Hands-on Science

Innovative Education in Science and Technology

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

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Foreword

Innovative Education in Science and Technology

Along the past 16 years the Hands-on Science Network community worked hard with great pleasure and strong commitment trying to contribute actively to the improvement of science education exploring new ways and revisiting adjusting and improving well established ones. A large number of very interesting and meaningful contributions were brought and presented to our annual conferences and tested in a large number of activities organized all over the world at all school and education levels in formal, non-formal and informal contexts. In the committed open and inclusive way that characterizes HSCI we definitely enjoyed exploring our ways of improving science education and scientific literacy in our schools and communities, sharing our experiences and knowing and exploring each other' approaches and contributions… innovating in Science and Science and Technology Education.

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 16th International Conference on Hands-on Science held in Kharkiv, Ukraine, September 2 to 6, 2019.

Vila Verde, Portugal, July 30, 2019.

Manuel Filipe Pereira da Cunha Martins Costa
Editor in chief

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FOREWORD

CONTENTS

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Combination of Inclusive and STEM Education

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Abstract. In this paper the results of a two-year experiment of involvement children with special needs, who are studying in special schools to STEM-based events at higher education institution are presented. The key factors contributing to the successful combination of inclusive and STEM education are analyzed. The results of sociological surveys concerning the formation of tolerant for children with special needs society are given. The examples of classes for both special and common children of different ages are described.

Keywords. STEM-Education, Inclusive Education Special Children, Common Children.

1. Introduction

Ukraine, as many other countries, faced with problem of declining the popularity of technical disciplines and reducing the level of student's and teacher's interest to study the cycle of mathematical and physical school courses [1-2]. STEM education is the key for solving this problem. Prolonged unstable economic situation in Ukraine influence the possibility of different educational institutions to provide STEM education. So, institutes and universities became STEM education base for schools, schoolchildren and teachers.

2. Participants of inclusive and STEM education

All children with special needs in terms of their ability to be involved in projects within the framework of STEM education in their physical and mental condition can be conventionally divided into the following groups:

1. children with visual impairments. Today there is no mechanism for their involvement in STEM education, since visualization of fundamental principles and laws is the main way of motivating and increasing interest for students to study technical disciplines;
2. children with hearing impairments. If such children can read on lips, then their integration into the STEM space is no different from that of ordinary children. If children can only work with an interpreter, then provided that such a specialist is at the place of primary education in a specialized boarding school, these children also join STEM education without special problems;
3. children with severe mental disorders, including autistic children and children who are not socialized in society. Often, such children are not involved in education at all and cannot be involved in STEM education;
4. children with severe physical defects, especially problems with the mobile device, but their intellectual development corresponds to the level of ordinary peers and even exceeds them. This group of children can be involved in STEM education provided that they create conditions for their movement in higher education or if they establish a communication channel via the Internet in real time.
5. children who study in specialized boarding schools and have deviations in psychophysical, psycho-emotional development of moderate severity, these children are socialized, studying on special programs, including children with autistic disorders of moderate severity. Such children can potentially become key participants in the STEM education program under certain conditions.

3. Project idea

The idea of STEMCampSchool, established in 2018 at National Technical University "Kharkiv Polytechnic Institute" was to support children in their scientific projects using different types resources of university. 100 children from schools of Kharkiv region were invited, among them 15 children with special needs, who are studying in specialized boarding school (Figure 1). In this summer camp, work was carried out on the following areas: energy and electronics, ecology, physics, chemistry, engineering design and mathematical modeling. 10 children with

special needs were invited to STEMCampSchool in 2019 (Figure 2).

One of the item of STEMCampSchool is to break social barriers in communicating between children with special needs and ordinary children that is the result of no other places for their joint occupations.

Figure 1. Children with special needs at STEMCampSchool in 2018

Figure 2. Children with special needs at STEMCampSchool in 2019

4. Results and discussion

The largest number of children with special needs -13 people aged 14 years in 2018 and 6 in 2019 - took part in "ecology" direction.

While studying at an orphanage, these children do not study subjects such as "biology", "chemistry", "geography" according to the traditional school curriculum, but they have a sufficient imagination of the surrounding world, natural phenomena and processes in order to be interested in experiments and their understanding.

Table 1. Factors (left) and their weight (right) that affect the successful combination children with special needs and ordinary children within the framework of STEM education

Factors	Brief description	%
Incognito	During the first meeting schoolchildren called only their names and favorite heroes. This approach allowed to preserve a certain secret of children with special needs for several days, because they were not at all different from ordinary ones	30
Trainings for mentors and volunteers	Before the start of the project, a psychologist from specialized boarding school conducted a series of trainings aimed at explaining and teaching the basics of communication and interaction.	20
Adaptation of educational materials	Before the direct execution of the projects, the students received intensive theoretical and practical training. A discussion was arranged in the audience, during which mentors asked children with special needs only those questions that they could answer based on their level of knowledge and understanding.	30
Volunteer support	The main role of the volunteers accompanying each group was to notice any manifestations of aggression from ordinary children and the beginning of a non-standard behavior of special children and a quick reaction to such events with the simultaneous attention of the mentor	20

A combination of children with special needs and ordinary children within the STEMCampSchool took place through collaborative work for 10 days over their own projects. Only faculty members who became mentors (mentors) in each direction knew that their groups had children with special needs. Among the factors contributing to the successful inclusion of children with special needs for STEM education, the most important

authors consider the lack of prior information to ordinary children about the presence of children with special needs in their group (Table 1), since communication between children began without any social or educational labels.

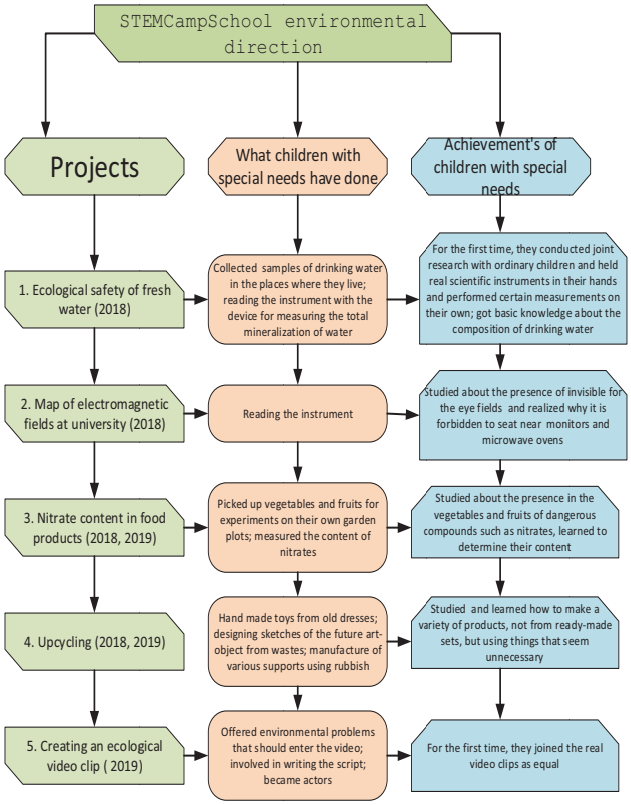

Figure 3. Projects and achievements (STEMCampSchool 2018, 2019)

The project, that were realized during 2018-2019 STEMCampSchool in direction “ecology” and their importance for children with special need are shown at Figure 3.

In authors own opinion, the most successful in terms of further development and use in everyday life is the involvement of children with special needs in projects of upcycling (the conversion of potential waste to useful modern things or objects) (Figure 4). It should be noted that, in general, children with special needs can do a lot of their own hands, and fine motor skills are well developed. But mostly they do their own craftsmanship not from secondary or used materials.

Attracting the attention of special children to the problem of utilization of household wastes by turning them into useful or beautiful things has become an impetus for awareness of general problems of household waste for these children. Of course, apiculture in the performance of children with special needs is not able to solve the problem of reducing the amount of household waste in the country. At the same time, such projects can attract public attention and become useful in shaping the ecological consciousness of Ukrainians.

Figure 4. Project “Upcycling” (from top to bottom): pencil stand from used cardboard tubes; backet from plastic caps; art-object from old shoes (STEMCampSchool 2018)

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The Periodic Table as a Didactic Resource for Understanding "Bioelements"

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Abstract. Bioelement concepts assimilation by the students of Primary and Secondary school levels is not simple or immediate. The UN proclaimed 2019 as the International Year of the Periodic Table, an initiative to strengthen the relationship between chemistry and biochemistry. The bioelements are those that are part of living beings. They can be classified into Primary bioelements (C, H, O, N) Secondary bioelements (S, P, Mg, Ca, Na, K, Cl) and Trace bioelements (Fe, Zn, F, I,...). In this article we present two board games. One with twenty-one cards (21 different bioelements) and the other one with five big cards and 15 bioelements. Both with the intention to get students and people to increase their biochemical knowledge.

Keywords. Games, Students, Society Biochemistry, Bioelements.

1. Introduction

The Periodic Table of Chemical Elements is one of the most significant achievements in science. 1869 is considered to be the year of the discovery of the Periodic System. The Russian Dmitri Mendeleev [1-2] found that elements fall into families with similar properties when they were arranged into an increasing number of atomic mass. Mendeleev called this observation the periodic law. 2019 will be the 150th anniversary of the Periodic Table of Chemical Elements and has therefore been proclaimed the "International Year of the Periodic Table of Chemical Elements (IYPT2019)" by the United Nations General Assembly and UNESCO [3-4].

The vertical columns of the periodic table are called groups, IUPAC recommended names are: alkali metals; alkaline earth metals; coinage metals; pnictogens; chalcogens; halogens and noble gases. These groups identify the principal families of elements which have the same number of electrons in their outermost shell and that determines in large part how elements interact with other elements to form a diversity of molecules.

The horizontal rows are called periods and are numbered from the top down, 1 to 8. For the first three horizontal rows in the periodic table, elements in the same row have the same number of shells, and so also have the same number and types of orbitals available to be filled by electrons.

Figure 1. International Year of the Periodic Table of Chemical Elements (IYPT2019) [3-4]

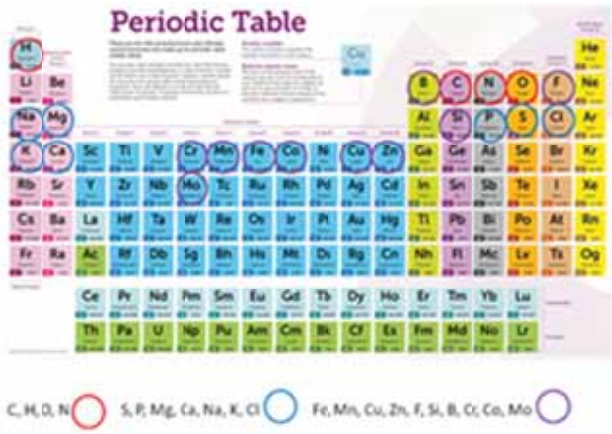

Figure 2. The current periodic table (2017) © Royal Society of Chemistry [5]

2. The biological elements

The biogenic elements or bioelements [6] are those that are part of living beings. They can be classified into three categories:

a) Primary bioelements (C, H, O, N) which form very stable covalent bonds between them. Up to 99% of the majority of the cell mass is composed

by carbon, hydrogen, oxygen and nitrogen.

b) Secondary bioelements (S, P, Mg, Ca, Na, K, Cl)
c) Trace bioelements (Fe, Mn, Cu, Zn, F, Si, Y, B, Cr, Co, Mo ...) present only in traces.

b and c categories absence or excess can be harmful to the body.

The functions that these bioelements develop can be:

a) Plastic or structural, building the human body and living organisms. They are indispensable to form organic biomolecules, proteins, carbohydrates, lipids and nucleic acids.
b) Catalytic function, iron (Fe^{2+}) acts in the transport of oxygen and electrons and zinc (Zn^{2+}) is present in the active center of some enzymes, and
c) Osmotic function, ions such as sodium and potassium cations and chlorine anion (Na^+, K^+ and Cl^-) intervene.

Living organisms are not an exception from the other things in the known unifiers in what refers to their composition. These organisms are made by the same building blocks, chemical elements; nevertheless, up to 99% of most cellular mass is constituted by Carbon, Hydrogen, Oxygen and Nitrogen.

The Universe is composed by mainly Hydrogen and Helium, which are made inside the stars. There are 94 elements found naturally on earth. About 70 of these elements can be found in living organisms but only 4 of them make the most of us, as stated before. In fact, this is not surprising when most living organisms are mainly made of water, which is made of O, and H. Human beings are made of approximately 70% of water (H_2O).

In addition, the elements C, H, O, N, S and P are completely necessary to make most biomolecules.

2.1. Carbon (C)

Carbon atoms can form bonds between them and with other atoms. Carbon is a pretty especial element as its ground state electron configuration does not allow tetravalency, which is the rule in the vast majority of organic compounds and Biomolecules.

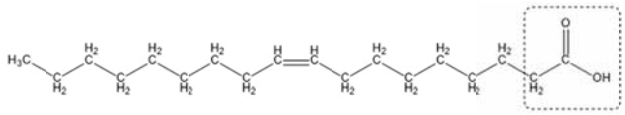

Figure 3. Oleic acid

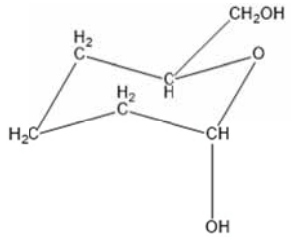

Figure 4. Glucose

2.2. Hydrogen (H)

Hydrogen is the most abundant chemical substance in the Universe. Our Sun is mainly composed of hydrogen in the plasma state. Hydrogen is not only the main component in water molecules, H_2O, but it also bonds covalently with Carbon. These bonds are stable enough to remain bonded but also weak enough to allow many different reactions to occur. It is the main substituent in carbon chains, especially in fatty acids and its derivatives. In addition, the hydrogen bonds stabilize DNA polymers.

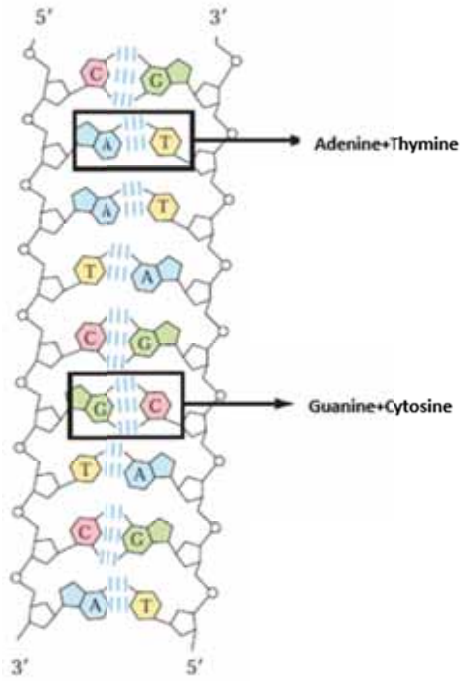

Figure 5. Example. This pairing causes the characteristic shape of DNA; the double helix. Image adapted from [6]

2.3. Oxygen (O)

Oxygen is found in water, which is essential for life, and in a lot of different other kinds of molecules. At 20ºC, the element is a gas, O_2, diatomic oxygen gas constitutes 20.8% of the Earth's atmosphere, it is necessary for our breathing. In addition, in living beings, it can be also found in biomolecules making covalent bonds with other atoms as in oleic acid and glucose.

2.4. Nitrogen (N)

Nitrogen is an essential element in life, mainly because it is a component of the basic structure of all amino acids, and therefore, of peptides and proteins, and nitrogenous bases, which are part of the monomers of DNA and even in some complex structures such as heme groups, present in chlorophyll and haemoglobin. It is one of the most abundant elements in the atmosphere, N_2, diatomic nitrogen gas constitutes 78,2% of the Earth's atmosphere.

2.5. Sulphur (S)

Sulphur mainly appears in the form of a thiol or sulfhydryl group and its derivatives like sulphides and disulphides. The amino acid cysteine has a thiol group, and therefore it can make disulphide bonds with other cysteines, a bonding that is important in maintaining the tertiary structure of proteins.

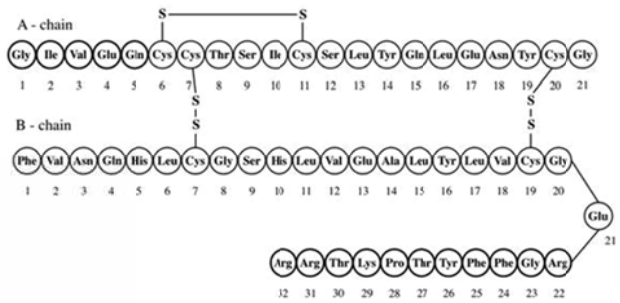

Figure 6. Insulin molecule

2.6. Phosphorous (P)

Phosphorous is always inorganic, that means that we find it in the shape of a phosphoric acid (H_3PO_4) and its deprotonated forms ($H_2PO_4^-$, HPO_4^{2-}, PO_4^{3-}). These phosphates appear in many organic molecules, from structural lipids like in biological membranes to the backbone of the main nucleic acids (DNA, RNA) and also in free nucleotides that participate in many organic reactions like ATP or NADP. Furthermore, the calcium salts from these acids ($H_2PO_4^-$, HPO_4^{2-}, PO_4^{3-}) are used to strengthen structures like bones in mammals and exoskeletons in non-vertebrates.

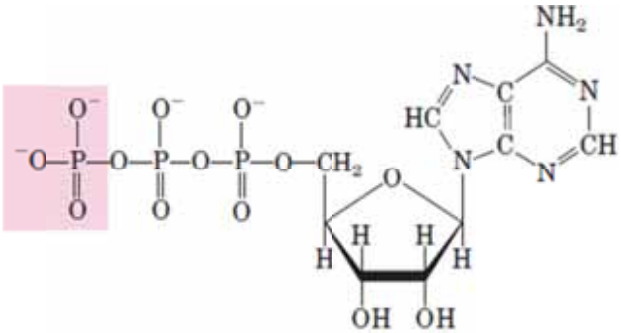

Figure 7. Adenosine triphosphate, ATP

2.7. Other secondary bioelements

2.7.1. Sodium (Na) and Potassium (K)

In biological systems, both elements are present in ionic form, Na^+ the main cation in animal interstitial liquid and K^+ the principal cation in the cytoplasm of animal cells. Both play a central role in the Sodium/Potassium pumping processes.

2.7.2. Chlorine (Cl)

In its ionic form, Cl^-, is the main anion in animal interstitial liquid. On the other hand, it is important to produce hydrochloric acid (HCl) in the stomach.

2.7.3. Calcium (Ca)

It is an essential element needed in large quantities. The Ca^{2+} ion acts as an electrolyte and is vital to the health of the muscular, circulatory, and digestive systems. It is indispensable to the building of bone; and supports synthesis and function of some cellular enzymes.

2.7.4. Trace elements

2.7.4.1. Iron

65 % of the iron in the human body is located in Haemoglobin and myoglobin (storing oxygen) and the rest is present in some proteins such as ferritin, which stores iron inside the cell.

Figure 8. The heme group [7]

2.7.4.2. Iodine

Iodine is part of some human thyroid hormones triiodothyronine (T3) and thyroxine (T4). If the amount of iodine decreases both hormones cannot be synthesized. These hormones are crucial in the metabolism of most tissues, especially in early stages of development.

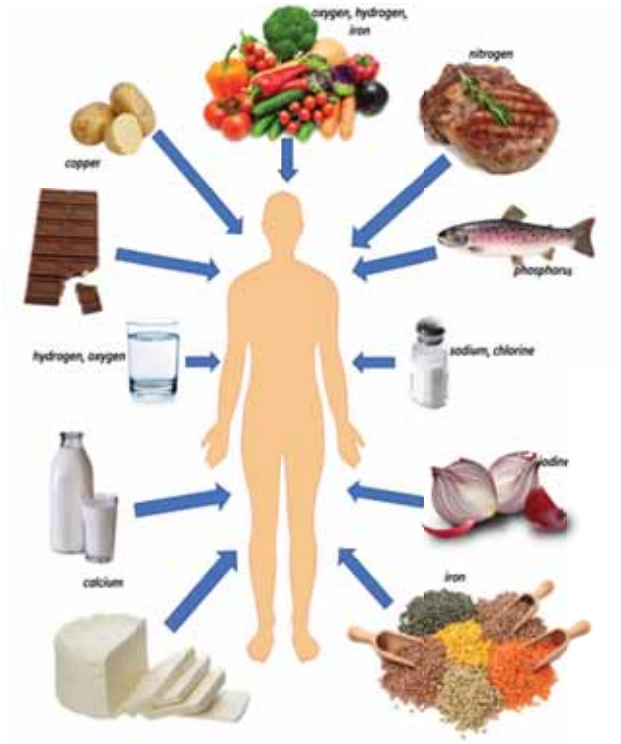

Figure 9. Some of the elements that we need to live and their sources [8]

2.8. Biomolecules

They can be divided into:

1. *Monomers* such as amino acids, nucleotides, monosaccharides, lípids, fatty acids, sterols.
2. *Polymers* such as peptides, proteins, DNA, RNA, polysaccharides, glycoprotein, proteoglycan

Biomolecules in general, have a hydrocarbonated basic structure, and the presence of oxygen in these compounds confers a certain degree of polarity.

This fact explains the solubility of some carbohydrates and the amphipathicity of a diverse range of lipidic compounds.

These properties are very important for the proper functioning of the metabolism and the creation of essential structures of the cell.

In some biomolecules, when there is nitrogen and sulphur in addition to carbon, hydrogen and oxygen, we talk about proteins. Furthermore, if there is nitrogen and phosphorus, we talk about the nucleic acids.

3. Playing with bioelements

Bioelements can be used as didactic resources. Some different card games can be useful for science teachers at different educational levels, to deepen and innovate in the teaching of many concepts such as biochemistry and bioelements.

Two board games are presented: one with twenty-one cards (21 different bioelements) and the other one with five big cards and 15 bioelements. Both with the intention to get students to improve their biochemical knowledge by playing with these sets.

3.1. 21 Bioelements

The game with 21 cards is designed to teach Bioelements and their characteristics to students at different education levels. The game rules are:

- The participant has to choose one of these 21 cards (no mark, no show, no tell, no see no feel)
- The cards are mixed and they are

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placed in 3 heaps.

- The participant must indicate the heap where the card chosen is.
- Always from left to right, we pile up the three heaps again. Making sure that the heap picked by the participant will be in the middle.
- We put the cards in three heaps again and the whole process is repeated 2 more times.
- Finally, we have 1 heap with the 21 cards.
- After all, the card in the 11th position will be the one chosen.

Figure 10. The three heaps

3.2. 15 Bioelements

The game with 5 cards is designed to show Bioelements and their characteristics to people. To play this game you need:

One card (A) containing 15 pictures representing 15 bioelements. And four cards containing 8 pictures each one, representing 8 bioelements in card A.

The game rules are:

- The card (A) with 15 bioelements is shown to the participant.
- The participant must choose one bioelement (no mark, no show, no tell, no see no feel).
- Then the presenter shows to him/her the 4 different cards with only 8 bioelements each.
- The participant has to indicate in which of the 4 cards is the chosen bioelement.
- Finally, with the last four cards on the table, the presenter reveals the chosen Bioelement and its characteristics and properties
- The presenter guesses the chosen bioelement.
- It is magic!!!

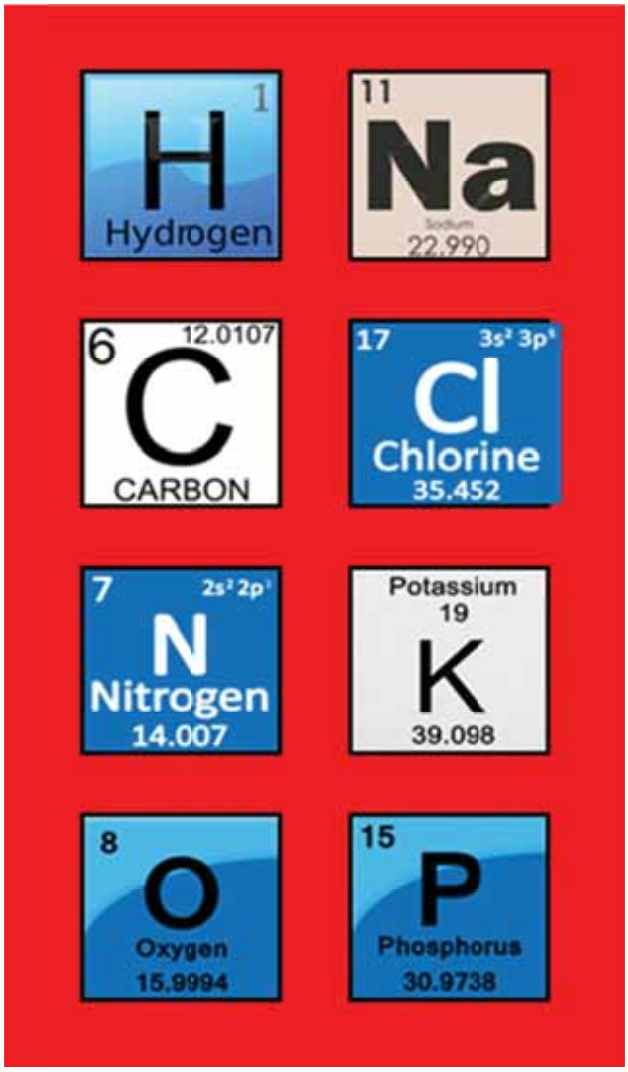

Figure 11. One of the four cards

4. Acknowledgements

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Smart Campus Design - U_CODE Tools Tested for Co-Designing the CJD Learning Campus, Sangerhausen Case Study

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Abstract. Going beyond existing participation processes in urban development, the newly developed procedure ensures proper citizen involvement from the very start of a project up to design selection, plus a lean and feasible conduct of the overall campaign. The framework involves all necessary stakeholder groups, who are addressed by specific tools and algorithms. The EU funded H2020 project "U_CODE Urban Collective Design Environment" (2015-2019) aims to create a co-design platform for urban design that allows participation for a large number of (simultaneous) participants by way of crowdsourcing design gaming. It develops a comprehensive participation process which involves all necessary stakeholders with novel IT collaboration and communication tools. Within this framework, each process step is supported by at least one specific tool that ensures low-friction communication between the stakeholder, and maintains an overall lean and feasible procedure. The complete process can be adapted to the needs of the project by adding loops when needed or skipping some steps (with the effect of a reduced quality). This paper reports on the Life Testing of process and tools for Christian Youth Village Germany - CJD Learning Campus, Sangerhausen Case Study.

Keywords. Campus Design, Co-Design, ICT, Co- Design Tools, Participation, Smart City, Urban Development, User Engagement.

1. Introduction

Last year's shown an increasing interest in participatory approaches in urban design and urban development. Citizens demand direct involvement in urban development projects beyond the level of mere information. They ask for active roles in the overall process as co-creators and decision makers. Public voice is a new force in urban design. Over the past decades, the methodology of urban design and development in democratic countries transformed into complex procedures of public participation and user involvement.

Now it is not only expert's groups and professional stakeholders like urban designers, developers, or public authorities that interact in order to scheme new buildings, urban quarters, or infrastructure projects. Thus, it has become difficult for municipalities and governments to carry out large scale development projects without appropriate involvement of civic stakeholders. Subsequently, research on, and application of participatory methods and tools is increasing, and there is a growing body of knowledge on the issues of participation, co-creation, and co-design.

2. Background & Current Challenges

Design collaboration and participation: Various cases of public disagreement in different European countries have shown that perusing a thorough design and planning process is by no means a guarantee for a broad public acceptance of an envisioned urban project. The measures already in place to inform the public and negotiate potential disagreement are based on classical media. This procedure disconnects more and more from the perception of today's citizens. Public planning administration and the public itself need effective platforms to share and further evolve projects of common interest in order to perceive each other as partners in a collaborative process.

The co-design environment that we present with U_CODE project is going to be the conceptual, organizational and technical platform for this demand. Whereas many tools for e-participation have been developed and tested already, there are no digital instruments yet which enable the creative participation of the citizenship on a massive scale. The very challenge for future co-design environments is to enable communication and collaboration between large numbers of staekholders as citizen and professional experts. There is a need for collaborative tools and environments that allow co-creation to follow public opinions and sentiments, and to gain design intelligence from them.

As a powerful influence, the public has emerged as a new stakeholder group which seeks participation throughout the whole project lifecycle, from the creation of initial ideas to final implementation and execution. In many cases, public resistance has heavily disrupted the regular design and development process [1].

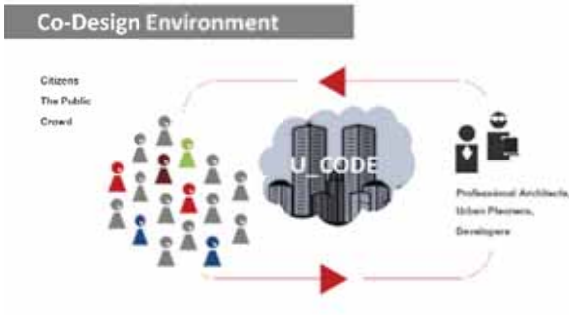

Figure 1. Co-design environment

Today, the public can easily express and exchange ideas, organise and amplify its opinion via Internet, social media, and smartphone. The new media has given powerful effect for voicing the public opinion, which may range from powerful support to scepticism and even blunt rejection. Negligence of public opinion and miscommunication about planning endeavours on the side of professional experts and stakeholders has led to disastrous development of many urban projects [2]. In various cases, opposition has even built up into massive protests and riots e.g. in the case of the Stuttgart21 in Germany. Existing frameworks for public participation are often based on single tools and methods [3] rather than on comprehensive processes, which pay tribute to the increasing complexity of urban design projects.

Over the past decades, citizen engagement has turned out a major demand in many fields and disciplines, ranging from science, administration to urban planning and development [4]. As a specific field, Urban Planning and Design (i.e. the creative planning of urban districts, compounds and neighbourhood) has emerged as a field with high applicability of citizen engagement and participation. Research and practice have established a variety of approaches to support the involvement of various stakeholders and user groups in the process of city making, e.g. Planning Cells or Design Charrettes [5]. Some cities have strongly pushed their activities in the field and started to implement solutions to enable broad participation as a key aspect of smart city development in areas such as economy, governance, environment, mobility, or housing [6].

Although only little literature can be found about decision making in digital participation processes, various researchers have already addressed the issue of design problem solving and decision-making [7-8]. In the field of architecture and urban design, Christopher Alexander has argued for a rational process in collective design and decision-making [9]. However, it was Herbert Simon´s systematic description of the design sciences as problem solving processes, which made decision making a central concern in the design field [10]. Contemporary concepts draw for instance on gaming approaches where decisions are achieved in a playful and informal manner [11].

