry for her extraordinary dedication and groundbreaking discoveries in chemistry, radioactivity, and the study of radioactive elements.

However, besides Marie Curie, there are other female in Chemistry who lived in the twentieth and twenty-first centuries [4].

4.1. Women and the periodic table

Figure 5 shows the six women who actively participated in the discovery of some chemical elements [5].

In recognition of Marie Curie contributions, the element with atomic number 96, synthesized in 1944, was named curium (Cm) in honor of both Marie Curie and her husband, Pierre Curie. Together, they were renowned for their discovery of radium and their pioneering work that laid the foundations of modern nuclear science.

Lise Meitner (1878-1968) her research led to the discovery of uranium fission. She and Otto Hanh were the first to isolate the isotope protactinium-231. In 1944 Hahn received the Nobel Prize for Chemistry for discovering nuclear fission and, some have argued that Meitner merited a share of the award. The chemical element with atomic number 109, named meitnerium (Mt) was later named in her honour.

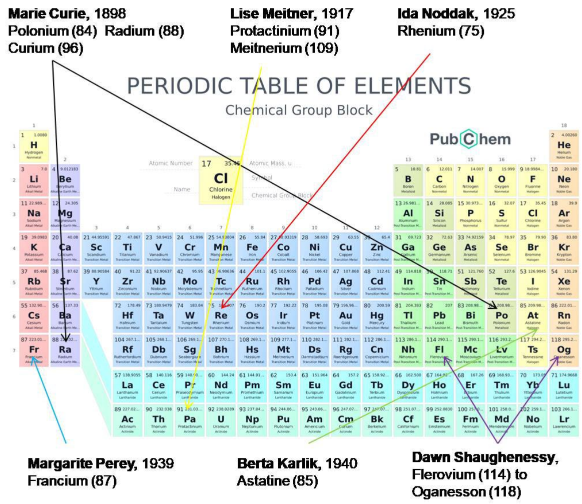

Figure 5

Ida Noddack (1896-1978) was a German chemist who codiscovered the chemical element, with atomic number 75, named rhenium (Re) and who first proposed the idea of nuclear fission.

Marguerite Perey (1909-1975) was a French physicist and a student of Marie Curie. In 1939, Perey discovered the element, with atomic number 87, named francium (Fr) by purifying samples of lanthanum that contained actinium.

Berta Karlik (1904-1990) was an Austrian physicist. She discovered that the chemical element, with atomic number 85, named astatine (At) is a product of natural decay processes.

Dawn A. Shaughnessy is an American radio-chemist and principal investigator of the heavy element group at the Lawrence Livermore National Laboratory. She was involved in the discovery of five superheavy elements with atomic number, 114 named Flerovium (Fl), 115 named Moscovium (Mc), 116 named Livermorium (Lv), 117 named Tennessine (Ts) and 118 named Oganesson (Og).

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4.2. Women and the Nobel Prize

Eight women have won the Nobel Prize in Chemistry for his outstanding contributions [6]: Marie Curie was awarded in 1911 in recognition of his service in the advancement of chemistry by discovering the elements radium and polonium, for the purification of radio which has allowed the study of the nature of the compounds of this remarkable element (1 in Figure 6). Irène Joliot-Curie was awarded in 1935 for the synthesis of new radioactive elements (2 in Figure 6). Dorothy Crowfoot Hodgkin was awarded in 1964 for his research and analysis by X-ray structure of vitamin B-12 (3 in Figure 6). Ada E. Yonath was awarded in 2009 for studies on the structure and function of the ribosome (4 in Figure 6). Frances H. Arnold was awarded in 2018 for the directed evolution of enzymes (5 in Figure 6). Jennifer A. Doudna and Emmanuelle Charpentier were awarded in 2020 for the development of a method for genome editing (6 & 7 in Figure 6). And, finally, Carolyn Bertozzi was awarded in 2022 for the development of click chemistry and bioorthogonal chemistry (8 in Figure 6).

Figure 6

4.3. Other Women chemists

Gerty Theresa Cori (1896-1957) [5] Helped establish glycogen is broken down in muscles then remade and stored as an energy source (the Cori Cycle). In 1947 she jointly won a Nobel Prize in Physiology or Medicine for her work.

Kathleen Lonsdale (1903-1971) [4] Pioneered use of X-rays to study crystals and also used the technique to confirm that a benzene ring is flat. A form of carbon "Lonsdaleite", is named after her.

Rosalind Franklin (1920-1958) [4] made X-Ray diffraction images of DNA crucial in allowing DNA's structure to be discerned. This contribution was not fully acknowledged until after her death.

Gertrude Belle Elion (1918-1999) [5] Developed numerous drugs, including the first immunosuppressive drug used for organ transplants. She and her colleague, George Herbert Hitchings, received the Nobel Prize in Physiology or Medicine 1988. They both discovered and developed treatments for previously incurable diseases. Acyclovir was the drug both developed. She trained a group that found a cure for AIDS and HIV

Too often, we forget the many women who made significant contributions to the promotion and teaching of chemistry. This article aims to offer a small tribute to Rosa Sensat Ferrer, a Catalan woman who defined an era and carried out an extraordinary mission as a teacher and spread chemistry.

5. Rosa Sensat Ferrer

A brief biography tells us that she was born in El Masnou, near Barcelona, in 1873, and died in Barcelona in 1961 [7 and 8 for a review]. She was a teacher with an immense desire to learn, *a teacher with the fullest sense of the word*. She studied the new educational movements emerging across Europe and worked to apply their principles in her own community. In 1903 she settled in Barcelona, where she dedicated herself to spreading these innovative pedagogical ideas. She was entrusted with designing the curriculum for the Institute of Culture and the Popular Library for Women (*Institut de Cultura i Biblioteca Popular de la Dona*), where she developed a comprehensive program aimed at working-class and middle-class women.

Although Sensat was a highly motivated and dedicated teacher, she had not had the opportunity to pursue university studies in chemistry. To understand the connection between Rosa Sensat and chemistry, it is enough to summarize part of her book published in 1923.

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From a chemical standpoint, this popular book for women covers everything from the description of laboratory materials and the basic knowledge needed to perform simple chemical manipulations, to straightforward definitions of elements and compounds. Concepts such as chemical affinity are introduced, while more advanced topics like atoms, molecules, and the symbols of the chemical elements are intentionally left aside.

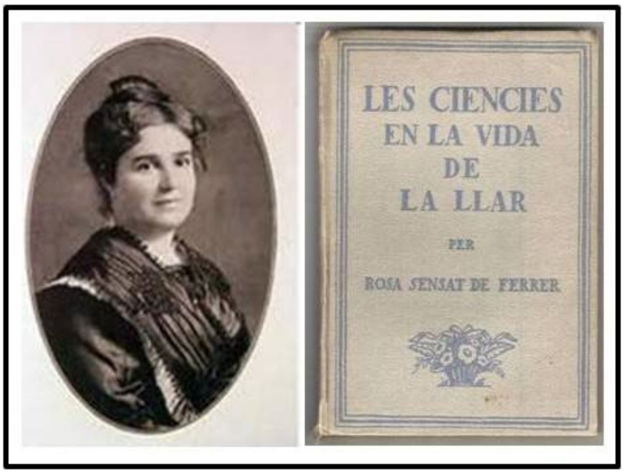

Figure 7. Rosa Sensat picture and her book

Cossos	Simbols	Cossos	Simbols
Ferro	Fe	Platí	Pl
Coure	Cu	Hidrogen	H
Zenc	Zn	Oxigen	O
Plom	Pl	Carboni	C
Estany	Sn	Sofre	S
Calci	Ca	Fòsfor	Ph
Sodi	Na	Nitrogen	N
Bari	Ba	Clor	Cl
Potassi	K	Iode	I
Bismut	Bi	Brom	Br
Argent	Ag	Fluor	Fl
Alumini	Al	Bor	Bo
Or	Au		

Figure 8

Even the symbols of the most common chemical elements encountered in daily life were presented so that housewives of all income levels could have access to this knowledge. Some mistakes in these symbols were later corrected in an errata sheet added at the end of the book. These included the symbols for lead (listed as "*Plom*" in the image), platinum (written as "*Platí*" in the image), phosphorus (shown as *"Fòsfor"* in the image), and fluoride (shown as *"Fluor"* in the image).

The book also provides a thorough study of the gases present in the air—oxygen, nitrogen, and carbon dioxide—describing their properties as well as simple experiments that can be performed with them. Figure 9 shows how to collect gases produced in a chemical reaction.

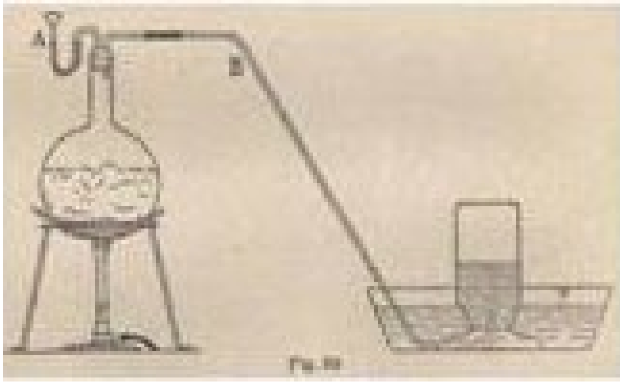

Figure 9

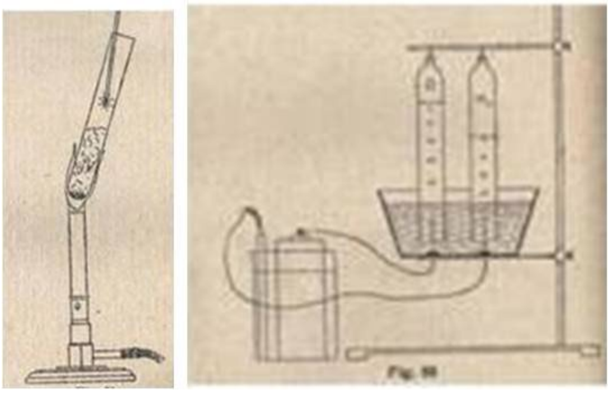

Figure 10

In Figure 10, Rosa Sensat shows, how to heat a test tube in which another reaction is taking place. She even includes the complete process for decomposing water into hydrogen and oxygen through electrolysis.

In addition, to understand the relationship between science and women in the early decades of the 20th century, it is helpful to read Rosa Sensat's own words in the preface to her book "Science in Home Life" written in the Catalan language (*Les Ciències en la vida de la Llar*) [9, 10]. In it, she writes (translated from the original):

"Women should know the reason for the things they do, the causes of the phenomena that occur before them, the how and the why of those simple facts that govern daily life. They deserve the respect given to those who think, and good

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housekeeping requires knowledge. A person can devote themselves fully and enthusiastically to their tasks only when they understand them and possess the knowledge needed to ensure success."

These words capture her vision: empowering women by giving them access to scientific understanding, especially in relation to the chemistry behind everyday household activities.

Through education, she sought to elevate women's daily work, turning it into a source of knowledge, autonomy, and dignity.

Knowledge of the material needed for simple Physics and Chemistry manipulations. Practical indications for its use.

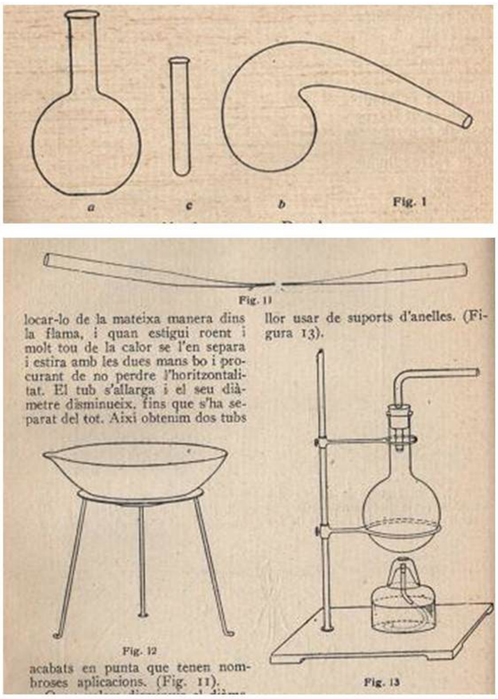

Figure 11

In Figure 11, we see the presentation and description of the glassware and materials used, as well as their proper placement for carrying out experiments.

Finally, Rosa explained food [11]. She gave justifications about albuminous substances, fats, and carbohydrates, along with their properties and methods of preservation.

Her greatest challenge was helping women who were already highly skilled in managing their homes and kitchens acquire the chemical knowledge necessary to understand the processes involved in cooking and food preparation. This task required not only dedication but also the ability to translate scientific concepts into accessible explanations supported by clear, well-designed illustrations.

$CO_2 + H_2O = CO_3H_2$.
Anhidrid carbònic + aigua = àcid carbònic.
$SO_3 + H_2O = SO_4H_2$.
Anhidrid sulfúric + aigua = àcid sulfúric.
$Ph_2O_5 + 3H_2O = 2PhO_4H_3$.
anhidrid fosfòric + aigua (tres molèculas) = àcid fosfòric.

$CaO + H_2O = CaO_2H_2$
òxid de calci + aigua = hidrat de calci o càlcic
$Na_2O + H_2O = 2NaOH$
òxid de sodi + aigua = hidrat de sodi o sòdic
$K_2O + H_2O = 2KOH$
òxid de potassi + aigua = hidrat de potassi o potàssic

Figure 12

Examples of chemical reactions explained in her book. Rosa Sensat left as a legacy "The teachers' school Rosa Sensat, Escola de mestres Rosa Sensat" established in 1965 and "The teachers' Association Rosa Sensat, l'Associació de Mestres Rosa Sensat", officially founded in 1980 but rooted in the earlier school.