Another important reference are models that describe the design process as a succession of divergent and convergent phases. A prominent example is the Double Diamond scheme; often used in Design Thinking [12-13]. The basic pattern connects a divergent phase dedicated to the production of alternative variations with a convergent phase which assesses the variations and selects an appropriate solution to continue with in the further process. This diamond shaped basic pattern can be sequenced to form a chain of diamonds (hence “Double Diamond”) [14], with some models presenting complex versions of this principle [15]. The divergent stage of design processes is well described and understood [16-17]. There is relatively rich knowledge about the stimulation of creativity and the generation of alternatives [18-19].

3. The U_CODE participation process model: the Minimal Viable Process

U_CODE aims at providing a procedural and instrumental framework for enabling massive citizen participation in urban planning projects via digital collaboration and communication tools. Derived from a structured analysis of existing formal and informal participation processes in urban development we developed a comprehensive process supported by specific digital tools for massive participation. This Minimal Viable Process fulfils a) good practice standards for participation while b) utilising as

few as possible technical means and procedural steps.

For this purpose, several workshops with authorities and professional designers have been performed to estimate the advantages of the different strategies. In a next step, the necessary tools and their interlinkages were developed and tested with a test-run of the process and with mockup-tools.

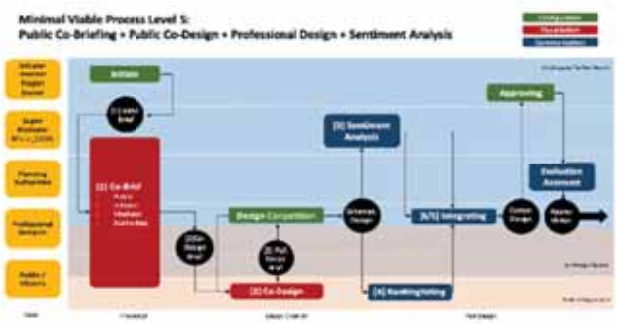

Figure 2. Complete U_CODE Participation Process

The complete process of U_CODE is depict in Figure 1. The picture shows a swim-lane diagram, which visualizes time, roles and the flow of activities. The process starts in the upper left with the activity “Initiate”: the initiator of a project creates an initial brief which is a document containing the goals, requirements and constraints from the initiators perspective.

Second activity is the collection and definition of the Co-Brief, a summary of knowledge, demands and expectations of all other stakeholders in this project phase: in this case the teachers, the pupils and external experts. The resulting Co-Design brief is a extraction of the Co-brief which functions as an orientation for the Co-Design phase in which the public (teachers and pupils) can create their own design sketches. These sketches have not the intention to be complete solutions but have three important functions: at first the public can express their ideas in a visual and tactile manner. The second function is to get into the position of a designer and feel the complexity of this situation. This learning experience allows the public could lead to a more empathetic attitude, which enables a more constructive communication with the professional designers at a later stage. Thirdly, it gives the planners an impression of the demands and inspiration of possible solution elements that to be integrated into their designs.

The comprehensive public participation methodology for urban development – described here as “Minimal Viable Process” – has been successfully tested by a Dummy Test Bed under controlled lab conditions in 2018. The overall process, the methods, as well as individual tools were validated, and useful insights could be drawn for the conceptual and technical development of the U_CODE tool sets and mmethodology. The focus of the test bed was not on pursuing in detail single procedural steps or technical tools, but to provide an overall proof of process from the initiation of a new project over collection information from the public towards co-designed ideas and professional planning schemes.

4. Sangerhausen CASE – Procedure of co-designing a Smart Learning Campus with U_CODE Tools

To test the overall U_CODE process, methods and tools we conducted a live test with a project from the Christian Youth Village Germany (CJD) planning a new special school in Central German City Sangerhausen. CJD provides schooling and vocational training as well as socio-pedagogical help for the young and disabled. The overall project goal is the creation of an inclusive learning place that strengthens the city and the region with new educational concepts.

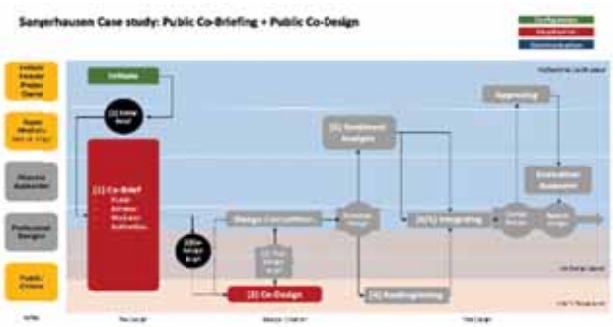

Figure 3. Focussed Participation Process in Sangerhausen Case

The concrete project design task was to cluster in one location north of Sangerhausen the currently separated two special schools: (1) School for Mental Development, (2) School for Socio-Emotional Development. The new school building shall comprise, among others, a convention hall, classrooms, laboratories, creative workshops, as well as a library. In

addition, good accessibility to the outdoor natural environment shall be given, and with the existing built structures, a campus-like atmosphere shall be achieved for these handicapped pupils with their special need.

4.1. Adaption of the MVP model for process design of Sangerhausen Case

In the case of Sangerhausen the initiators are the school administration. In the current case the whole process was not possible because if and when the new school can be build is dependent on complex financial issues.

Nevertheless it was useful to start with the early stages in order to proceed quicker and more informed when the project continues.

The early stages of the process do not include the roles of planning authorities and the professional designers because these are needed later only.

In order to capture the information in the different project phases we developed a suite of tools: for massive input we developed online tools which are able to interact with thousands of people and for intensive design work we developed offline tools which have to be used in face-to-face workshops with small groups. We explain the tools in the order they were used in the Sangerhausen case.

4.2. KNOWLEDGE Campaign

Figure 4. Process steps and activities in the Knowledge Crowdsourcing phase

The adapted process for the Sangerhausen case is shown in Figure 4. It starts with a call for participating in an information gathering process, after which the contributions are analyzed by several methods (Concept Maps, Topic Clusters, Word Clouds) and assed according to their importance by an expert. All contributions were stored in the Knowledge bank, an online document which contains all created information and design items.

This phase ends with the construction of an abstract of all the collected and filtered information in order to provide a “Co-Design brief”, which is the starting point for the next phase.

4.2.1. Information Collection Tool (Co-Brief)

After the initiator started the project it is essential that the other stakeholders are asked about their background knowledge (in order to collect relevant information which is not included in the initial brief) and their ideas about different aspects of the project.

Figure 5. Online questionnaire

An online questionnaire was developed that allowed the participants to provide facts and ideas regarding the following topics:

- outdoor and open spaces
- existing or newly planned buildings
- usage, function, and operations of building
- building design, shapes, sizes, style
- access, road and transportation infrastructure
- local history and culture
- local natural environment
- local society, community, and neighbourhood
- costs, financial support and resources
- local cooperations
- pedagogical concepts, education formats and environments

The duration of this phase lasted for two weeks in which 89 participants provided 562 contributions. These where more than 7000 words on 25 pages condensed information because the participants mainly used keywords instead of whole sentences.

4.2.2. Analysing and Evaluation Tools

Figure 6. Cloud visuals for topic threats

In order to cope with the information we developed different approaches for visualization, evaluation and summarization. Due to space limitation, we can give a short description only. One way of visualizing, textual data are Wordclouds which show the frequency of words by changing the font size of these words. The problem is that thematically similar words often appear in different areas of the cloud obfuscating the frequency and spread of topics.

Figure 7. MultiCloud for the section "Outdoor space"

MultiClouds are ways to semi-automatically find similar keywords in texts and groups them together to create multiple clouds of thematically separated topics. These MultiClouds were generated for each topic area (outdoor space, building, nature, learning etc.)

This process needs just a few hours to filter all contributions and was the basis for the Co-Design brief. This document was the input for the Co-Design phase in which the teachers and the pupils of the school could design their own ideas about how the future school area and building could look like.

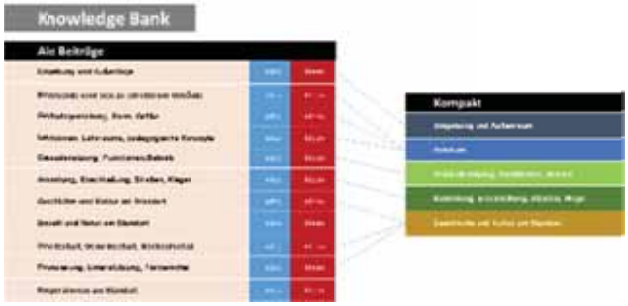

Figure 8. Knowledge Bank – all contributions in one data base overview

4.3. DESIGN Campaign

Figure 9. Process steps and activities of the Design

For the "Design Campaign" the goal was to motivate and enable all participants to create their own ideas on how the school of the future could look like. The Co-Design brief was send to all participants and was also available inside the Playground tool.

In the two week long phase of online design activities 58 design were created and published in the design gallery. After finishing the design phase a design feedback tool was activated. All designs were rated and commented many times. Derived from the comments and especially the ratings a ranking of all proposals was created.

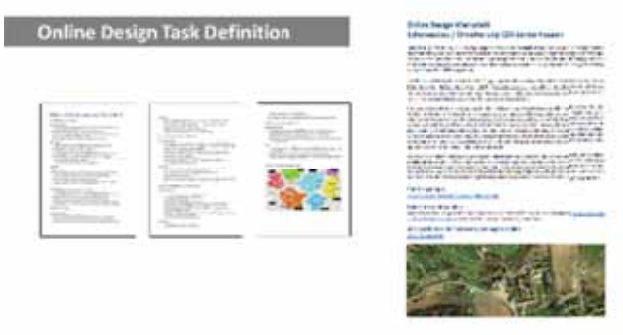

Figure 10. Design Task Brief Description

4.3.1. Online playground

In order to get the most people involved into the process of Co-Designing we provided them a web-based online tool named "U_CODE Playground".

Figure 11.Online Co-Design Playground

It is a very simple, easy to use drag-and-drop program which uses a block metaphor for building. Blocks of different shapes (cube, box, cylinder, cone, sphere and carpet) and colours for each intended use (classroom, workshop, park, sports, cafeteria and relaxing zone) allowed the participants the fast creation of spatial designs with functional meanings.

Figure 12. Design in solo mode – pupils designed their campus – via online game

In addition annotations could be added to each object in order to describe the idea behind it. We collected 58 designs and showed them in an online gallery.

Figure 13. Online design Gallery

4.3.2. Design feedback tool

An important part of the Co-Design phase is the mutual voting and rating of the proposals. Therefore we created groups of 8 designs and put them into 7 questionnaires which presented the designs and asked five questions to each: 1. Which aspects they like, 2. Which they don't like, 3. What is interesting, 4. How good is the spatial arrangement and 5. How creative/original is the design. The questions 4 and 5 allowed to create a ranking of the designs while the other questions provide qualitative information about why the designs were rated that way.

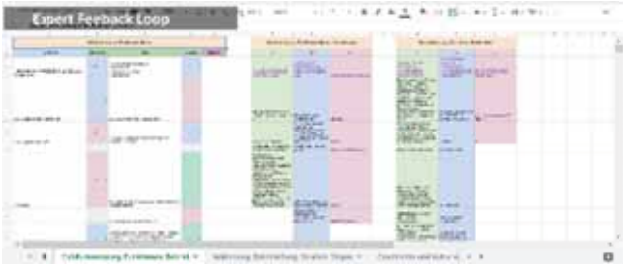

Figure 14. Expert Feedback Loop

The collection of designs in the online phase means that participants are sitting alone at home or in the classroom in order to create their designs. In order to get to a more intensive discussion in small groups we developed offline tools which provide a more direct und intensive interaction between the participants. In these situations the design and evaluation of the proposals is mixed because the group members can directly response. These settings are intended to be used in small teams we call "focus groups" because they focus on more specific design problems in contrast to the open online crowd.

Figure 15. Visualisation of the Analysis Design Quality

4.3.3. Expert Feedback Loop

In order to evaluate the importance of each contribution we provided an expert interface where all statements have to be rated with a value from 1 (important) to 3 (unimportant). If a rating was given the tool copied the contribution in the respective list in order to filter the most important messages.

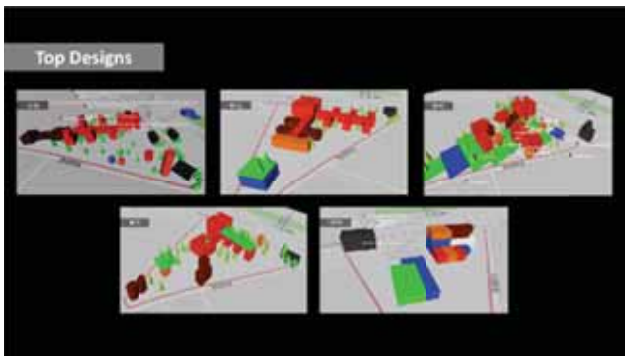

Figure 16. the 5 best ranked online game solutions

4.4. CO-DESIGN Tool Workshop

Figure 17. Local Co-Design Workshop

We used the results from the two campaigns as inputs for an on-site co-design workshop with the pupils and teachers of Sangerhausen, thereby testing DesignStormer, PlaceShaper touchtable and VR_Fox. For that we organized two sessions, one with 25 disabled pupils and one with 25 teachers, grouping to groups of five people and together designing their ideas for the campus with all three tools. Additionally, each group was asked to build a proposal with their hands in a hands-on workshop.

The offline tools were used together with the playground in a one day workshop in Sangerhausen. 24 pupils and 16 teachers were present and worked with each of the tools in small groups from 4 to 6. Each group worked for 30 minutes and created several designs.

Session 1	Session 2
10:00- 10:30 - Introduction and review of previous steps 10:30-12:30 - Co Design session 1 (4 stations à 30 mins) 12:30 – 13:00 - Discussion and results 13:00 – 14:00 BREAK	14:00 – 14:30 - Introduction and review of previous steps (including first session of the day) 14:30 – 16:30 - Co Design session 2 16:30 – 17:00 - Discussion and results

Figure 18. Time Schedule

4.4.1. Touch Table Tool

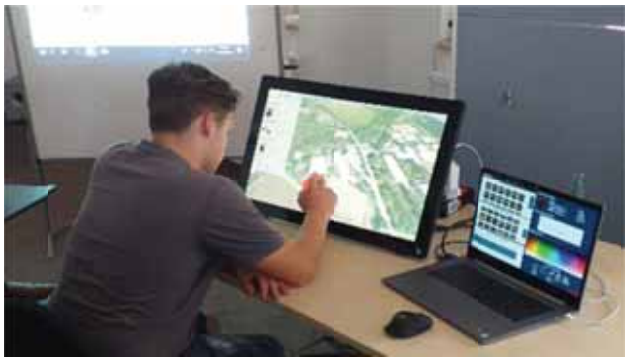

Figure 19. Touch Table Tool use during co-design workshop

The Touch-Table Focus Group uses a multi-touch table with a digital representation of the built environment of an area. Participants can investigate the planned project from different viewpoints, modify, comment and rate it. Different proposals can be compared, and consent may be requested for given schemes. The touch table is intended for solitary and small group work. It is like a huge tablet but it can show much more information and the non-interacting team members can directly see the actions of the team member in charge.

4.4.2. Virtual Reality (VR) Tool

The VR Focus Group uses a Virtual Reality Headset to create an immersive environment with drag-and- drop building environments, as can be seen in Figure 20. Buildings can be

placed in the virtual environment, modified and commented in order to express the ideas and visions of the participant. Other group members can follow the activities on another monitor and immediately react and comment to the actor because they share the same viewpoint.

Figure 20. VR Tools use during co-design workshop

6. Outcomes & Outlook

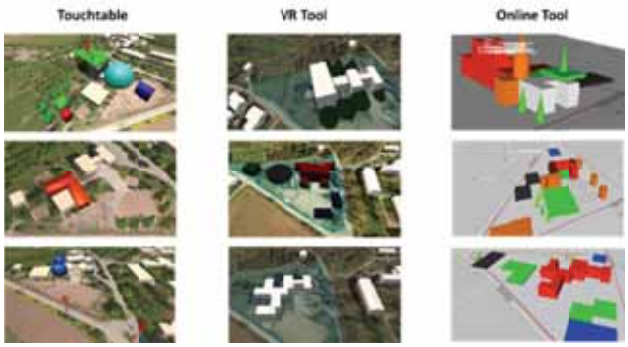

Figure 21. Design Output of the Co-design Workshop

Though the period was rather short in order to give each person the chance to work and get experience with modern participation tools. The feedback was very positive, the participants liked the different ways of developing their ideas and where satisfied with the results. In a final round all new designs were explained, discussed and ranked. The main output of the whole process was an online document called the “knowledge archive” which contains all documents, statements and pictures created during the participation process.

The Live Test entailed a U_CODE campaign, under real world conditions, with target end-users, in a semi-controlled environment. The entire process was closely monitored in order to save learnings for future development.

Figure 22. Participants through the different campaigns

In the second campaign we invited the participants to provide first design proposals via the DesignStormer App and also asked them to comment on these proposals. Here we collected 56 designs and 78 comments from 78 participants. Again, we did some analysis regarding the used functionalities and the comments added by a participant voting including 200 votes on originality and arrangement from 31 participants.

Figure 23. Contributions through the different campaigns

Part of the U_CODE campaign was the co-briefing stage and co-design stage. Therefore, citizens and professionals were asked to contribute expertise and ideas in two online-campaigns: In the first campaign we collected 562 ideas and facts about the planning area, functionalities, historical issues and so on from around 90 participants. We did some analysis with focus on categorizing, filtering out the most promising and innovative ideas and facts and aggregated the data to some descriptive statistics e.g. count of entries.

The next step in developing and testing our method is the application in an urban development project in the city of Dresden. In contrast to the Sangerhausen Case it will have different challenges: the area is not built and

the investors don't have a concrete idea what can be done with the site. Because of this there are no future users that can be involved. But the site is near the university campus and a lot of students and other pedestrians bypass the site. One idea is to involve them into a participation process in order to get insights which needs of the bypassing people could be satisfied by this place or a building. The challenge is now how to get contact to these people and how to involve them. This document will be the starting point for the next phase in the future, when the professional architects have to be involved and informed about the facts, needs, wishes and early ideas about their future school.

Figure 24. Overall Process of Sangerhause Case

7. Acknowledgements

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Research on Applied Microbiology: Bacteria Isolated from Environmental Samples and Antimicrobial Design

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Abstract. In this work we present a set of didactic experiments to introduce students to the world of microorganisms, emphasizing the concepts of human microbiota, antibiotics and antimicrobials among others. The main purpose of this work is to approach scientific research and didactic experiments to primary school education. An introduction to applied microbiology is reached with two main blocks: the first set of activities are focused on finding the possible location of different bacteria. The second section of the research emphasizes the concept of antimicrobials allowing pupils to test the susceptibility of bacteria to diverse substances. These activities are directed to 7 to 9 years old pupils but can be adapted to a different range of ages. These educational experiments allow teachers to introduce students into the world of microbiology and also increase their interest in the microscopic world.

Keywords. Microorganisms, Bacteria, Antibiotics, Microbiota.

1. Introduction

For the time being, everything that we cannot perceive directly with our eyes is apparently difficult to understand and explain. Consequently, some microbiological concepts such as how antimicrobials do their function are a challenging topic. It is regularly said that an exceptional way to ensure that students understand the microscopic world is by making the invisible visible. Therefore, in order to embrace this purpose, some experiments are presented.

The main purpose of this paper is to approach the bacterial world to pupils.

Bacteria are organisms that consist of a single cell without a nucleus and with distinct structural, physiological and evolutionary characteristics. Bacteria form one of the three domains of life; the others are archaea and eukaryotes. Bacterial species and their habitats exhibit great diversity [1].

Although when we hear the word “bacteria” we tend to instinctively think about unhealthy germs, the majority of bacteria pose no real threat to humans or other living species; in fact, bacteria are essential to life and most of them are actually good for us such as probiotics and microbiota. However, there are some microorganisms which negatively impact our lives, colonizing different surfaces and pathogenic bacteria cause infection [2].

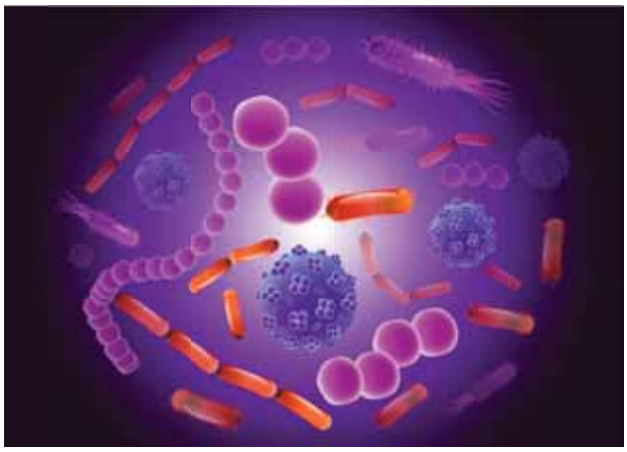

Figure 1. Diversity of structure of bacteria

2. First contact with microorganisms

It has to be considered that bacteria can be found, not only in external places, but also in the human body, in order to understand bacteria. Bacteria are everywhere, even in more places where one might think: in the floor, in your hands, in the food, in your mouth and so on. In this first set of experiments, students will discover where bacteria can be found around them and in themselves.

In addition to that, it is important to ensure pupils understand that bacteria can be beneficial, damaging or have no impact in their lives.

With these activities pupils will find out that bacteria exist in more places than they expected and there are ways of controlling bacteria. The first experiment can be an approach to the concept of human microbiota.

The human body is colonized by a vast number of microbes, collectively referred to as the human microbiota. Alterations in microbiota composition are associated with several

chronic conditions, including obesity. Therefore, a healthy and balanced microbiota is key to ensuring proper organism functioning [3].

2.1. Bacteria in our body. Bacterial handprints.

2.1.1. Introduction

With this primary activity, pupils will understand the importance of good hygiene preparing a bacterial culture before and after washing their hands. They will have a first contact with microorganisms and with the concept of human microbiota.

Although it is a highly common activity is recommended for those students that never have been part in a similar activity.

2.1.2. Materials

- Two petri dishes with growth medium for each pupil (If possible use agar plates but the growth medium can be alternatively prepared at school with gelatine, sugar and stock cubes [4]).
- Permanent pen.
- Hand soap.
- Water.
- Paper tissue.

2.1.3. Procedure

Using a marker pen, label two plate with your name. In one plate label “before” and in the other one “after”. Afterward, place the “before” plate in a table and open it carefully.

Press your hand or your fingertips in the plate. Make sure to catch harder-to-reach-areas such as the sides of your thumbs. The plate should be open the least possible time.

After that, wash your hands thoroughly with soap and dry them with a paper tissue.

Place the “after” plate in a table and open it carefully with the hand you will not use in the next step.

Press your hand or your fingertips in the plate. Cover the dish.

Finally, leave the petri dishes in a safe area. Incubate them at constant temperature for 24 hours or when bacterial colonies are seen.

Figure 2. Students before washing hand

2.1.4. Discussion

It seems clear that the plate with the highest quantity of UFC must be the one before washing hands given that soap’s chemistry helps to remove microorganisms from our hands. However, it is normal to have few UFC in the plate after washing hands. Nevertheless, the number of UFC in the before plate should be larger.

Note that it is possible to count all the UFC in both plates to compare the results quantitatively.

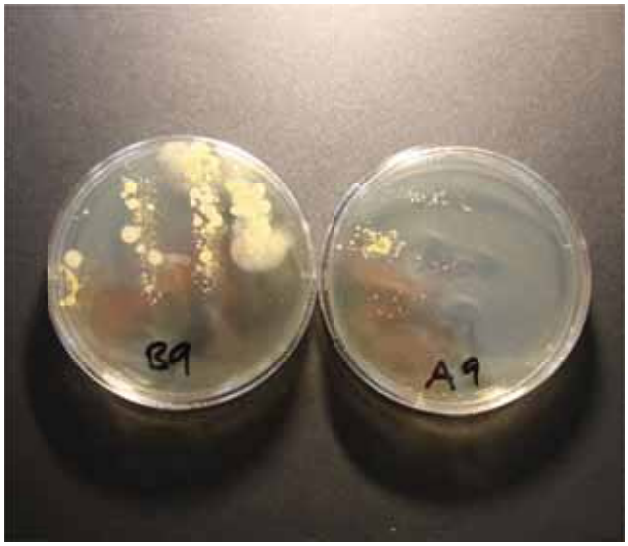

Figure 3. Plates of student 9 before and after washing hands

In this case these results are clearly observed, by using water and soap the number of bacteria decreases compared at the first plate. Therefore, by this way pupils observe the huge impact of washing hands.

To sum up, it is highly important for students to understand that promotion of improved hand hygiene is recognized as an important public health.

2.2. Bacteria in our environment: in search of microorganisms at school

2.2.1. Introduction

The aim of this activity is to discover where microorganisms can be found. In groups pupils choose different locations at school and cultivate them in an agar plate. Then the UFC can be counted and compared between the different locations.

This activity can be presented to the children as a contest in which group has to find the location with most microorganisms at school.

2.2.2. Materials

- Petri dishes with growth medium.
- Physiological saline solution (9 grams of sodium chloride dissolved in water, to a total volume of 1000 mL).
- Sterile cotton swabs.
- Permanent pen.

2.2.3. Procedure

Using a marker pen, label a plate with the name of the group and the chosen location. Dampen a cotton swab in physiological saline solution and then rub the cotton swab in the chosen location.

Once the sample is collected, drain the swab against a surface to eliminate excess moisture. Rub the plate with the cotton swab making a zigzag pattern. Cover the petri dish and leave it in a safe area. Incubate it at a constant temperature for 48 hours or when bacterial colonies are seen.

Finally, count the number of colonies and compare the results of the groups.

2.2.4. Discussion

Depending on the location chosen the growth will be different. The main factors that have an influence in the results are the cleanliness and the size of the sample, time spent rubbing the surface of the location.

In this case, student groups observed colonies in all the locations: classroom floor, playground floor, pc keyboard, toy, door knob, toilet push button and table. The number UFC of all the plates was counted and compared between all the plates.

- Which plate has more UFC? Why?
- Which plate has less UFC? Why?
- Do you think it is important to have a cleansing routine?
- Which is the result surprised you the most? Why?

Figure 4. Incubated plates. From top left to bottom right: toy, toilet push button, pen, pc keyboard, playground floor and classroom floor samples

3. Hunting microorganisms: Antibiotics and antimicrobials

At this moment, pupils will be aware about the definition of bacteria and where can we find them. The aim of the following part is to ensure they realize the importance of the antimicrobials, and the concept of resistance.

Antimicrobials induce bacterial cell death or stop their proliferation. They are used in bacterial infections, but not in infections caused by virus. The abuse in these substances can lead to resistance.

Over several decades, bacteria causing common or severe infections have developed resistance to each new antibiotic coming to market. Antibiotic resistance leads to higher medical costs, prolonged hospital stays, and increased mortality.

Faced this with reality, it is important to change the way we use antibiotics and also reduce the spread of infections through

vaccination, hand washing, and good food hygiene [5].

3.1. Introduction to antimicrobials
3.1.1. Introduction

In this activity pupils will understand the action of antibiotics. Moreover, the effects of different antibiotics will be compared between two different bacterial species.

Our understanding of how antibiotics induce bacterial cell death is centred on the essential cellular function inhibited by the primary drug-target interaction. Antibiotics can be classified based on the cellular component or system they affect, in addition to whether they induce cell death (bactericidal drugs) or merely inhibit cell growth (bacteriostatic drugs) [6].

3.1.2. Materials

- Petri dishes with growth medium.
- Bacterial colonies (if possible use one Gram - and one Gram + bacteria).
- Inoculating loop.
- Different antibiotic disks.
- Thick paper and a paper punch.

3.1.3. Procedure

Using a marker pen label the dish with the name of the group and the name of the bacteria given. Afterward, using an inoculating loop spread the bacteria on the petri dish. Drag across the surface of the agar back and forth in a zigzag motion.Add antibiotic disks (one antibiotic against gram negative bacteria and one against gram positive bacteria is recommended). Finally, cover the petri dish and leave it on a safe area. Incubate it at a constant temperature for 48 hours or when bacterial colonies are seen

Note: You can prepare your own antibiotic discs using paper, scissors and antibiotics. Dissolve 300 mg of a pill or powder into 200 mL of water. Soak a 3-6 mm diameter circle of thick paper in the solution. Place the disk in the plate with spread bacteria. You can prepare the circle with a paper punch.

3.1.4. Discussion

It is clearly seen how antibiotics can affect different bacteria and not cause any alteration in others. This is due to the dissimilarity in their composition and genome. It has been also considered the difference in the structure of their bacterial cell wall. Gram-positive bacteria do not have an outer cell membrane found in Gram-negative bacteria. In this case Bacillus Cereus, which is Gram-positive bacteria, did not grow with chloramphenicol, amoxicillin and azithromycin. However, Pseudomonas Fluorescents, which is Gram-negative bacteria did not grow with chloramphenicol. Nevertheless, amoxicillin and azithromycin cannot affect these bacteria. These antibiotics take action in different levels. Chloramphenicol block the activity of the peptidyl transferase enzyme by binding to the 50S subunit of the ribosome, preventing the formation of the peptide bond. It acts in Gram-positive and Gram-negative.

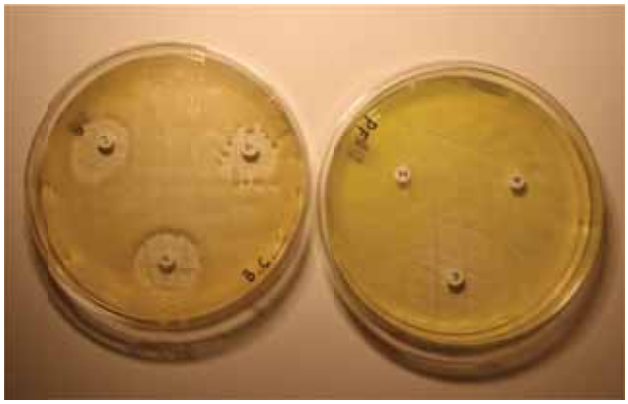

Figure 5. Two plates of Pseudomonas Fluorescents and Bacillus Cereus incubated with three different disks: azithromycin (Z), chloramphenicol (C) and amoxicillin (A)

Amoxicillin is a semi-synthetic antibiotic derived from penicillin. It is an amino penicillin. It acts against a broad spectrum of bacteria, both Gram-positive and Gram-negative. It is not stable against beta-lactamases, such as Pseudomonas Fluorescents. Finally, azithromycin inhibits the synthesis of bacterial proteins by binding to the 50s subunit of the ribosome and inhibiting the translocation of the peptides. These terms are difficult to understand for children. That is the reason why it has only been explained that an antibiotic works against many different types of bacteria by stopping them from growing and multiplying.