This teachers' association is distinguished by the shared between its members to improving education through several key principles:

- Disseminating educational theories and pedagogical practices aimed at fostering the holistic development of each individual, grounded in respect for the personality and freedom of every child.
- Promoting the active participation of children in their own learning, encouraging curiosity, autonomy, and engagement.
- Training teachers through a balance of theory and hands-on experimentation, supported by both individual and collective reflection.
- Working toward a public, democratic, and secular school system, deeply rooted in the community and engaging all its members, teachers, parents, students, and school leadership in shaping the educational project of each center.

6. Conclusion

Tapputi's story offers a remarkable window into the early development of scientific

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knowledge in ancient Mesopotamia. As one of the earliest known chemists, she pioneered techniques that would later become fundamental to modern chemistry and perfumery. Her use of distillation, filtration, and solvents reveals a level of technical sophistication far ahead of her time, while her position within the royal palace underscores the respect and authority she held in her profession.

Though many details of her life remain unknown, Tapputi's contributions stand as a testament to the foundational role women played in the origins of scientific practice. Her legacy continues to enrich our understanding of the history of chemistry and highlights the importance of recognizing women's success across the ages. Women scientists have been present in society since we have written records. In antiquity, in the Middle Ages, and from the eighteenth century onwards we have women chemists. Finally, we now have eight women awarded the Nobel Prize in Chemistry. We hope that this number will increase in a few years.

Although chemistry is fundamentally the study of chemical reactions, explaining these reactions is not always straightforward. It may be relatively easy, even for non-chemists, to understand how a bain-marie (double boiler) works or to observe how egg whites change when heated. But introducing the concept of chemical reactions to those who have never studied science is a much greater challenge. Despite this difficulty, Rosa Sensat succeeded: in her book, she presents chemical reactions accompanied by thoughtful, comprehensible explanations tailored to beginners.

Understanding the historical and contemporary relationship between women and chemistry is essential. Sharing these stories with young students, especially girls, is a powerful step toward inspiring future scientists and advancing gender equality in the years to come.

7. Acknowledgements

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Hands-on Workshop on Structured Query Language (SQL)

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Abstract. SQL is a language designed for database management, data analysis, and backend development. In the SQL workshop, you will become familiar with the basic commands of the SQL language for creating a database, inserting, modifying and updating data, as well as querying data. The workshop will be held in a computer lab.

Keywords. Structured Query Language (SQL), relational databases, Data Definition Language (DDL), Data Manipulation Language (DML).

1. Introduction

A Database is a collection of well-organized records in commonly available mass storage media. A database serves one or more applications in an optimal way and allows a common and controlled approach to data entry, modification and retrieval [1]. A database captures a view of the real world and is created to be used by a specific group of users and to serve specific purposes.

The design of a database is carried out in four consecutive stages. Each of these stages receives information from the previous one and feeds the next one. These stages are:

- Requirements Analysis
- Conceptual Design
- Logical Design
- Physical Design

In each of the above stages of designing a database, the appropriate model is adopted: the conceptual, the logical and the physical model. A few models have been proposed for database design, but the relational model is the one that has prevailed for the design of databases based on structured data [2].

The relational model: was proposed by Codd in a publication [3] which presented that information stored in large databases can be accessed without the need to know how this information is structured within the database. This approach does not require the database user to be an expert and to know details about the structure of the database, while all the "elements" of the Database are available for access and processing.

A Relational Database consists of relations (also called tables). A relation is any logical entity or sub-entity of the system that is represented in the database. Each relation consists of data elements called attributes. Each attribute has a domain. Each distinct instance of data values of all attributes of a relation is called a record.

Relations (tables) are linked to each other through relationships that are achieved through foreign keys. An attribute (or set of attributes) is considered a foreign key of a relation if that attribute is a primary key in some other relation. The relational model is the most established in the field of databases and is managed by 4th generation languages, such as SQL.

2. Structured Query Language (SQL)

SQL (Structured Query Language) is a standardized language used to manage and manipulate data in relational database management systems (RDBMS). With SQL users specify what data they want to work with and do not define how the database engine should retrieve it [4-7].

The SQL commands are separated into the following categories:

Commands for querying data: Retrieving specific subsets of information (e.g., using SELECT).

Data Manipulation Language (DML): Inserting, updating, and deleting records within tables (e.g., using INSERT, UPDATE, DELETE).

Data Definition Language (DDL): Creating and modifying the structure of database tables, views, indexes etc. (e.g., using CREATE, ALTER, DROP).

Data Control Language (DCL): Managing user permissions and security within the database (e.g., using GRANT, REVOKE).

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2.1. Basic DDL Commands

The primary DDL commands are CREATE, ALTER, DROP, TRUNCATE and RENAME.

- CREATE Builds a new database object (e.g., table, view, index).
- ALTER Modifies the structure of an existing object.
- DROP Deletes an existing object and all its data/structure permanently.
- TRUNCATE Deletes all records from a table quickly; structure remains.
- RENAME Renames an existing database object.

Most DDL operations cannot be easily rolled back using standard ROLLBACK commands, as they typically auto-commit changes to the database schema. A user typically needs specific administrative privileges to execute DDL commands. Commands like DROP and TRUNCATE result in immediate data loss.

2.2. Basic DML Commands

DML (Data Manipulation Language) is a subset of SQL commands used to manage the data stored within the database objects (like tables) defined by DDL commands. DML focuses on content rather than structure. The four fundamental DML operations are often referred to by the acronym CRUD (Create, Read, Update, Delete).

- **INSERT**: Adds new rows of data into a table
- **SELECT**: Retrieves data from one or more tables/views
- **UPDATE**: Modifies existing data within a table
- **DELETE**: Removes existing rows from a table.

2.3. Basic DCL Commands

DCL (Data Control Language) commands in SQL manage database access and permissions, primarily using two commands:

- GRANT: gives users specific rights like SELECT, INSERT, UPDATE, DELETE on database objects
- REVOKE: removes those permissions, ensuring database security and controlled access

During the workshop, participants will have the opportunity to work in a relational database, learn its structure and the way in which the tables that compose it up are related, and become familiar with the basic SQL commands. Specifically, a database hosted in the Oracle APEX Server will be used as an example and participants will be able to use it in order to practice with DDL and DML commands.

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Beyond Grooming: Understanding What Pet Owners Value Most in Pet Grooming Services

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Abstract. The pet grooming industry has undergone significant evolution in recent years, shaped by shifting owner expectations and heightened demand for quality, safety, and holistic care. This research investigates the primary factors that influence pet owners' satisfaction and decision-making when choosing grooming services, moving beyond basic grooming treatments to uncover deeper value drivers. Through a mixed-methods approach combining quantitative survey data and qualitative open responses, we explore dimensions such as cleanliness, animal handling and safety, staff expertise, product quality (e.g. hypoallergenic materials), price, convenience, and pre/post guidance. Our study sample of pet owners reveals which attributes hold greatest weight in consumer choice, and how these priorities differ across demographics (age, pet type, frequency of grooming, etc.). The findings provide actionable insights for grooming businesses to tailor their service offerings, enhance customer experience, and foster loyalty. Moreover, this paper offers recommendations for industry best practices, design of service packages, and marketing strategies that resonate with pet owners' values.

Keywords. Decision Criteria, Pet Grooming Services, Service Quality.

1. Introduction

As pet ownership continues to rise globally, grooming services have become an essential part of animal care. However, grooming is no longer viewed as a luxury or purely aesthetic service—it is increasingly tied to hygiene, health, and emotional well-being. This paper explores what pet guardians truly value in grooming services and how businesses can adapt to meet these evolving expectations.

2. Methodology

A cross-sectional, descriptive research design was employed, utilizing a mixed-methods approach. This approach combined quantitative data to identify and measure trends with qualitative data to provide depth and context to the numerical findings. The goal was to obtain a comprehensive understanding of pet owners' priorities, behaviors, and perceptions. Data was collected through a structured online questionnaire created with Google Forms. The survey was distributed through digital channels, including social media groups and professional networks, targeting pet owners in Greece.

3. Results and Analysis

The analysis of the survey data revealed clear and actionable insights into the priorities and behaviors of Greek pet owners.

3.1. Sample Demographics

The respondent pool was predominantly female (70%), with the largest age group being 45-54 years old (42%). The majority were dog owners (56%), followed by cat owners (38%).

3.2. What Owners Value Most

When asked to rate the importance of various groomer attributes, the factors related to the pet's well-being and the groomer's competence were overwhelmingly prioritized. This underscores that technical skill is a prerequisite, but the empathetic and calm management of the animal is the true differentiator.

Table 1. Importance of Groomer Attributes (Percentage rating as "Very Important")

Attribute	Percentage
Groomer's Patience with the Pet	85%
Handling of Anxious Pets	80%
Groomer's Experience	78%
Hygiene Result	75%
Reviews	70%
Facilities of Salon	65%
Add-on Services	60%
Groomer's Certification	55%
Price of Services	45%
Use of Natural Products	40%
Convenience of Location	35%
See the Pet During Grooming	30%

3.3. Barriers to Professional Grooming

A significant portion of the market remains untapped or under-serviced due to several key barriers. The primary reasons for non-use or infrequent use were:

- "Not Necessary" for Pet's Coat Type (40%): This indicates a significant educational opportunity for groomers to inform owners about the health and hygiene benefits beyond aesthetics.
- Cost / Price is Too High (35%)
- Pet's Anxiety/Stress (33%): This finding directly reinforces the critical importance of the top-valued attribute (Handling of Anxious Pets).

3.4. Grooming Habits and Service Demand

A large segment (30%) never uses professional grooming services, while another 20% groom their pets every 3 months. The most sought-after service is a "Full Groom" (28%), followed by basic "Bath" services (22%).

Table 2. Most Desired Grooming Services

Service	Percentage
Full Groom	28%
Bath	22%
Haircut	16%
Nails	12%
Brushing	2%
Ears	2%
Teeth	2%
Not Specified	16%

3.5. The Emotional Impact and Primary Motivation

This highlights that owner's view grooming as a core component of responsible pet healthcare. An overwhelming majority of pet owners (76.6% declared it "Very important") place a very high value on the transparency of grooming product brands and composition. The transparency of products (76.6%) remains the top priority, followed closely by the ability to stay/supervise the grooming process (74.5%). Getting advice on daily care (71.3%) is also highly valued. The emotional toll of grooming is a major concern. A third of owners (34%) reported their pet becomes more anxious or fearful after a grooming session. Despite this, the primary motivation for grooming remains Hygiene (60%), far outweighing Aesthetics (14%).

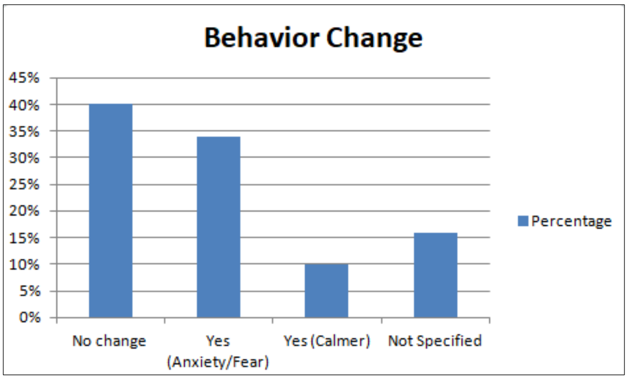

Figure 1. Pet Behavior Change After Grooming

3.6. Booking Method Preferences

The survey reveals a strong preference for traditional communication, with the phone being the dominant booking method at 60% of respondents. However, digital channels are significant, with booking apps being the second most popular choice at 24%, followed by social media platforms like Instagram and Facebook at 10%. A small segment (6%) still prefers to book appointments in person. This indicates that while a modern, multi-channel approach is necessary to reach all customers—especially younger, digitally-inclined demographics—maintaining reliable phone-based communication remains essential for serving the majority of the client base.

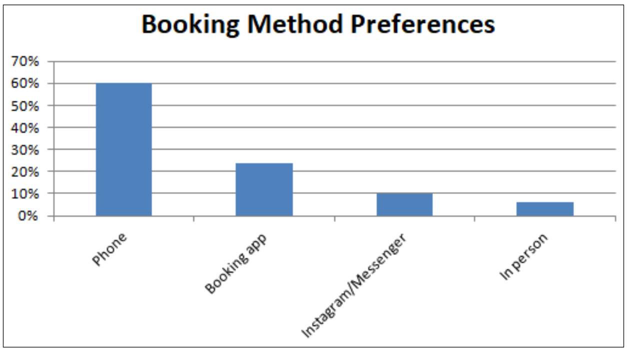

Figure 2. Booking Method Preferences

3.7. Key Findings by Gender and Age Group

Based on the demographic analysis, the data reveals that women, who constitute 70% of the market, prioritize their pet's emotional well-being, valuing groomer patience (88%), handling of anxious pets (83%), and hygiene (77%), and are more willing to pay for premium, anxiety-reduction services. In contrast, men are more pragmatic, showing higher price sensitivity (53%) and a preference for basic, convenient services. Age-based trends further segment the market: younger owners (≤34) are digitally savvy and cost-conscious, the crucial 35-44 female segment are the ideal regular clients who value quality, middle-aged groups (45-54) require education on grooming necessity, and older clients (55+) prefer traditional communication and basic maintenance. Therefore, a successful strategy must tailor its messaging and service offerings—emphasizing empathy and premium care for women, value and efficiency for men, and adapting communication channels and educational content to specific age groups to convert infrequent users into loyal customers.