3.2. Antimicrobial design
3.2.1. Introduction

The aim of this activity is to present pupils antibiotics alternatives. Students will find the

common substances that can be used as an antimicrobial. This activity can be presented as a contest where each group has to find the substance with the most antimicrobial power.

3.2.2. Materials

- Petri dishes with growth medium.
- Bacterial colony.
- Antimicrobials.
- Thick paper and a paper punch.
- Inoculating loop.
- Physiological saline solution.

3.2.3. Procedure

Using a marker pen label the dish with the name of the group, the substance chosen and the name of the bacteria given. After that, using an inoculating loop cultivate the bacteria on the petri dish and soak a circle paper in the `antimicrobial´. Try to use the same quantity of the antimicrobial in each case.

Add this paper in the middle of the cultivated area and cover the petri dish and leave it on a safe area. Finally, incubate it at a constant temperature for 48 hours or when bacterial colonies are seen.

3.2.4. Discussion

Depending on the nature of the substance the results will be different. Two types of substances are observed. First of all there are substances that do have an impact in bacterial growth and viability. When a substance of this category is added to the bacterial plate there is normal growth and no transparent halo around the circle with the substance. Secondly, there are substances that have the ability to reduce the presence of microbes. In this case, a transparent halo is observed in the plate. The diameter of the halo is proportional to the concentration of antimicrobial and its power. That is why, in order to be compared, the amount of antimicrobial in the disks should be equal in all the plates.

In this case, the groups of students used different substances, lemon juice, alcohol, essential oil, turmeric, garlic, salt, egg, vinegar, mouthwash with no ethanol and hydrogen peroxide.

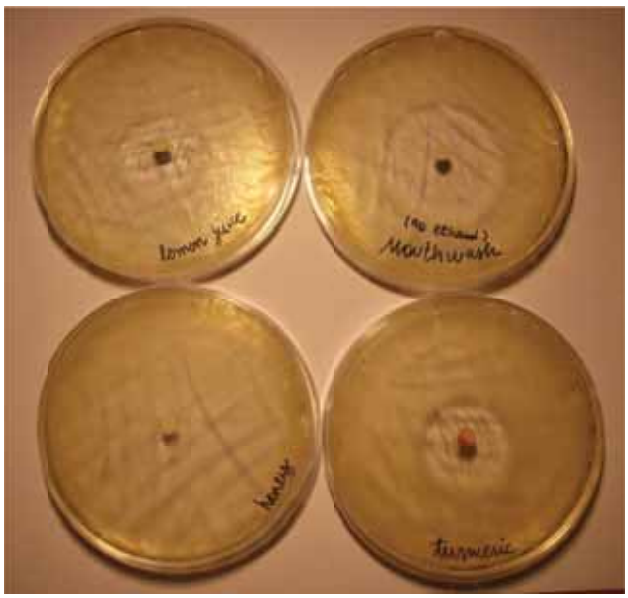

Figure 6. Examples of tested antimicrobials. From top left to bottom right: lemon juice, mouthwash, honey and turmeric

In all of them we saw clearly an Inhibition Zone Diameter (IZD) with a similar diameter: Turmeric: 2,6 cm. Mouthwash: 3,4 cm. Garlic: 2 cm. Essential oil: 3,1 cm. Lemon juice: 2,4 cm. Ethanol: 2,1 cm. Salt: 2,5 cm. Honey: 0 cm.

- Which substance has more power in reducing the bacterial growth?
- How do you think the substances used as antimicrobials reduce bacterial growth?
- Is there a result that surprised you?

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Lively and Exciting Hands-on Experiments: Sound Wave

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Abstract. I introduce some hand-made simple and essential experiments of sound wave and discuss the roles they play in classes. I have shown the characteristics of simple and essential hand-made experiments in the past HSci conferences. One was taking students out of the world of the textbook to the world they live, the other was helping students understand Physics concepts. In the field of sound wave, it is important to show or let students do experiments because sound wave is invisible. Various instruments have been used in the classes of sound to visualize sound or vibration, thread telephone and Kundt's experiment for example. I show Improved or developed instruments of them we invented to help students' understanding and raise their curiosity. I also show some simple musical instruments which explain the fundamental principles of sound clear. Series of produced musical instruments impress students that the principles are simple and useful. The musical instruments I introduce here can be used in Hands-on activities because they are made easily using materials in daily life.

Keywords. Simple and Essential Experiments, Hand-made Experiments, Sound Wave.

1. Introduction

In the past HSci Conferences I showed some simple and essential hand-made experiments in Mechanics, Electromagnetics and Wave. We (Stray Cats group) invented [1-3] and discussed their roles they play in enjoyable and fruitful Physics classes [4-6]. Following to these presentations I demonstrate here some experiments in the field of sound wave and discuss roles they play in classes and students' activities. The characteristic of the field of sound wave is that sound wave is invisible. So, first thing that should be done is to give image of the sound wave to students by experiments that visualize sound wave. Some hands-on activities help students understand that sound is a transmission of vibrations. Some contrived hand-made experiments are needed to impress that sound is a kind of wave that has the common properties wave has; interference, independence, standing wave etc. Students' understanding of concepts becomes deeper and deeper by repeating processes between hypothesis and test using simple and essential experiments as I told in HSci2017 [5].

I introduce experiments of sound by classifying them into two categories. One is the fundamental experiments that visualize the phenomena of sound and clarify the mechanism of the phenomena. The other is the experiments of musical instruments that make students find Physics in them.

2. Fundamental experiments

Variety of experiments have been invented and used in Physics classes to visualize sound wave and clarify the phenomena concerning about sound wave. I introduce some experiments below which are invented by improving original ones. The difference between original one and our equipment are that the latter are made of the materials around us. That makes students feel what written in the textbook really happen in nature.

2.1. String telephone, "Echo microphone" and their evolution

String phone is popular equipment that is suitable for introduction for learning of sound. It consists of two cups and string. Bottoms of cups are connected by the string. Two people hold cups respectively and pull the string tightly. If one of them speak to the cup, the other can hear the voice from the cup. Students understand sound is a transmission of vibration through the medium because students can experience vibration of sound by touching the string.

On the other hand, "Echo microphone" is a toy for children. When we speak or sing a song with it, we can make sound with reverberation. Though we cannot see inside the toy, it is easy to guess that a spring is inside because of the sound when we hit it. We can make it easily using plastic bottles, cups and spring. It makes reverberation if we speak to one of cups because sound wave is reflected at the cups several times and superposed.

Echo telephone was invented by connecting string telephone and "Echo microphone" (Figure 1). Because the wave transmits on the spring much slower than in the air and it transmit without much loss. So, if we use spring instead of string, we can make echoes.

Figure 1. Picture of the echo telephone. Two cups are connected by the long spring

2.2. Interference experiments using megaphones

Figure 2. Picture of the horn of megaphone. Horn is separated into three parts and folded

Few students know a megaphone has a long horn. So, we can make students surprise by taking a megaphone into parts and connect them in a line (Figure 2). Horn is a shape that emit sound outside with small reflection from the bigger end. Horn is also good equipment to collect sounds. Sounds entered from outside are reflected at the inner surface of the horn, concentrate and sent out from the smaller end.

I show interference experiments using horns. As in Figure 3, pick up sounds in the two different places using two horns and detect mix sound using a microphone. If horns locate the places with the same distance from the speaker, mixed sound becomes big because they reinforce each other. If the distances (l_1 *and* l_2) from the speaker are different each other, we can find constructive places (1) and destructive places (2) according to formulas below:

$$|l_1 - l_2| = 2m\frac{\lambda}{2},\ m=0,1,2,\ldots \quad (1)$$

$$|l_1 - l_2| = (2m+1)\frac{\lambda}{2},\ m=0,1,2,\ldots \quad (2)$$

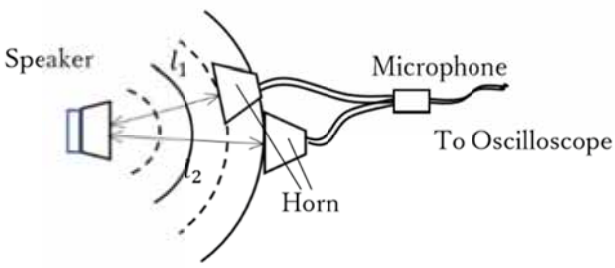

Figure 3. Block diagram of apparatus of interference of sounds. The sounds picked up by two horns are mixed and detected by the microphone

2.3. Bottle Kundt's experiments

Kundt's experiment is a popular experiment of sound wave and effective as an experiment that enable us to visualize standing waves created in the air columns. I demonstrated Kundt's experiment using whisky bottle in the plenary lecture at HSci2016. Small space like a whisky bottle enable us to see the standing wave clearly. Both end of the bottle becomes node in this case.

I used sealed speaker, glass bottle and Styrofoam balls (Φ8mm). Length of the bottle is 0.17m. So, the wavelength λ of the fundamental mode is 0.34m. If we assume the speed of sound V=340m/s, frequency (f) of the fundamental mode is calculated as below:

$$f = \frac{V}{\lambda} = \frac{340}{0.34} = 1000Hz \quad (3)$$

Styrofoam balls move to the place of anti-node quickly and make a wall at the fundamental frequency. By increasing the frequency, we can observe 2nd mode and 3rd mode standing wave.

It is easy to do the experiment of air column that has an open end. At the resonant frequency, Styrofoam balls moves quickly to the open end.

2.4. Consideration on the experiment of column resonance

Experiment of column resonance is popular mainly in senior high school. A tuning fork is used usually for the source of vibration. Because the sound becomes louder at the resonant frequency, we can measure the wavelength of sound by measuring the length of the air column at resonant points. However, if we use a speaker as a source of the vibration, the experiment is different. We hear the smaller sound at the resonant point. It seems that the sound is absorbed in the air column at the resonant point. However, this phenomenon is not changed if we make the sound from the speaker smaller.

Mr. Ishikawa, Stray Cats' member, did further experiments and found that there are two significant frequencies; one is the frequency at which the sound becomes smaller, the other is the frequency at which the sound becomes bigger. He found the former frequency was the same as that done using tuning fork. However, the latter frequency was higher than the former one. He considers that both frequencies are the resonant frequencies that have different modes; the two vibrators vibrate in phase or out of phase.

3. Musical Instruments

Musical instruments are good topic to apply fundamental of wave. We can find various fundamental phenomena in musical instruments; three elements of sound, superposition of waves, standing wave, interference of waves, etc.

3.1. Instruments that explain "What is pitch?" directly

Though it is possible to explain what pitch is by projecting the wave form on the oscilloscope, it is also very effective to use some musical instruments that explain pitch of sound. The instrument that is historically famous is "Gear wheel musical instrument" (Figure 4a). It consists of some toothed gears. As the ratio of the number of teeth is the same as that of musical scale, we can make the musical scale by making sounds by putting the thin paper to the rotating toothed gears. Students understand that the pitch depends on the frequency directly. Furthermore, we can make various musical instruments using this principle; if the ratio of the frequency is the same as musical scale, we can make musical instruments. Figure 4b is one of the instruments. Holes are bored on the side surface of the plastic bottle. Rotate it and send a wind to the holes through a straw. If holes are bored in the ratio of the frequency of musical scale, we can make musical scale by blowing the holes.

Various musical instruments using the principle "The musical scale is made by the sounds which have specific ratio of the frequencies" have invented so far. Series of produced musical instruments impress students that the principle is universal.

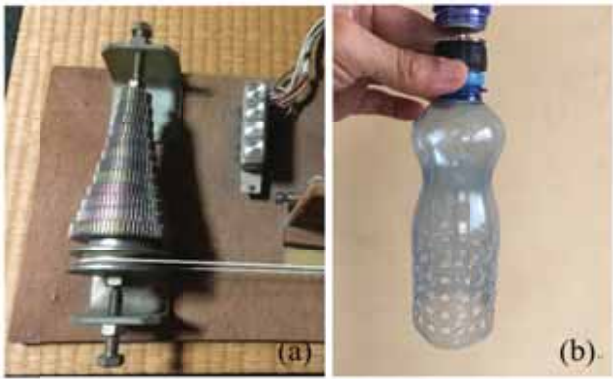

Figure 4(a). Gear wheel musical instrument (b) Siren musical instrument

3.2. Musical instruments and standing waves

It is fun and effective for learning for students to make musical instruments using the materials in our daily life. Because we can get materials easily, experiments using them are suitable for Hands-on experiment. I show a few examples below.

Pitch of almost all musical instruments are decided by the standing waves created along or in the materials in the musical instruments. As the formula (3) indicates, there are two parameters, V and λ, which change the pitch (f; frequency) of the sound. So, hand-made musical instruments are classified into two types.

If the velocity of the sound (V) is constant, pitch is decided by the wavelength (λ). I can introduce musical instruments using straws for the example. The end of the straw cut in a mountain shape makes vibrations and the vibration resonates to the air column is enhanced and make a sound. Long straw makes a low pitch sound and short straw makes a high pitch sound.

If the wavelength (λ) of the sound is constant, pitch is decided by the velocity of the sound (V). I can introduce musical instruments using plastic bottle for the example. Sound is created by hitting the plastic bottle. If the pressure in the plastic bottle increases, the sound becomes high pitch. Because the shape of the standing wave created on the plastic bottle does not change due to the pressure inside, the wavelength of the fundamental mode is constant. It is considered that the pitch is changed because the pressure in the bottle changes the velocity of the sound transmits on the plastic bottle.

4. Conclusions

As I told through the examples in 2 and 3 above, simple and essential hand-made experiments not only fascinate students but also play important roles in classes of sound. They make the phenomena of sound visible and help students' understanding of sound. Concepts become deeper and deeper by repeating processes between hypothesis and test using simple and essential experiments.

I hope hand-made experiments are used in Physics classes more than ever and make classes more enjoyable.

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The Importance of Teaching Nanotechnology in High Schools for Technical Specialties

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Abstract. The article deals with the importance of nanotechnology in the modern world for technical specialties and the importance of the introduction of nanotechnology in the educational process of secondary and higher schools. The introduction of new interdisciplinary courses related to the development of nanotechnology in the educational process of secondary and higher educational institutions is considered. At the moment, courses and programs in nanotechnology are practically absent in the educational process, while this direction is very promising and important. Special attention is paid to the experimental base and computer modeling of processes during training.

Keywords. Nanotechnology, Teaching in Universities, Nanotechnology in the Educational Process, Qualified Specialists, Computer Modeling of Nanoprocesses.

1. Introduction

One of the most relevant areas in science and technology is currently nanotechnology. In the near future, nanotechnology can make a revolution in society, exceeding the scale of the consequences of the widespread use of computers. The prefix “nano-”, in recent decades, has quickly entered people's minds. It encourages to speculate about the big changes in technology and science. Now we are already seeing the onset of nanorevolution: new computer chips, new materials, and the use of nanoparticles in medical diagnosis.

In the future, our life will be difficult to imagine without nanotechnology, as it is now without computers and phones. There will be new professions related to nanotechnology and will need specialists who will have knowledge in this area. Therefore, it is very important to introduce a course on nanotechnology in the educational process in universities for technical specialties and not only if the country wants to move to a new level of technological development.

2. The importance of studying nanotechnology and introduction to the educational process of the University

Relatively recently, nanotechnology has entered the modern world. The beginning of the XXI century was marked by the revolutionary beginning of development of nanotechnologies and nanomaterials. Today, they are in great demand in all developed countries and in the first place it concerns the most important human activities (industry, defense, information, electronics, energy, transport, biotechnology and medicine). Analyzing the growth of investments, the number of publications on this subject, as well as the pace of implementation of fundamental and exploratory developments, it becomes clear that in the next 20 years the use of nanotechnology and nanomaterials will play a key role among the scientific, economic and defense development of States.

The use of nanotechnology keeps a huge number of advantages: it nanorobots "living" in the body, killing cancer cells and restoring damaged tissues and organs, as well as automotive engines that do not pollute the environment.

This means that in the near future such professions as nanorobot programmer or molecular computer designer may become in demand. And people who are just thinking about their future profession may need to think about the prospects of this sphere.

The above-mentioned prospects for the development of nanomaterials and nanotechnology require the training of specialists in this field through the rapid opening of new specialties and specializations, retraining programs, the introduction into educational programs of disciplines necessary for the training of specialists capable of effectively and at the present level to solve fundamental and applied problems in the field of nanomaterials and nanotechnology [4].

Unfortunately, the modern system is aimed at the formation of highly specialized "cogs" of the outdated mechanism, and not

independently thinking harmoniously developed people. Often you can find a person who is well versed, for example, in computer technology and programming, but it is not familiar with the achievements of modern chemistry, biology, or vice versa.

By the way, if we talk about the connection of nanotechnology with the fundamental Sciences, we can say that almost any subject that is studied in school, one way or another will be associated with the technologies of the future. The connection of "nano" with physics, chemistry and biology is unambiguously predicted. Obviously, these Sciences will receive the greatest impetus for development in connection with the nanotechnology revolution, which is already steadily moving forward [1-2].

The introduction of new interdisciplinary courses related to the development of nanotechnology in the educational process of secondary and higher education institutions will contribute very well to meet the public demand in qualified specialists in the field of nanotechnology.

3. Terms

The term "nanotechnology" is rightly considered one of the key concepts of the early XXI century, a symbol of the transition to the sixth technological mode, which has recently been constantly introduced into the economies of developed countries.

The term "nanotechnology" was introduced into scientific use in 1974 by the Japanese physicist Norio Taniguchi, who proposed it to refer to mechanisms smaller than one micron. Nanotechnology — methods of production and use of artificially created objects of nanometer size. Substances created on the basis of nanotechnology are called nanomaterials. With the naked eye, a person is able to see an object of about 10 thousand nm. The pace of scientific and technological progress has become dependent on the use of nanotechnology in recent years.

Features of nanomaterials differ significantly from our usual materials. The transition to the nano-area dramatically changes the characteristics and properties of materials, and allows you to achieve properties that can not be achieved in conventional materials. For example, splitting a solid material into nanoparticles increases the total surface area by millions of times. Nanomaterials melt, flash and absorb much more easily than their solid massive counterparts.

The prefix "nano" in the term nanotechnology comes from the word nanometer, that is, the billionth of a meter or 10^{-9} m (the thickness of a human hair on average 50 000 nm). Nanotechnology operates on the order of a nanometer, it is a negligible value, hundreds of times less than the wavelength of visible light and comparable to the size of molecules. Nanotechnology boundaries start at the size of atoms and molecules and end at 100 nm. Within these limits, the manipulation of individual atoms and molecules begins. Therefore, the transition from "micro" to "nano" is no longer a quantitative, but a qualitative transition, since at such scales nanomaterials do not obey the laws of Newton's mechanics, the laws of quantum mechanics dominate there.

4. Experimental and theoretical basis

The most important condition for the rapid and successful development of nanotechnology is the development of training courses and programs to work in this field of science and technology. The task is to create conditions for the sustainable functioning and development of the system of training, retraining and consolidation of personnel and ensure the effectiveness of research and development in the field of nanoindustry.

One of the main problems in the study of nanotechnology in Ukraine is the underdeveloped infrastructure for the practical study of nanotechnology. In particular, the lack of special equipment, limited use of existing equipment and the lack of cooperation of departments of universities and enterprises for the effective use of unique equipment. Modern training equipment on nanotechnology is relatively expensive and knowledge-intensive. It is possible to use the available equipment at the departments of universities to begin the study of nanotechnology.

In recent decades, information technology has been widely used to teach nanotechnology. The modeling method is recognized as the main method. Computer modeling is necessary

in the study of processes that are difficult or impossible to observe. Computer modeling also provides an opportunity for students to demonstrate the results of modeling in the form of animation, which increases interest in the subject [3].

Consider the possibility of several computer programs for the study of nanoobjects,

RasMol is a freely distributed program for visualizing the spatial structures of macromolecules. This is a program for beginners and students, it can be considered basic, as it can work on computers with minimal hardware requirements. When working with the program, a number of atoms are released. All actions are carried out with this system of atoms. The initial data for visualization is a list of atoms with the coordinates of their centers.

Qutemol, a real-time program, has a high-quality molecular Visualizer that offers many innovative visual effects. QuteMol aims to increase the transparency of the simulated images and provide a better understanding of the molecular 3D format and spatial structure. Many viewing modes allow the program to obtain high-quality images of structure models, as well as save animated images using the Realistic mode.

The program of simulation of molecular dynamics - GROMACS. The program of molecular dynamics is based on classical Newtonian mechanics, and this is the weakness of the method. On the one hand, it allows us to model systems with many atoms. On the other hand, the calculations are only at the level of intermolecular interaction, and the calculation of chemical reactions is difficult, unlike quantum chemistry, which takes into account all the interactions. Especially powerful supercomputers are needed for quantum mechanical calculations.

Gaussian is a software package for calculating the structure and properties of molecular systems in the gas-phase and condensed state, including a wide variety of methods of computational chemistry, quantum chemistry, molecular modeling. Created by Nobel laureate John Pople and his research team and has since been constantly updated. Software packages series "Gaussian" are considered by experts one of the most powerful in terms of capabilities and common in everyday use.

Thus, the development and application of programs for modeling nanoobjects is a promising direction in the teaching of nanotechnology in universities.

5. The importance of qualified specialists in technical specialties

In recent years, thanks to scientific and technological progress in the field of nanotechnology, the role of technical professions in this specialty has increased. Time does not stand still and every time life brings us more and more new challenges. To be ready and be able to adapt to the ever-growing needs, self-respecting professionals should have in their Arsenal a broad Outlook and willingness to qualitatively solve specific problems in specific areas to facilitate the lives of modern people.

The development of nanotechnology is growing every year, and technical specialties are well-founded and moving forward the core for the scientific and technological progress of nanotechnology and nanomaterials. Therefore, experts in this field every day become much more popular than in recent decades.

With the naked eye it may seem that the modern world is driven by the commercial basis, but in further analysis it becomes clear that all this is driven by the Executive system in the face of technical specialists. The development of nanomaterials and nanotechnology in the face of medicine, industry and industry can not do without appropriate professionals who know their business. And competition is an excellent source of new ideas and attract orders from manufacturers so that they are among the first to try to use a unique or profitable offer. Thus, the scientific work is carried out for the introduction of new technologies and all sorts of innovations [5].

It is important to master both high-quality and necessary material. Therefore, entering the University, it is important not to chase the "prestige" of the Institute or specialty, but it is necessary to understand that a specialist without knowledge, who became them by cramming will not be necessary in any scientific

field. Specialties in the direction of nanotechnology and nanomaterials are in demand only if there is knowledge, in particular, their quality.

In such circumstances, a good specialist becomes very popular for employers, which can increase the specialist and salary, and add additional bonuses. After all, employers in search of such workers, understand that their efforts will be justified. After all, it is with the help of such employees with their innovative ideas that the company's profit increases. Or sometimes they help the company to avoid large losses with the help of their own knowledge and suggestions. Their innovative ideas increase productivity, reduce production costs and efficiently allocate production resources. A competent Manager will never miss such a specialist, understanding that such employees for the most part earn money for the company. A competent Manager will also take into account that it is not easy to work out difficult ideas for nanomaterials and nanotechnologies that require time for different tests, and after being made and as something separate, will bring income, becoming part of the new high-tech products.

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Getting Them into Science

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Abstract. Science should be about exploring ideas and concepts from a very early age for the rest of our lives. However, learning science in school often loses its magic, and children easily get diverted if not kept motivated and stimulated. Innovative lessons that use local examples often provide stimulation. Further, out of school projects, (when children can work with adults like Citizen Science,) may increase their interest in observing and recording events. The author relates several successful large innovative school science projects which captured the imagination of the groups involved and which could be copied anywhere, at different scales.

Keywords. Exploring Ideas and Concepts at Early Age, Imaginative Stimulating Science, Innovative Projects which Can Be Repeated.

1. Introduction

Science should be fun for everyone, of all ages. In school, science must be relevant [1-3] and taught in a way that makes learning a memorable experience [4] from an early age. Researchers have found that unforgettable childhood science colours opinions about the subject for the rest of our lives [5], so it is vital that school science, in particular, offers opportunities for events that are stamped on our memories. These events don't need to involve expensive outings or resources but most frequently result from an innovative lesson given by an enthusiastic teacher. Our out of school science experiences can be simple when children are young too, and don't need to involve expense. My own children enjoyed a range of outside science experiences that cost nothing – bug hunts in the garden, finding the first blue/yellow/red flower in the woods or fields, looking for fossils in local gravel paths or driveways, and finding the best places to fly kites.

2. Memorable experiences

The astronaut Tim Peake stimulated thousands of children's interest in science during his time in space. Children were invited to devise 'space meals' and experiments [6], some of which were implemented on his journey. His school links [7] by satellite enthused hundreds of children and provided many ideas for discussion in class. The Royal Horticultural Society sent 2 kg of seed into space which on return were sent to participating schools to see whether they grew better or worse than seed which had not experienced space [8]). The results are currently being co-ordinated.

In a further published innovative idea, a Turkish teacher used the snowy weather to encourage his class to record issues surrounding school closures after heavy snowfalls, which made the children think of the problems associated with extreme weather conditions [9]. Local flooding in Suffolk was used by another teacher to stimulate interest in problems arising from extreme rainfall in their town, again arousing interest in local science issues [10]. Citizen Science projects throughout the world offer stimulating experiences for many adults to participate in real innovative science [11]).

3. My science experiences

As a student and a teacher, I think I have always been a rebel. This is partly because I only seem to learn anything through experiences. Most of the teaching I experienced at school was straight forward facts – which were either dictated or we copied from the board or text book. I did not respond very well to this and found learning facts very difficult. However, when I joined the weather forecasting service, my life was full of practical observation, plotting and recording and some of the physics facts that I had tried so hard to memorise actually began to make sense! I started to understand physics for the first time in my life. Consequently when I later decided to become a teacher, I vowed that I would try to appeal to all the different ways that children learn. This of course, made teaching for me much more interesting, but also more difficult in that I was always trying to find innovative ways of teaching! I must say too, that my innovative methods were not always approved of by head teachers – taking children out to measure snow depth all over the school field and ending the lesson with a snow ball fight was a case in mind. But I was fortunate enough to have

forward looking, understanding head teachers who were not overly critical so long as the children achieved good results.

4. Flexibility is key

One needs to be flexible when teaching children and this flexibility must take account of current circumstances – often the weather (nothing upsets a class like a windy or wet day) or local events – when I was teaching in Manchester this amounted to football cup ties. If Manchester United were playing on a weekday, half the class would be absent – if Manchester City were playing, the other half would be away, and if they were playing each other – well, it wasn't worth having a lesson at all. In another school a local child killed in a motor cycling accident unsettled children for days. All sorts of things unsettle children and this plays on their learning ability. At these times doing something different will distract children and hopefully add something to their knowledge, but one has to be creative. It's a good idea to have a range of ideas secreted away for a rainy day.

I have sent classes out to collect ten stones each which we then classified into sizes, shapes, colours or even rock types. Students of all ages enjoy this: they have drawn graphs, tried to find where the source of these pebbles is, how far they have come, whether water moved – so many questions can be examined from this one exercise. Mapping shadow zones around a school building then questioning the implications of too much light, not enough light, finding the warm or cool areas of the building, the need for sun blinds: again all sorts of questions can be generated from a simple idea. Mapping windy zones where litter collects, rain shadow zones all provide ideas for innovative questioning sessions.

5. Support for teachers

Since moving on from the classroom to a role of supporting teachers by thinking up innovative ways of teaching specific science topics, I have been able to spend more time researching and planning ways that will provide opportunities for all types of learning, for all ages of students. I have also learnt more and understand more too!

One of the first things I began to appreciate more in my supportive role was the use of language [12]. I had always been aware as an earth scientist that science and particularly earth science, had a vocabulary of its own, and that there needed to be ways of introducing technical words through explanation and continual reinforcing use. One day I was asked to review a programme developed specifically by a company for young children about 'gases'. On reading through the initial programme, it seemed to me that the programme was assuming all manner of technical words – the first being 'gas'. The programme was aimed at 5-7 year olds and I ventured to ask some children what they thought 'gas' was. Their replies were many and various, and I soon discovered that there were other words which we as adults assumed children understand but which meant very different things. Words like temperature, - what is hot, or cold? Wet and dry were usually understood, but the word liquid caused issues… To go back to the company I was working for, I rewrote their programme in language for 5-7 year olds, with explanations of very basic technical words. I now always try to get teachers to think carefully about even very simple words and language, for example: hot or cold – what do these really mean – think about it! We use a lot of words in science that can have different meanings to children, depending on their age: e.g. force, pressure, plant. When we use scientific words in a technical situation we need to ensure that children understand what we mean in that specific situation so that we all can communicate from the same baseline.

6. An innovative primary science day– 'who lived on my school field?'

In 2010 a school asked me if I could devise a programme for a whole day to stimulate interest in science, as their school science was seen to be 'failing'. Something exciting and investigative was needed, that would raise the status of science for everyone. After talking with the teachers I suggested that we might spend a day investigating what might have lived on the school field prior to the last Ice Age [13]). Giving footprints and teeth of different animals alive at the time, and linking this to environments through rocks might be something that would provide a range of investigations and give room for discussion and

interpretation. I started by identifying four animals that could have lived in the area at the time – mammoths, hyenas, hippos and man. I visited local museums and universities to see what items I could borrow, bones, teeth skulls – and enlisted the help of a university professor who would come and give an introductory talk at the start of the day.

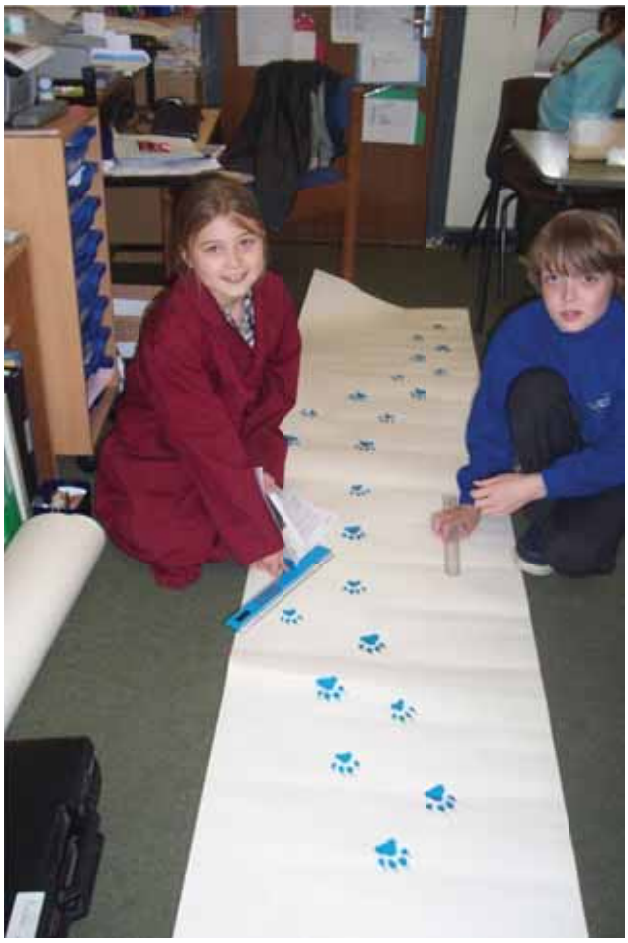

Figure 1. Working on footprints

With the teachers we set up three laboratories for each year group. The footprints lab asked children to discover the height of their animal from ground to shoulder by measuring footprints. They needed to compile two graphs: of their own stride lengths against their shoulder heights and their foot size against shoulder height. Any adults in the room could be included too, so that straight line (more or less!) graphs could be drawn up. In this way the animal's height could be gauged from a track of footprints.