4. Conclusion

The study finds that dogs and cats are the most popular pets, with most owners owning just one pet. This preference reflects global trends due to the companionship and ease of care associated with these animals.

This research demonstrates that pet grooming clients evaluate service quality through both practical and emotional lenses. Cleanliness, professionalism, and gentle handling emerged as the most valued attributes, while cost, though relevant, was not the primary driver. Salon owners should therefore prioritize hygiene protocols, staff training in animal behavior, and transparent communication with clients. Implementing welfare-oriented grooming practices can serve as a differentiator in a competitive market. Future studies could explore longitudinal satisfaction and behavioral outcomes in pets post-grooming, as well as cross-cultural comparisons.

5. Acknowledgements

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Artificial Intelligence in Universities: Assessing Student Intentions Based on the Theory of Planned Behavior

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Abstract. Artificial intelligence, and especially generative artificial intelligence tools, are increasingly being used by university students. Despite reports of concerns about the misuse of artificial intelligence, convincing students to accept responsible and ethical use of artificial intelligence remains challenging. Further research is needed to understand the underlying factors guiding students' intentions to engage in ethical habits when using artificial intelligence. The Theory of Planned Behavior is used to identify attitudes, social norms and behavioral control in 54 university students toward two intentional behaviors related to the use of artificial intelligence: ethical use and plagiarism. Using a Google Form survey, the major factors of the Theory of Planned Behavior model as they relate to the students' intention to engage in these two behaviors were assessed. Positive attitudes were found to have a strong influence on students' intention to use generative artificial intelligence ethically, while social norms were equally likely to incline students to engage in both behaviors.

Keywords. Artificial Intelligence, Higher Education, Theory of Planned Behaviour, Ethical Use.

1. Introduction

Artificial intelligence (AI), and especially generative AI (Gen AI) tools, have been widely used by university students for many years now. The implications of the widespread use of this new technology, both beneficial and problematic, are being actively studied and the results discussed in numerous publications [1-3].

Recently, researchers and higher education leaders have increasingly focused on the ethical use of GenAI tools by both students and faculty.

The need to ensure responsible use of GenAI begins at the school level. Systematic research helps create the structures and resources needed to fully realize GenAI's potential in shaping the educational environment, particularly in the school system [4-5]. A growing number of universities are developing and implementing AI Acceptable Use Policies (AUPs) to prevent inappropriate and unethical use of GenAI [6-8].

When integrating GenAI into educational practices, it's important to understand students' intentions regarding its use, as unethical behavior is not only reprehensible in the eyes of society but also harmful to the students themselves, which they may not always realize. It must be acknowledged that the irresponsible misuse of GenAI impairs students' cognitive abilities, which inevitably leads to a decline in the quality of education.

Various educational studies have used various models and theories to examine students' intentions to engage in risky behavior. One such model is the Theory of Planned Behavior (TPB) [9].

This theory examines attitudes, subjective norms, and perceived control over a given behavior and assesses how these factors influence a person's behavioral intention to engage in that behavior.

Attitudes are defined as how a person feels about performing a certain behavior (positive or negative).

Subjective norms are formal or informal rules about how to behave or how the behavior is perceived by others.

Perceived behavioral control examines the extent to which a person feels they have control over performing or not performing a certain behavior in their life.

Previous research has shown that TPB is an effective model of intention for various behaviors [10-11].

Plagiarism is probably the most common manifestation of unethical student behavior. Therefore, for this study, we selected two dominant and contrasting behaviors among students using AI in their studies.

2. Methods

This study was approved by the Ethics Committee of the University of Information Technology and Management (UITM) in Rzeszow, Poland. Participants were undergraduate students at UITM and Lviv National Polytechnic University (LPNU), Ukraine.

All participants read and agreed to the Declaration of Consent form at the beginning of the survey before completing it. Students were included in the survey only if they were over 18 years of age. The online survey was designed using Google Forms.

The online survey was designed to assess three core factors of the TPB (attitude, perceived behavioral control, and social norms) associated with participants' intention to engage in two different behaviors:

1. rational and ethical use of GenAI (Using GenAI as a source of reference and data to gain knowledge through critical thinking and analysis with the help of your own intelligence). and
2. GenAI Plagiarism (submitting GenAI results as your own work despite possible disclosure and consequences such as grade reduction, project rejection, etc.).

To assess the study's primary focus, for each of the two behavior types (rational and ethical use of GenAI and GenAI plagiarism), participants were asked to respond to questionnaires corresponding to the four key factors of the TPB using a five-point Likert scale (1 = strongly disagree/very unlikely and 5 = strongly agree/very likely).

Specifically, participants were asked to indicate their perceived social norms associated with the social norms (six questions), behavioral control (six questions), attitudes (eight questions), and intentions to engage in the behavior (six questions).

The target values were obtained by averaging the corresponding questionnaire items. Respondents also answered demographic questions.

At this stage, the study is preliminary in nature, so only a basic analysis of the obtained data was carried out in order to identify characteristic features and the appropriate type of subsequent, detailed analysis.

3. Results

3.1. Participants

A total of 54 undergraduate students completed the survey: 18 – from LPNU, and 36 – from UITM. Respondents were, on average, 22 years of age. In terms of gender, 63% % were male, and 37% - female.

3.2. TPB Attitudes

Mean values are presented in Table 1 for both behaviors.

It was found that students have a more positive attitude towards the ethical use of GenAI (mean 4.06-4.09), although this value is not much different from their negative attitude - 3.83.

The level of acceptance of GenAI plagiarism is alarming - from 2.65 to 3.41, although the level of rejection is still somewhat higher - 3.61.

Table 1. Mean values for attitude responses

Response	Behavior 1	Behavior 2
Good	4,09	2,65
Beneficial	4,06	2,91
Positive	4,09	3,41
Negative	3,83	3,61

3.2. TPB Social norms

Participants believed that their social network could facilitate engagement in a certain behavior. However, data on social norms presented in Table 2 show that both behavioral options receive approximately equal support (3.4 – 3.9) from important others - students, friend and family.

Table 2. Mean values for social norms responses

Response	Behavior 1	Behavior 2
Other students	3,8	3,7
Friends	3,8	3,4
Family	3,9	3,6

3.3. TPB Perceived behavioral control

Participants also indicated that they have more perceived control over the ethical use of GenAI (3.5 – 4.1) than they did over GenAI plagiarism (2.6 – 3.5).

Mean values are presented in Table 3 for both behaviors.

Table 3. Mean values for perceived behavioral control responses

Response	Behavior 1	Behavior 2
Great difficulty	3,5	3,3
Easy	3,9	2,6
Able to control	4,1	3,5

3.4. TPB Intention

The results indicate that respondents are willing to use GenAI ethically (4.0) or recommend such behavior to others (4/0), but they are less likely to actively engage in the ethical use of GenAI (3.8).

However, they do not actively resort to GenAI plagiarism (2.8) and will not recommend it to others (2.5), but they show a greater willingness (3.2) to use GenAI plagiarism when the opportunity arises.

Mean values are presented in Table 4 for both behaviors.

Table 4. Mean values for intention responses

Response	Behavior 1	Behavior 2
Actively engaged	3,8	2,8
Recommend to others	4,0	2,5
Willing to engage	4,0	3,2

4. Conclusions

The study supports the application of the TPB model to evaluate the factors that may explain university students' behavior towards using GenAI. Early results of this study showed that attitude has a strong influence on students' intention to use GenAI ethically, while social norms are equally likely to incline students to engage in both behavioral options.

This study is preliminary and includes a moderate number of respondents, which is insufficient to determine the relationship between factors influencing the use of GenAI by university students. However, the results of this study will serve as a guide for future research on this issue.

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Concentration of Tantalum, Niobium and Associated Elements in Tantalite Ore from the Mutala Region in Mozambique

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Abstract. The study of the richness in minerals, rare minerals especially, of our lands, became particularly important on recent years. It is therefore important to contribute to educate students and citizens on this issue.

This communication presents an example of a study on particular mineral elements present in tantalite ore coming from a region on central Mozambique. This study investigates the concentration of tantalum, niobium, and other elements found in tantalite ores from two reference samples and tantaliferous pegmatites in Mozambique. These minerals are important because tantalum is widely used in modern electronics, such as capacitors and microchips. To understand the composition of the samples, we used Scanning Electron Microscopy (SEM) together with Energy Dispersive X-ray Spectroscopy (EDS). These techniques allow us to observe the mineral surface and identify the elements present. The results were complemented by calculations of standard deviation and variance. The analyses confirmed typical components of tantalite, including tantalum, iron, oxygen, manganese, aluminum, silicon, and titanium.

Keywords. Tantalite, SEM-EDS, Zambézia, Mineral Heterogeneity, Tantalum Concentration.

1. Introduction

Together with tin, tungsten, and gold, tantalum is considered one of the most strategically important mineral resources worldwide. However, in several African countries, the lack of adequate technologies for exploration, extraction, and efficient mineral processing limits the contribution of these resources to local economic development [1-3].

Tantalum is a metal of high economic importance due to its physicochemical properties, such as a high dielectric constant, corrosion resistance, and the ability to form stable oxides, which make it essential in sectors such as electronics, aerospace, nuclear, and biomedical industries [1]. It commonly occurs associated with niobium, and both are mainly extracted from minerals of the tantalite–columbite group, as well as from granitic pegmatites and greisen-type rocks [4]. Together with tin, tungsten, and gold, tantalum is part of the strategically important 3TG minerals, often linked to conflict-affected regions [2,5]. The commercial value of concentrates depends primarily on their tantalum pentoxide (Ta_2O_5) content, and prices are negotiated directly between buyers and sellers [2,3]. Central African countries, such as Rwanda, play a significant role in global supply, although many African nations still possess undervalued reserves [5].

In Mozambique, the Zambézia Province and particularly the locality of Mutala hosts confirmed occurrences of tantalite, although they remain insufficiently studied [6]. Determining the grades of Ta, Nb, Sn, Ti, and rare earth elements is essential to evaluate the economic potential of the ore and to support the development of sustainable mining projects in the region [1].

2. Materials and Methods

In this study it was used tantalite and tantaliferous pegmatite samples collected from an active mine in Mutala, Zambézia Province, Mozambique. Tantalite was manually extracted, crushed, ground, sieved to <125 μm, washed with deionized water, and dried at 80 °C for 24 h. Pegmatite samples consisted of coarse crystals and fine-grained fractions [7]. Morphological characterization was performed using a FEG-SEM NOVA 200 NanoSEM, employing LVD and GAD detectors at accelerating voltages between 10–15 kV. Chemical composition was determined by EDS using an EDAX Si(Li) detector, applying ZAF corrections for qualitative and quantitative elemental analysis.

3. Microstructural Analysis

The Figures 1 and 2 below present SEM

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micrographs of the tantalite and tantaliferous pegmatite samples, obtained using the LVD and GAD detectors at 1000× magnification and accelerating voltages of 10–15 kV. The objective was to observe the surface characteristics of the samples. In images (a) and (b), of Fig. 1, corresponding to the tantalite, distinct mineral phases with well-defined boundaries and strong brightness contrast are identified, mainly resulting from atomic number differences and surface topography.

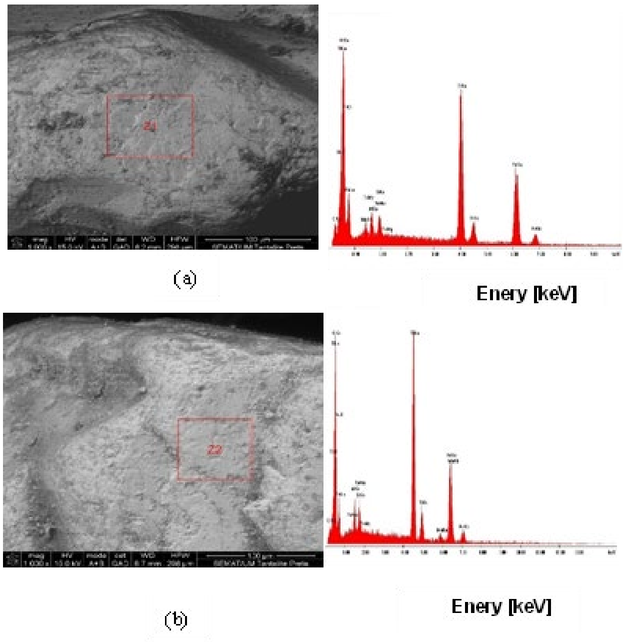

Figure 1. SEM and EDS analysis of the surface of tantalite, Ref. Z1 e Z2

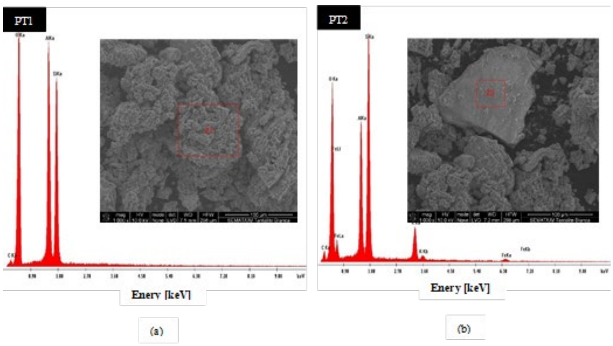

Figure 2. SEM-EDS analysis of the surface of tantaliferous pegmatites, examined in zones PT1 and PT2

In images (a) and (b), of Figure 2, referring to the pegmatites (PT1 and PT2), a partially homogeneous distribution is observed, with irregular structures, fragmentation, and particle aggregates, suggesting variations associated with crystallization processes or mechanical fracturing.

4. Energy Dispersive X-ray Spectroscopy (EDS)

The images to the right in Figure 1 show the EDS spectra obtained from different surface regions of the tantalite sample. The results consistently reveal the presence of Ta, Ti, Fe, O, Si, Al, Mg, C, and Mn, although peak intensities vary between zones Z1 and Z2, reflecting differences in relative elemental abundances and indicating local chemical heterogeneity. In the tantaliferous pegmatites (Fig. 2), the spectra display predominant concentrations of O, Si, and Al, accompanied by lower amounts of Bi, P, C, K, and Fe, which are consistent with mineral phases characteristic of pegmatitic lithologies [16]. The presence of carbon peaks suggests possible carbonate minerals, whereas silicon is associated with silicate phases such as quartz or feldspar [8,10].

Overall, the analyses identified metals (Ta, Fe, Mn, Ti, Al), nonmetals (O, C), and the metalloid Si. Tantalum concentrations ranged from 0.10 to 1.23 wt%, while Nb was not detected in any of the analyzed regions. The high Fe and O contents support the classification of the sample as Tantalite-(Fe), according to established mineralogical nomenclature.

Table 1 - Classification of Weight Percentages (wt%) and Atomic Percentages (at%) from EDS of the Tantalite Sample (Reference)

Elements	Chemical Composition of the Sample					
	Weight Percentage (wt%) and Atomic Percentage (at%)					
	Ref.1		Ref.2		Ref.3	
	Wt %	At %	Wt %	At %	Wt %	At %
Ti	26.92	15.23	31.34	19.16	23.46	12.35
Si	1.42	1.37	1.32	1.37	1.88	1.69
O	33.55	56.83	29.71	54.39	41.73	65.76
Al	1.54	1.55	1.80	1.95	2.39	2.23
Mg	0.94	1.05			12.32	20.04
Ta	0.01	0.10	1.23	0.20	1.00	0.20
Mn			1.84	0.98	1.65	0.76
C	3.77	8.51	2.48	6.06	2.53	5.31
Fe	31.86	15.46	30.28	15.88	26.36	11.90

The concentration levels identified in this study are consistent with those reported by Habinshuti et al. (2021), who also observed high concentrations of oxygen (O), silicon (Si), and aluminum (Al), as well as low levels of economically relevant elements such as tantalum (Ta) and niobium (Nb) prior to gangue mineral removal. The results obtained here align with the literature describing samples analyzed before gangue separation. However, they diverge from the findings reported in [13-15], which document significantly higher concentrations of Ta and Nb using leaching-based separation techniques.

Table 2 - Classification of Weight (wt%) and Atomic (at%) obtainned from EDS (PT samples)

Elements	Chemical Composition of the Sample							
	Weight Percentage (wt%) and Atomic Percentage (at%)							
	PT.1		PT.2		PT.3		PT.4	
	Wt %	At %	Wt %	At %	Wt %	At %	Wt %	At %
Si	24.51	17.08	29.61	22.49	11.19	7.78	20.49	14.99
O	49.58	60.66	45.47	60.63	46.92	57.30	50.03	64.29
Al	22.08	16.02	14.99	11.85	15.91	11.52	20.67	15.75
C	3.83	6.24			12.32	20.04	1.73	2.97
K			7.57	4.13				
P					3.88	2.45	2.32	1.54
Bi					9.78	0.91	4.76	0.47
Fe			2.35	0.90				

Table 1 presents the quantitative concentrations of the elements identified in the tantalite sample, expressed in weight percent and atomic percent. The low concentrations of tantalum (Ta) and niobium (Nb) observed may result from both geological factors and analytical limitations. From a geological perspective, Ta- and Nb-bearing minerals such as Tantalite-(Fe) and Tantalite-(Mn) are heterogeneously distributed within the mineralized body, which affects point-based analyses conducted on small areas. Surface weathering processes may also cause partial leaching of these elements [9,12]. From an analytical standpoint, the EDS technique has relatively high detection limits, which may underestimate elements present in low concentrations.

Table 2 presents the quantitative results for the tantaliferous pegmatites, revealing high concentrations of oxygen, silicon, and aluminum, and lower amounts of iron, bismuth, carbon, and potassium. This elemental distribution is consistent with mineral assemblages typical of pegmatitic environments, reflecting the presence of accessory minerals associated with the mineralogical evolution of tantalite-bearing pegmatites [11].

4. Conclusion

In this study, it was possible to evaluate the concentration levels of tantalum and associated elements. The evaluation was performed both directly in the tantalite ore and indirectly through tantaliferous pegmatite obtained from Alto Molocué, Mutala region, Zambézia Province, Mozambique. The surface morphology and elemental composition of the samples were analyzed using Scanning Electron Microscopy (SEM) for morphological characterization and Energy-Dispersive X-ray Spectroscopy (EDS) for quantitative elemental analysis.

The concentrations of tantalum observed in are comparable to those reported in recent works analyzing samples before the removal of gangue minerals. However, the results differ from studies that employ leaching-based concentration techniques, such as Inductively Coupled Plasma Mass Spectrometry (ICP-MS) and X-ray Fluorescence (XRF), which typically report significantly higher Ta and Nb contents after mineral processing.

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Lens Blocking Solution Using Synthetic Gypsum-Based Plaster for Optical Glass Lenses

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Abstract. The production of high-quality lenses and optical components for high-end optical instruments, such as cameras or binoculars, is a demanding process requiring advanced skills and careful training, as well as rigorous quality control throughout both the manufacturing chain and the final products. In this communication, an overview is presented of the processes involved in lens manufacturing. Recent advances in lens blocking techniques that are crucial to the success of multi-lens production will also be reported. These developments aim not only to improve efficiency and reduce production time, but also to ensure that the strict optical and geometric tolerances required for premium-grade optics are consistently met. The way lenses are blocked has a direct effect on the quality and efficiency of the process. In alternative to traditional methods, we propose using synthetic gypsum-based plaster in high quality lens blocking that improves stability, cost effectiveness and an improved overall high quality lenses production process efficiency.

Keywords. High Quality Glass Lens, Lens Blocking, Lens Polishing and Grinding, Gypsum-Based Plaster.

1. Introduction

The production of high-end optical instruments requires the use of high-quality lenses and optical components. The industrial multi-lens production of top-quality lenses is a demanding process requiring rigorous quality control. Optimized lens-blocking techniques are crucial to the success of multi-lens production. These developments aim not only to improve efficiency and reduce production time, but also to ensure that the strict optical and geometric tolerances required for premium-grade optics are consistently met.

The production of high-quality glass lenses begins with an optical blank whose surface radii are close to the intended final values. Each surface undergoes three abrasive processes—grinding, fine grinding, and polishing—during which the surface roughness is progressively reduced, and the shape approaches the final [1]. As in many industrial contexts, reducing the production time of optical surfaces is an important objective. The way lenses are blocked has a direct effect on the quality and efficiency on the process. Improper blocking methods can produce mechanical stressing, misaligning, and even worse, defects on the optical elements [1].

Blocking is the process of temporarily mounting one or several lenses onto a support so that grinding, fine grinding, and polishing can be performed sequentially without the need for remounting. This allows multiple surfaces with the same radius to be produced simultaneously [2].

Conventional blocking methods use hot melt bonding or adhesives such as UV curable glues. While these methods provide good adhesion, they also have considerable disadvantages in the form of internal stress, risk of contamination, and problems with deblocking. To improve grinding and polishing efficiency, this study investigates the use of plaster as a blocking material. Plaster offers several advantages, including dimensional stability, low thermal expansion, ease of shaping, and low cost, making it a promising option to produce high-quality optical surfaces.

The surface shaping state of optical lenses involves three main abrasive processes: grinding, fine grinding, and polishing. Grinding is the first step, where a large amount of glass is removed to form the basic curvature of the lens. This can be done using diamond tools or in a more archaic way, an abrasive mixture applied to a tool whose curvature is opposite to that of the lens, allowing the initial shaping of the optical surface. Fine grinding follows, using smaller diamond pellets or finer abrasive grains to reduce surface roughness and bring the lens closer to its final dimensions. Finally, polishing removes most of the remaining irregularities and gives the surface its required optical smoothness and transparency. This process combines mechanical and chemical actions (chemical–mechanical polishing) to reach roughness values below one nanometer, ensuring the precision and performance required for optical applications [1].

2. The production process of optical glass lenses

The production of a lens begins with the blank, which is rough-shaped during grinding, where the initial curvature and thickness are defined. This is followed by fine grinding, which refines the geometry and reduces surface roughness using progressively finer abrasives. In the polishing stage, the lens acquires its transparency and optical precision, reaching its final radius. Next comes centering, aligning the optical and mechanical axes, followed by cleaning to remove any residues. Finally, coatings are applied, the components are bonded, and the process ends with lacquering, resulting in a finished lens ready to be integrated into the final product [2]. The surface shaping of optical lenses comprises three abrasive processes: grinding, fine grinding, and polishing. Grinding removes most of the material to generate the lens's basic curvature, using either diamond tools or, more traditionally, an abrasive slurry applied to a tool with the complementary curvature. Fine grinding then employs smaller diamond pellets or finer abrasives to reduce surface roughness and refine the geometry. Polishing is the final step, eliminating remaining irregularities and giving the surface its required optical smoothness and transparency. Combining mechanical and chemical mechanisms, this stage (chemical–mechanical polishing) achieves sub-nanometer roughness, ensuring the precision needed for optical applications [1].

3. Using plaster as a blocking method

All hot-melt bonding methods rely on fixing the lenses using a resin heated to approximately 150 °C. One of the main issues with this technique stems from the difference in the coefficient of thermal expansion (CTE) between the aluminum support and the glass lenses. Because these materials expand and contract at different rates, internal stresses develop within the assembly. When the lens is de-bonded, these stresses may be released, causing distortions in the interference pattern and ultimately degrading the optical quality of the lens [3]. Additionally, this technique can present specific difficulties when applied to concave and convex lenses, the metal support/plate may not provide a uniform pressure distribution, leading to variations in the material removal rate during polishing. these variations compromise the final efficiency of the method, after the deblocking. Tests conducted using hot-melt bonding allow for efficiencies above 80\% for cases where the lens is flat on the side that is to be processed, and the side glued to the plate. In the case where the side pressed against the plate is concave, the percentage of lens that meets the tolerances decreases to 0%.

UV bonding uses adhesives that cure under ultraviolet light exposure, making it a widely used method due to its fast-curing time and strong adhesion to glass surfaces. However, this process presents significant technical challenges. One of them is oxygen inhibition, where the presence of oxygen in the environment can prevent the adhesive from fully curing on the exposed surface, making the adhesion less reliable [4].

3.1. Processing a flat surface of a lens

To test the suitability of plaster for lens blocking, test lenses with a flat surface and a concave surface (82 mm radius and 25 mm diameter), made of S-BSL7 and with a Knoop hardness (HK) of 570 were used. The Knoop hardness test measures how resistant a material is to scratching and deformation by pressing a small diamond indenter into the surface; higher HK values indicate harder glass [2].

After individual rough grinding, the lenses were blocked with the flat side to upwards to be processed, fine-ground, then the lenses were polished, which is the longest and most meticulous part of the process, where the lenses are polished using a film micro-cell polyurethane foam, that polishing pad is pressed against the lenses, and the plaster block is spun, with a constant slurry with cerium oxide in suspension. After this stage all lenses must meet both functional tolerances, according to the ISO 10110-5 norm (3/(0.5/3)), and must have no surface damages, scratches and stains.

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Before deblocking, interference patterns indicated that the support could behave as a larger lens. Concentric rings suggested slight curvature (concave or convex) (Figure 1 left), while parallel stripes indicated near-flatness (Figure 1 at right). Lenses followed SAG, IRR and RSI tolerances according to ISO 10110-5, where SAG defines the intended curvature of the surface, IRR measures large-scale shape deviations, and RSI refers to small-scale surface imperfections or micro-roughness that affect light transmission [1].

Before deblocking, interference patterns indicated that the support could behave as a larger lens. Concentric rings suggested slight curvature (concave or convex) (Figure 1 left), while parallel stripes indicated near-flatness (Figure 1 right). Lenses followed SAG, IRR, and RSI tolerances in the ISO 10110-5 norm, with a 3(0.5) specification for this flat surface, measured via Fizeau interferometer [2].

When fracturing the plaster block, both criteria mentioned above were analysed in terms of how many lenses met the SAG, IRR, and RSI parameters and how time-efficient the process was.

For the first premise the highest efficiency achieved topped at 72%, however for premise 2 the lowest efficiency was 93%. This means that for the test were the pattern in (Figure 1 at right) 93% of the lens in those tests met both the functional tolerances and the aesthetic criteria.

For both methods, the polishing plate and foam remained the same, differing only in how much pressure was applied during the process. The support was kept below, with the polishing tool above. In the case of Method 1, to achieve the pattern shown in Figure 1 left, pressure was applied using a spring for 20 minutes, followed by another 20 minutes without the spring. The results after the first 20 minutes were already similar to Figure 1 right, but the additional 20 minutes with reduced pressure (only the weight of the polishing tool) significantly improved the interference pattern quality, particularly in the outer lenses.

For Method 2, two 20-minute cycles with spring-applied pressure were followed by an additional 10 minutes without the spring to improve the shape of the outer ring of lenses, resulting in a total process time of 50 minutes.