In the second lab the children examined the given teeth, and had to decide what kind of food their creature would eat. Either bones or skulls were also available for examination to give extra clues.

Figure 2. Examining mammoth bones

Figure 3. Examining a fossil skull

Finally the third lab had rock samples from the specific kind of environment where the animal might have lived, eg dry desert area, grassland, muddy environments, using sandstones, clays and mudstones and limestones – all rocks the children would need to identify then refer to a chart which showed the possible environment. Then, armed with this information, each class needed to draw its own animal, and be able to explain to the rest

of the school what they had discovered and why.

The day was very successful and thoroughly enjoyed by staff, helpers and children. Science was seen to have a purpose. The children had worked together in teams, made lots of observations, recordings and drawings and analysed their information to get a result. The hippo head and the mammoth tooth and bone were the star show of the day and eventually all children were able to see these. Altogether this day enthused everyone and gave science a boost – from where it has gone on to much greater strength in this school.

Figure 4. Looking at rocks

7. An Innovative secondary science day - The Alternative Energy Project

Another school, this time a secondary one, asked for help linking a STEM careers event with an energy programme. I worked with the school's community liaison officer Allan and together we came up with an idea which subsequently ran for thirteen consecutive years [14]. We decided that with the help of local engineers we might be able to make large working models of alternative energy generators – wind, solar and water projects. With the help of three engineers we devised plans for some nine different projects that we felt could be made within a day. Allan set about sourcing resources, and I located funding and engineers. The plan was that some 16 engineers would each work with a team of about 12 students aged 14-15, so a whole year group was involved. The students would have a lesson about alternative energy prior to the project day so that they were aware of the ideas they would be working with.

On the day itself after an early breakfast briefing, each engineer began with a short discussion about science and engineering careers in each group. Each group split into two teams, decided on team names, and identified a project manager. Then it was 'all go' to build the project they had been assigned. These varied from water wheels and solar panels to wind generators of all kinds, all of which had to show that they could produce energy. A basic idea was given to each group but they had to design their own working model, with help from their engineers. The result was incredible! Some 16 working models were all completed within four hours and displayed some inside, some outside to establish that they worked. We all gathered around for demonstrations. The local fire service provided water tanks and pumps to get the waterwheels and other water devices working, and the solar water heaters were set up in a sunny position.

Figure 5. Working with an engineer

Figure 6. The solar panel water heater

All the models produced recordable energy.

The teams were judged on their teamwork, and creativity, and small prizes of book tokens donated by a local bookseller were allocated. This programme became legendary within the school with all students wanting to participate in the Year 9 event. It was not without incident, one year a deputy head was engulfed in water when one of the water tanks split open – his street cred increased enormously. In later years, we added a literature dimension, where 4 members of each group became journalists for the day; interviewing well known campaigners for alternative energy by phone, and producing a newssheet of their group's activities and model type.

Figure 7. The water wheel

Figure 8. A wind generator

The programme was innovative, very successful and memorable for all who participated. Exhausting but rewarding for Allan and me as we felt all the children had learnt from their experiences –and were now more aware of STEM careers and engineering projects as well as learning numerous skills. The engineers signed up to return every year, and getting their teams to win became a challenge for them too. Unfortunately after 13 years, Allan retired and no-one replaced him. It had become difficult to raise the funding too - £2000 was required, which really was not a great deal for the amount of benefit gained by some 200 plus students.

8. Conclusions

Innovation in Education is really all about getting children to learn whilst doing something they enjoy. However, teachers do need to be given time to think through their ideas. They need the support from their management teams so they can initiate ideas. Language and use of technical terms must be at an appropriate level. Science *should be fun.* Science IS fun, particularly when it is relevant.

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Outreach educational activities of the International Optical Societies in Kharkiv

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Abstract. East-Ukrainian Local Section of the Optical Society (OSA) is a new group of optics professionals in Kharkiv. OSA Local Section Membership is a way to connect with optics professionals, keep up-to-date on technical and business innovations, and take part in philanthropic activities that benefit country and local community in Kharkiv. The members of LC organized the scientific popular events in 2019: “Day of Science”, “Science for everyone in ILTPE for all interested children and adults” and Celebration of the International Day of Light, Festival "Family Sun_Days", International Day of Women in Science. We advocate an active learning of Sciences through an enlarged use of hands-on experiments.

Keywords. East-Ukrainian Local Section, Optical Society, Hands-on Experiments, Outreach Educational Activities, Optics Demonstrations.

1. Introduction

The Optical Society (OSA) is a professional association of individuals and companies with an interest in optics and photonics. It publishes journals, and organizes conferences and exhibitions. In 2019 it had about 22,000 members in more than 100 different countries, including more than 300 companies [1]. The Optical Society has a long and successful history. OSA was founded in 1916 as the "Optical Society of America", under the leadership of Perley G. Nutting, with 30 optical scientists and instrument makers based in Rochester, New York [2]. It soon published its first journal of research results and established an annual meeting. The first local section was established in Rochester, New York (USA) in 1916, and the Journal of the Optical Society of America was created in 1918 [3]. Today, there are thousands of individual section members located in 22 OSA Local Sections around the world (13 in the U.S. and 9 non-U.S.).

Figure 1. Celebration of International Day of Women in Science

Figure 2. Science for everyone in ILTPE

In Kharkiv, optical chapters for students of OSA and SPIE was founded by PhD students of B. Verkin Institute for Low Temperature Physics and Engineering of the NAS of Ukraine (B. Verkin ILTPE of NASU), O.Ya.Usikov Institute for Radiophysics and Electronics of the NAS of Ukraine (IRE NASU), and Institute of Radio Astronomy of the NAS of Ukraine (IRA NASU) as an "Institute of Radiophysics and Electronics (IRE) SPIE & OSA Student Chapter" in 2007. Since 2007, the members of chapters have been involved in outreach and have been organizing the various educational and professional optical development activities for local community in Kharkiv. The student members' staff of OSA chapter changed the name of the chapter to "ILTPE OSA Student Chapter" in November 2017 [4]. East-Ukrainian Local Section of the Optical Society (OSA) is a new group of optics professionals in Kharkiv that grows from the IRE SPIE and ILPE OSA Student Chapters in 2019 [4-5]. After defending the PhD, a lot of members of SPIE & OSA Student Chapters continue their Outreach

educational activities. At the same time the young researchers that get PhD cannot be the member of Student Chapters. E-U Local Section is the way for consolidation and organisation the efforts of these young researchers in their educational activities.

Figure 3. Optical Demonstration for Kharkiv pupils

2. East-Ukrainian Local Section educational activity

In general, the OSA Local Section Membership is a way to connect with optics professionals, keep up-to-date on technical and business innovations, and take part in philanthropic activities that benefit the country and local community in cities. OSA's national organization supports sections through activity grants, awards, publications, guest lecturer programs, leadership training, year-round networking opportunities and more.

The members of East-Ukrainian Local Section are researchers from B. Verkin Institute for Low Temperature Physics and Engineering of NAS of Ukraine (ILTPE) that focus their efforts on the next objectives:

1. to promote awareness of optical science and optical engineering among the local communities,
2. to facilitate communication and interaction between academic, government and industry professionals,
3. to interact with The Optical Society members and its local organizations with a focus on information sharing and networking,
4. to raise awareness of post-graduation and career opportunities.

Figure 4. Presentation of the OSA and SPIE chapters at XV Ukrainian student science conference "Physics and technological progress"

In collaboration with IRE SPIE and ILPE OSA Student Chapters the members of LC organized the scientific popular events in 2019: "Day of Science", "Science for everyone in ILTPE for all interested children and adults" and Celebration of the International Day of Light, Festival "Family Sun Days", International Day of Women in Science. Some photos from these events are shown in the Figures 1-6.

Figure 5. Scientific Demonstration in Day of Science 2019 ILTPE

We talked about the optical research in ILTPE and explained the role of optics for the improving of the quality of everyday life. In particular, we told about the International optics societies OSA and SPIE. In the optical demonstration was shown the geometrical optics. The children saw the images of insects in the optical microscopes and used Optical Suite Case tools for observation the diffraction and dispersion effects.

A lot of the members of the Local Section also the members of The Council of Young Scientists of B.Verkin ILTPE of NASU [6] and the Organizing Committee [7] of the International Conference for Professionals and Young Scientists "Low Temperature Physics" - ICPYS LTP that held in Kharkiv every year (see Figure 7). Traditionally, the authors of the best presentations are chosen by the Program Committee and awarded (Figure 8).

Figure 6. Organizing team of the event of the International Day of Light Science, IDL 2019

Figure 7. International Conference for Professional and Young Scientists LTP 2019

Figure 8. Ceremony of awarding for the best presentation in the closing of the conference - ICPYS LTP 2019

3. Acknowledgements

The members of East-Ukrainian Local Section thanks to the Optical Society (OSA), ILPE OSA Student Chapter, IRE SPIE Student Chapter, and The Council of Young Scientists of B.Verkin ILTPE of NASU for fruitful educational collaborations and activities.

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Hands on Science and Science Education for Adults

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Abstract. The scientific activity is formed by knowledge, methodologies and processes of inquiry. This methodology has been used both in workshops and conferences for adults. For our audience, the inquiry involves making observations, asking questions, performing experiments, analyzing and interpreting the results, proposing explanations and asking further questions. In general, the activities in these workshops are carried out in groups. The experiments are carried out by a male scientist and a female scientist. It is important for us to emphasize the presence of women in science. This paper presents 2 activities, workshops and conferences to promote science at home. It is necessary to open a dialogue between science in general and our society to correct certain attitudes against science.

Keywords. Chemistry, Women, Kitchen, Experiments, Society.

1. Introduction

The scientific activity is formed by knowledge, methodologies and processes of inquiry. In this human activity, scientists, professors, teachers and those people related to scientific dissemination must be involved.

Everything that we encompass within the word "science" shows us that any of them, biology, chemistry, physics, biotechnology, engineering, mathematics and others, are formed by knowledge, methodologies and processes of inquiry.

From the dictionary [1], inquiry means a seeking or request for truth, information, or knowledge. In addition, the act of inquiring implies seeking information by questioning.

The methodology of the inquiry has been used both in workshops and conferences for adults, some with little or no scientific knowledge. Significant experiments were prepared for them.

For adults, the investigation involves observations, asking questions, performing experiments, analyzing and interpreting the results, proposing explanations and asking further questions.

The kitchen activities are carried out in groups of 2-3 people [2]. It is intended that participants develop their own initiatives, contrast them with colleagues' proposals and all together enjoy scientific experiments.

The experiments are carried out by a male scientist and a female scientist because important scientist women and their findings correlated with the field of experimentation, chemistry, in order to increasing the participation of the girls and women. It is important for us to emphasize the presence of women in science [3].

It is necessary to open a dialogue between sciences in general and our society to increase public understanding of science and to correct certain attitudes against science or specific anti-science beliefs [4]:

- The four major anti-science issues are Humans are not responsible for global warming/climate change.
- The Earth is only a few thousand years old. Vaccines can cause autism.
- Genetically modified organisms (GMOs) are harmful.

Here we present two different activities, workshops and conferences. Both with the same objectives: to establish a relation between chemistry and the kitchen and to promote science at home.

2. Non-formal education

All those activities are performed outside the school environment, in order to develop the intellectual and moral competences of the individuals [5]. "Non-formal education" UNESCO defines Non-formal education [6]: it can cover programs contributing to adult and youth literacy and education for out-of-school children, as well as programs on life skills, work skills, and social or cultural development.

Non-formal education refers to explicit objectives which are not directly directed to the provision of the proper grades of the regulated educational system. [7]. That is to say, non-formal education is a type of education that will include all the processes and practices that involve a heterogeneous social group, but whose institutional structure does not certify for school cycles.

Non-formal education objectives of the institutions like the Official College of Chemists of Catalonia [8], Col·legi Oficial de Quimics de Catalunya, (CQC):

- Create educational programs that foster attitudes, values, competences and forms of social organization, capable of changing previous ideas.
- Create training programs that expand employment opportunities, improve family income and change living conditions.

Non-formal education objectives of the participants:

- Transmission of basic knowledge and skills for science communication in our society.
- The programs are aimed at people who are different in age, gender, social status, race, etc.

3. Methodology

This informal learning was used both in the practical workshops and the science conferences for adults

The Department of Biochemistry and Molecular Biomedicine [9], Department de Bioquímica I Biomedicina Molecular (DBBM, www) at the University of Barcelona [10], in collaboration with the Official College of Chemists of Catalonia, Col·legi Oficial de Quimics de Catalunya, (CQC, www) designed activities aimed at adults. These activities / experiments are carried out both in the laboratories of the DBBM itself and in civic centres.

Furthermore, the CQC, taking advantage of the fact that the UN declared 2019 [11] as the International Year of the Periodic Table of Chemical Elements (IYPT 2019) coinciding with the 150th anniversary of its presentation by Russian chemist Dmitri Mendeleev, has designed workshops, related with this celebration, aimed at adult people.

Some of these workshops are

- "Chemistry in the kitchen",
- "The Periodic Table",
- "History of the chemical elements", "Biochemistry of diabetes, obesity and cancer",
- "Science and toys",
- "The chemical elements and the importance of the periodic table"

All of them are carried out in municipal facilities such as libraries and civic centers.

To enhance the importance of the presence of women as scientists the experiments are always carried out by a female scientist and a male scientist.

Some important women/scientists are named in the field of experimentation, Marie Curie was the most known, to emphasize the participation of the girls.

4. Results

4.1. Chemistry in the kitchen for adults

Explaining chemistry at home is an innovation for adults in the field of cooking as well as in education.

This activity was developed in the kitchen of the civic center "Vil·la Urania" [12] in Barcelona.

The combination of chemistry and culinary techniques [13] is a scientific discipline called "Molecular cooking". High-level Catalan chefs such as Ferran Adrià and Carme Ruscadella are worldwide known for their contributions to this discipline.

In this context, the living organisms or not from which we obtain the foods are made of atoms, this is chemistry.

We work and explain the core ideas of

- liquid nitrogen freezing,
- protein structure change,
- spherification procedures
- food base pH indicators.

Figure 1. The kitchen will be a space for leisure and dialogue between scientists and attendees

To understand nitrogen freezing basis, ice creams and cocktails can be prepared, and lack of water solidification is noticed in the product.

To appreciate protein structure change, egg white colour and structure modification due to temperature is compared with egg white changes when pH is modified.

Spherification as one of the most impressive molecular cooking techniques is used to explain the basis of ion bonds.

pH indicators. Red cabbage can be boiled, and the extract is being used as a pH indicator- we gave to the assistants a rack with a variety of typical house products such as vinegar, lemon, diluted bleach. When red cabbage extract was added they could observe the solution colour change.

Finally, experiments are carried out with bioelements and biomolecules such as sugar, oil and proteins.

As an approximation to the chemical elements of the Periodic Table, participants worked on some chemical elements of different kitchen tools such as copper, iron, aluminum, lead.

In addition, from the alloys we talk about brass, bronze and stainless steel, its chemical and physical properties.

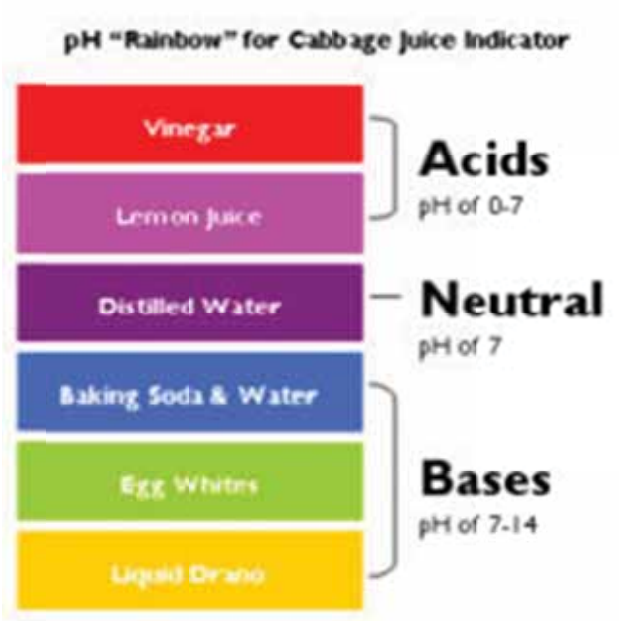

Figure 2. Cabbage and pH [14]

The response of the participants has been very favourable to continue in this way.

4.2. Conferences about the Periodic Table

We try to answer " why is the periodic table important?". This activity was done in the civic center Golferichs Centre Cívic Golferichs [15] in Barcelona.

Figure 3. 2019 has been proclaimed the "International Year of the Periodic Table of Chemical Elements (IYPT2019)" by the United Nations General Assembly and UNESCO

The Periodic Table of the Chemical Elements is one of the most significant goals of science, because it captures the essence not only of chemistry, but also of astronomy, of physics and of biology and other natural

sciences. It is an essential and unique tool that allows scientists/chemists to predict the appearance and properties of matter on Earth and in the Universe.

Also, many chemical elements are crucial for the manufacture and development on an industrial scale of numerous products present in our daily life and necessary to maintain our current lifestyle and preserve the planet.

The four most recent elements (115-118) were added in full in the Periodic Table, with the approval of their names and symbols, on November 28, 2016.

4.3. Conferences about Biochemistry, Diabetes, Obesity and Cancer

This activity was done in the Friends of UNESCO local Amics de la UNESCO Barcelona [16] in Barcelona.

Conference starts with an initial description about biochemistry and the metabolism of three diseases, diabetes, obesity and cancer.

How organisms obtain energy through biomolecules and in what way the organism can generate its own biomolecules.

- Carbohydrates such as glucose,
- Lipids like palmitic acid
- Proteins like insulin or ovoalbumin.

In addition, we summarize the latest advances in the field of cell biology and biomedicine in an understandable manner.

Basic concepts were thought to understand the paradigm shift from 50 years ago until now. The diseases in question produced the death of a high percentage of people only 50 years ago and now, in our country, this percentage has fallen notably thanks, in part, to the important advances in biochemistry.

Iron, Fe, is basic for life. For example, is the key element of haemoglobin, a protein responsible for transporting the oxygen, from lungs to our tissues, through the red blood cells (RBCs) of the blood. Haemoglobin also does other fundamental functions for our body and our health.

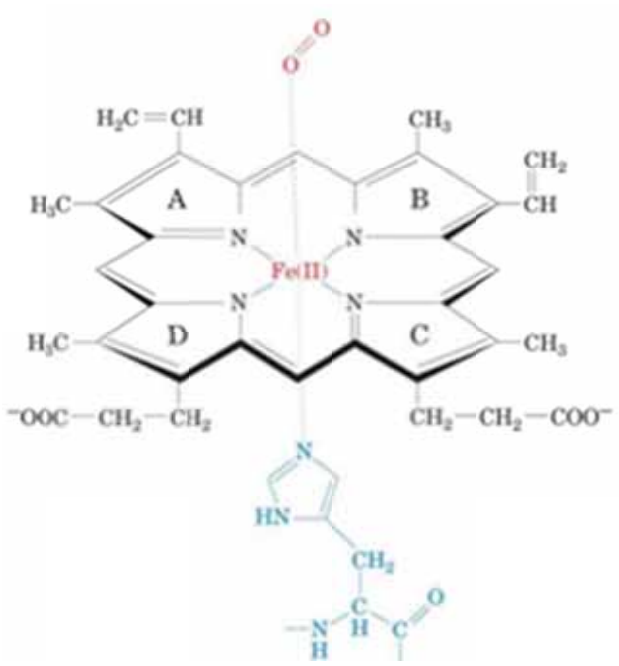

Figure 4. The heme group [17]

In this table you can see different meanings of some words when they are used in scientific field or in daily life.

MEANING OF WORDS AND CONCEPTS		
	In the scientific field	In daily life
Chemical agent	Any substance that acts as a reagent or an active ingredient	James Bond, secret agent. Something dangerous
Complex	Chemical compounds that involve transition metals	Situation of difficult solution or psychological condition
Medium	For which the waves travel or the microorganisms grooving	Neither large nor small psychic person
Model	Scientific representation or description of a process	Naomi Campbell model of a 2ndWW plane
Transfer	Move from one organism to another genetic material	Transfer money. Soccer player changes of team
Volume	Space occupied by an object in solid, liquid or gaseous state	From a collection of books Sound force

5. Conclusions

The principle objective of this activity is to allow participants, adults and elderly people, to experience science in a less-structured and more playful manner. All these experiments are designed to be straightforward and the simple materials are chosen with safety in mind. They can repeat kitchen activities at home.

The main purpose of conferences is to promote science. It is necessary to open a dialogue between science in general and our society to improve the relationship between science and society. Our participants can fight against the false ideas against the science.

In addition, the scores given by the participants, were 4.3 and 4.5 out of 5 indicate the great acceptance of these methodologies, experimental workshops and conferences, among them and encourages the teaching staff/science disseminator to continue in that direction.

6. Acknowledgments

We thank all participants for their inputs and cooperation. We also thank the Official College of Catalan Chemists “Col·legi Oficial de Quimics de Catalunya” and civic centers for their support and finally, to Mr Enric Gascó for his assistance in preparing the English manuscript.

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Hands-On Approach Experiment for the Study of Recombinant Protein Production and Regulation of Gene Expression in Genetic Transformed *Escherichia coli* BL21(DE3) Strain

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Abstract. Biotechnology, which integrates high school curriculum, has allowed the genetic transformation of bacteria for human benefit. For some students, genes are the only determinants of the organismal phenotype, therefore it is important that they understand that environmental factors influence gene expression and that this can condition the general phenotype of an organism. With this experience students can observe, in practice, positive genetic regulation and catabolic repression. It also allows students to experience transformation of *Escherichia coli* with plasmid DNA and use of antibiotics for positive selection of transformants, both of which are essential techniques for gene cloning technology.

Keywords. Bacterial Transformation, Inducible Promoters, Regulation of Gene Expression, m-Cherry, Recombinant Proteins.

1. Introduction

Biotechnology has become an impactful field in society, therefore citizens must be able to understand its main concepts and its potential and draw-backs, so that they can make well-versed decisions concerning its applications. Therefore, in Portuguese curricula, biotechnology and modern molecular biology are mobilized to concrete daily situations and rely on hands-on laboratory classes.

In biotechnology, genetic transformation is a commonly used process that transfers a gene from an organism to another, that becomes capable of producing a new protein that was encoded by said gene. This allowed for some biotechnological applications, such as the production of human insulin in bacteria. But genes are not the only factors for a certain phenotype in bacteria. Environmental factors are partly responsible for the phenotype expressed in an organism. Bacteria respond to environmental and nutritional changes by regulating its gene expression.

All cells regulate gene expression so unnecessary transcripts and proteins are not produced, regulating their metabolism and efficiently using limited nutritional resources. It is common in cells cultivated in nutrient-poor media to minimize or “turn off” the expression of genes not necessary for nutrient metabolization, reducing the synthesis of RNA and proteins because transcription and translation are energy-expensive processes. In bacteria, the most usual mechanism for regulation occurs over messenger RNA (mRNA) transcription, and those genes are said to be “transcriptionally regulated” [1].

Generally, bacterial genes are switched off by repressor/inhibitor proteins that regulate expression by fixing to an operator DNA sequence, adjacent to the promoter sequence of an operon, successfully blocking the access of the RNA polymerase to the DNA sequence, resulting in operon gene expression repression [2].

Bacteria optimize metabolic pathways by adjusting and finetuning their enzyme levels and structural components because of a modulatory effect caused by the sensitivity to nutrient levels of repressor proteins. Thus, organism such as *Escherichia coli*, only produce the proteins they need to survive in specific conditions [1]. Around 50% of bacterial genes are clustered in operons, and each operon encodes enzymes that are involved in a metabolic pathway or interacting proteins that form functional complexes [3].

An operon is composed by multiple individual structural genes, that are all under the control of the same promoter and regulatory sequences such as an operator that controls the transcription of the structural genes which are transcribed into a single mRNA molecule [4].

The lac operon is the most commonly known operon of *E. coli*. It is a DNA fragment that includes a promoter, an operator, and three structural genes lacZ, lacY and lacA, which encode for lactose-metabolizing enzymes. Its promoter is the RNA polymerase biding site,

and its operator, which is located between the promoter and lacZ gene, is the repressor biding site. Located upstream the promoter, the regulatory gene lacI encodes the repressor protein [1]. For expression in a Lac promoter-driven gene, the presence of lactose (inductor) and absence of glucose (inhibitor) is required to have high levels of expression. In this process, two regulatory proteins are involved, Lac repressor (LacI) and catabolite activator protein (CAP). The lac operon is negatively regulated by this repressor protein, but is inducible by the presence of allolactose, that inactivates the repressor by directly biding to it. Lactose is a precursor of allolactose, so it is an inducer molecule that activates the expression of the lac operon [2]. The CAP forms a complex with cyclic AMP (cAMP) that activates transcription through the increasing of the affinity of the RNA polymerase for the lac promoter. CAP and cAMP positively regulate the lac operon [3].

When glucose is present in the media, a second level of gene regulation takes place. Because glucose is preferentially used by bacteria, the metabolism of other sugars is repressed, even in the presence of the inducer lactose. This type of gene downregulation is termed “catabolite repression” [3]. In this situation, cAMP is low and therefore the CAP-cAMP complex does not bind, resulting in a reduced affinity of the RNA polymerase for the lac promoter. With this mechanism, the cell can measure the presence and concentration of glucose, further inhibiting the transcription of the lactose metabolizing enzymes [1-3].

In this work, we aimed to develop a hands-on approach for the study of the regulation of the lac operon in *E. coli*, that can be visually assayed by the expression of a reporter protein. The regulation of the lac operon and catabolite repression can be visually assayed by the expression of a red fluorescent protein, mCherry. The coding sequence of mCherry was inserted in two vector plasmids, the pMCSG53 expression plasmid and the pBluescript II SK plasmid.

Systems that use T7 promoter are extremely popular for recombinant protein expression. Expression plasmid pMCSG53 contains the hybrid T7*lac* promoter [5] which contains a lacO operator downstream of the T7 promoter allowing binding of the lac repressor at this site and so it can also be induced by lactose [6]. Those vectors also carry their own lac repressor gene (lacI) to ensure that enough repressor is made [7]. These characteristics of the system make it ideal for avoiding basal expression, making it a good repressor system [6]. In this system, the gene of interest is cloned downstream a promoter that is recognized by the phage T7 RNA polymerase, which should be provided in another plasmid or placed in the bacterial genome in a prophage (λDE3) that encodes for the T7 RNA polymerase under the transcriptional control of a lacUV5 promoter [6].

A single *E. coli* strain was used in this work, the BL21(DE3) strain. This strain is one of the most used strains for protein expression. Because it is deficient in the Lon protease and is missing a gene for the outer membrane protease OmpT, it does not degrade most of foreign proteins and does not digest the recombinant protein after cell lysis. In expression systems under the control of the promoter T7, it is necessary to provide a T7 RNA polymerase. In this strain, the λDE3 prophage was inserted in the chromosome of BL21 and it contains the T7 RNA polymerase gene under the control of the lacUV5 promoter [6]. This strain is a Biological Safety Level One (BSL-1), which represents a basic level of containment that relies on standard microbiological practices with no special primary or secondary barriers recommended, other than a standard procedures like hand washing and safe disposal. It is non-pathogenic and unlikely to survive in host tissues and cause disease [8]. The bacteria were transformed with two plasmids – pSK-mCherry and LIC-mCherry, both recombinant plasmids that possess the gene for the reporter protein mCherry [9]. The mCherry protein is a red fluorescent protein that was derived from DsRed, which was extracted from disc corals of the genus *Discosoma*. DsRed was engineered in the Tsien lab and after some cycles of mutation, directed modification and evolutionary selection, the mCherry protein was produced [10]. In the recombinant plasmid pSK-mCherry, the red fluorescent protein was cloned in the pBluescript SK II vector, in frame with the β-galactosidase, successfully creating a functional fusion protein under the control of the lac promoter. In the recombinant plasmid LIC-mCherry, the reporter gene is under the control of the hybrid promoter T7/lac operator.

A simplified scheme of the regulation of the reporter gene expression is shown in Figure 1.

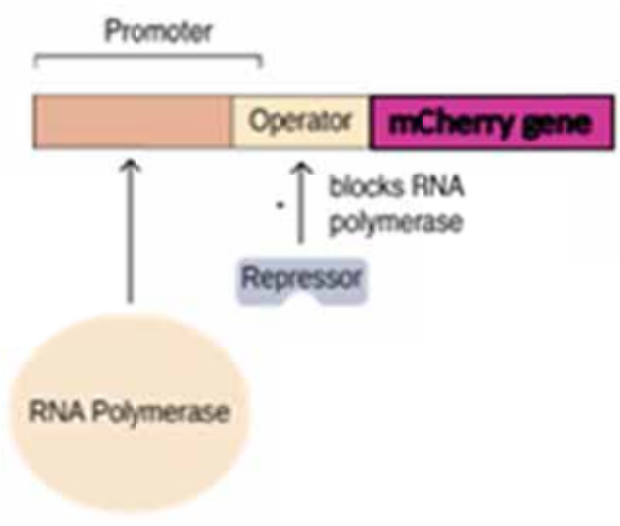


Figure 1. Scheme of the regulation of expression of reporter gene in LIC-mCherry, adapted from [11]

Expression of reporter proteins was assayed in the presence of lactose and glucose. The main objective is to create a laboratory activity evidencing the effects of sugars in the regulation of recombinant protein expression, that can be easily integrated in biology classes to students of various levels, but principally to 12th grade and higher education students, since production of recombinant proteins is a part of its curricula.