Regarding the production time per lens, considering all necessary steps, -placing the lenses, preparing and pouring the plaster, fine grinding, polishing, removal, cleaning, and interferometric inspection-, the total time was 3:52 min for Method 1 and 4:10 min for Method 2. These low processing times were only achievable due to the polishing tool's geometry being close to the ideal shape after rectification.

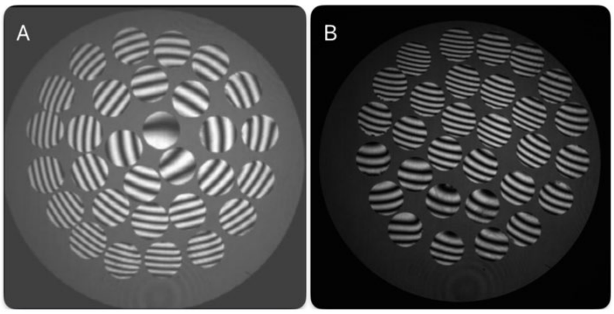

Figure 1. Comparison of the two possible interference patterns before breaking the plaster. On the left is the interference pattern showing concentric fringes, indicating a curved surface, on the right Interference pattern with parallel fringes, suggesting a nearly flat surface

3.2. Processing a concave surface

The production volume of curved lenses far exceeds that of flat surfaces, making their processing significantly more relevant for a company. This study follows the same principles as the previous tests but focuses on optimizing the polishing process for concave surfaces.

The following tests were conducted using a biconcave glass blank of S-TIH13 Glass with a Knoop hardness (HK) of 510 (radii: 52.188 mm and 14 mm), but only the 52.188 mm side was processed the tolerance for this optical surface was in the ISO 10110-5 norm, 3/3(0.75).

Monitoring by interferometry differs slightly for curved lenses compared to planar surfaces. Since the reference surface is not flat, the radius introduces a focal distance. When placing a lens in the interferometer, we must first locate this focal point and define it as our zero reference. This is the point where the laser beam converges to a minimal spot. After adjusting with a micrometer screw for a parallel equidistant interference pattern, then we proceed to adjust the lens to the correct radius—moving it farther from the reference surface if concave and closer if convex. A lens in the correct position, meaning

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at the proper distance from the focal point for the desired radius, will produce different interference patterns depending on its curvature [5].

For a concave lens, if the lens has the exact same radius as the reference, the interference pattern will consist of parallel, equidistant fringes. However, if the radius differs, the pattern will appear as concentric rings. The number of rings indicates how far the lens is from the intended radius. If pressing down on the lens holder causes the rings to contract, the lens has a lower radius than intended. If they expand, the lens has a higher radius.

For a convex lens, the situation is the opposite. After finding the focal point, the lens should be moved closer to the transmission sphere. If the pattern appears as concentric rings, and they contract, the radius is higher than intended. If they expand, the lens has a lower radius than intended [5,6].

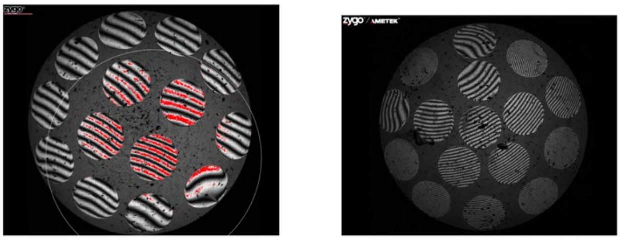

Figure 2. Comparison of lens arrangements in concave surface tests, pattern visualized with a 4" f/0.65 transmission sphere. On the left is the first concave surface test: inner ring with 4 lenses, outer ring with 10, on the right-side interference pattern before breaking the plaster block

In the first test, Figure 2 at left, a total of 14 lenses were arranged in two concentric rings: an inner ring with 4 lenses and an outer ring with 10 lenses. However, there was no lens positioned at the center of the concavity. For tests 2 and 3, an additional lens was placed in the central position, Figure 3 right, increasing the inner ring to 5 lenses, while the outer ring remained unchanged with 10 lenses. The additional lens at the center enables more precise monitoring within the interferometer, including the radius and the previously mentioned parameters. This lens allows for locating the focal point, ensuring an accurate measurement of the radius [6].

Regarding surface damage observed on polished lenses, only minor scratches were recorded. These did not require reprocessing through fine grinding but could be resolved with an additional polishing step not as lengthy. Across all tests, a total of 46 lenses were processed. Of these, two failed to meet interferometric tolerances due to exceeding IRR specification. Among the remaining 44 lenses, 22 exhibited minimal surface scratches, with the rest meeting all criteria both in the interferometer and in the aesthetic realm.

Table 1. Efficiency results for the concave surface

Test	1	2	3
Lenses per test	14	16	16
Functional Tolerances	13	16	16
Light scratches	6	8	7
Scrap	1	0	2
Finished lenses	12	9	10
Efficiency (%)	63	50	66

The complete process from plaster preparation to final individual cleaning took 135 minutes. Assuming a support holds 16 lenses, the production time per lens is approximately 7 minutes and 4 seconds. This represents a reduction in overall processing time, not only during polishing but also in the fine grinding stage. The use of test plates to check the shape of the surface explain the number of lenses with scratches.

4. Conclusion

The improvement of the lens production process is everyday studied in top quality optical components factories. The blocking of the lens using plaster is a promising, cost-effective alternative for both flat and concave surface lenses, enhancing efficiency in the simultaneous processing of multiple optical lenses

5. Acknowledgments

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Green Mınd Lab

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Abstract. This study examines the educational impacts of the Green Mind Lab, an ecological learning environment designed to integrate sustainability and science education. The creation of the laboratory was made possible by the growing need for an application area that emerged from STEM and environment-based activities conducted from an early age. Within the Green Mind Lab, multidimensional units have been structured, including agroecology, soil-less farming, aquaponics, worm composting, mushroom observation, ant colony study, rainwater harvesting, and waste recycling. These units enable students to use their scientific process skills, observe ecosystem cycles, and develop sustainable living habits. Organized in line with the United Nations Sustainable Development Goals, the laboratory enables students to produce solutions to real-life problems from a science perspective. The study is significant in that it demonstrates the extent to which experiential science education practices can be effective in supporting sustainability awareness.

Keywords. Sustainable Development Goals, Sustainability, Science Education.

1. Introduction

It is well known that science education requires learning environments that enable students to understand the environment not only at a theoretical level but also through direct observation and experience. It has been observed that existing classroom environments are inadequate in light of the interest students show in STEM applications from an early age and their desire for hands-on learning. This process revealed the need to create an ecological learning space based on students' suggestions, curiosities, and needs. Therefore, Green Mind Lab was structured based on needs assessment studies conducted with students, and the content of the learning environment was shaped according to students' concrete suggestions. Student engagement in this process took place as part of the ICSE Science Factory European Union Project implemented at Maya Schools.

2. Purpose and Theoretical Basis of Green Mind Lab

Experiential learning, constructivism, and systems thinking theories were used as the basis for the design of Green Mind Lab. Through the laboratory, the following are targeted: linking environmental problems to scientific evidence, establishing conceptual integrity regarding the functioning of ecosystems, structuring sustainable living habits at an early age, applying scientific process skills in natural contexts, and internalizing responsible consumption and recycling behaviors through experience. The units that the laboratory will include have been determined based on studies conducted with students, thus creating a jointly designed learning ecosystem.

3. Laboratory Units and Learning Processes

All units in the laboratory have been determined based on discussions with students, classroom observations, and needs analyses. Units such as agroecology, aquaponics, worm composting, mushroom cultivation, ant colonies, and rainwater harvesting have been structured to meet students' desires to “see, understand, and produce solutions.”

4. Model of Innovation

Based on:

- Design Driven by Need and Student Participation: The emergence of the laboratory was shaped by the identification of needs encountered during STEM-based studies and by student suggestions.
- Ecosystem-Based Learning: The laboratory is designed like a micro-ecosystem with cyclical processes.
- Student Agency: Students are actively involved in system building, data collection, and project development processes.

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- Interdisciplinary Integration: A learning environment integrating science, mathematics, engineering, and design has been provided.

Figure 1

5. Learning Outcomes and Impact

Improvements in scientific process skills, increased ecological literacy, the development of sustainable living behaviors, strengthened systems thinking skills, and increased environmental awareness extending to students' families have been observed. Furthermore, as a result of designing the laboratory together with the students, it has been determined that student voice has been strengthened and active participation in decision-making processes has increased.

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Hands-on STEM Education Models: The Case of UAE Schools and Universities

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Abstract. Researchers stress the need to move towards co-produced transdisciplinary research that uses hands-on materials and activities. The UAE shows an increased interest in research for STEM education where the integration is as natural. The purpose of this study was to find the factors that influence the development and transition of integrative skills in universities and high schools within the UAE context. The qualitative document revealed several results. Local universities emphasize the importance of integrative, innovative programs, such as STEM education. Universities and high schools emphasize the development of skills in collaboration, communication, critical thinking, systems thinking, leadership, and lifelong learning.

The multidisciplinary approach involves different disciplines working on a common problem but retaining their own boundaries and methods. The transdisciplinary initiatives promote the co-creation of knowledge with community and industry stakeholders [1] and ensure curriculum integration and knowledge co-production. Interdisciplinary and transdisciplinary research have come to symbolize a broad shift in research agendas toward an emphasis on utility [2]. Researchers argued that research needs to move towards co-produced transdisciplinary research. In doing so, research can be more representative of stakeholder interests and knowledge and also make important contributions to academic impact [3]. Moving to transdisciplinary teaching and learning has several advantages. This approach helps students to learn by extending from conceptualization to implementation. The transdisciplinary approach in schools and universities offers students meaningful learning experiences through curricula and programs that cross traditional subject boundaries. In doing so, students pursue their interests, inspired to study and work in emerging fields. In addition, as found by [4], the transdisciplinary approach redefines students' roles as co-researchers and mediators across institutional boundaries and the importance of long-term partnerships between academia, municipalities, and industry. The purpose of this study was to find the factors that influence the development and transition of integrative skills in universities and high schools within the UAE context. The main research question is: What are the influential factors that aid in the development and transmission of integrative skills within the university and high school contexts in the UAE?

The theoretical framework is based on Vasquez et al.'s work [5, p.9], Table 1, 'where different forms of boundary crossing are displayed along a continuum of increasing levels of integration, with progression along the continuum involving greater interconnection and inter-dependence among the disciplines.'

Table 1. Levels of Integration (adapted from Vasquez et al. 2013)

Form of integration	Features
1. "Disciplinary"	"Concepts and skills are learned separately in each discipline."
2. "Multidisciplinary"	"Concepts and skills are learned separately in each discipline, but within a common theme."
3. "Interdisciplinary"	"Concepts and skills are closely linked and learned from two or more disciplines to deepen knowledge and skills."
4. "Transdisciplinary"	"Knowledge and skills learned from two or more disciplines are applied to real-world problems and projects, thus helping to shape the learning Experience."

Traditional teaching methods have changed due to the shift to skills-oriented education in the 21st century. Education started to focus more on competencies such as digital literacy, critical thinking, and sustainability. In this shift, teacher competence has become a key factor for successful skills integration. Research shows that having well-designed curricula is not enough. Effective integration relies on teachers' readiness, technological skills, and access to ongoing professional development [3,6]. Overall, the literature points out strong connections between teacher competence, teaching methods, and the quality of skill-integrated education programs.

The methodology followed a qualitative approach supported by the constructivist

philosophy and the use of document analysis. Several key themes are identified, including skill development, soft skills, career preparation, and life skills. The skill development theme is supported by several codes, such as self-awareness, collaboration, problem-solving, communication, and presentation skills. These codes were derived from objectives that call for acquiring appropriate content, enhancing self-awareness, collaborating with peers, and connecting personal interests and values to potential career paths. Another theme that emerged from the document analysis of local UAE universities is soft skills and career preparation. The codes that reinforced this theme are self-discovery, professional profile, industry dynamics, and career aspirations, planning, and preparation. Some of the objectives that guide this theme include assessing students' interests, skills, and values to define their personal brand, conducting self-assessments to identify strengths, preferred programs and course offerings, and nurturing career aspirations and related internships. The life skill theme has code such as communication skills, introspection, self-care, professional interactions, and self-learning. Also, school coding revealed patterns of integration that spanned through the four levels as in [5] model, disciplinary, in the majority, multidisciplinary, for the majority, interdisciplinary, and rarely transcdisplinary. Examples of strategies included: inquiry-based learning, project-based learning, problem-based learning, gaming, and role-playing learning. Despite strong momentum, persistent systemic barriers hinder the full realization of transdisciplinary and multidisciplinary learning. Teacher competence gaps—particularly in digital literacy, green skills, and design-based pedagogy—remain a major obstacle, underscoring the need for sustained, high-quality professional development. Another recommendation is based on a challenge that underscores the urgent relevance of curriculum reform for career readiness in the UAE and globally. The Ministry of Education has the pressing charge of mandating policies to develop and close gaps in integrative skill development between high school and university, ensuring students are prepared for both academic progression and workforce demand. The study recommends establishing a continuous, scaffolded skills development across school and university foundation levels. There is a need to adopt human-centered, competency-based curriculum models, with industry collaboration, a licensure approach, and benefit from artificial intelligence (AI).

Keywords. Hands-on, STEM Education, Transdisciplinary Integration, UAE Schools and Universities.