2. Materials & Methods

2.1. *E.coli* genetic background – BL21(DE3) strain

For the incorporation and propagation of the recombinant DNA one strain of *E. coli* was used – the BL21(DE3) strain. This strain was selected because it is an expression strain, and one of the mostly used strains for protein expression [6]. BL21 cells are deficient in the Lon protease, that degrades many foreign proteins [12] and are missing the gene that codes for the outer membrane protease OmpT, that degrades extracellular proteins. It also possesses a mutation that disrupts DNA methylation and degradation, which prevents plasmid loss. In this strain, the λDE3 prophage was inserted in the chromosome of BL21 and it contains the T7 RNA Polymerase gene under the lacUV5 promoter [6].

2.2. Vector plasmids

The vector plasmids used in this experiment were pMCSG53 and pBluescript II SK. pMCSG53 is a ligation independent cloning (LIC) plasmid and is an expression vector regulated by the T7 promoter/lac operator, as shown in Figure 2. It was conceived by the Midwest Center of Structural Genomics [13] to have high levels of expression. This plasmid also has a lacI gene, producing more repressor, therefore, an inducer (lactose) is needed to activate the transcription, producing the protein. Both vectors also have a β-lactamase gene that confers ampicillin resistance to the transformed bacteria. pBluescript II SK also possesses a partial lacZ gene, encoding for the α-peptide of the β-galactosidase enzyme, as shown in Figure 3.

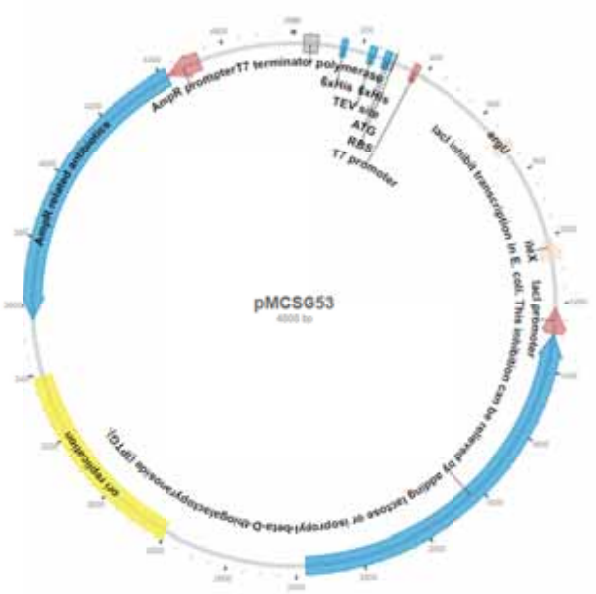


Figure 1. Map of the vector pMCSG53. Retrieved from [14]

mCherry is a red fluorescent monomeric protein which matures tremendously quickly, allowing to a very fast visualization of the protein, after transcription is activated. Another additional advantage is that it does not require the use of an external UV-light source, due to its spectral properties, it holds a pink-reddish hue in the range of the visible spectrum of light [9].

The pSK-mCherry and the LIC-mCherry recombinant plasmids were previously built at our Biology Department. In the first case, by inserting the mCherry gene into the MCS of the

pBluescript II SK plasmid, in fusion with the lacZ α gene and under the control of the lac promoter sequence. And the second, by inserting the mCherry gene into the pMCSG53 plasmid.

Figure 2. Map of the vector pBluescript II SK. Adapted from [15]

2.3. Growth media, competent cell preparation and transformation

To avoid contamination, all the experiments were performed by the flame and media were sterilized with a microwave, which is known to be as efficient as a normal autoclave and more likely to exist in a school lab [16].

To prepare the plates that were used in the experiment, firstly a 50 ml stock of glucose (40% w/v) and a stock of lactose (20% w/v) were prepared. In a flask, 20 g of monohydrated glucose MERCK were diluted in 50 mL of distilled water and, in another flask, 10 g of monohydrated lactose MERCK were also diluted in 50 mL of distilled water. The flasks were then sterilized in the microwave.

To prepare de Luria-Bertani media (LB) DIFCO (25 g/L), 18,75 g of this media were dissolved in 750 ml of distilled water in an Erlenmeyer flask. Then, in three flasks, 3,75 g of Agar (15 g/L) PANREAC were dissolved in 250 ml of LB media on the microwave, sterilizing it. The media was left to cool down and then 250 µL of ampicillin were added to each flask (100 µg/mL). Afterwards, in one of the flasks 6,25 mL of lactose (0,5% w/v) were added and in another one 12,5 ml of glucose (2% w/v) were added, to produce the compositions of media as shown in Table 1. The media was then plated, and the plates were marked.

To make the competent *E. coli* BL21(DE3), a modified method of [17] was followed. For this, 800 µL of a culture of these bacteria was inoculated in 12 mL of LB medium, formerly prepared. The tube was centrifuged for 3 minutes at 4000 rpm. The cells were then resuspended in 6 ml of $MgCl_2$ and centrifuged, again, for 3 minutes at 4000 rpm. Subsequently, the cells were resuspended, in 6 mL of $CaCl_2$ and centrifuged, again, for 3 minutes at 4000 rpm. Finally, the cells were resuspended in 800 µL of $CaCl_2$ with 20% of glycerol. Once the cells are competent, they can be stored at -80 ° C.

Table 1. Composition of the media used in the experiment for both plasmids

	Composition of the media
BL21(DE3) transformed with LIC-mCherry	LB + Ampicilin
	LB + Ampicilin + Lactose
	LB + Ampicilin + Lactose + Glucose
BL21(DE3) transformed with pSK-mCherry	LB + Ampicilin
	LB + Ampicilin + Lactose
	LB + Ampicilin + Lactose + Glucose

To transform *E. coli* BL21(DE3), the tubes must be kept on ice all the time. From the stock of competent bacteria previously made, after thawed on ice, 100 µL of these competent bacteria were added to two pre-cooled tubes. In one of them, 2 µL of LIC-mCherry were added, and in the other one, 2 µL of PSK-mCherry were added. Both tubes were marked and then incubated on ice for 30 minutes. After the incubation, the cells were subjected to a heat shock, for 45 seconds at 42 °C, and then immediately transferred back to ice for 2 minutes. With this transformation process it is expected that some plasmids may have been transferred to the intracellular medium of some bacteria. After this process the cells need to recover, so 900 µL of LB medium were added to each tube and then the cells were incubated for 30 minutes at 37 °C.

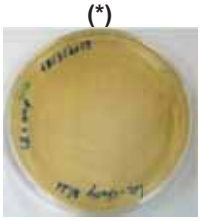
After the incubation, the cells were plated in the previously *prepared plates, as shown in* Table 1, for selection of the transformed cells,

and incubated for one day at 37 °C. After that, they were stored in the refrigerator.

3. Results

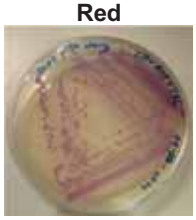
After the experiment, the plates were observed. One night after the plating, the LIC-mCherry recombinant cells in the LB-agar + Ampicillin plates were white, the cells in the LB-agar + Ampicillin + Lactose were red and the ones in the LB-agar + Ampicillin + Lactose + Glucose were white, as shown in Table 2. After a week, the same plates had some differences. In the plate with LB-agar + Ampicillin the recombinant cells were mostly white but some of the isolated colonies turned pink, the ones in the LB-agar + Ampicillin + Lactose plates had a more reddish colour and the cells in the LB-agar + Ampicillin + Lactose + Glucose plates, like the ones in the LB-agar + Ampicillin plates, were mostly white but contained some isolated pink colonies, as shown in Table 2.

Table 2. Observed results from *E. coli* BL21 cells transformed with the LIC-mCherry plasmid and plated on the media: LB-Agar + Ampicillin; LB-Agar + Ampicillin + lactose; and LB-Agar + Ampicillin + Lactose + Glucose
(*) Mostly white and some of the most isolated colonies are pink

Media	*E. coli* BL21 with the LIC-mCherry plasmid	
	After one night at 37ºC	After one week
LB-Agar + Ampicillin	**White** 	**(*)** 
LB-Agar + Ampicillin + Lactose	**Red** 	**Intense Red** 
LB-Agar + Ampicillin + Lactose + Glucose	**White** 	**(*)** 

In the pSK-mCherry recombinant cell plates, a night after the plating, in the LB-agar + Ampicillin, the recombinant cells were white, in the LB-agar + Ampicillin + Lactose, the cells were pink and, in the LB-agar + Ampicillin + Lactose + Glucose the cells were white. A week after the experiment, like in the LIC-mCherry colonies, some differences appeared. In the LB-agar + Ampicillin, the recombinant cells turned pink, in the LB-agar + Ampicillin + Lactose, the cells started to look a bit more reddish and, in the LB-agar + Ampicillin + Lactose + Glucose, the cells turned pink, as shown in Table 3.

Table 3. Observed results from competent *E. coli* BL21 cells transformed with the pSK-mCherry plasmid and plated on the media: LB-Agar + Ampicillin; LB-Agar + Ampicillin + lactose; and LB-Agar + Ampicillin + Lactose + Glucose

Media	*E. coli* BL21 with the pSK-mCherry plasmid	
	After one night at 37ºC	After one week
LB-Agar + Ampicillin	**White**	**Pink** 
LB-Agar + Ampicillin + Lactose	**Red**	**Red** 
LB-Agar + Ampicillin + Lactose + Glucose	**White**	**Pink** 

4. Discussion

In this work, the conditions of incubation media and times were established to obtain relevant results in didactic terms. The results obtained were as expected.

For expression in a Lac promoter-driven gene, it is required to have the presence of lactose (inductor) and absence of glucose

(inhibitor), to have high levels of expression. In this process, there are two regulatory proteins involved, catabolite activator protein (CAP) and Lac repressor (LacI). So, when lactose is present in the bacteria environment, allolactose is produced, binding to the LacI repressor and, therefore, inhibiting its association with the promoter region. This releases physical space for RNA polymerase to bind and transcribe the Lac operon. But, when both lactose and glucose are present in the environment surrounding the bacteria, a second type of control mechanism, catabolite repression, acts to prevent lactose metabolism. The CAP forms a complex with cyclic AMP (cAMP) that activates transcription through the increasing of the affinity of the RNA polymerase for the lac promoter. CAP and cAMP positively regulate the lac operon. When glucose is absent, cAMP concentration is high, so the CAP-cAMP complex binds to DNA and increases the affinity of the RNA polymerase for the lac promoter, significantly activating transcription. Because glucose is a preferable energy source, when it is present in the media, cAMP is low and thus the CAP-cAMP complex does not bind, resulting in a reduced affinity of the RNA polymerase for the lac promoter. With this mechanism, the cell can measure the presence and concentration of glucose, further inhibiting the transcription of the lactose metabolizing enzymes [1-3].

Despite being an inducer molecule for the lac operon and a synthetic analog of lactose, commonly used in laboratories worldwide, Isopropyl β-D-1-thiogalactopyranoside (IPTG), was not used in this work because many students might find difficult to associate its function with that of the inducer molecule, besides IPTG is an expensive and toxic substance. Thus, lactose was chosen to be the inducer in this work, as it happens in the natural system.

It is important for students to discuss the composition of the media, to understand the mechanism of induction and repression in regulating the expression of a recombinant protein, and predict the outcome. It is also important to note that with longer time, even without the inducer, the recombinant cells start to produce the protein, changing the expected results. In the LIC-mCherry LB-agar + ampicillin + lactose + glucose plate, after the metabolization of glucose, the metabolism of lactose starts, inducing gene expression and, therefore, there are some pink isolated colonies in the plate after a week. With the same media, the pSK-mCherry colonies were all pink, because in this system not enough repressor is made leading to basal expression. In the LIC-mCherry LB-agar + ampicillin plate, after a week, most colonies were white, while the pSK-mCherry colonies, in the same media, were all pink, because, as mentioned before, this system does not have a good repression system. Even with LIC-mCherry, which has a good repression system, after a week, without inducer, some isolated colonies turned pink, because of basal expression [6].

As expected, with expression vector LIC-mCherry higher levels of expression was achieved with very intense red colonies. Also basal expression is efficiently reduced until lactose induction. For this reason and for the intended objectives, the LIC-mCherry is a better vector to use in didactic terms rather than pSK-mCherry. Using the pBluescript-Cherry system the expression of reporter protein is directed by a lac promoter in the common cloning vector pBluescript II SK. This is a simpler system but expression can eventually be observed in the absence of inducer ("leakiness") due to low levels of the lac promoter repressor protein LacI [6].

With the LIC-mCherry system, T7 RNA polymerase must be provided by expression hosts (λDE3 lysogens) such as bacterial strains BL21 (DE3). Besides, even in systems based in common cloning vector pBluescript II SK, the BL21 strain was chosen because, unlike other strains that are widely used in the laboratory, such as DH5α, it has the Lac operon and the ability to transport and metabolize lactose.

5. Conclusion

In this work we were able to produce a simple and reproducible experimental setting for the genetic transformation of *E. coli* with a recombinant vector, containing a mCherry marker.

With the different media compositions, it was possible to macroscopically observe several biological phenomena such as Lac promoter activation and catabolite repression.

With these results, we are confident that this activity is a simple, practical and reproducible tool for the teaching of biology and adaptable to students of various levels, but particularly at a high-school to University setting. Furthermore, this experience can be explored in an educational context, on the subject of biotechnological production of recombinant proteins in bacteria.

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STEM Techniques in History Lessons

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Abstract. The article analyses STEM-methods, shows tips and tricks that could be useful in history lessons, especially when we are talking about “History of science” or “History of technology”. Based on the own experience article proposed methods which could make lessons more interesting, give them more freshness and fun. We special chose the examples, which could be easily repeated in every class. Most of them needn’t special materials or equipment. It also helps to deepening of knowledge and systematization of skills, forms interdisciplinary connections. But the main point of shown methods – that them could deal with the problem of small rating of natural sciences in youth and could change its dramatical reduction.

Keywords. IBSE, NTU "KhPI", STEM Education, Natural Science, Technical Science, History of Science, History of Technology.

1. Introduction

History repeats itself. Nowadays in Ukraine technical specialties every year become less and less popular among applicants who are going to Universities. A lot of school leavers who is going to study at technical (for instance mechanical or electrical engineering) demonstrated one of the least levels of knowledge in the main subject field (in average amount of universities it was mathematics). That is, we personally witness a dilemma when students with low balls enter complicated and important for innovative development of the country's specialties [1]. First of all, that demonstrates the rapid decline in the rating of natural and technical sciences among young people. And this situation is quite usual not only in Ukraine, but also in the global context.

As said David Goodstein in the American Association of Physics Teachers: “The simple fact is, we are failing. If teaching physics were a business, we would be filing for bankruptcy” [2]. Americans among the first began to alarm and reorganize the education system to address this problem. In the mid-1990s, one of the responses to the dangerous challenge, taking into account the features of the new generation of students, was the inclusion in the US National Education Standard so called Inquiry Based Science Education (IBSE). The new approach included holding regular extracurricular creative activities of educational character, holding summer academic camps and national competitions on a wide range of topics. The main slogan of that time was: explore everything! Nevertheless, IBSE was not able to provide a genuine technological breakthrough. Instead, he allowed the accumulation of a substantial base of valuable methodological material from the natural sciences, which is now worthy of use in native education.

At the turn of the millennia, a new approach to education which was named STEM appeared. The STEM abbreviation stands for "Science, Technology, Engineering and Mathematics" – fields that underlie in this educational methodology. At the same time, all courses are studied as a united complex of disciplines. At the same time, the practical application of the acquired skills plays an important role. Children not only acquire new knowledge, but also learn to apply them in practice. Thus, the main difference of the new method that focuses on interdisciplinary and pragmatism.

2. History of science and science of history

The course "History of science and technology" is taught at the majority of faculties of NTU "KhPI". This is a rather unusual subject for higher education, the main purpose of which is the formation of a holistic scientific outlook of a young generation of specialists. At the same time, unlike the usual course of history, which has an economic and political character, the history of science and technology has a scholarly and ideological orientation and aims at forming an understanding of the role of personality in science, as well as the social function of science in general in the advancement of human civilization. At the same time, the course in science and technology covers all the key stages that humanity has undergone: from the ancient

world and completing the scientific and technological revolution and discoveries of the XXI century. That is, we are exploring history from the onset of the initial knowledge of the environment and man in the ancient world. We are gradually moving towards the philosophy of antiquity, the development of scientific knowledge and techniques of the Middle Ages, the Renaissance and the Scientific revolution in the natural sciences of the XVII century, the industrial revolution of the XVIII-XIX centuries and the gradual systematic transition of industry from the manufactory to the major machine industry, the newest scientific revolution in the XIX century and the scientific and technological revolution of XX century.

And if you carefully look at the sequence of events mentioned above, one can easily see that they played a key role in the development of mankind and are "milestone" for each country, which indicates the decisive role of science and technology in human life and the development of civilization in general. Thus, these techniques can be applied at any lesson in history. In addition, the emphasis on the place of science and technology, will allow demonstrating the organic relationship of natural, technical and socio-humanities, without which humanity's progress would be impossible. And so science will be seen as something integral, inseparable, integrated, and fully consistent with the method of STEM.

3. History, STEM and Rock-n-roll

The idea of experimentation during the lesson is not new. But conducting several experiments can become an entirely new, fresh breath for history lessons. Of course, it's difficult to provide recommendations on experiments that will be relevant to any lesson in any school class or university course. At the same time, the accumulated decades of experience of science-promoters can allow everyone to pick up an experimental base that will fit the epoch referred to in the lesson and give the spirit of experimentation.

During the study of the history of antiquity, such an experiment may be a demonstration of the world's first steam engine – Aeolipile (Heron engine, Figure 1), which was built in the 1st century by Heron of Alexandria - a mathematician and engineer who was active in his native city of Alexandria, Roman Egypt. The "engine" cylinder for this experiment can be entirely made at home, for example, from oil cans, bolts, nuts and tubes and a soldering iron.

During lessons when you will talk about the invention of the printing industry and the first print publications, it would be a good idea to experiment with boiling water in a one-time paper cup for coffee. To do this, it is enough to make two holes in the glass and hang it at a small distance above the candle, pre-drawing a little water. After a certain period of time water will begin to boil. And the glass will not burn, although it is made of paper and under normal conditions immediately burns. All this is due to the large difference in the temperature of the burning paper (230°C) and boiling water (100°C). So the water will not let the paper heat up to the combustion temperature.

Figure 1. Aeolipile

The first scientific revolution has become an important stage in the development of mankind. Its beginning was the transition from the idea of geocentric structure of the universe to heliocentric. During the school lessons, a detailed study of the difference between these two worldviews may be quite appropriate, and

the values played by Copernicus, Kepler, and Galileo. To do this, you can divide the children into groups and assign the task of positioning the planet in the correct sequence from the sun for one concept or another (Figure 2). An actual production of a self-made telescope with an enlarged and diminished lens and two paper tubes will become relevant. In this case, as a tube can be used, for example, a hub from paper towels or just makes it from cardboard.

Figure 2. Lesson about Geocentric and Heliocentric conceptions

4. Conclusions

In fact, the field for experimentation during the history lessons is extremely wide. The development of the Internet allows everyone to join this movement. Even in the absence of your own ideas, you can find materials that suit you on various YouTube channels and so on. In the end the main significance of science is that we do not invent a wheel every time, but move further, using the workings of our predecessors. It's hard to come up with something new, but knowing the experience of others will help us to do a little more. It could be easy to make your product a little better than it used to be. This is relevant for anything. And first of all, for the lesson. Indeed, the inspiration for experimentation during schooling will contribute to the fact that more and more children will continue to choose engineering and technical professions. And as history shows, it was the engineers and scientists who moved this world forward.

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The Experience of Using the Moodle LMS Scheduler Plugin to Control the Appointment Management

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Abstract. The use of open-source software applications has become an important tool to support modern approaches in medical education. The experience gained during the implementation of the Moodle, an open-source Learning Management System, at Horbachevsky State Medical University in Ternopil (TSMU) is presented regarding some aspects of a teaching process in medical education. A Moodle-based system enabling students' self-appointment to complete missed classes is proposed. This system is implemented through integrating the Scheduler plugin. The experience of developing, using and supporting this system at the TSMU is described. Also an example of how the version control system was applied to manage the processes of open-source software adaptation and support is shown.

Keywords. Distance Education System, Learning Management System, LMS Moodle, Medical Education, Open-Source Software, Scheduler Plugin, Software Development, Version Control System.

1. Introduction

There is a great importance of application of information technology in the healthcare system and medical education now. The field of medical education should provide training for specialists who can effectively use the capabilities of modern medical information systems. To achieve this goal, modern learning tools and technologies must be used in higher medical education. [1]. Conceptual approaches to introduce modern information technologies in medical education have included application of Learning Management information Systems (LMS) which also often provide services of distance education too - as well as learning material management systems (LMMS or LCMS - learning content management systems).

2. The use of LMS Moodle in the educational process at Ternopil State Medical University

The leading position among free and open source LMS/LMMS/LCMS software for years has been taken by open source LMS Moodle (https://moodle.org/). TSMU has been using this LMS in the educational process since 2006. At the beginning, LMS Moodle was used only to implement test assessment of students' self-training results before classes in the teaching process at TSMU. It was a small part of integrating the credit-module system into the academic process at TSMU.

The methods and approaches of the LMS Moodle application within the TSMU academic process has improved significantly until today [2-4]. Educational capabilities of the LMS Moodle-based system at TSMU were significantly extended during recent years to meet specific needs of the academic process in medical education. It was achieved by introducing a few additional Moodle's third-party modules (plugins). Some of them may include a source code customization feature [5-6].

An online repository of versions of LMS Moodle programming code has been created by Andrii Semenets to support and track the changes in custom codes. It is published as the branch (fork) of the main LMS Moodle's project on the GitHub server [7]. The repository is updated on a regular basis using the version control system (VCS) git, in according to LMS Moodle stable releases has been published.

Continuously increasing level of automation of the educational process sets new requirements to LMS/LMMS/LCMS software. In particular, in 2013 it has become necessary to implement a system enabling students' self-appointment to complete missed classes according to the class schedule at the TDMU.

The aim of paper is to present author's experience regarding the implementation of the

system for students' self-appointment to complete missed classes using LMS Moodle capabilities and further support of this system as well.

3. Advantages of implementing the system for students' self-appointment to complete missed classes

At the beginning of developing the system authors decided to implement it as a component of LMS Moodle which was already exist in TSMU by the time. Such decision has been made to ensure the maximum level of integration (both users' data and system features) and unification of programming approaches as well. The basis of the system is the module activity Scheduler [8] which allows to implement the scheduling feature to make appointments and determine meeting time. The specified "activity" module allows teachers to create and edit schedules of appointment time for individual meetings with students, as well as to keep attendance and score records. Simultaneously, students are given the opportunity to register for a particular hour of a visit and review their grades.

Numerous changes were introduced into initial programming code of the module in order to meet the requirements of higher medical education process and take into consideration some specific features of the TSMU academic process as well. Among them are:

1. Teachers were given the opportunity to create a list of multiple dates when missed classes may be re-scheduled by selecting those dates interactively using the Calendar tool.
2. Ability to create several schedules within different courses for the same teacher, with timeslots being overlapped.
3. Automatic limitation of the total number of students when they try to make appointments with the same teacher within overlapping timeslots.
4. The custom configuration setting option which allows a teacher to ask a student why he/she wants to make an appointment.
5. The TSMU-specific optimum configuration pre-sets.
6. Minor user interface upgrades and some bug fixes of the code.
7. Localization for Ukrainian and Russian languages.

The Scheduler plugin programming code for the version adopted at the TSMU has been developed by Andrii Semenets and published as the branch (fork) of the plugin major developer repository [9] on the GitHub server.

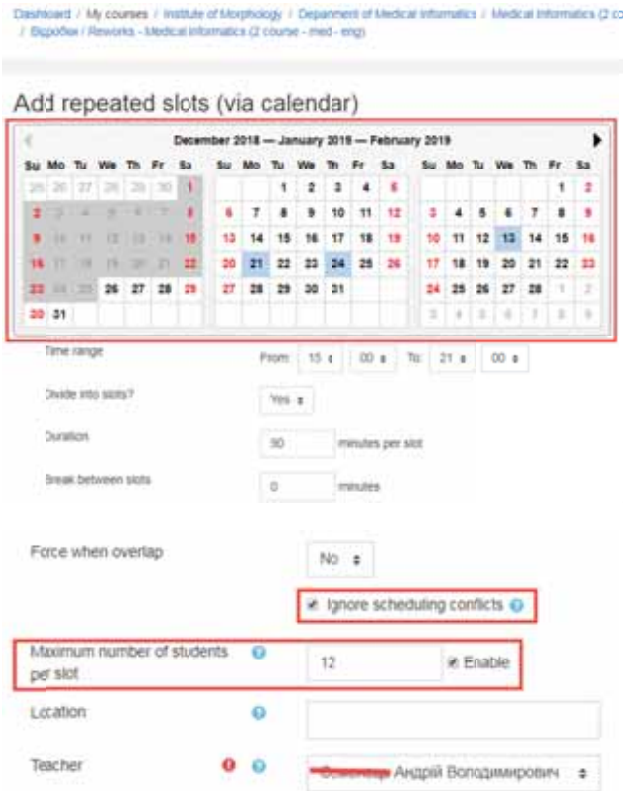

Figure 1. A dialog to create a list of dates for instant scheduling of numerous appointment timeslots

Some new features of the customized LMS Moodle module are presented below with more details. A dialog to create a list of dates for simultaneous scheduling of multiple appointment timeslots on available dates is shown in Figure 1. It is based on the YUI Calendar control, which allows users to select (mark) as many dates as needed. A set of timeslots (hours for completing missed classes) will be created within a given time range for all selected dates. Most of the configuration parameters have already been assigned default values which are recommended to be used at the TSMU.

The process of choosing timeslots (to make an appointment to complete missed class) by student is shown in Figure 2. A list of available timeslots is displayed along with the names of

corresponding teachers, a number of students who have already got appointments and a modal window to enter reasons to complete a missed class within a timeslot being currently selected.

Figure 2. The process of students' self-appointing to complete a missed class

The view of the teacher's panel in the modified self-appointment module is shown in Figure 3. It contains a list of all timeslots with names of students, who have already chosen certain timeslots for an appointment with a teacher. The following controls are available for a teacher to manage students' appointments:

1. A complete list of timeslots available for choosing by students with names of those students, who already have chosen a particular timeslot.
2. Checkmarks, which indicate that a particular student attended the appointment made.
3. Surnames of students who already have chosen particular timeslots as well as names of teachers who repeatedly conducted missed class.
4. Action buttons: the main (a gear icon) - to access a dialog to configure each timeslot and the "quick link" - to delete a timeslot or switch it between "individual" and "group" appointment modes – postponed by a number of still allowed choices (in the red square) in case of the "group" appointment mode (default at TSMU).
5. Student's grades (if the assessment mode is enabled for this Moodle "activity").
6. Action buttons to delete a current timeslot or cancel all choices made for it.

Many improvements and changes were made by authors in the module code during 2014-2018:

1. To provide the compatibility with new releases of LMS Moodle.
2. To integrate changes that were made by the major developer of this module - Dr. PhD Henning Bostelmann [10].

Over updating and refactoring of the module programming code the following main changes were made:

1. A JavaScript-library of the Calendar interactive tool was replaced. The programming code of booking event handler was adjusted according to LMS Moodle guidelines for developers (Figure 1).
2. A part of the custom code which provided the feature to force students to enter messages explaining the reasons why an appointment is made was removed - because the idea of this feature was adopted by the major developer and implemented within the core plugin code.

The latest version of the modified self-appointment Scheduler plugin with all code upgrades is available at a special branch of the Github repository mentioned above [11].

Figure 3. The user interface of the teacher control panel in the Scheduler modified module

4. Conclusions

The wide-scale application of free- and open-source software is essential to modern trends in developing an adequate learning environment at institutions of higher medical education.

The author's experience of implementing the open-source Learning Management System Moodle focused on some specific aspects of medical education at Horbachevsky State Medical University in Ternopil is reported. A Moodle-based system for student's self-appointment to complete missed classes was

developed. This system was implementing through introducing the Scheduler plugin was. The experience gained in the course of the development, use and support of this system at the TSMU is described. Additionally, an example of how the version control system can be applied to the processes of open-source software adaptation and support is given.

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Basic in Electricity Kit. Made with Waste Materials

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Abstract. From a very young age, children are fascinated by how their toys can be moved at the touch of a button, or by turning on a television or talking to their parents through a mobile phone. And everything is thanks to electricity. This kit designed for a first contact of primary school children with the subject, allows them, in addition to taking the first steps in the learning of electricity to become aware of the care of the environment, since the kit is made of waste materials that could contaminate it.

Keywords. Electrons, Electricity, Battery, Circuits, LED.

1. Introduction

The Kit aims at facilitating children to perform various experiments in basic electricity [1-4] and allows recycling materials that could contaminate the environment (Figure 1). The novelty of the project is that the children themselves build the kit with the waste materials found.

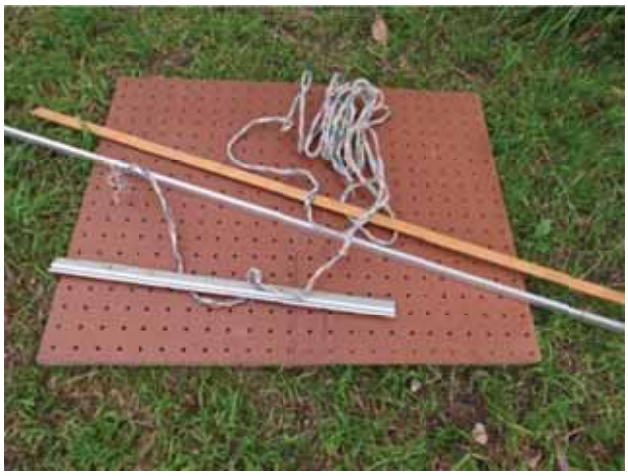

Figure 1

The basis of enormous interesting developments in electricity is a tiny particle knows as electron. We know that atoms of all substances contain electrons that revolve in definite orbits around the nucleus. No one has ever seen an electron; yet everyone knows that these particles are extraordinarily mobile.

Under the action of external force, electrons gain their freedom and direction. If the electrons are easily accessible to the external force (like external voltage), then they form a conductor. On the other hand if this access is not easy, such material forms insulators.

It required hundreds of brilliant guesses and many thousands of experiments conducted by scientists throughout the world over countries to obtain a clear picture of this unseen; imaginary particle “electron”. Now for us it is just enough to connect a metal plate or metal wire to the two poles of a voltage source (a battery) and the electrons inside the metal immediately acquire their aim. They start flowing in one direction causing “current”. Voltage (v) is named after the scientist Volta and the unit of voltage is “volts”. Current (I) is measured in “amperes” and it is named after the scientist Ampere. The electric charge (q) is measured in the units of Coulomb; again named after the scientist Coulomb. Faraday was another genius to state about “electric fields”, based on the fact that all electric changes are surrounded by their own small fields.

Ohm succeeded in connecting the facts together with his famous Ohm`s law I = V/R. And the unit of resistance (R) is given a name “ohm”. This is how electricity progressed in past it progressed so fast that our entire life now depends upon it.

2. The experiments

All experiments are planned using ordinary batteries. Thus, there is no risk or hazard for children. They will never have to connect wires to mains AC supply.

2.1. Experiment 1: Inside Battery

The battery cell is made up to outer covering of Zinc can, central Carbon rod and powered Manganese di-oxide, soaked in Sal Ammoniac solution (Electrolyte). Take a used battery, with a saw, cut the cell in half and observe its structure. Carbon rod is placed in a centre and acts as a positive pole of the battery. The outer Zinc casing or Zinc can is the negative pole of the battery. In between positive and negative poles, there is an electrolyte. Electrolyte is a chemical, which acts on the plates of the cell. Notice how the Zinc has been eaten away by the chemical. Observe that the chemical

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materials were sealed into the Zinc can with hot pinch. The battery cell usually gives 1,5 V. Flash pocket battery output 9 V. The dry cell or batteries last only for a certain time. When run down, they are usually thrown away. The Zinc can then suffers corrosion and the salt ammoniac solution gets dried up. The Carbon rod and powered manganese di-oxide however remain perfectly all right.

Figure 2

2.2. Experiment 2: Simple Electric Circuit

Do you know what LED stands for? Light Emitting Diode. LED, unlike filament lamps, allows the passage of electricity in only one direction. Connect the wires as shown in the picture. The LED has a short terminal and a longer one. Connects each terminal of the LED in the connectors and introduces the cables of the poles of the battery. Check in what direction the electric current should circulate so that the LED lights up (Figure 3).

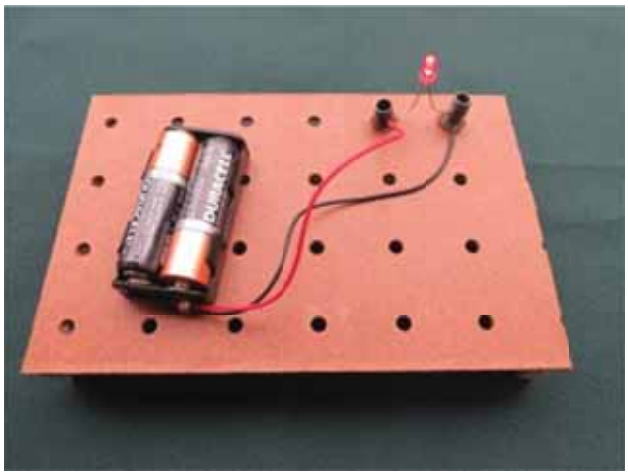

Figure 3

2.3. Experiment 3: Insulator or Conductor

The conductivity testing can be done by building a "conductivity test unit". Keep the object (Table 1) to be tested on this unit so as to touch both metal bracket plates, and close the electric circuit. The LED will light up if the object is a conductor. In the other cases it will not: these are insulators (Figure 4).

Table 1

MATERIAL	GOOD	BAD
Euro coin		
Pencil		
Copper strip		
Rubber		
Plastic bottle		
Wood		
…		

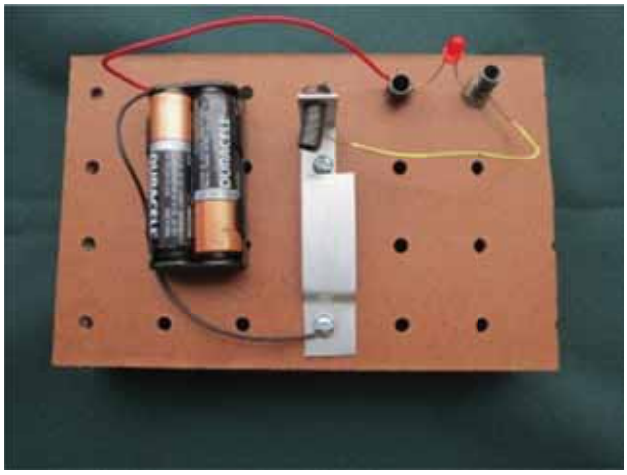

Figure 4

2.4. Experiment 4: Switch "on" the light

The picture shows an electric button or switch and its connection to the battery an LED. By connecting the button, you close the circuit. The LED will light as long as the switch plate is in contact with the metal bracket. This arrangement can be applied to regular domestic switches (Figure 5).

2.5. Experiment 5: Two switches for 1 LED

What type of installation is required if a LED is in the middle of the staircase, and we wish to switch it on and off, both on the ground floor as well as on the first floor. For this purpose two switches, a LED, a source of power (battery) and corresponding connecting wire are necessary. The picture shows the details of this construction. Two metal strips make two switches which can be turned on and off. They are connected to the LED. The switches are

also interconnected. Each switch can be applied for both switching on and off. Besides, the LED can be switched on by one switch and then switched off by the other (Figure 6). Remember that two metal “L” brackets on both sides of switch plates serve as “on” and “off” positions for each switch. The switch plate must rest on either of these brackets.

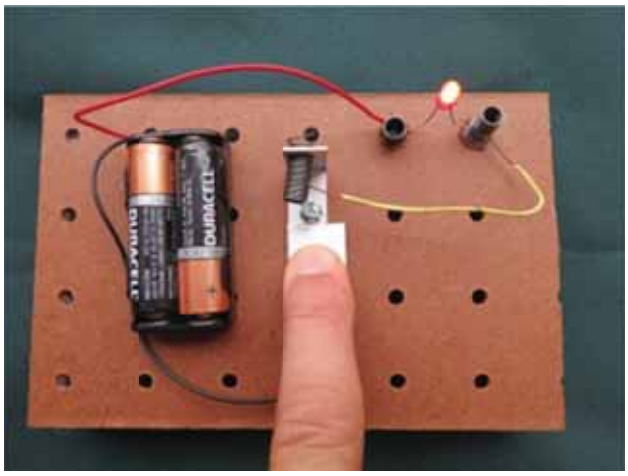

Figure 5

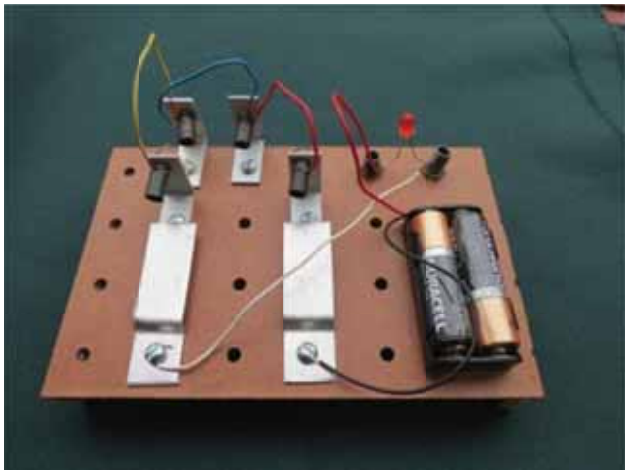

Figure 6

3. Conclusions

The project is aimed at primary school children who have their first contact with the subject of electricity current in their course of Natural Science. The project contributes to recycling materials that could otherwise cause environmental pollution in the school area. The Kit is built by the students themselves, which in addition to promoting the craftsmanship allows them to know the characteristics and physical properties of the materials used for their construction. The IBSE method applied to the project allows creating the knowledge base on the subject of electric current to elaborate another kit of greater complexity in the future.

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Teaching Object Oriented Programming in Primary Education

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Abstract. Object Oriented Programming (OOP) is considered as an advanced subject and it is usually taught late at the curriculum [1]. Current paper is about a research that was implemented at Ralleia Experimental Primary Schools in Piraeus, Greece, for three years during the animation after class club. Primary school pupils from 10 to 12 years old were introduced to the basic Object Oriented Programming concepts through real life examples. Subsequently, visual OOP software was used by pupils in order to create simple animation projects using the acquired knowledge. As a final step of the current research pupils were taught a more difficult OO programming environment, based on C++, to use to their animation projects.

The findings of the specific research were several: At the beginning, pupils were able to understand the basic OOP concepts like objects and distinguish the difference between object properties and object methods. They could also understand the concept of a class using examples derived from real life. Inheritance was also an easily understood for pupils concept. On the other hand, the concepts of polymorphism and information hiding were more difficult for them but in this case real life examples were also helpful for them to acquire the appropriate knowledge.

Software like Scratch, Alice, Web Cartoon Maker etc. were used to help pupils understand how they can create objects and implement their knowledge of OOP. With the appropriate worksheets pupils were able to change the properties of an object, create the behaviour of each object using the appropriate commands, understand the class concept, and finally at the end of the research, students from primary school, using the appropriate manual given by the teacher, were able to write C++ code to identify the behaviour of their objects.

This approach requires from the teacher a set of simple worksheets and manuals to guide the pupils gradually deeper to OOP during the lessons. The more important finding was that the pupils could easily correlate the specific concepts to real life issues. This fact helped the teacher give more knowledge compared to the initially teaching plan.

Keywords. Object Oriented Programming, Primary Education, Scratch, Alice, Web Cartoon Maker.

1. Introduction

In Greek schools, pupils are taught computer science from the primary school for one hour per week. In the first grades, pupils learn what a computer is and how they can use it, acquire basic skills in the use of specific software (painting, word processor, etc.), use information technology as a tool for creating conceptual maps, etc. In higher classes, primary school pupils learn programming and implement the appropriate activities to expand and enhance their programming skills. Scratch programming environment is widely used in these classes.

Current paper concerns the research implemented at Ralleia Experimental Primary schools for three years, 2016- 2019. In the specific school, as an experimental one, after the relevant proposal from the school and the corresponding approval of the Ministry of Education, ICT course was taught two hours per week the last three years. At the same period, in the school, after class clubs were set up to help students acquire further knowledge in specific cognitive domains, such as the animation after class group. Within this group, apart from others, students were taught the basic concepts of object-oriented programming and implemented their knowledge using the appropriate software in order to create animation projects. This paper briefly presents the steps followed and the findings of the specific attempt.

2. Teaching basic OOP concepts

Object is one of the basic concepts of Object Oriented Programming. An effective way to teach objects is to consider our OO programs as "parts" of the real world. Real world consists of different kinds of objects. We can think our programs as models of a real-world microcosm

and consider the virtual world as a program consisting of objects. In OOP objects can be people, vehicles, animals etc. Objects have properties - characteristics that differentiate one object instance from another and methods which specify their behavior. For example, a man has the color-eyes, age, height, etc., the airplanes have a flight number and a destination, etc. The properties are essentially: weight, height, color, destination, etc. If the two objects have the same properties then they look the same, just like two twins. They can behave in the same way, but they are two different objects. For a virtual world, these values for objects' properties must be stored to the appropriate variables.

In addition to the properties, objects have also a specific behavior, that is, methods which can be performed by them. Each object has its own behavior that is described with verbs and defines what each object does. The objects' behavior is implemented with methods. Primary school children with the appropriate worksheets can easily describe the different objects of a specific microcosm (like the class, the zoo etc), their properties (height, weight, color etc) and methods (speak, walk, bark etc). Subsequently, they can also create their simple virtual microcosm using a programming environment like Scratch and make their objects interact.

Other OOP concepts like classes and inheritance can be also taught using real world examples. In real world we can group together the objects that look like the same: quadrupeds, birds, humans, vehicles etc. Alice programming environment has several classes which contain groups of objects. Pupils can easily choose the desired object from each class in Alice and identify the appropriate properties and behavior. Pupils are also familiar with the concept of inheritance from their real life experience. Most of the pupils can talk about characteristics (properties in virtual world) which have been inherited from their parents or siblings. Information hiding and polymorphism are more difficult concepts for the pupils because it is more difficult for them to use abstraction. Examples from real life can also be used from teacher to explain these concepts.

Programming environments like Scratch and Alice can be used to help students create new instances of their objects. Web Cartoon Maker can also be used only for pupils who like writing code but it requires step by step worksheets by the teacher to help these pupils create their objects and give them the appropriate behavior.

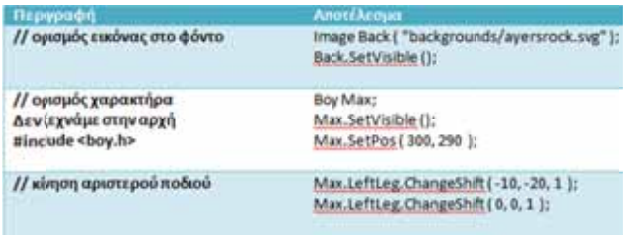
3. OOP software used for primary schools pupils

There are several programming environments which can be used to teach OOP. For current research Scratch, Alice and Web Cartoon Maker were used.

Scratch [5] is widely used in primary education to teach programming. It was developed by the MIT Media Lab and has been translated into 70+ languages. Alice [6] is an innovative programming environment that makes it easy to create animations and other projects like interactive narratives and games which motivates learning through creative exploration. It is an attractive for primary school pupils environment and they can create simple projects from the first lessons. More complicated applications in Alice require more effort and involvement from students.

4. Results and discussion

Figure 1. Snapshot from an Alice project created by primary school student



Περιγραφή	Αποτέλεσμα
// ορισμός εικόνας στο φόντο	Image Back ("backgrounds/ayersrock.svg"); Back.SetVisible ();
// ορισμός χαρακτήρα Δεν ξεχνάμε στην αρχή #incude <boy.h>	Boy Max; Max.SetVisible (); Max.SetPos (300, 290);
// κίνηση αριστερού ποδιού	Max.LeftLeg.ChangeShift (-10, -20, 1); Max.LeftLeg.ChangeShift (0, 0, 1);

Figure 2. A part of the manual given to pupils

Web Cartoon Maker is a standalone desktop application for making animations using C++. This environment was used at the final step of the specific research. A compete program and a short manual were given to primary schools pupils to begin. With these tools pupils were able to create their own projects by replacing

the existing objects with new ones and adding behavior (talking, walking, barking etc) to them.

```
4   #include <santa.h>
5   #include <deprechaun.h>
6   #include <cat.h>  // sweden
7   #include <dog.h>  //portugal
8   #include <kolobok.h>  // poland
9   #include <wolf.h>     // spain
10  #include <bear.h>  // german
11  #include <alien.h> // greece
12   // play music
13
14   SetTime ( 0 );
15   void Scene1 ()
16 - {
17      Image Back0 ( "backgrounds/stars.svg" );
18      Back0.SetPos ( 0, 0 );
19      Back0.SetVisible ();
20      Text Intro ( "Ralleia Experimental Primary Schools" );
21      Intro.SetFont ( "Calibri" );
22      Intro.SetColor ( "FFCC00" );
23      Intro.SetStyle ( "B" );
24      Intro.SetSize ( 20 );
25      Intro.SetVisible ();
26
27      // make it to appear
28         Intro.SetScale ( 0 );
29      THIS_TIME Intro.ChangeAngle ( -360, 1 );
30      SAME_TIME Intro.ChangeScale ( 2.5, 1 );
31      Sleep ( 1 );
32      Intro.SetVisible (false);
```

Figure 3. Snapshot of a program created by primary school pupil in Web Cartoon Maker

5. Conclusions

Object Oriented Programming (OOP) is considered as an advanced subject and it is usually taught late at the curriculum. Current paper briefly presents an approach of teaching OOP at primary school. During the period of the last three years involved pupils were introduced to OOP basic concepts and created their own projects using the above programming environments. Using examples derived from real life pupils were able to understand the OOP concepts. They also used software which has been developed for older students. Most of the pupils could also use the Web Cartoon Maker programming environment and write their own simple C++ programs. As a conclusion, current paper suggests teaching of OOP in primary school.

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Development and Implimentation of STEM Education Via Preuniversity "#STEMCamp School"

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Abstract. The article describes the implementation in Ukraine of a pre-university STEM- and CDIO-based educational project "STEMCamp School", that was realised in a format of summer camp. The paper presents the main tasks and challenges of the STEM (Science, Technology, Engineering and Mathematics) and CDIO (Conceive Design Implement Operate) education in a secondary school and the possibility of its implementation within an active technical university integration into the process. A positive experience of the project is presented as well as the main results of using STEM technologies and project-oriented methodology for out-of-school education of young people.

Keywords. Out-of-School Education, STEM, CDIO, Pre-university Education, Inquiry-Based Science Education.

Dedication

A group of authors, together with young scientists of NTU "KhPI", who were the organizers and participants of the #STEMCamp School project, endure immense gratitude and appreciation to the wonderful Kharkiv enthusiast of STEM education and popularizer of natural sciences, our good friend and mentor of young scientists Alex Kazachkov. Thanks to Alex's valuable recommendations and practical advice, this and other educational projects for children, schoolchildren and young people of Ukraine have appeared and were implemented. To our deep regret, Alex Kazachkov could not see the final implementation of these projects, but his contribution to the development of the popularization of technical education in the Kharkiv region cannot be overestimated. He was the leader of the students' scientific associations, international coordinator of the university projects, conducted training for teachers of schools of Kharkiv and did not spare the time to popularize the natural sciences among the young people. Alex could always surprise and inspire to create something new and exciting from improvised means.

He taught us to see science everywhere around us. His enthusiasm and faith in us gave confidence and strength to hold the HSci conference precisely in Kharkiv.

1. Introduction

A modern world requires two contrary necessities for a new generation that helps them do not lost in the actively developed complicated technologies and abstract informational/communicational spaces.

The first is the more fundamental education and in the field of natural science that can help to understand modern technologies, helps to use them effectively and in a proper way.

The second one is the strong need in a good level of soft skills, i.e. the ability for free communication with colleagues and people with different tempers, requirements and cultures; to work in the team, to present their ideas and concepts and etc.

The modern youth has a myth that a world digitalisation and does not require them to know the natural sciences because of ICT tools and accessibility of complicated technologies in everyday life. So, mastering of high technologies, implementation of the research approach, and encouragement of students' creativity are both the necessities and a great challenge of contemporary education. Traditional pre-university education in Ukraine unfortunately does not provide appropriate competencies for its graduates.

The concept of STEM aims to solve the first mentioned problem, i.e. the school students' learning motivation, engagements to natural science and research activities. Adoption of the relevant experiences by Ukrainian teachers and students is an important component of reforming secondary education. Unfortunately, STEM education introduction in Ukrainian schools remains low due to the lack of a methodological base and the relevant teachers' experience. The introduction quality of STEM-education is largely determined by the competence of the educators. It is important how and how active they use the research

competencies in education process. The best solution is to add universities into the chain of methodological support for schools. Technical universities are great stakeholders of STEM and actively supports activities based on STEM education approaches.

The second mentioned above problem is also required to introduce to the education of new principals and concepts. The easiest way to develop soft skills is an education humanisation that is very popular in Ukrainian secondary school. But this concept strongly leads away from the solution of the first problem (a good education in natural sciences), so it should not be mainstream. The solution of the contradiction can be found in the implementation of Project-based education (the CDIO concept). An introduction to the STEM education the team Projects will help to develop soft skills.

The current paper describes a successful experience of the STEM CDIO-based project that was realised in Kharkiv in 2018 and 2019 years.

2. Brief project description

The project was implemented in 2018 and 2019 by the NGO «Young Scientist Council of the National Technical University «Kharkiv Polytechnic Institute» with the support of the US Embassy in Ukraine.

The goal of the project was to create an out-of-school, comprehensive and socially accessible educational space in a summer school format. The project contributed to the reform of the Ukrainian school, expanding the ability of informed choice of students for further profile education. It also helped expand STEM's components into public education projects and provided creative education for children.

The project brought together schoolchildren, students and university lecturers in a single educational and creative space. This raised the level of awareness of schoolchildren to help them make a conscious choice of their future profession.

The project was attended by 100 schoolchildren in the city of Kharkiv and the region, of which 15% are children with disabilities. The project was implemented on the basis of the "royalty-free" fee based on the NTU" KhPI "and lasted for 2 weeks and included activities aimed at studying Ukrainian and American culture and their interaction.

The project started with the dissemination of information on holding "#STEMCamp School" and a selection of participants (volunteers and schoolchildren).

The selection of participants was conducted on a competitive basis on the following criteria:

- level of activity and purposefulness;
- motivation in the knowledge of technical sciences;
- indicators of achievement in the exact and natural sciences.

The project was based on the principles of equal access to technical education for students from large cities and small settlements, as well as for children with special educational needs.

At the same time, volunteers were selected. So far, the project involved young graduates of the university (students, post-graduate students, young scientists) on different roles: as volunteers, mentors and their assistants. The work in the project, with the support of the US Embassy, had an impact on the responsibility of the youth at the university and on the additional motivation for further education at the technical field. The problem of the low popularity of technical sciences among schoolchildren was one of the main issue at the start of the project. The active engagement of students in the educational process during the Camp made it possible to implement the peer-to-peer learning method, which undoubtedly affected the high level of motivation and creativity in implementing projects (student's feedback comments).

The camp was implemented in several stages, which had used both, intensive training and elements of game learning. The following activities have the most positive school student's feedback: scientific quest, the presentation of their project and the Science Festival. The game activity allowed to change the notion of "boring and complex" for technical sciences. Almost all project participants reached the final stage, which indicates a high

degree of a positive attitude towards to natural and engineering sciences. This gives serious hopes for the possibility of implementing such pre-university camps in technical and classical high schools on a permanent basis.

Figure 1. Participants of "#STEMCamp School"

The project has implemented the right of the participant to the conscious choice of the of his priority in the direction of the educational process, i.e. to choose the main field of study. In the current Project, this option has been proposed for the secondary school students, which is enshrined in the concept of the new Ukrainian school, as a freedom to choose the profile of secondary education. One of the findings of the project was the giving for school students ability to choose and implement their own technical project, which allowed to develop soft-skills such as the ability to work in the team, communications, to make a public presentation, to realise creativity in a technical field etc. This allowed the participants to look at the perspective and relevance of the technical education (more than 58% of the participants changed their opinion towards the choice of engineering specialities).

The advantage of the project was the positioning of technical and natural sciences from the point of view of the research approach (Inquiry Based Science Education). This approach allows you to look at standard school courses from a completely different angle, to see the demonstration of natural sciences in everyday life, to apply the basics of engineering design to solve everyday tasks. The students have positively changed their attitude to such disciplines as physics - 26%, chemistry - 25%, math - 17%, ecology, power engineering y by 16%.

At the end of two weeks, the Hands-on Science Festival, which brought together mentors, students, school teachers, schoolchildren and their parents, local authorities (about 1,500 participants), took place. The festival was conducted on the basis of NTU "KhPI" and had an open laboratory base and presentation of the results obtained by students during the summer school. At this event, scientific projects that were developed by the participants of the camp were presented.

Figure 2. Presentation of the project "Investigation of the stability of the transmission line model to various factors"

The project allowed a new look at the issues of inclusive education in the field of technical sciences. Students with disabilities (15%) who participated in the project, under the supervision of a psychologist, were included in absolutely all stages and types of project activities.

Figure 3. Presentation of the project "Sugar Blast Theory"

Particular interest among these students had a teamwork over the creation of technical projects together with students without disabilities. Such an inclusion had a significant impact on the motivation on future inclusion for

the school students with disabilities and also has made a huge impact on the school students and young mentors on the issues of attitude to persons with disabilities.

After the end of the second stage of the summer school, the ten best teachers of the NTU "KhPI" conducted exciting lectures and master classes for two hundred senior high school students from the Krasnokutsky district of Kharkiv region! Living physics and chemistry, turbine secrets, secrets of making aromatic drinks, mechatronics and more!

Figure 4. A lesson from mechatronics for students of the school of Krasnokutsk district (Kharkiv region)

In total, during the third stage, 15 schools were visited and STEM activities were conducted for more than 400 school students from 10 to 16 years old.

3. Analysis of the effectiveness of the summer school

During the project implementation, a sociological survey was conducted among the participants. The sociological survey among participants at “#STEMCamp School” had to solve the following tasks:

- to define the understanding of the project participants by the essence of the specialties of engineering direction and their motivation for further engineering education;
- identify the assessment and attitude of the participants to the “#STEMCamp School”;
- determine the impact of the “#STEMCamp School” activities on the career guidance of participants;
- identify the relationship between children and mentors during the “#STEMCamp School”.

All students who took part in the “#STEMCamp School” event upon completion of the project were asked to complete a questionnaire. Participants showed a high level of response to the proposal - 96% answered all questions of the questionnaire.

4. Conclusions

The paper describes the implementation in Ukraine of a pre-university STEM- and CDIO-based educational project “#STEMCamp School”, that was realised in a format of summer camp.

A positive experience of the project is presented as well as the main results of using STEM technologies and project-oriented methodology for out-of-school education of young people are presented.

One of the findings of the project was the giving for school student’s ability to choose and implement their own technical project, which allowed to develop soft-skills such as the ability to work in the team, communications, to make a public presentation, to realise creativity in a technical field etc. This allowed the participants to look at the perspective and relevance of the technical education (more than 58% of the participants changed their opinion towards the choice of engineering specialities).

This approach allows you to look at standard school courses from a completely different angle, to see the demonstration of natural sciences in everyday life, to apply the basics of engineering design to solve everyday tasks. The students have positively changed their attitude to such disciplines as physics - 26%, chemistry - 25%, math - 17%, ecology, energy and e-logic by 16%.

We consider that further development of the project could be found in inclusion the school teachers of the natural sciences in the process of training in the camp. Such an approach will allow to more effectively implement the

foundations of STEM education in secondary schools.

This gives serious hopes for the possibility of implementing such pre-university camps in technical and classical high schools on a permanent basis.

5. Acknowledgements

The Project “#STEMCamp School” was released under financial support of USA Embassy in Ukraine (SUP30018GR0051), and administration support from Kharkiv region state authority and National Technical University “Kharkiv Polytechnic institute”.

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Chemical Magic in Action

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Abstract. For 15 years I have been a chemistry teacher at Municipal institution “Krasnorichensky Establishment of the General Secondary Education” of Lugansk region, Kreminsky district, village Krasnorichensk. I try to introduce chemistry as the “constructor” of chemical formulas, equation of react, to develop a science for children. I believe that implementation of various experiments is necessary part of education process. I give my children the possibility to experiment, to feel pleasure of reaction holding.

We live in an incredibly interesting era, the era of change, and times of high information breakthrough technologies. The question of quality in the education system has always been the most actually. At the present stage, it understood as the level of subjective skills associated with self-determination and self-realization of the individual. Knowledge acquired in the context of the model of future activity.

As a teacher-practitioner with 15 years of teaching experience, I, every day, begin a lesson with the thought: “How to interest students in science?” and “How to “enchant” the students?” – since only motivated students can achieve high results! Fortunately, I have been teaching chemistry for many years – a science that can create miracles!

During my work, I have accumulated my "luggage" of interesting experiments, which I demonstrating to interest pupils in science on lessons and after school. These experiments could selected in three "nominations": the magic of organic and inorganic compounds, the magic of household appliances.

Keywords. Activity, Chemistry, Education, Experiment, Science.

1. Introduction

The purpose of article is generalization of approaches for realization of an experimental component of the chemistry in the course of basic general secondary education, formation of internal motivation of pupils to studying of chemistry as science.

2. Nomination first "Magic of inorganic compounds"

Pupils begin the acquaintance to chemistry with inorganic substances, which «magic» I, want expedient to open, through performance of the interesting experiments: "rustiness of a precipitate", growing "colloidal garden" or "chemical seaweed" from silicate glue and crystals of salts. Motivating to studying of the chapter "water", "mysterious hobnail" or "who is stronger", volcanoes of ammonium dichromate and soda (sodium carbonate hydrogen).

For formation of steady interest there are in an opportunity educational projects that provide in course of chemistry [1]. In the seventh form – is "Chemicals around us" (pupils have an opportunity to investigate substances that meet every day or about which want to learn more), "Historical value of fire" (the subject allows to show connection of chemistry with other sciences, which contains high potential for integration to subjects). "The chemical phenomena in the nature", "The chemical phenomena in life", "Using of the chemical phenomena in art creativity and national crafts", "Substances and the chemical phenomena in literary works and folk art" (a big scope for creativity of pupils – from drawings, interesting stories, video-presentations to creation of the database of the chemical phenomena). To a course of chemistry of the seventh form, it brought some chapters, by what promotes formation of ecological competence of pupils, formations public positions "A problem of air pollution and ways of it solving" and "Improvement of an air condition in the classroom during the lessons", "Research of water quality from different sources". "The research of physical and chemical properties of water", "The ways of water purification", and "Maintaining purity of reservoirs: solving of problems in your area", and the eco-economic project "Keeping water – I save the family budget".

In the 8th class subject of projects: "From the history of the Periodic Table opening", "Forms of the Periodic Table", "Chemical elements in literary works", "Interesting historic

facts from opening and origin of names of chemical elements", "Use of crystals in the equipment". "Crystals: beauty and advantage", "Inorganic substances – representatives of the main classes in construction and life", "The chemical composition and use of minerals", "Influence of chemical compounds on the environment and healthy of the person".

The subject of projects in inorganic chemistry in the ninth form very saturated also is interesting «ground» for the organization of research of pupils: "Electrolytes in modern accumulators", "Growing of salt crystals", "Production of solutions for rendering the medical aid", "Researches of soils pH", "Researches of influence of acidity and alkalinity of soils on growth of plants". "Research of an atmospheric precipitation pH, and their influence on various materials in an environment", "Researches of natural objects acid-alkaline main indicators", "Research of mineral waters pH of Ukraine", "Endothermic reactions on service of the person", "Exothermic reactions in activity of live organisms".

The organization of "a house experiment", that provided by the program, also helps the teacher to motivate pupils:

1. Interaction of baking soda with sauerkraut juice, citric acid, kefir.
2. Purification of the polluted water by hand-made filter.

Of course, the imagination of the teacher, his desire to develop and motivate pupils, always induces to expansion of interesting experiments within a lesson and after hours [2].

2.1. Experience "Colloidal garden"

As for me, I suggest pupils "play" with silicate glue ("Colloidal garden", various slimes).

Equipment and reactants: a support for test tubes, a test tubes, glass sticks, chemical spoons, silicate glue or "liquid glass" (water alkaline solution of sodium silicates $Na_2O(SiO_2)_n$ or potassium silicates $K_2O(SiO_2)_n$), crystals of various salts ($CoCl_2$, $CoSO_4$, $CuSO_4$, $FeCl_3$, $FeSO_4$, $NiSO_4$.

For experience, it is necessary to dissolve glue with water in the ratio of 75% of glue and 25% of water.

Figure 1. Colloidal garden

It is possible to add crystals to separate test tubes after one substance, or to mix several salts, that will take interesting and unique result. To investigate "magic" of certain crystalline hydrates salts transformation during "growth" crystals of which change color, more expedient is performance of experiment on the scheme "one salt – one test tube". More beautiful there are "seaweed" from crystals of the bigger size. Most quickly grow "seaweed" from cobalt salts.