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Hands-on Diffraction

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Abstract. Light diffraction is a central concept in Physics because it reveals its wave nature. At the same time, it connects different scientific and technological fields of knowledge, for example, lens design or spectroscopy, optical diagnostics or medical imaging techniques, crystallography o material analysis, signal processing or semiconductor manufacturing. As an everyday phenomenon, it is sometimes confused with others, as refraction, or goes unnoticed. It reveals the "size" of light when it encounters an obstacle on the order of its wavelength. The complexity of the associated mathematical treatment sometimes makes its introduction in the classroom difficult, but the phenomenon can be addressed through models, analogies, and hands-on experiments. So students can learn: a) that light has wavelength and phase; b) that superposition of waves provides diffraction patterns related with everyday situations; or c) that the shape and size of the diffraction pattern, as a universal wave phenomenon, encode physical information that gives us information about obstacle´s dimensions, wavelength, distances, …

There are well-known experiments aligned with curriculum standards that are generally carried out in laboratories as structured practical exercises to convert diffraction into a measuring tool, for example, diffraction of a narrow slit or measurement of wavelength using a diffraction grating. But, in this workshop a different set of safe and simple hands-on activities that connect classroom concepts with real-world applications and other disciplines and ideas: colour, chemistry, biology, technology, …. Is presented. These activities can be used as hands-on demonstrations in masterclass or as support to inquiry-based teaching [1-8]. They can be scaled from middle education to university level. The simple hands-on activities presented in this workshop have been used successfully with our students of the Master's Degree in Science Teaching at the University of Vigo since the 2020/2021 academic year and in more than a hundred informal/non-formal masterclass in high schools in Galicia-Spain since 2011 [9].

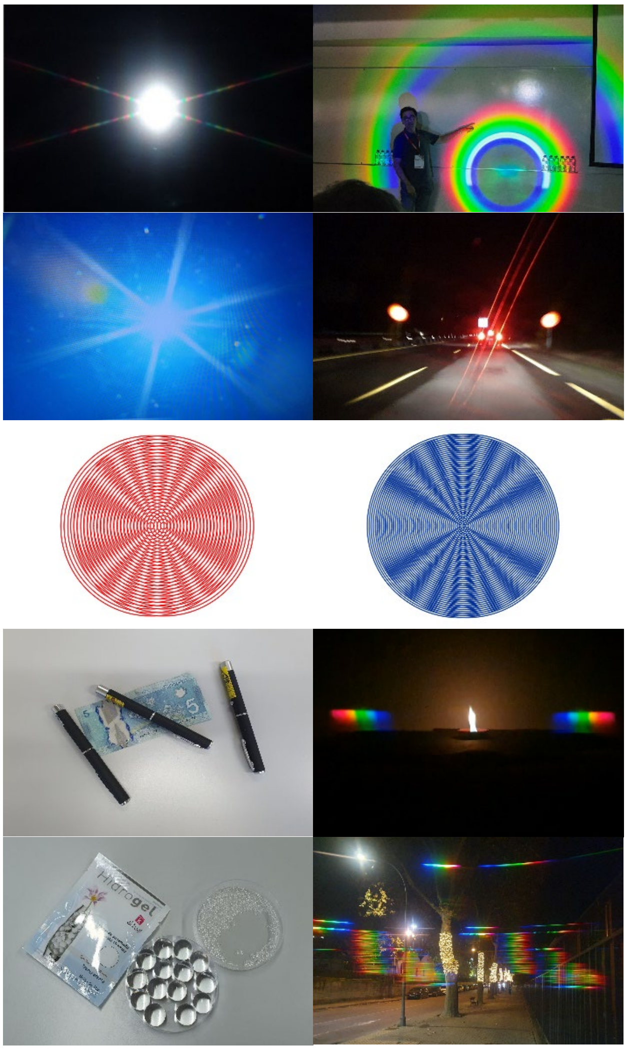

Figure 1. Some hands-on diffraction activities inside and outside the classroom

Keywords. Hands-on, Diffraction, Formal Education, Informal Education, Non-Formal Education, Training of Teachers.

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Electron Transport and Oxidative Phosphorylation Taught through a Traditional Narrative

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Abstract. By engaging deeply with the details of a traditional narrative, imagination is stimulated in some way that significantly enhances memory formation. Curiosity is closely linked to the release of dopamine, a neurotransmitter that facilitates attention and learning. Narratives satisfy innate curiosity and expose learners to diverse ideas and perspectives [1-4]. Thus, story telling could be a good innovation tool to learn. Electron transport and oxidative phosphorylation are commonly recognized as challenging concepts for biochemistry students [5]. Some aspects, including how electrons are transferred from NADH until oxygen by using complexes I, III and IV, structure of ATP synthase or complex V, and the roles of inhibitors, uncouplers and ionophores are difficult to understand, Consequently, framing these topics through the storyline of Rapunzel may serve as an effective pedagogical approach. The tale of “Rapunzel, or “The Maiden in the Tower,” writted by the Brothers Grimm [6], is classified as ATU (Aarne–Thompson–Uther) 310, within the group of “tales of magic”.

The story tells how a young couple are in love and want to have children. They live next to a cabbage patch belonging to a wicked witch. The wife wants to eat the cabbages from this patch, and her husband goes at night to pick some for her. He is caught by the witch, who tells him that since he steals her vegetables, she will steal his daughter as soon as she is born. The wife becomes pregnant after eating the cabbages, and after some time, a girl is born. The witch kidnaps the child and locks her in a tower with no doors, and only a small window. The girl, whom the witch names Rapunzel, grows up believing that the witch is her mother. The witch tells her that the world outside the tower is full of thieves and that she is safe inside. To visit her, she asks Rapunzel to let down her golden hair.

One day, the prince hears Rapunzel singing and discovers the tower, but he cannot enter. Secretly, he discovers how the witch climbs up, so when she leaves, the prince asks to Rapunzel to let down her hair, and he climbs to the window using her braided locks. Rapunzel is surprised by the visit, but when she talks to him, she discovers that the world is not as bad as the witch had told her. She decides to accompany the prince, but she can't get down from the tower. When the witch returns the next day, she discovers that Rapunzel has had a visitor from outside. The witch punishes her by cutting off her hair and abandoning her in the middle of a swamp.

When the prince arrives the next day to the tower, the witch lets down the cut hair, and the prince climbs up and discovers the witch. Trying to escape from her, he falls out of the window onto a bramble bush and he becomes blinded. Wandering through the swamp, the prince finds Rapunzel, who recognizes him and cries on his shoulder over their shared misfortune. Rapunzel's tears heal the prince, who can see again, and they both live happily ever after in the kingdom.

In analogy with the tale, ATP synthase or complex V (Rapunzel) requires protons (represented by the cabbages stolen by Rapunzel’s father) to operate. The witch abducts Rapunzel and confines her to a tower without doors (the mitochondrion). Transport to the mitochondria is not easy. The witch instructs Rapunzel to lower her golden hair (the electron transport chain) through the window. The prince (NADH) ascends her hair, sequentially through complexes I, III, and IV. The witch works as an uncoupler: by cutting Rapunzel’s hair, she disrupts the coupling between the ATP synthase (Rapunzel) and the electron transport chain (the golden hair). Abandoned into the swamp, Rapunzel becomes inhibited, as she is not in the tower anymore (mithocondrion disrupted). By the other hand, while escaping the witch, the prince falls into a bramble bush and loses his sight, thus becoming incapacitated (electron transport is also inhibited), until he finds Rapunzel in the swamp. Her tears restore his vision, enabling both characters to regain function. Analogously, ATP synthase operates only when electron transport is active.

This narrative framework can thus be a valuable

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tool for improving comprehension of electron transport and oxidative phosphorylation, including the roles of substrates, inhibitors, uncouplers, and ionophores.

Keywords. Biochemistry, Electronic Transport, Oxidative Phosphorylation, Fairy Tales.

Acknowledgements

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Mind of Perceptron: A Simple Tool to Understand the Basics of the First Neural Network

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Abstract. The study and understanding of artificial neural networks have become increasingly relevant in the educational context, as they allow students and researchers to internalize fundamental concepts of machine learning and artificial intelligence [1]. However, the mathematical and algorithmic complexity of such networks often poses a challenge for beginners. In this context, we present Mind of a Perceptron, a pedagogical software developed with the aim of facilitating the comprehension of the functioning of the Perceptron [2,3], one of the most basic neural network models.

Modern neural networks—including deep learning architectures—are direct extensions of ideas first introduced with the Perceptron [4]. By studying these foundational models, students and researchers can better grasp how complex systems learn from data, recognize patterns, and make decisions.

The tool enables users to visualize and interactively manipulate the main features of the Perceptron, including activation functions, learning rate, and number of epochs.

Through practical and visual experimentation, the software allows users to draw letters of the alphabet and test whether the program can recognize them using different Perceptron configurations. It is expected that image preparation, classification, and parameter adjustments will render more concrete and accessible some of the abstract concepts involved in understanding some fundamental principles of artificial neural networks, thereby contributing to student engagement and comprehension, while fostering active learning and interest in artificial intelligence.

The software offers an interactive platform for exploring the functioning of a Perceptron model. Users may utilize preloaded test images or create their own samples directly within the interface, with simple options to replace or remove images as needed. All input images are interpreted as uppercase, machine-style letters.

The system allows selection of the dataset corresponding to the target letter (26 letters of the alphabet) and provides configurable parameters, including the activation function, learning rate, and number of training epochs. Parameter combinations have been pre-optimized to achieve a balance between recognition accuracy and computational efficiency.

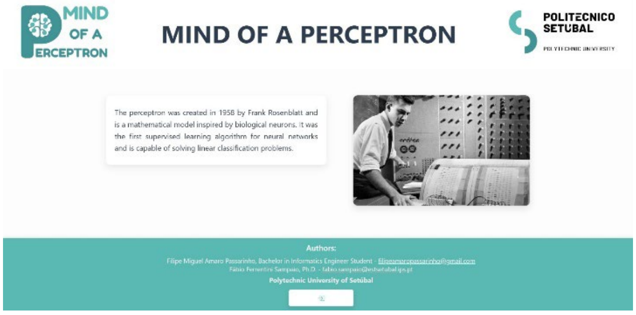

Figure 1, Open window of *Mind of a Perceptron*

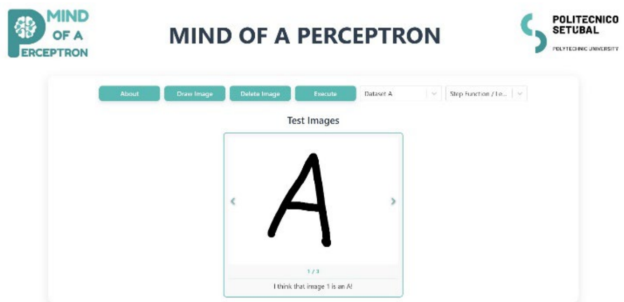

Figure 2. *Mind of a Perceptron* recongnizing letter “A”

Upon completion of training, the software evaluates all test images and presents the predictions in the Results section. This approach enables users to explore and observe the influence of different configurations on the model’s performance (Figures 1 and 2).

In addition, the software can run as a standalone desktop application on Windows systems, without requiring an internet connection once installed. This ensures accessibility even in offline or restricted-network environments. Users interested in obtaining a Windows installation package can contact the authors to receive the necessary files and setup

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instructions.

Keywords. Perceptron, Neural Networks, Educational Tool.

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The Effect of Family-Involved Environmental Education Practices on Children's Scientific Process Skills and Environmental Awareness: The Case of Global S.O.S. "Little Explorers"

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Abstract. This study investigates the effect of family-involved environmental education practices on the scientific process skills and environmental awareness of children aged 8–9. The study is based on the implementations carried out under the title "Little Explorers" with a family group among the project teams operating within the international Global S.O.S. (Save Our Species) initiative during the 2024–2025 academic year in Antalya, Türkiye. The study involved field observations, experimental activities, STEAM-based game design, a waste paper collection campaign and sister-school interactions conducted with active family participation. Using a qualitative case study design, the study analyzed children's observation notes, project products, photographs and quantitative field measurements. The findings indicate that activities conducted under family guidance significantly enhanced children's process skills such as scientific observation, measurement, classification and inference. Furthermore, it was determined that children developed environmental responsibility and patterns of sustainable behavior through direct interaction with nature.

Keywords. Environmental Education, Family Involvement, Scientific Process Skills, STEAM Education, Sustainability.

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This study has been carried out by the Antalya Little Explorers Family Group within the scope of the Global S.O.S. project. Second author would like to thank Nilgün Erentay, Global SOS Project Coordinator, for her contribution to the Little Explorers through the educational program and activities implemented throughout the project period, along with the annual project plan; Association EXPEDU - Expedition to Education (Expedu Eğitime Yolculuk Derneği); all family members and children; Songül Topcu for her digital support and Erdal Göksu for his technical support.

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No Barrier to Vision

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Abstract. This interdisciplinary STEM project was developed to address the themes of health, digitalization, and sustainability through the design of an assistive technology that enhances the safe and independent mobility of visually impaired individuals. A voluntary group of 11–12-year-old students followed an engineering design cycle that included identifying accessibility challenges, researching existing smart cane solutions, and establishing design criteria. The students refined their ideas through consultations with experts from engineering, psychology, and technology fields, as well as visually impaired users who provided authentic feedback.

Using LEGO-based mock-ups, Arduino microcontrollers, ultrasonic sensors, vibration motors, and sound alerts, the students created and iteratively improved a functional prototype capable of detecting obstacles and providing timely feedback. The project allowed students to integrate concepts from mathematics, science, and information technologies with hands-on engineering practices. It also supported the development of empathy, collaboration, creativity, and problem-solving skills while raising awareness of the daily challenges faced by visually impaired individuals. Overall, the project highlights the value of student-centered engineering experiences in real-life learning contexts.