2.2. Experience "Gold nail"

Experiences are interesting, which can be created using a number of metals activity, for example "a gold nail", "the mouse acquires wool" or "forces out weaker stronger".

Equipment and reactants: a support for test tubes, a test tube with $CuSO_4$ solution, an iron nail on a thread. Before conducting of experience, together with pupils we investigate color of nail and we establish of which metal it made (we use a magnet). Then we lower a tack in solution for some time. For effective time using, it is possible to hold mini-competitions as solving of rebuses or interesting riddles on chemical or ecological subject. We check out

our nail, we are surprised change of color on gold, and then we explain chemismtry of the experience.

2.3. Experience "Volcano from dichromate ammonium"

Fire and reactions that with it connected very much excite pupils. Classical experiences there are "Volcano from dichromate ammonium", "Coloring of the fire with cations of various metals", "Iron burns?".

Figure 2. Volcano from dichromate ammonium

Equipment and reactants: volcano model, mix of crystals ammonium dichromate and powder of magnesium, stick, matches. To start exothermic reaction, it is necessary to initiate it by means of a burned stick. Experience is a striking example of a redox, exothermic reaction, contains many signs of the chemical phenomena and can be used both at the beginning of chemistry studying in the chapter "chemical phenomena", and in the 9th form in a subject "redox reactions". Usually we conduct experience at the end of a lesson, classes or educational suppression.

It is impossible, opening secrets of inorganic compounds to pass a chapter "invisible ink", which have many variations from change coloring of flowers from filter paper to interesting story about the Cat-researcher, made by my pupils, preparing educational action for chemistry.

I recommend to use such couples of “invisible ink” and developers: sodium solution (NaHCO3) or a alkaline (NaOH) – phenolphthalein; solutions of apples or onions juice – heating; laundry detergent - light of an ultra-violet lamp; starch (rice broth) – iodic sodium; aspirin – Ferum salts; solution of copper vitriol – liquid ammonia; solution of Ferum(III) chloride – solution of potassium or ammonium thiocyanate; solution of Cobalt(II) chloride – heating; “yellow blood” salt – solution of Ferum(III) chloride [3].

Figure 3. Presentation of work “Careless researcher”

3. Nomination second "Magic of organic compounds"

Pupils are acquainted with organic chemistry in the second semester of the ninth form. For understanding of organic compounds properties, the ability to create models and structural formulas of organic molecules, an important role has imagination of pupils. It is very good when the teacher have sets of atoms for compilation. An alternative is creation of molecules models from beads, plasticine or plastics.

Non-standard and interesting is using beads as atoms models. This work interests creative pupils, who create their own masterpieces.

Figure 4. Molecules models from beads made on lessons

In my opinion, it is need to beginning modeling of molecules, since the eighth form and a chapter "Chemical bond and the structure of substance”. For a start it is possible to offer models to pupils, and organize mini-quest – "Guess substance", and then to go to the creation of own handmade substances with

various types of chemical bond.

Also after acquaintance to chemical elements and studying of the chapters "Complex substances", "Chemical formulas" and "Valency", I began work on production of molecules models by means of beads, models of atoms and plasticine. Creating volumetric models of molecules, pupils understand such difficult concepts as "Valency", "Graphic formula", become closer the term "Relative molecular weight".

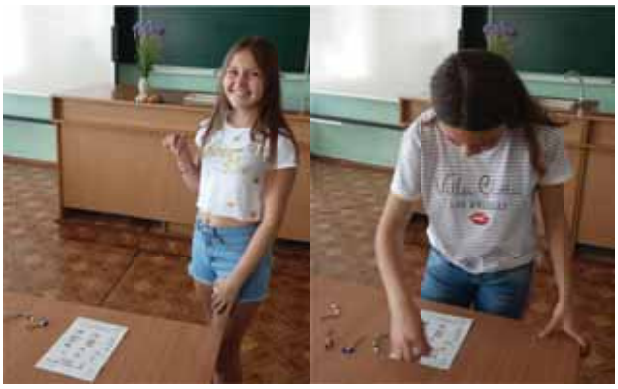

Figure 5. Game "Guess the molecule"

Incredibly interestingly and saturated was held the quest in the 11th form, devoted to generalization of a chapter "Substances with Nitrogen" where models of mediators, as important Nitrogen containing substances, are created by me, inspired pupils for active search work and emotional representations of results.

Figure 6. The quest in 11th form «Substances with Nitrogen»

Interesting and informative there are high-quality reactions of organic compounds [4].

Glycerin, glucose, proteins – to hold high-quality reactions of characteristic groups of these substances and peptide connection it is necessary to buy copper vitriol (from which we will receive solution of copper(II) sulfate) and potassium or sodium hydroxide.

To realize the abilities and to get new knowledge, pupils can in works, projects or articles which themes for organic chemistry is many-sided too: "Using of polymers: eco-economy aspect"; "Alternative energy sources"; "Ecotrophology – science about ecologically safe food"; "Production of soap from soap base"; "Researches of the chemical composition of food"; "Chemical composition of gum";

"Chemical composition of mouth care products"; "Second life of paper"; "Sources of organic pollution of the territory".

4. Nomination third "Magic of applied chemistry"

Opening secrets of chemical transformations, I try to bring closer pupils to reality, to those substances, which are nearby and are use in life.

Figure 7. Masterclass «The chemistry is near. Handmade bombs for a bathtub»

For example, from such substances as urea (fertilizer known as carbamide) and liquid glue based on polyvinyl alcohol it is possible to grow up unusual crystals.

After lessons-work helps to motivate and develop pupils.

I attract pupils to creation of various interesting actions; I give the ability to find information about variously substances and unusual transformations with their participation.

Children with pleasure find and prepare own experiments, investigate substances, surprise others during the presentation at student's conferences or masterclasses.

Interesting example was the masterclass "The chemistry is near. Handmade bombs for a bathtub", which I held together with active pupils of the ninth form for a week of natural sciences in April 2019.

EdCamp Ukraine gain momentum - unique educational movement for the professional growth of Ukrainian teachers. Exactly thanks to a meeting on “Mini-EdCamp Krasnorichensjke” with experts of NTU "KhPI" Sergey Petrov and Sergey Radoguz, we got many opportunities for development of science at our school.

We visited in NTU "KhPI" such events as Scientific Saturday with Polytechnic University: "Chemistry?! Think about it!", "The International Day of Light", online laboratory works, the purpose of which is approach of science to pupils, incitement of curiosity to natural sciences.

We are very grateful to experts for participation in the scientific and practical conference "My Step to Science" within the “Exceptional Children” project, devoted to Day of Science of Ukraine, which took place at our school!

Figure 8. Experts of NTU “KhPI” in our school

Experts of KhPI showed experiments and modern scientific workings of students and scientists of Polytechnic University, and gave popular scientific lectures with demonstrations. All attendees with interest plunged into space of Sciences!

Figure 9. The first steps in Science, project "Crystals – source of chemical magic"

This year during the student's conference "Step to Science" my pupils presented projects and researches on such subjects as "Crystals – source of chemical magic" (Degtyarenko Konstantin the pupil of 3th form), “Polyfunctional vitamin C" (Taranukha Andriy the pupil of the 10th form).

Figure 10. Very unusual crystals

Andriy represented his work on V All-Ukrainian scientific and technical conference "Current Problems of a Scientific and Industrial Complex of Regions – 2019" that was organized by Institute of Chemical Technologies of the East Ukrainian National University of Volodymyr Dahl (Rubizhne) together with the Municipal Institution "The Luhansk Regional Small Academy of Sciences of the Studying Youth".

Andriy Taranukha three years in a row takes victory places in a regional stage of the All-Ukrainian Olympic Games in Chemistry. Along with theoretical knowledge of a subject constantly works on practical researches on

various subjects. In this year, he held work on a research of vitamin C content in various foodstuff and researches of crystals anisotropy.

Figure 11. Research of vitamin C content in foodstuff in school laboratory

The chapter "Growing of crystals" deserves attention of teachers who want to interest and motivate pupils. Firstly, it is possible to use usual substances and techniques for growing crystals, for example from copper vitriol, salt or sugar. Secondly, growing and researches of crystals – an actual topic for modern scientific researches.

Figure 12. Representations of results on student's conference

Thus, I together with the pupil of the 10th form Taranukha Andriy were invited to participation in a final stage of the tenth All-Ukrainian competition of young researchers "Crystals" of Evgeniy Gladyshevsky that organize every year together with Lvivsky National University of Ivan Franko and the Lviv regional Small Academy of Sciences.

Andriy represented the practices on the subject "Monocrystal as Anisotropic Physical Object".

The format of a scientific discussion is very interesting; during protection of projects, pupils must argument their own points of view that allows them: develop, study, and explain the received results. Competition organizers, participants, heads of researches, dear jury, held large-scale work!

Figure 13. Protection of scientific research "Monocrystals as Anisotropic Physical Object" in Lviv

The format of a scientific discussion is very interesting; during protection of projects, pupils must argument their own points of view that allows them: develop, study, and explain the received results. Competition organizers, participants, heads of researches, dear jury, held large-scale work!

Figure 13. In search of future scientists

It was very pleasant to be among participants in this event! Such actions develop character of pupils, inspire on self-improvement! The positive example of classmates motivates to self-development and increasing knowledge!

Search of new forms and methods to get pupils closer to science is a basis of my activity, and I am sure that a practical side with which I acquaint pupils, their first experiences and

scientific works will promote by all means formation of creative and extraordinary persons!

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Explanation of the Basic Models of Color Mix in the Classroom for Physics

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Abstract. The article describes the demonstrations that allow you to show the basic color mixing models, and presents the developed simple colorimeter.

To understand the features of additive color mixing, which is used in self-luminous objects, an enlarged image of the monitor screen is used and the developed bluetooth lamp, the main element of which is the RGB LED. It is shown that by sending a combination of three numbers you can get the color of different hues and saturations.

The features of the subtractive color mixing model are clearly demonstrated by mixing paints. The achromaticity of the eyes of each student is determined with the help of a multicolored strip, the colors to which smoothly change as in the quasi-continuous spectrum of visible light.

At the end of the article a detailed description and calibration process of the color sensor is presented, which allows determining the quantitative composition of the color of paper, fabric and plastic.

Keywords. Color Mixing Models, RGB LED, Colorimeter.

1. Introduction

mong the various methods used for better mastering new material, a special place is occupied by demonstrations of real physical phenomena and processes. They provide a basic, deep perception of the educational material, broaden the horizons and create a sensory-empirical basis of knowledge [1], that is, they are an important method of cognitive activity of a student.

One of the elements of the “Optics” section is the material “The human eye, as a selective photodetector”, which examines the physical aspects of a person’s vision, various color models and their perception.

Therefore, vivid demonstrations of the basic models of color shift will not only improve the absorption of the material, but also check the features of the color vision of each student.

2. Demonstration of color mixing models

The most common color mixing models are the additive and subtractive models [2].

It is known from a school biology course [3] that a normal human eye contains three types of cones sensitive to different regions of the visible spectrum: red (long wavelength), green (medium wave) and blue color (short wavelength).

To demonstrate an additive model based on the addition of colors of self-luminous objects, a white monitor screen [2] is used, which is viewed at high magnification (Figure 1). On the screen you can clearly see red, blue and green stripes, which, under normal consideration (without magnification), merge. The eye in this case, simultaneously perceives all the rays of the same intensity with different wavelengths and sends a signal to the brain, which summarizes all the information and therefore the monitor screen is white.

Figure1. Additive model (by the example of a monitor screen)

The student remembers that the main colors of this model are red, green and blue - the RGB model, and the mixture of all these colors gives a white color.

In the digital world, each color is characterized by saturation, which can take 256 values - from 0 to 255. Therefore, to

demonstrate the additive color mixing model in digital format, an RGB bluetooth lamp was developed, the functional diagram of which is presented on Figure 2.

For mixing colors used 30 W RGB LED. The color with which the lamp is lit is controlled by using signals with wide-band pulse modulation, which is generated by the Arduino Pro mini board (based on the Atmega 328 microcontroller).

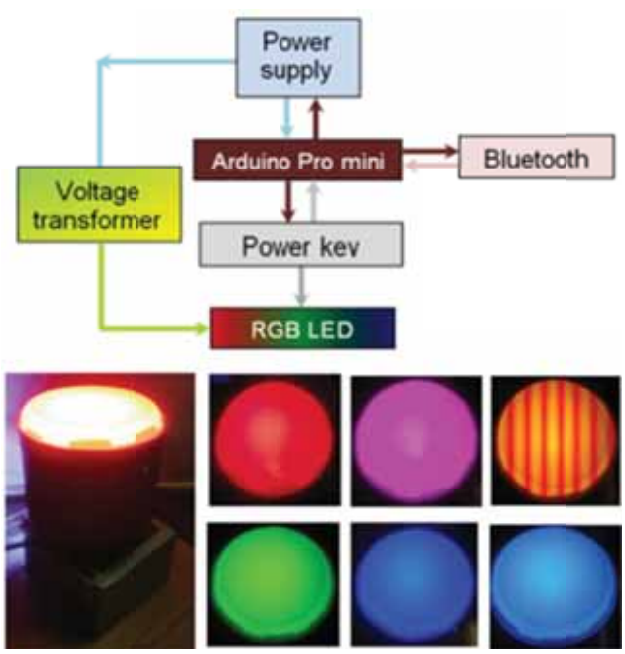

Figure 2. RGB bluetooth lamp

The control signal of each channel of the RGB LED goes to the base of the bipolar transistor operating in the key mode (power switch), which allows changing the saturation of each color separately (see Figure 2 blue color). The lamp is controlled by a smartphone with the help of a specially developed program in the App Invertor 2 environment via the Bluetooth module. The value of the RGB code is sent to the hardware serial port of the microcontroller.

To demonstrate mixing colors, a three-digit code is sent from the phone, each of which is in the range from 0 to 255. The student observes that when mixing colors, the resulting color is brighter, and the sum of all three (RGB) components of maximum saturation gives white. Pulse band modulation can be seen only by looking at the luminous lamp through the camera of the phone. The observed image is alternating stripes of the same color tone, but of different saturation (see Figure 2. orange color).

To demonstrate *the subtractive color mixing model*, ordinary paints are used. The attention of the student is focused on the fact that the main components of this model are the colors obtained by subtracting the additive model from the white color of the primary colors.

On the table have glasses with diluted colors: blue, red and yellow. Next, the student himself mixes them to obtain the secondary colors of the model: green, orange, purple (see Figure 3). When it is absorbed that the colors are a kind of light filter, that is, if you mix blue and yellow paint, then the first cuts off the long-wave part of the spectrum, and the second (yellow) - short-wave. Consequently, only the middle part of the visible spectrum remains and the eye sees green paint.

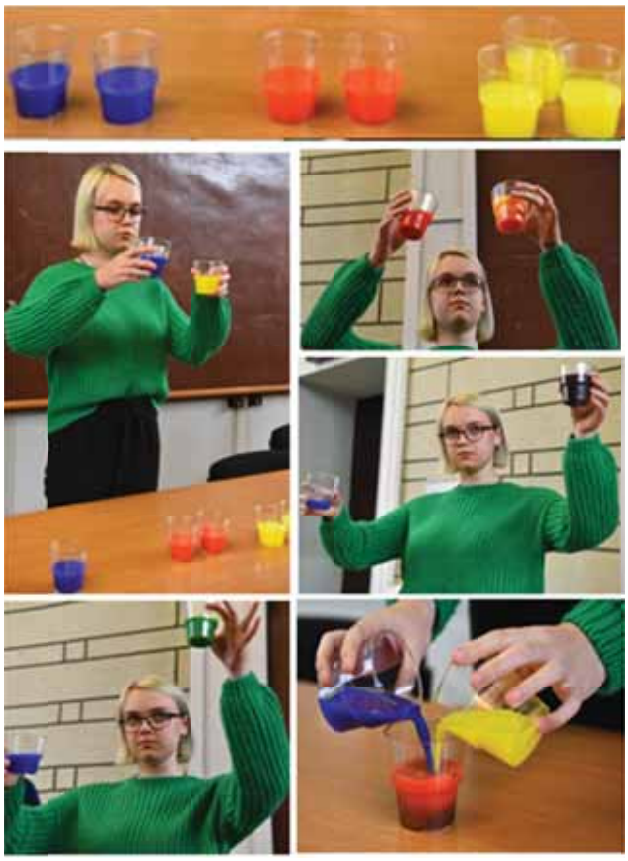

Figure 3. Subtractive model (mixing paints)

Special attention is paid to the fact that the mixture of the three main components of this model gives a color close to black, but not saturated black. This explains the addition to

the three primary colors of the subtractive black model. To evaluate the chromaticity of each student's vision, he is invited to study the quasi-continuous spectrum of visible light (Figure 4) and determine the number of bands of different light shades [4]. Further, depending on the results of the calculations, it is possible to estimate in which region of the visible spectrum, which type of cones work best, that is, determine to the dichromates, trimchoramots or tertrochramats the eye.

Figure 4. To determine the chromaticity of vision

3. Designed colorimeter and its calibration

Next, students are introduced to the scientific approach of determining color and the corresponding instruments — colorimeters, which provide color information by a set of three numbers corresponding to the components of the RGB model.

A budget simple colorimeter was developed at the Department of Physics of NTU "KhPI" to determine the color, the functional diagram of which is presented in Figure 5. The sensitive element of the device is the color sensor TCS34725 [5], which consists of 12 photodiodes of 3 each with red, with green and blue light filters, and 3 without a light filter. The sensor has built-in ultraviolet and infrared filters and it is possible to adjust the gain and integration time, which makes it possible to amplify the signal and accumulate it longer in case of weak illumination of the object. The sensor is controlled via the I2C bus using the Arduino Uno board. To eliminate the influence of ambient light on sensor data, it was placed in a protective opaque cylindrical housing. To display information, a TFT screen is used, which displays three RGB coordinates and a rectangle whose color is similar to the color of the object under study.

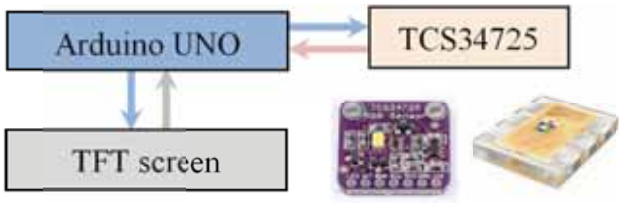

Figure 5. Color sensor and circuit developed colorimeter

In order for the color sensor to correctly determine the coordinates of the RGB components of the model, it was calibrated with the help of a monitor screen of the three colors of different saturation that is illuminated with a different color of the monitor screen and printed on a color printer. In both cases, the color saturation (blue, green and red) was changed in 25 steps from 0 to 255. Dependencies of the output signal voltage of each sensor channel were plotted on the saturation for each color. Based on the data obtained, a software for the microcontroller was developed, which allowed the output of the color sensor to be converted to RGB coordinates and automatically distinguish the material of the object (various reflection coefficients), the color of which is determined: plastic, paper, cloth. Figure 6 shows examples of the work of the colorimeter on various materials.

Figure 6. Examples of the work of the colorimeter: blue and red plastic; white, green and orange paper; magenta fabric

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Creating of STEM – Equipment: Transmission Information on Distance Using Laser Beam

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Abstract. The main task and the present stage of sustainable development of STEM – education in Ukraine [1] is the development of key devices for demonstration, popularization [2] and study of basic physical laws at the modern technical level. One of the key areas of physics, optics, is rather difficult to understand and needs extreme technical support.

The work proposes the technical implementation of a set of devices for a simple demonstration of the possibilities of an optical beam to transmit information, for example, sound vibrations, at a distance. The set consists of a transmitter based on the transistor, which performs the amplitude modulation of the input sound wave in a laser beam and a receiver based on a two-stage operational amplifier, which receives a laser beam at the expense of the photodiode and conducts demodulation with the release of the low frequency component of the sound wave. The audio signal is amplified and fed to the audio output.

The developed set of devices is a fairly simple demonstration of which students will be able to work independently by connecting their sound devices and master the basic principles and laws of optical physics.

Keywords. Audio Output, Amplitude Modulation, Innovative Development of Education, Laser Beam, Logical Thinking, Optics, Photodiode, Sound Vibrations, STEM – Education, Transistor, Transmitter.

1. Introduction

Today, Ukraine is on the path of intensive development and needs a large number of highly skilled specialists in the innovation sphere, which will be the key to the successful economic development and competitiveness of our state in the near future. One of the directions of innovative development of education is the system of training STEM, through which children develop logical thinking and technical literacy, learn to solve the problems, become innovators, inventors. STEM-education will strengthen and solve the most pressing problems of the future.

2. Objective

The purpose of the work was to offer, develop and implement a simple, practical and, besides, non-standard device for demonstrating the possibilities of light. A basic requirement for implementation was a fairly simple demonstration, from which students could work independently, connecting their sound devices, and master the basic principles and laws of optical physics.

3. A simple demonstration

The paper proposes the technical implementation of a set of devices for a simple demonstration of the possibilities of an optical beam to transmit information, for example, sound vibrations, at a distance.

Figure 1. Appearance of the set (without connecting cables)

The setup consists of a transmitter that performs the amplitude modulation of the incoming sound wave in a laser beam and the

receiver, which receives a laser beam at the expense of the photodiode and conducts demodulation with the release of the low frequency component of the sound wave. The audio signal is amplified and fed to the audio output. The appearance of the set is shown in Figure 1.

The transmitter, which performs the amplitude modulation of the input sound wave in a laser beam, is based on a bipolar transistor S8050 connected to work in active mode. In the initial state, the reference voltage on the basis of the transistor Q1 is balanced in such a way that the collector transition is partially open, and the laser LED D2 emits light at half the power.

The input signal is first filtered from the constant and low-frequency components by the capacity of C3 and then added to the reference voltage on the basis of the transistor Q1 (or subtracted in the antiphase).

The above leads to the amplitude modulation of the radiation power of the laser light on the background of its reference constant value. The schematic diagram of the transmitter unit is shown in Figure 2.

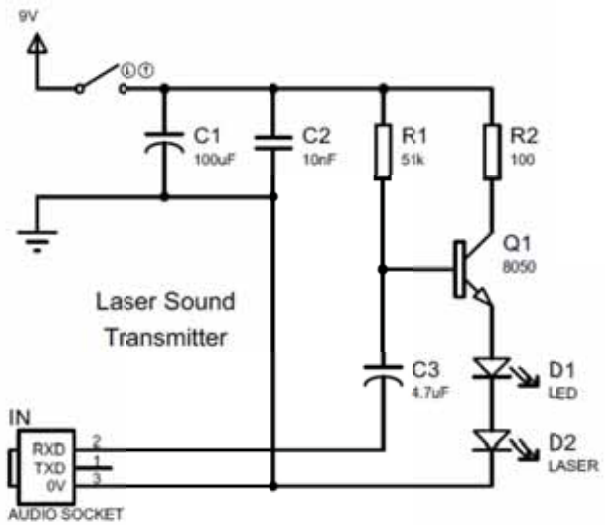

Figure 2. Principal electrical circuit of the transmitter unit

This block based on the portable battery is implemented, the location of the elements is shown in Figure 3.

To ensure ease of use and portability of the device, the power supply to the transmitter unit is carried out at the expense of two Li-ion rechargeable batteries with a standard voltage of 3.7-4.2V. The battery charger module, powered by USB, is used to safely charge the batteries. Along with this, the laser module is powered, as can be seen from the circuit in Figure 2, from the voltage 9V. For its power, a step-up voltage regulator is used, which has an input voltage at the specified level of 3-5V and output 9V. The general view of the transmitter unit is shown in Figure 1 on the right.

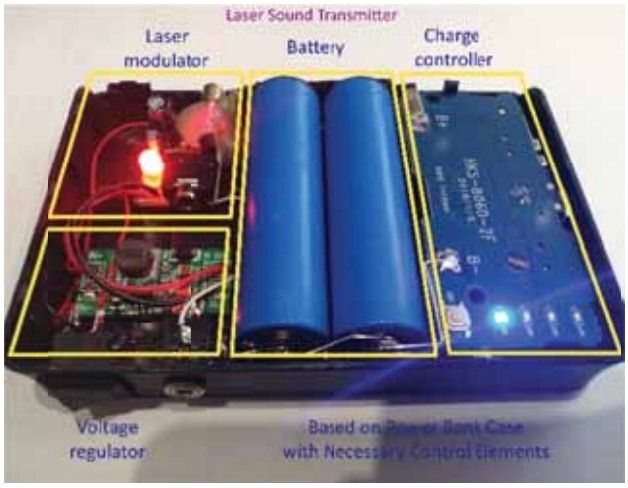

Figure 3. Placing elements of the transmitter unit

The receiver, which receives a laser beam at the expense of the photodiode and conducts demodulation with the release of the low frequency component of the sound wave, is made on the basis of an operating amplifier (OA) LM386. In the initial state, the voltage on the D3 photodiode depends on the voltage separation between the battery between the R3 resistor and the photodiode D3, thus the steady-state voltage and current are formed on the photodiode. However, between the photodiode and non-inverting input OA consecutive C4 capacitance is included that filters the constant current component. As a result, in the original state, the non-inverting input OA signal is absent, and as a result, there is no amplified output signal. If the D3 light source is received at a constant intensity, this will result in a voltage imbalance between the R3 resistor and the photodiode D3, but its value will also be stationary and will be filtered out. In the case of an incident light flux, such as our laser beam with amplitude modulation, the value of the voltage on the photodiode D3 will vary with the background of the constant

component. The high-frequency voltage component will be interrupted by the non-inverting input OA, amplified by the OA's power supply from the battery, and the output signal after the filtering of the C9 OA own noise will enter the audio output. The proposed principle circuitry of the receiver unit is shown in Figure 4.

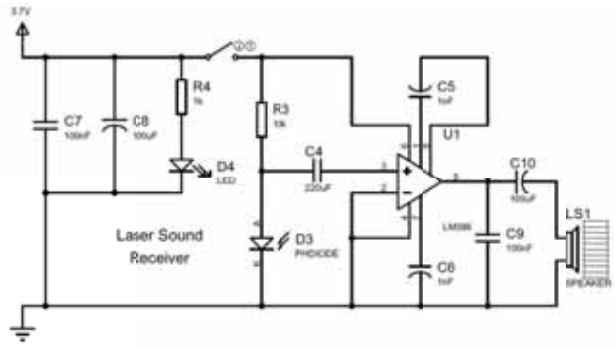

Figure 4. The basic circuit diagram of the receiver unit

This unit is implemented, similar to the transmitter, on the basis of the case from a portable battery, the placement of elements is shown in Figure 5.

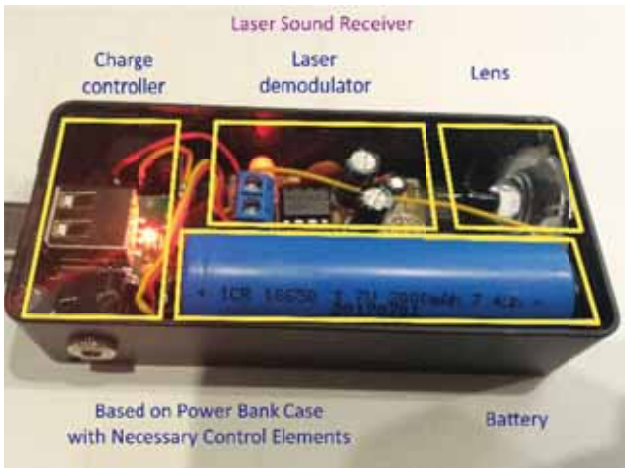

Figure 5. Placement of elements of the block of the receiver

Power supply to the receiver unit is carried out at the expense of one Li-ion battery with a standard voltage of 3.7-4.2 V. For safe charging of the battery, the USB charging module module is used. The laser waveform demodulator works stably from the voltage of the battery pack and does not require a separate voltage regulator. The general view of the transmitter unit is shown in Figure 1 on the left.

4. Conclusions

In practical use of the set as the source of the sound signal can be used any device with the audio output TRS (the transmitter unit is equipped with a TRS connector), the receiver unit is equipped with a similar output. Thus, for demonstration of the device, there is no need for the use of additional specific equipment. As a sound source, a smartphone for students with music that they like exactly to them can be used. As sound reproducers, you can use any computer speakers that are available in almost every class.

Thus, a set of devices for the simple demonstration of the possibilities of an optical beam is used to transmit information, for example, sound vibrations, at a distance.

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"Computational Tinkering". An Educational Project for the XXI Century Children in Northern Italy Primary Schools

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Abstract. During the school year 2018-2019, MUSE-Science Museum of Trento and Xké? Science Center of Torino led an experimental project on transitioning tinkering to school. 70 teachers have been engaged in training sessions and classes provided with specific tools and materials (KITs to be shared as in a library), then each teacher ran a year-long program with their students. The paper describes the activity designed to integrate the informal approach of tinkering in the formal context of primary school, and discusses the most relevant aspects of learning, activity design and innovative education, considering the alliance between museums and science centres with schools.

Keywords. Tinkering, Learning-by-Doing, Soft-Skills, Computational Thinking, Coding, BBC Micro:bit, Primary School, STEAM, Italy, Museums and Science Centre.

1. Introduction

The project "Computational tinkering" aims to develop tools and practices to foster the diffusion of a tinkering approach into primary schools as a year-long program organized by the teachers. After tinkering experiences inside museums and science centres, the experience has been transferred as a new tool available for teachers who manage and facilitate the activity with their classes. Teachers' engagement and the museum's central role as a reference point for training and mentoring, along with materials and devices supply, are the crucial aspects allowing a broad impact over a large scale. The project comprehends basic tinkering activities, focused on everyday materials manipulation and assembly, linked with electronics and coding, thus providing an in-depth and advanced STEAM setting – the main focus is on teachers' training in order to contribute with the tools to use confidently tinkering as a learning approach.

The project "Computational tinkering" comes after a two-year experimentation (Project "Be Wise" 2016-2018) carried out by Xké? Science Center and the primary school "De Amicis" in Torino that allowed us to fine-tune a guide to organize a tinkering program at school (KIT A) and test the feedback of teachers. Then the project has been extended, including electronic devices and coding (KIT B and C), in collaboration with Riconnessioni. Finally, the whole project "Computational tinkering" has been run with more than 70 teachers in two different areas in northern Italy: the province of Torino and the Autonomous Province of Trento. In Trento, we took the opportunity of the project for a deep focus on evaluation and developing tools for assessing the impact of tinkering activity on learners. In collaboration with the Education Department of the Free University of Bolzano, we have planned a specific research design, based on observations during tinkering activities in classes, focus groups with teachers and informal interviews with students.