Keywords. Assistive Technology, Inclusive STEM Education, Middle School, Smart Cane, Visual Impairment.

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Enhancing Students' Ecological Awareness Through Digital Mapping of Endemic Species

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Abstract. The 20th century witnessed the destruction of biodiversity and natural resources at an unprecedented rate in human history as a result of unsustainable development. The damage inflicted on biodiversity has reached a level that cannot be compensated merely through regulating land use or designating certain protected areas. Climate change, all forms of environmental pollution, and the unsustainable use of natural resources are making it impossible for humanity to maintain its well-being and/or meet even its minimum vital needs. In this context, it is essential to take concrete steps to make sustainable development a national policy. In education, topics and learning outcomes related to biodiversity should be prioritized in order to increase students' awareness of natural resource conservation.

The sustainable use of biodiversity is a necessary policy instrument, and structural changes must be implemented so that all sectoral policies can be integrated with unique strategies that prioritize the conservation of biodiversity. This study purpose is to draw students' attention to our country's rich vegetation through digital mapping techniques and to enable them to apply the knowledge they gain on maps using games, simulations, and coding tools, while also raising awareness of endemic species.

Our country possesses an extremely rich flora due to factors such as its geographical location, geological structure, and climate diversity. The number of taxa (plant species) in Turkey is approximately 11,400, and the number of endemic taxa is around 3,700. In this respect, our country is one of the richest in the Middle East and Europe in terms of both total species and endemic species. Having sufficient knowledge of the resources we possess is a prerequisite for protecting them. Although topics and learning outcomes related to our country's geography and vegetation are included in school curricula, it is evident that we lack sufficient knowledge about Turkey's fauna and flora due to insufficiently enriched educational content and limited instructional time.

The final beneficiaries of our project are primary and secondary school students. With this project, we aim not only to examine the vegetation we have today but also to shed light on plant populations that existed in the past.

Keywords. Environmental Project, Endemic Species, Digital Mapping.

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Creating of STEM Equipment: Entanglion for Quantum Mechanics Education

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Abstract. As part of the development of innovative teaching methods in physics, we propose to introduce the board game Entanglion during classes on quantum mechanics. This game is designed not as a competition but as a cooperative card-based project, where students explore concepts such as entanglement, superposition, and quantum measurement. The hybrid nature of the game (available both online and offline) allows participation regardless of students' location, which is especially relevant in wartime conditions in Ukraine, when many students are displaced or studying remotely.

The mechanics of the game encourage teamwork, problem-solving, and critical thinking, while the card format provides a tangible way to interact with abstract ideas of quantum mechanics. Students can simulate the building of quantum algorithms, encounter challenges similar to decoherence or noise, and collectively find strategies to overcome them. This approach makes quantum physics more accessible and engaging while promoting collaboration and creativity.

Incorporating Entanglion into the curriculum contributes not only to understanding theoretical foundations but also to the development of soft skills such as cooperation and communication. The flexibility of the game format enables its integration into short workshops, semester courses, or extracurricular STEM activities. Such methods of game-based learning create an effective and inclusive educational environment even under challenging circumstances.

Keywords. Quantum Mechanics Education, Game-Based Learning, Entanglion, STEM Education, Cooperative Learning.

Evaluating Natural Alternatives to Chemical Pesticides: Environmental and Soil Health Perspectives

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Abstract. In recent years, the demand for healthy and organic foods has been steadily increasing. One such food, microgreens, has attracted the interest of consumers due to their vibrant colors, delicate structure, strong aroma, and especially the positive health effects associated with their bioactive compounds. Microgreens are greens harvested after the seeds of various vegetables, plants, or grains germinate and the first true leaves emerge. Thanks to the high levels of phytochemicals they contain, microgreens can play an effective role in preventing various diseases. In our project, our aim is to raise awareness for the development of local and national products that will benefit society by acting with a sense of social responsibility during these times when agricultural production is highly important, and to make use of digital educational materials.

Feeding the continuously growing global and Turkish population has become a major concern and naturally increases the demand for food. On the other hand, agricultural lands are constantly being lost due to misuse, environmental pollution, and other factors. This situation makes the protection and sustainability of agricultural land even more critical. Soil is one of the most essential factors in agricultural production. Although studies on soilless agriculture are ongoing, it is clear that these methods will not be sufficient to meet the food demand of a growing population and cannot diminish the importance of soil. Additionally, soil is the second largest carbon reservoir after the oceans; therefore, ensuring the sustainable use of soil contributes to reducing the amount of carbon dioxide in the atmosphere and thus helps mitigate the greenhouse effect.

In our project, our goal is to demonstrate that extracts obtained from the microgreens of different seeds can be used as an alternative to chemical fertilizers—which lead to increased soil salinity, heavy metal accumulation, eutrophication in waters, and greenhouse gas emissions in the atmosphere. We also aim to share the results of experiments conducted through a mobile application, to show students, educators, and professionals working in agriculture that alternative solutions can be tried to combat soil pollution, and to raise awareness on this issue.

Keywords. Soil Fertility, Environmental Project, Microgreens.

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Methods for Eradicating Water Hyacinth at Nile River and Waterways

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Abstract. The objective of this paper is show how to extract water hyacinth from waterways to prevent its harmful effects and to utilize it for financial gain. The core idea is based on innovative thinking through the use of creative tools to accomplish this task, moving away from the simple tools currently used by workers, such as forks and the unknown human element. This stems from an idea I presented in the early 2000s to the Academy of Scientific Research, Egypt under the name "Zayed Submersible Water Network for Water Hyacinth Extraction." This idea was showcased at the Technological Innovation Exhibition at the Mechanical Engineers Association in Ramses in 2002. I am prepared to provide a scaled-down model of this network should the idea be accepted, along with a full explanation of its operation and handling methods, and to present new ideas.

To deal with water hyacinth in large bodies of water. The net is designed with a length equal to the width of the waterway plus 4 meters to allow it to be placed 25 cm below the floating plants. The net is fixed in the preparation area on one of the paved banks of the waterway, which is equipped with a filter to remove any water that has adhered to the extracted plants. The net is placed in the preparation area between two "sluices," which are adjacent metal drums used to control the flow of water hyacinth. Sluice number 2 is fixed, while number 1 moves against the floating water hyacinth plants pushed by the waves. Water hyacinth plants equal in width to the net are allowed to pass through using sluice number 1. Then sluice number 1 is closed, leaving the water hyacinth plants floating on top of the net submerged between the two sluices. The net is hauled in by the haulage equipment located on the extraction platform to unload its cargo, and then the above steps are repeated.

To repeat the process, the extracted material is left for a few minutes to remove excess water, then transferred for processing and use as animal feed after removing the roots due to their potentially harmful components. Alternatively, it can be dried and used as organic fertilizer or processed to extract biogas.

To extract water hyacinth from large bodies of water, a specialized machine is used: a motorized cabin (similar to a marine launch) with a 4-square-meter movable box at its front. The box has U-shaped sides, a height of 30 centimeters, and a perforated bottom. The machine moves freely towards the plants, similar to a loader, extracting approximately 16 square meters of the plant and transporting it to a prepared extraction dock for processing.

Keywords. Water Hyacinth, Environmental Project.

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Project Enhancing Students' Ecological Awareness Through Digital Story of Endemic Species

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Abstract. The 20th century witnessed the destruction of biodiversity and natural resources at an unprecedented rate in human history as a result of unsustainable development. The damage inflicted on biodiversity has reached a level that cannot be compensated merely through regulating land use or designating certain protected areas. Climate change, all forms of environmental pollution, and the unsustainable use of natural resources are making it impossible for humanity to maintain its well-being and/or meet even its minimum vital needs. In this context, it is essential to take concrete steps to make sustainable development a national policy. In education, topics and learning outcomes related to biodiversity should be prioritized in order to increase students' awareness of natural resource conservation.

The sustainable use of biodiversity is a necessary policy instrument, and structural changes must be implemented so that all sectoral policies can be integrated with unique strategies that prioritize the conservation of biodiversity. The purpose of this study is to draw students' attention to our country's rich vegetation through digital stories created by students about endemic species, and to enable them to apply the knowledge they gain using games, simulations, and coding tools, while also raising awareness of endemic species.

Our country possesses an extremely rich flora due to factors such as its geographical location, geological structure, and climate diversity. The number of taxa (plant species) in Turkey is approximately 11,400, and the number of endemic taxa is around 3,700. In this respect, our country is one of the richest in the Middle East and Europe in terms of both total species and endemic species. Having sufficient knowledge of the resources we possess is a prerequisite for protecting them. Although topics and learning outcomes related to our country's geography and vegetation are included in school curricula, it is evident that we lack sufficient knowledge about Turkey's fauna and flora due to insufficiently enriched educational content and limited instructional time.

This study was carried out within the scope of Global S.O.S Project.The final beneficiaries of our project are primary and secondary school students. With this project, we aim not only to examine the vegetation we have today but also to shed light on plant populations that existed in the past.

Keywords. Environmental Project, Endemic Species, Digital Mapping.

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STEM in Action: Student-Designed Adaptation Solutions to Climate Change

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Abstract This work presents an educational intervention implemented during the 2024–2025 school year at the Experimental Junior High School of Rethymno, University of Crete, within the framework of the Science Club “Learning About Climate Change” and the School Activities Program “The Climate Is Changing: We Learn, We Plan, We Adapt”. The intervention engaged students in a series of two-hour sessions featuring activities drawn primarily from the Teacher’s Guide developed through the Hellenic Foundation for Research & Innovation (H.F.R.I.–funded STEM-ID) program [1].

Following a structured sequence—(a) Problematic Situation, (b) Background Knowledge, (c) Causes of Climate Change, (d) Impacts of Climate Change, and (e) Mitigation Measures—the students explored the scientific, environmental, and societal dimensions of climate change [2].

Collaboration with students from the Programming Club enabled the integration of technology-based solutions, with a particular focus on climate change adaptation measures. Students designed and constructed physical models enhanced with robotic systems, which they programmed under the guidance of the supervising teachers [3]. The resulting projects, “Coastal Area: Protecting a Building from Sea-Level Rise” and “Rural Area: Protecting an Outdoor Crop from Extreme Sunlight and Temperature,” were showcased at the Science Celebration held in students home town (Rethymno, Crete) in May 2025.

The presentation will outline the full educational pathway followed and highlight the interdisciplinary nature of the project, demonstrating how STEM fields can be meaningfully integrated into the study of climate change and the development of adaptation strategies.

Keywords. Climate Change, STEM Education.

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Sweet Illusion. How a STEAM Project Develops Critical Thinking About Food Products

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Abstract. This paper presents an extended description of an interdisciplinary STEAM project titled *"Sweet Illusion"*, carried out with students in grades 4–7 in a primary school setting. The project was designed to strengthen critical thinking, scientific literacy, and informed consumer awareness through hands-on investigations of widely available food and drink products. By integrating science, technology, engineering, arts, and mathematics, the project offered students a cohesive and engaging learning experience that connected curricular content with real-life decision-making.

The scientific component invited students to explore the chemical and biological aspects of sugars found in commonly consumed products, especially beverages. Through practical experiments, students identified different types of sugars, observed their properties, and discussed their metabolic roles. They also examined how sugar content influences health, energy regulation, and dietary habits. These activities supported inquiry-based learning and encouraged students to form evidence-based conclusions.

Technology was introduced through the use of mobile applications and online tools that allowed students to scan product barcodes, interpret nutritional information, and compare ingredient lists across brands. This demonstrated how digital tools can support scientific inquiry and consumer education. Mathematical reasoning played a significant role in the project: students calculated sugar quantities, created proportional comparisons, translated nutritional data into visual forms such as bar charts and diagrams, and analysed consumption in relation to daily recommended values.

The engineering and design component challenged students to create models of products with transparent, honest labelling. They explored how packaging influences perception and how design decisions affect consumer choices. This naturally led into the arts segment of the project, where students produced posters, infographics, short videos, and visual campaigns confronting misleading advertising techniques. These creative works revealed the contrast between marketing-driven "sweet illusions" and scientific reality. Students thus gained experience translating data into persuasive and accessible visual messages, enhancing their communication skills.

The interdisciplinary nature of the project allowed students to understand food products not only from a biological or chemical perspective but also through mathematical analysis, technological support tools, and artistic expression. This expanded understanding helped students develop a more nuanced and critical attitude toward everyday products. The project also fostered teamwork, creativity, problem-solving, and digital competencies, all of which are essential for navigating contemporary information-rich environments.

The outcomes demonstrate that STEAM-based education can be an effective approach for addressing topics relevant to students' lives while simultaneously building foundational scientific and analytical skills. This project can be replicated or adapted for different educational contexts, providing a model for how science education can be linked with health awareness, responsible consumer behaviour, and social understanding. Moreover, the project illustrates the value of connecting school learning with the broader societal landscape, making education meaningful, relatable, and empowering for young learners.

Keywords. Critical Thinking, Hands-on Science, Interdisciplinary Learning, STEAM Education.

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Science for the Society: Science Café

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Abstract. All aspects of public interaction with science, including science communication, literacy, outreach, and awareness, are collectively referred to as "science engagement." Simply put, science is the systematic knowledge generated in research institutes and universities across all societies. It has the potential to address any challenge, particularly in developing nations, which is why scientific institutions in these countries, together with science cafés and clubs, are essential for enhancing scientific understanding and taking significant steps toward meeting societal needs. Our journey began at the National Research Centre, then extended to Ain Shams University, and later to the National Institute of Astronomy and Geophysical Research.

In Egypt, there are numerous initiatives aimed at establishing Science Cafés. Designed to bridge the gap between academia and the public, the Science Café is an informal gathering that presents scientific concepts in an accessible way for all. We believe that science is for everyone and that it holds the power to solve problems not only in developed nations but also perhaps even more critically in developing nations, where it can help overcome challenges tied to current living conditions. During each conference, we host a Science Café for the public and for schoolchildren, where we share some of our ideas and simplify scientific missions previously carried out in our laboratories. These gatherings also provide valuable opportunities for the public to engage directly with scientists on specific topics. Ultimately, they support our mission to build a scientifically informed society.

Our activities can be followed through the following links: a) the Science Café YouTube Channel [1]; b) The Science Café Facebook Page [2]. The Science Café team also participates in various initiatives aimed at promoting scientific awareness both within and beyond the National Research Centre (NRC). In this context, we will present the units that launched the Science Café at NRC and Ain Shams University. The goal is to pave the way for the practical adoption of these modern approaches in advancing science and addressing societal needs.

Keywords. Science Communication, Literacy, outreach.

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[2] https://www.facebook.com/Science-Cafe-307592752957399

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Enhanced Electrodes for Salinity Gradient Power Cells Using Activated Carbon-Coated Stainless Steel Mesh

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Abstract. Salinity gradient power cells are an emerging and sustainable energy technology that harnesses the energy difference between two solutions of varying salinity—typically seawater and freshwater—to generate electricity. The underlying mechanism depends on the movement of ions across selective electrodes that convert chemical potential energy into electrical energy. However, the performance of such systems is strongly influenced by the choice of electrode materials. This study presents the design and fabrication of a cost-effective, high-performance electrode based on stainless steel mesh coated with activated carbon. The stainless steel mesh was chosen due to its high corrosion resistance, mechanical stability, and availability in the Egyptian market at a relatively low cost of 80–120 EGP per meter. To improve its electrochemical properties, a coating of activated carbon was applied.

Activated carbon, derived from coconut shell charcoal or water filter carbon, is known for its large surface area, excellent electrical conductivity, and chemical stability in saline environments. Its price in Egypt ranges between 100–150 EGP per kilogram, making it an affordable option for large-scale applications. The coating mixture was prepared using the following composition: 70% activated carbon, 20% binder material (either polyvinyl alcohol or graphite adhesive), and 10% light solvent (distilled water or ethyl alcohol). Optionally, 10–15% graphite powder was added to further enhance the electrode's electrical conductivity. The components were thoroughly mixed until a uniform semi-liquid paste was formed. The prepared paste was then applied to the stainless steel mesh using either a fine brush or a spray applicator. After coating, the electrodes were dried at room temperature and subsequently heated at 100–150°C for 30 minutes to ensure proper adhesion and uniform distribution of the active layer. The fabricated electrodes were integrated into a salinity gradient power cell consisting of two chambers: one filled with freshwater and the other with seawater. The coated stainless steel mesh served as the active electrode in both chambers, separated by an ion-selective membrane. The potential difference generated between the two solutions was measured and analyzed for current density, internal resistance, and stability under continuous operation.

The activated carbon-coated stainless steel electrodes exhibited significant improvements in electrochemical performance compared to uncoated electrodes: - Increased Active Surface Area: The porous structure of activated carbon provided a larger electrochemical interface, promoting faster ion exchange between the two solutions. - Reduced Internal Resistance: The enhanced conductivity of the activated carbon and optional graphite powder minimized internal resistance, improving overall current output. - Stable and Durable Operation: The coated electrodes demonstrated strong adhesion between the carbon layer and metal surface, resisting delamination and corrosion even in high-salinity environments. - Cost-Effectiveness: The total cost of electrode fabrication was substantially lower than traditional materials such as titanium or platinum, without compromising performance. Performance comparisons revealed that the stainless steel–activated carbon electrodes achieved 10–15% higher conductivity and a notable reduction in cell impedance, contributing to increased energy conversion efficiency. This research highlights the feasibility of using stainless steel mesh coated with activated carbon as a practical, durable, and low-cost electrode for salinity gradient power cell applications. The combination of high conductivity, corrosion resistance, and enhanced ion transfer efficiency makes it an attractive alternative to expensive electrode materials like titanium. The successful development of this electrode design could pave the way for scalable, sustainable energy systems that harness natural salinity gradients as a renewable resource.

Keywords. Salinity Gradient Power Cells, Activated Carbon-Coated Electrodes, Stainless Steel Mesh, Electrochemical Performance, Ion Transport Enhancement, Renewable Blue Energy, Low-Cost Electrode Materials, Energy Conversion Efficiency.

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Methane Miner: Plasma-Based Methane Conversion System

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Abstract. Climate change is one of the most crucial problems in the 21st century. The production of greenhouse gases reached 53.82 billion metric tons in the year 2023. One of the most dangerous greenhouse gases is methane. Methane stores 28 times more temperature than carbon dioxide. This study intends to create and design a non-thermal plasma-based methane conversion system using a DBD plasma reactor capable of converting methane into hydrogen fuel and solid carbon while eliminating carbon dioxide emissions. The computational work was carried out in MATLAB.

A thermoelectric generator was incorporated to recuperate and transform waste heat into electrical energy. Four experimental trials were performed with differing methane flow rates, purities, and plasma power inputs. The four tests indicated that the success of the system is very dependent on how the methane flow rate, plasma input power, and methane purity work together. Run 1 had the best overall efficiency (125.49%) since the plasma power was moderate (90 W), the methane flow rate was 1.0 L/min, and the gas purity was almost 100%. The combined energy recovery from hydrogen and thermoelectric generation yielded 112.94 W of usable energy, which was more than the input power.

The balance in Run 1 shows that efficient operation doesn't always require maximum plasma power, a moderate input can yield high energy recovery if the system's heat and reaction zones are properly coupled. This study introduces an innovative, zero-emission technique for transforming methane into useful energy resources.

Keywords. Hydrogen generation, thermoelectric conversion, Plasma-based methane conversion, Dielectric barrier discharge (DBD), Climate change.

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Using of Zinc Nanoparticles and Zinc Oxide Quantum Dots as Nano Fertilizer in Regulation of Growth and Biochemical Parameters of *Cucurbita Pepo*

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Abstract Due to the unique characteristics of zinc nanoparticles ZnONPS and quantum dots (QDs) as potential agricultural nanomaterials, zinc oxide nanoparticles ZnONPS were biologically synthesized using Padina Pavonica extract and zinc quantum dots. And applied on Cucurbita pepo seeds by using different concentrations (10, 20, 30 and 40 μg/ml), in addition to control to evaluate their influence on morphological and biochemical parameters of plants. The results exhibited an increasing impact of the low concentrations [10, 20 and 30 μg/ml] on fresh weight, dry weight, shoot length, and root length, and biochemical parameters like chlorophyll a, chlorophyll b, carotenoid contents, total pigments amino acids, protein banding, proline.

The best concentration was recorded at 20 μg/ml of ZnONPs and ZnOQDots after 15 days. Whereas, the high concentrations (40 μg/ml) had an inhibitory effect on seed germination. On the other hand, it increased in the total amino acids. Regarding protein banding, there are some bands that increased in quantum dots which are 35KDa (hydrolytic enzymes like amylase and protease),35-45KDa (digestion and metabolic enzymes) and 120-130KDa (rubisco holoenzyme (complete complex). Results of the antioxidant activity of Cucurbita pepo demonstrated that an increased concentration of ZnOQDots would improve the antioxidant activity of Cucurbita pepo by enhancing its SOD, CAT, and POD activities. Moreover, proline and total phenol were higher in ZnOQDot than ZnONPs at high concentration (40 μg /ml).

Keywords. Growth Rate, Leg Length, Zinc Nanoparticles, Zinc Oxide Quantum Dots.

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Advances in Dental Composite Biomaterials: Classification, Properties, and Clinical Impact

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Abstract. Dental composites are essential restorative materials, designed to restore the functionality and aesthetics of teeth by combining a resin matrix with inorganic fillers (biomaterials). These fillers are the key components that determine the final mechanical, physical, and biological performance of the material. This abstract provides an overview of the primary classification of dental composites based on filler size and type, including macrofilled, microfilled, hybrid, and nanofilled materials, and discusses their respective characteristics. We detail the essential properties required for successful clinical application, specifically focusing on biocompatibility, high mechanical strength, wear resistance, and minimal polymerization shrinkage. Finally, the abstract outlines the primary clinical advantages of using these biomaterial-based composites, such as their superior aesthetic appeal and enhanced bonding capabilities, while also considering their key limitations, particularly in long-term durability and cost.

Keywords. Biomaterials, Dental Composites, Teeth Filling, Resin Matrix, Inorganic Fillers, Biocompatibility, Polymerization Shrinkage.

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AI as the Catalyst: Revolutionizing CO_2 Capture through Accelerated Materials Design and Process Optimization

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Abstract. AI is revolutionizing carbon capture by accelerating the design of new materials and optimizing the performance of capture processes. It addresses the high costs and energy consumption that have long been barriers to widespread CO_2 capture technology. The most significant way AI is assisting in CO_2 capture is by rapidly discovering and designing novel materials with superior performance. This process, often called inverse design, flips the traditional method of trial-and-error. Beyond material design, AI is also optimizing the entire carbon capture process, making it more efficient and cost-effective. AI algorithms can analyze real-time data from sensors in a capture plant to dynamically adjust operating parameters such as temperature, pressure, and solvent flow rates. This allows the system to operate at peak efficiency, minimizing energy consumption and maximizing CO_2 capture. AI models can predict when equipment, like filters or pumps, is likely to fail, enabling proactive maintenance that prevents costly downtime. For direct air capture, which pulls CO_2 from the atmosphere, AI is used to optimize the highly energy-intensive sorbent regeneration cycles. By predicting the ideal conditions for heating and cooling, AI can reduce energy consumption by as much as 10-15%.

Keywords. AI, Carbon capture, CO_2 Capture, Energy Consumption.

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Exploring Materials from the Local Egyptian Environment by Consulting AI

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Abstract. Egypt possesses a diverse and often underutilized wealth of indigenous materials, ranging from industrial minerals to large volumes of agricultural waste. Annually, millions of tons of agricultural by-products-such as rice straw, sugarcane bagasse, and palm fronds-are generated, frequently leading to harmful environmental pollution via open burning. Simultaneously, local mining yields abundant resources like limestone, granite, sand, clay, and phosphate, and the persistent environmental challenge of plastic waste, particularly from recycling, provides a readily available raw material source. Artificial Intelligence (AI) and Machine Learning (ML) models offer a powerful solution to this underutilization, creating a virtuous cycle of discovery and innovation. ML models are trained on vast datasets of material properties and synthesis methods, allowing them to rapidly perform inverse design-identifying optimal formulations for high-value applications that would be impossible to discover manually. Once a promising material pathway is identified, AI further optimizes its production process, ensuring efficiency and sustainability. The integration of AI to explore and valorize these local Egyptian resources yields significant environmental and economic benefits. AI acts as a smart consultant, providing the computational power necessary to unlock the hidden potential of Egypt's indigenous resources, thereby fostering a more sustainable, innovative, and circular local economy.

Keywords. AI, Materials Science, Egyptian Local Resources, Sustainable Developments, Waste to Value.

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Novel Composite Biomaterials: A Cornerstone for Regenerative Medicine

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Abstract. The field of novel composite materials is fundamentally transforming medical science by overcoming the limitations of traditional biomaterials. By synergistically combining distinct components-such as polymers, ceramics, and metals-these composites are precisely engineered to mimic the complex architecture and functionality of natural tissues. This work reviews recent advancements in composite design, focusing on their transformative applications in tissue engineering, controlled drug delivery, and implantable medical devices.

We highlight how these materials offer superior mechanical properties, including enhanced strength, durability, and a tunable degradation profile, making them ideal for load-bearing scaffolds. Crucially, their bioactivity can be optimized to promote cellular proliferation, differentiation, and seamless integration with host tissue. The paper also explores the integration of smart functionalities, such such as stimuli-responsive drug release and piezoelectric properties, which further enhance tissue regeneration. While these innovations promise a leap forward for personalized medicine and regenerative therapies, we address critical challenges concerning long-term biocompatibility, stability, and scalable manufacturing. Ultimately, the unique combination of physical, mechanical, and biological properties positions novel composites as a cornerstone for future medical innovations.

Keywords. Biomedical Composites, Tissue Engineering, Drug Delivery, Regenerative Medicine, Bioactivity, Smart Materials.

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AI as a New Scientific Paradigm: Accelerating Discovery, Hypothesis Generation, and Autonomous Research & Development

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Abstract. The rise of Artificial Intelligence (AI) is fundamentally transforming science and technology, establishing itself as a powerful new scientific methodology that drives unprecedented speed and scale in discovery and innovation. AI's core power lies in its ability to automate complex tasks, analyze massive datasets, and generate novel hypotheses that human scientists might miss. In research, AI-powered tools rapidly screen candidates for drug discovery, analyze complex environmental data for climate modeling, and have achieved breakthroughs like AlphaFold's accurate protein structure prediction. Furthermore, AI is a general-purpose technology that is the engine for innovation across numerous sectors. It enables autonomous vehicles and robotics, powers sophisticated generative models (like LLMs) for content creation and software development, and enhances decision-making in finance and cybersecurity. Ultimately, AI is not merely an incremental tool but a force that is changing the very nature of research and development, enabling researchers to tackle previously intractable problems and accelerating the shift toward personalized, optimized, and automated systems globally.

Keywords. Artificial Intelligence, Science, Technology.

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