1.1. Museums and Science Centres' commitment to sustainability and education

MUSE-Science Museum is engaged in science education and communication, and since 2017 has oriented its activity around the UN 2030 Agenda (New York 2015) firmly declaring its commitment toward the 17 SDGs (as many science centres and science museums all around the world, Tokyo Protocol 2017). The project represents the opportunity to give concrete implementation in the SDG4 (Quality education) and particularly, the focus on computational tinkering fits with SDG5 (Gender equality) and SDG9 (Industry, innovation and infrastructure). This engagement is a small step toward a new generation of smart citizens, capable of adapting to a changing world.

Tinkering, as well as making, is characterized by interdisciplinarity with specific reference to STEAM (instead of STEM, [1-2]) also thanks to the current link with computational tools and therefore the intersection between virtual and physical worlds

[3-5]. Thus computational tinkering is a way to engage young students with science and providing them with a deep learning experience. According to literature, tinkering activities can be used to support deep learning [6-7] and moreover, through this approach we hope to increase interest in science in young students so that they would like to do science [8].

2. What is tinkering?

Tinkering is an informal learning approach, here applied in a formal context, totally focused on learners, project-driven and based on curiosity, experience and creativity. It is more than learning by doing, and we strongly believe that it is mainly "thinking with your hands" [9] since reflection is a fundamental aspect of the learning process. Through manipulation, design, attempts and changes, during individual or collective dynamics, students reach their goals autonomously and according to their own time, by understanding scientific phenomena and developing soft skills, scientific literacy, computational thinking and reflective attitude. For example, students may have the idea to build a tower placing a (heavy) glass tin on a long cardboard tube but then facing the problem of stability of the structure. Therefore, they have to try different possibilities to solve the problem and decide if the original idea has to be kept or either rejected. Petrich et al. [10] consider the process of becoming "stuck and unstuck" at the heart of tinkering. In this way, they discover properties of materials or phenomena, being proud of what they learn, and develop soft skills and social scaffolding.

According to Resnick and Rosenbaum a reliable source, "the tinkering approach is characterized by a playful, experimental, iterative style of engagement, in which makers are continually reassessing their goals, exploring new paths, and imagining new possibilities. (…) Is well aligned with the goals and spirit of the progressive-constructionist tradition—and, in our view, it is exactly what is needed to help young people prepare for life in today's society" [11].

Martinez and Stager [12] consider making, tinkering and engineering as three "ways of knowing" characteristic of the constructionist approach. Making is described as the active construction of a planned "product", while tinkering is depicted as a "mindset" based on a playful approach that implicates problem-solving through "direct experience, experimentation, and discovery." Today is common to consider making focused on "product" and tinkering focused on "process", even if it is often reported that tinkering is a branch of making [10, 12-13] since making refers to a broad "class of activities focused on designing, building, modifying, and/or repurposing material objects, for playful or useful ends, oriented toward making a product of some sort that can be used, interacted with, or demonstrated" [5] while tinkering is characterized by "improvisational, creative problem-solving" [15]. We can consider making related to artefact and object, therefore on what to make while tinkering is more concerning the process or how to make and also why building something (personally meaningful). As reported by Bevan at al. [13] "at the heart of tinkering is the generative process of developing a personally meaningful idea, becoming stuck in some aspects of physically realizing the idea, persisting through the process, and experiencing breakthroughs as one finds solutions to problems".

2.1. Tinkering at school

Transitioning tinkering to school allows setting long-term activities with students that have the opportunity to stay in the tinkering space/activity for several times during the school year. So, at school, the tinkering experience can persist in time. This aspect represents a key factor expanding the time students can tinker in a periodic event, like other school classes. Differently from the museum setting, one-time drop-in visitors, school classroom setting allows pupils to build a long practice of tinkering. Teachers and external observers can see changes or improvements over time, and which resources students bring from school discipline into the tinkering activity and vice versa.

The project "Computational tinkering" is an opportunity for teachers to try a facilitator-like approach, design new educative strategies and observe new learning outcomes, keeping the freedom of students and therefore engaging them personally and by meaningful experiences. Students learn how to use different materials and devices by themselves, then create a personal and meaningful project

(testing and facing problems and challenges). Finally, they report to the group the results they gained, the problems and the solutions, the process and the decisions.

Tinkering is entirely new in Italian schools, Vossoughi and Bevan [15] report that the main focus of educational application of making and tinkering is on middle and high school, little research is available on younger children [2, 7, 16-17], in this sense we believe our project covers a relevant topic in the field of nowadays science education.

The relevance of making and tinkering in the educational field is not under discussion [6, 12-13, 18-20] and it is widespread in out-of-school time settings such as museums, science centres and maker spaces, after-school programs and libraries [5, 15, 21-23]. The project "Computational tinkering" is about the integration of tinkering activities in school. The purpose is not to set activities where students can make something without a learning experience, this is not new in the Italian school system, but to use tinkering as an educational approach with consistent learning outcomes [11].

3. "Computational tinkering" project

3.1. Activity design

In order to bring tinkering at school, with the idea it should be a permanent activity organized by the teachers during the whole school year, we developed a guide that maintains the open-ended nature of tinkering. The structure is based on a circular and iterative scheme of five phases: exploration, creativity, sharing, experimentation, and sharing again (Figure 1). The tinkering program should be introduced to students with a title or slogan (e.g. "think with your hands", "objects' infinite possibilities") and students should know they will create something.

3.1.1. Explore (discover, learn, imagine)

Students can discover objects and materials through free manipulation, testing different physical properties. They can explore individually or in small groups, try to figure out how to manipulate objects and material (they know they will use them for a project). They can test the behaviour in water and air, can analyze what happens with light and so learn useful characteristics.

Teachers are free to prepare a more structured exploration designing specific protocols and reporting sheets.

3.1.2. Create (plan, create, test & change)

Students work in groups on a project. Taking inspiration from objects or materials they liked, or topics they learn from classes. The activity can be free or, at teacher discretion, oriented on a general theme (e.g. sport, animals, space, city). They have to start with a blueprint, in order to make firm the initial decision. It is not a constraint, will help students understanding the process that will guide them from the first plan to the result (this will be for sure very different from the blueprint). It could be a title and a list of materials, a rough sketch or something more complex. After that, the group begins realizing the project. Many problems will arise, and unexpected solutions they had never thought before will occur. The initial idea can change little or completely, and the work ends when the time is over. Time is the only constraint. If someone believes having completed the project and there is some time left, the teacher should invite to improve or extend. As claimed by Bevan et al. [24] "the endpoint is unknown and emergent".

3.1.3. Share

A collective reflection is needed in order to share the results: both the project they had realized and the process that led to the final object. Students also share feeling, discoveries, problems, solution and further ideas if something has been left uncompleted. This reflection helps "cross-pollination of ideas" [10] and forces the students to retrace the history of their artefacts.

3.1.4. Experiment (improve, modify, redo)

Students work in groups on one of the projects someone else had realized. They have to overcome any bond with their project and begin again in the building activity, taking inspiration from their experience and the object they inherit (it can be completely transformed, or improved, connected with others). This phase helps students focusing on the process and not on the product. They can try solving

unsolved problems, make some part working better, or find a different interpretation of the object. As in phase 2, the work ends when the time is over.

3.1.5. Share

A final reflection, similar to the previous one, close the tinkering activity cycle. Then the students disassemble the products with the idea that objects and materials can be reused again. Within this structure, teachers are free to organize at least three sessions (phase 1, phases 2-3 and phases 4-5) or even more, during a maximum of two months. They can work in the classroom if a multi-purpose room is not available. Each session can last about 2 hours.

Figure 1. Scheme of the circular process of five phases designed for the tinkering program at school

We strongly suggest that teachers do not fix a common goal. In our project, students tinker pursuing personally meaningful goals, following an in-depth self-driven and bottom-up approach. Even if this is not always the case in many tinkering activities that focuses on specific challenges, objects or materials (e.g. scribbling machines, paper circuits), this is well considered as a free and personal style where tinkerers begin by messing around with objects, materials and ideas, then goals emerge from this free and playful exploration [11]. We believe this is a preferable approach to be used in the classroom for a long-time activity, in fact, students are diverse and setting a common goal could limit the possibility of expression (and self-discovery) of each personality. Moreover, it is suitable for change during the school year (a student could be more operative and less creative at the beginning and then having several stunning ideas).

Nevertheless, in formal context students are usually asked for work toward a common task (indeed they are evaluated on it). We need to let them feel as much as possible in a new learning environment, not by the real space (they are still in their classroom) but through a different mindset that makes the activity more personal and meaningful. This aspect is in our opinion the best way to "provide multiple pathways" [24], in the sense that students are completely free to choose what is meaningful for them (true open-ended approach). If teachers want to keep the focus on a relevant topic, we suggest setting themes and not challenges [11]. Broad themes to explore can help teacher without reducing students creativity (e.g. when the teacher use "sport" as a theme for a 1st-grade class, a group of students that was inspired by a bottle to build a rocket, decide to put a football team inside!).

We say that students have to start with a blueprint (phase 2). Even if tinkering is generally intended in opposition to planning [11], we do not ask students to be "planner" – thus developing a precise plan, and executing it step-by-step, toward the fulfilment of the original idea. We want them "just make a tentative plan" after having been inspired by the materials available, they should decide their goal, what they want to do. Then they are pure "tinkerers" exploring different possibilities to realize the idea, facing unexpected problems related to the manipulation of the materials (they can draw a ship's mean mast; but can they find the stability of the structure using plastic, wood or cardboard?). In many cases they will completely change the initial idea, after their "conversation with the material" [26] and conversation with others, as reported by Resnick and Rosenbaum [11], they "continually adapt and renegotiate their plans based on their interactions with the materials and people they are working with". For this reason, the blueprint plays a fundamental role in the final reporting (sharing phase) because it helps even young students to remember the starting point

and retrace the process that led them to the final result.

3.2. Structure of the project

The project involves primary school teachers in setting up a permanent tinkering program at school, during the whole school year. The project comprehends three steps with an iterative design: basic tinkering activities, focused on simple materials manipulation and assembly (KIT A), linked with electronics devices (KIT B) and coding (KIT C), thus providing an in-depth and advanced STEAM setting.

Teachers are trained on tinkering and receive a first set of materials to work with the students (KIT A, which contains samples of objects of different materials: cardboard toilet paper rolls, plastic bottles, cans, egg boxes, caps and corks…) in order to experience what is tinkering and become comfortable with the approach.

After the first cycle of activity with KIT A, teachers pass to KIT B that contains electronic devices (lamps, LEDs, motors, buzzers, batteries, cables…). Teachers receive specific training through videos and a guide than can run the activity with the students. In phase 1, they explore the new materials discovering how they work. It is crucial that the teacher does not teach them how to turn on a lamp, they can discover by themselves just tinkering with the materials, trying different possible connections. Then they move to phase 2, setting a new blueprint for a new project using the material of KIT A+B and finishing with phase 3.

Finally, coding is added. KIT C contains BBC micro:bit that allows to programming the devices of KIT B in a quite easy and intuitive online programming space. Teachers received specific training and a guide to the new contents. During phase 1, students are invited to explore the different instructions set and resources of the program, testing the tangible connections and the practical outcomes on the micro:bit. Then they move on to phase 2 using the whole materials available (KIT A+B+C) and finishing with phase 3 (Figure 2). We suggest kit A and B from grade 1st, and kit C from grade 3rd but teachers are free to decide depending on their students' attitude.

3.3. Tools and approach

In KIT A, containing a selection of everyday materials, we suggest to think about 3 categories: objects (cans, bottles, egg boxes… - that represent a variety of materials: plastic, paper, cardboard, metals, fabric, glass…), connectors (glue, twine, rubber band, tape – we discourage hot glue guns), and tools (scissors, stapler, ruler…). However, we also underline that any category is not a constraint, and creativity may transform a tool into an object (e.g. glue's container is a plastic cylinder) or a connector can become a tool (e.g. using twin to take a measure), encouraging the possibility to use any object in a variety of ways. In KIT B, we choose a selection of electronic devices in order to provide different type of lighting objects (LEDs and bulbs), sound-producing device (buzzer) and motion (motors and servos). We want to keep a twofold level of devices, providing both raw materials (cables, bulbs, batteries) and high tech devices (crocodile leads, crumble components including bulbs, buzzer, switches, batteries pack), these can be easily connected with KIT C which provides BBC micro:bit.

KIT A is a sample of playful materials, intended to inspire teachers and students for collecting other materials. Each class receives a dedicated KIT A. On the contrary, KIT B and C are provided in the form of a library loan: each class can borrow the KIT B only after having completed the session with KIT A, and should give it back to us when the activity is concluded.

The idea of KIT's library responds to the need to provide specific devices (KIT B and C) to teachers. However, the topic of the tool set is delicate. Great enthusiasm lies in "special" devices that characterize making and tinkering space (from hot glue guns to 3D-printers and programmable robots) but as Martin [5] argues, "there is a distinct danger that its incorporation into school settings will be tool-centric and thus incomplete". He refers to the importance of keeping in mind three fundamental elements that should be integrated: tools, community and mindset. In other words, "designing contexts for tinkerability is as important as designing kits for tinkerability" [11]. Similarly, Bevan et al. [24] when pointing out suggestions to bring tinkering to school underline: "Don't equate making with tools alone - Although high-powered tools can

be seductive, remember that making is a creative, person-led process".

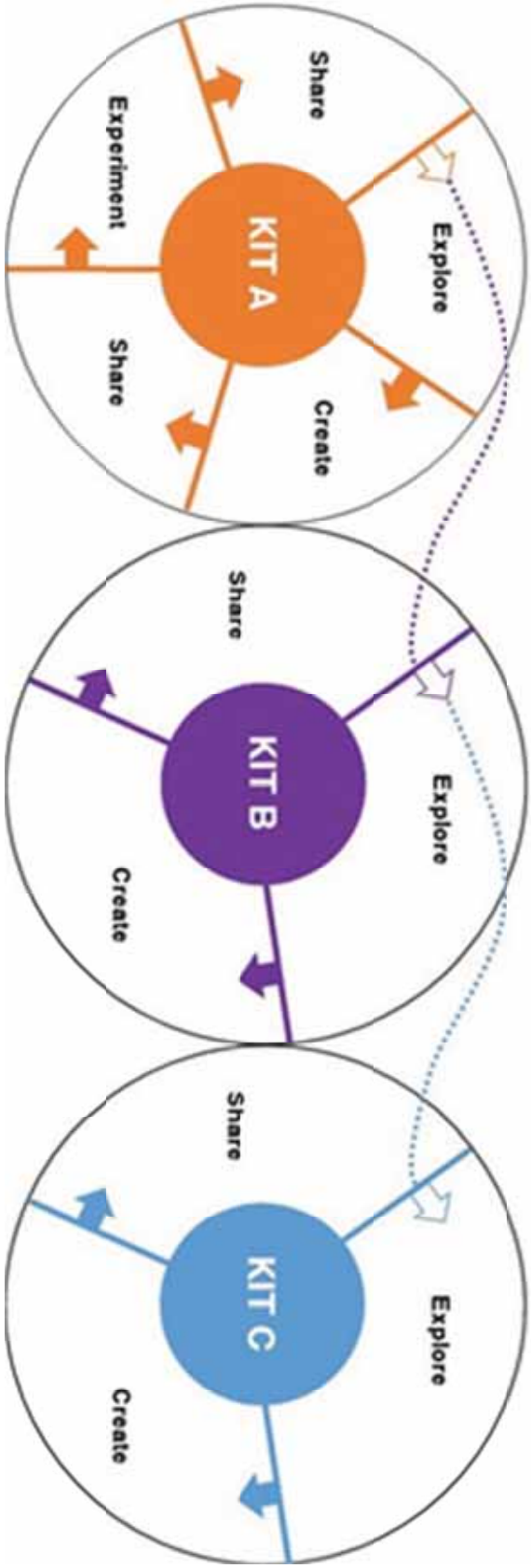

Figure 2. Structure of the project

This feature is the only reason why we insist on the tinkering approach (mindset) and use the library and several meetings to shape a community setting. The risk is much high for the more tech KITs because of the idea of technology conceptualized as a stand-alone driver for change [5].

This aspect is in agreement with authors considering digital fabrication capable of accelerating the process of invention and design because it allows a rapid transformation from an idea into a tangible product [6]. In contrast, we favour the position of authors that prefer working with everyday and familiar materials [10]. We find that using common materials, supports students to repeat tinkering out of session time, both in the school environment (breaks) and at home. They are invited to bring materials from home, thus engaging the families in the program and collecting a very diverse set of materials in different classes (e.g. wood scraps from parents working in carpentry, fabric from sewing shops). They also search for new materials and are inspired by objects they see with "new eyes", according to Vossoughi et al. [7] the use of everyday materials leads to an extended exploration across different contexts.

3.4. Research and evaluation

We took the opportunity of the project for a research focus on the learning outcome in order to understand which skills the computational tinkering approach can foster during a one-year project in primary schools. The most important focus of the research is on collecting data to set up a reflective tool that gives the teachers the awareness of the learning outcome happening during tinkering sessions. We also design an evaluation plan to get accurate feedback from teachers.

Research on tinkering as an educational practice is not new. Today the reference background is the Tinkering Learning Dimensions Framework [13], which identifies and describes how tinkering supports learning in museum settings (Tinkering Studio at the Exploratorium of San Francisco). The work expands a previous attempt to define qualities of learning (Petrich et al. [10] also referred to the museum setting of the Exploratorium) and contributed to the theoretical framework of learning through making and tinkering activities

being used as a reference in museums and science centres practice (e.g. [26], ECSITE 2019). Here we describe how tinkering activity can be transitioned to a school classroom setting and, therefore, the research outcome is to describe the learning dimension at school instead of a museum setting.

The authors (MM, researcher; MB and CR, practitioners) collected qualitative data through different methods: 1) observation and informal interviews with children. During tinkering sessions, we observe the students tinkering with the different KITs and take notes and pictures. We also conducted informal interviews in small groups to investigate the procedural thinking and the cognitive processes that emerged during the activities or after. 2) Interviews (focus group) with teachers during the project. Moreover, quantitative data were collected through online surveys administered to teachers after having run the sessions with each KIT.

The research team is working on data analysis to define a grid of skills that emerge during tinkering activity (results will be published soon in a dedicated paper). From our preliminary results, we set up a grid of skills grouped in 4 dimensions: *soft skills learner* concern individual attitude, *soft skills learner-learners* is on social scaffolding, *literacy* focuses on conceptual understanding (not only scientific), and *computational thinking* indicates the specific computational skills improved by tinkering with or without digital devices. Such a classification (Figure 3) is intended to be suitable for teachers, in order to help them to observe two dimensions of soft skills (at the level of individual and group) and two dimensions of skills more close to the curricula.

Among the expected output, we aim to figure out whether it is possible to provide teachers with an evaluation tool to be used during the year in order to assess learners' improvements and enhance the activity (work in progress).

4. Discussion and conclusion

The "Computational tinkering" project represents a first attempt to introduce an informal learning approach in primary schools in the provinces of Trento and Torino, and this not only means inside the school environment but engaging teachers instead of museum's facilitators.

In the design of the activity, we try to keep a straight focus on a specific idea of tinkering, starting from the "emphasis on process over product" [11]. We do not emphasize the final product (e.g. no goal, no individual projects, exchanging, disassembling) in order to reinforce the idea of the process (they can tinker at home because they have learnt how to do). We also define several reflective moments (sharing phases) to encourage students and teachers to think about the tinkering process, we suggest teachers as well to take pictures, videos and notes, in order to document what happens during the sessions for subsequent discussion and collective reporting. It is not a surprise to find that students easily dive in and immerse themselves totally in the process of tinkering; for this reason, we need to state that some reflection time is required clearly. Of course this is more effective with 3rd to 5th grade students, while it is quite tricky with younger children, we suggest to make it shorter and in a playful style (e.g. students present what they have done without telling the name/title, so the rest of the class can make a guess about what it is).

Figure 3. Specific skills emerged during tinkering session are grouped in 4 dimensions

It is unusual for a teacher to be a facilitator. They have no experience or training for such a role. However, we want the activity to be self-managed by teachers without any support from the museum's staff. Following basic rules as for facilitation of tinkering activities in museum setting (e.g. sparking interest, sustain engagement and deepening understanding; [10, 16]) teachers overcame initial hindrance and finally felt comfortable supporting students in their tinkering activity, basically referring to the motto "Pose questions instead of giving answers" [11].

Despite suggestions from Resnick and Rosenbaum [11] and Bevan et al. [24], we do not use examples. In our very free approach,

we do not show any examples of objects to the students. Even if it seems to be successful in museums settings, we believe students can find enough inspiration from the materials and later (since the activity lasts for the whole year) they can take inspiration from others and see examples realized by peers (actually they can work on some particularly inspiring examples – phase 4). However, in the end they have to disassemble, in a way that defines all the concrete results in a temporary dimension. The whole tinkering experience begins without previous creations (provided examples) and finishes without any "beautiful objects". It starts from the materials and goes back to them, in a very circular pattern, also related to the theme of recycling and reuse. This also reinforces the need for proper documentation (photo, video, poster) that can remind the process instead to keep the artefacts (that are not representative of the process at all).

Finally, our research will provide a skill grid that will integrate the Tinkering Learning Dimensions Framework [13], which is based on observation in the museum setting instead of school. It answers the question "it looks like fun, but are they learning?" [10], which sounds much more relevant in the school context than in informal settings. A one-year program guided by the teacher is far from any after-school program led by the museum's facilitators or activity in a tinkering space inside museums.

5. Acknowledgements

In Trento the project realized by MUSE–Science Museum is part of the Project TASK, founded by the Autonomous Province of Trento through the grant "I Comunicatori STAR della Scienza". In Torino the project has been designed and run by the Science Center Xkè? Il laboratorio della curiosità with Riconnessioni, a project of the Compagnia di San Paolo realized by Fondazione per la Scuola.

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Study of the Magnetic Field Current-Carrying Conductor of Various Geometric Shapes

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Abstract. The article presents a detailed description of an available compact measuring complex for studying the magnetic field of conductors with different currents based on the ATmega 328 microcontroller.

The conductor is fixed on the tablet (horizontal surface with a hole system containing a digital magnetic field sensor) with a thermoplastic adhesive. This makes it possible to investigate the magnetic field of not only closed circuits with a current of various geometric shapes, but also individual sections of the conductor. The use of a microcontroller allows to reduce the error of the obtained experimental results by automated repeated repetition of measurements and their subsequent averaging.

With the help of the developed complex, the Biot-Savart-Laplace law and the principle of superposition of the magnetic field for circular currents of different diameters, with different currents flowing through the circuit were verified using a graphical method.

It is established that the error of measurements of current strength and magnetic field induction does not exceed 10%.

Keywords. Microcontroller, Conductor, Circular Currents, Measurements of Current Strength, Biot-Savart-Laplace Law, Magnetic Field.

1. Introduction

Comprehensive knowledge of any physical phenomenon is achieved by observations and experiments with the unification of thought, word (record) and action. At the same time, the majority of school graduates, formulating laws and remembering various definitions, can hardly explain the simplest physical phenomena, that is, they do not possess the techniques of experimental work.

To get a complete picture of the phenomena being studied, young experimenters need to: do their own experiments, conduct observations, measure, etc. A student can go through all the stages of quantitative cognition of a phenomenon by performing independent laboratory work, in which mental activity is also accompanied by the activity of the organs of movement (motor).

The main components of magnetostatics are the law of Biot - Savart Laplace and the principle of superposition of the magnetic field [1], which allow to determine the force vector characteristic of the magnetic field (induction) of a conductor with a current of arbitrary geometric shape.

Therefore, the developed measuring complex will allow the student to verify in practice the basic laws of the magnetic field, and will also contribute to the formation of stable judgments about the phenomena studied. This will allow to get away from the formalism in the study of physics and magnetostatics in particular.

2. Designed laboratory setup

To study the magnetic field created by closed circuits and individual sections of conductors with current, a setup was developed consisting of two main components: a tablet and a measuring unit (Figure 1). In the center of the tablet, made of PCB, is a digital magnetic field sensor LSM303C [2]. The investigated conductor with current (CC) is fixed on the tablet with the help of thermoplastic glue; previously the contours of the conductor are applied with a marker. The ends of the conductor are threaded into one of the holes located on the surface of the tablet and are connected by connectors to the measuring unit.

The measuring unit (see Figure 2) contains: an ATmega 328 microcontroller (MCU), an analog current sensor ACS712 [3] (CS), a digital-to-analog converter (DAC), a voltage-current converter (CVC), a joystick control (J) and a liquid crystal screen (LCD), which displays: a module and three projections of the magnetic field induction vector, the current flowing through the conductor and the current adjustment step. The digital magnetic field sensor (MS) and the DAC are connected to the ATmega 328 via the I2C bus. The power supply

of the tunable current source is carried out using high-current lithium-ion batteries (PS), this allows the developed complex to be made mobile.

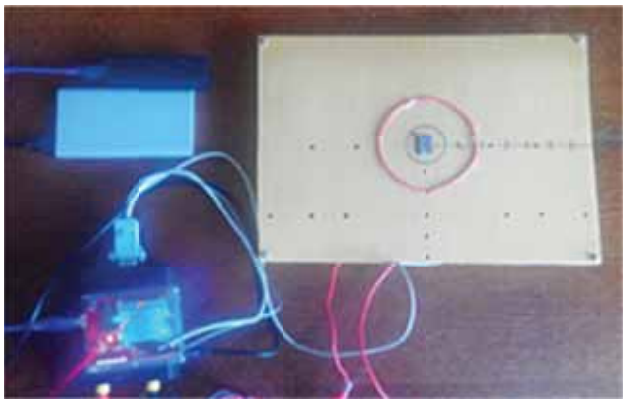


Figure.1 Designed setup

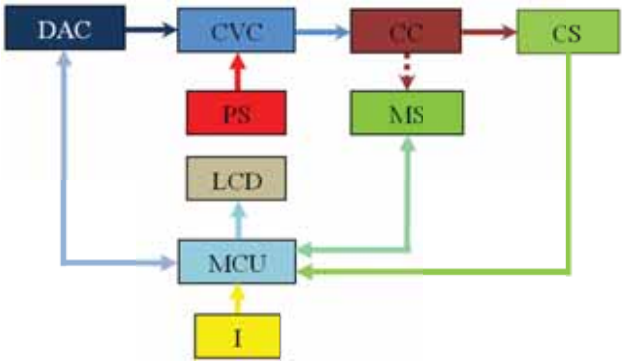


Figure. 2 The block diagram of the measuring unit setup

DAC and CVC are a controlled current source operating in the range from 0 to 3 A, with the smallest current tuning step of 12 mA. The DAC output voltage is converted to current flowing through a conductor (Figure 3). Moving the joystick up / down you can increase / decrease the value of the current flowing through the conductor, and when moving to the right / left - increase / decrease the step of adjustment of the current.

Since the output signal of the analog current sensor is voltage, the ACS712 sensor was calibrated (Figure 4). The voltage from the CS output goes to the analog MCU input, where it is digitized and averaged. By approximating the data obtained by the least squares method, a ratio was obtained which allows to recalculate the voltage into the measured current.

When the current does not flow through the conductor, the values of the "magnetic background" (Bx, By, Bz, B) in μT are displayed on the screen, due to the Earth's magnetic field and other sources of the magnetic field; the second line displays the data of the set value of the current through the conductor and the step of the current adjustment.

When you press the joystick button, the measurement mode is started and in the first line the current measured using CC value (I_e) and magnetic induction value (including "magnetic background") averaged over 200 values are displayed on the screen. The second line shows the values of the set values of the current and the step of adjustment (see Figure 5). In the upper right corner appears the inscription "On", indicating the operation of the setup in the measurement mode.

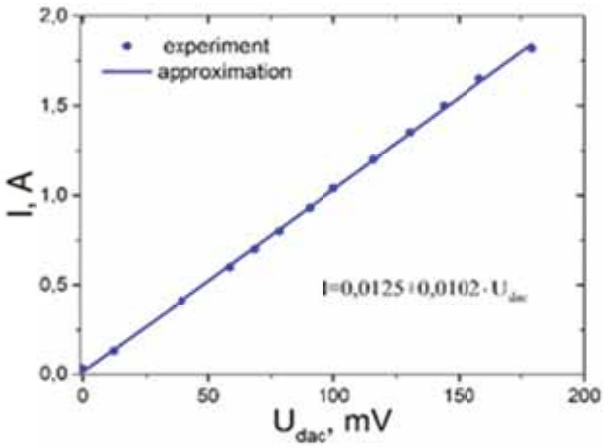


Figure.3 Dependence of the current at the output of the controlled current source on the output voltage DAC

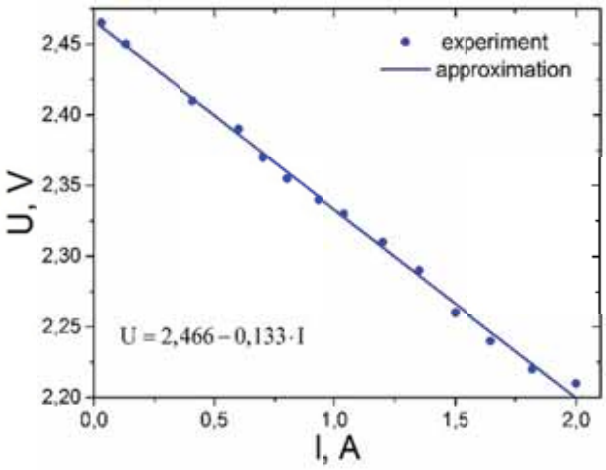


Figure. 4 The dependence of the output voltage of the ACS712 sensor on the flowing current

An experimental verification of the law of Biot-Sawart-Laplace and the principle of superposition of a magnetic field for a circular current (Figure 6) was performed in the work.

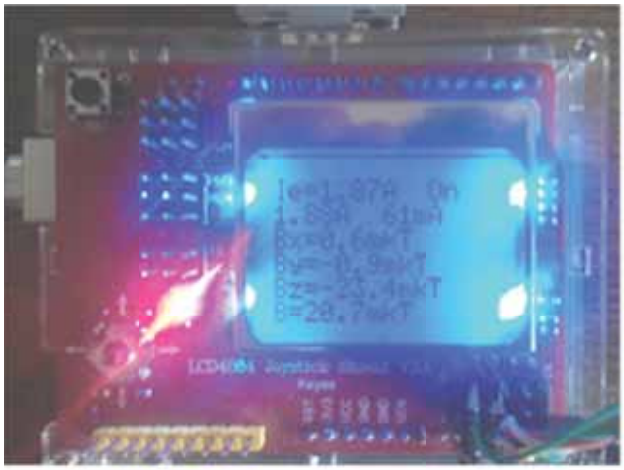


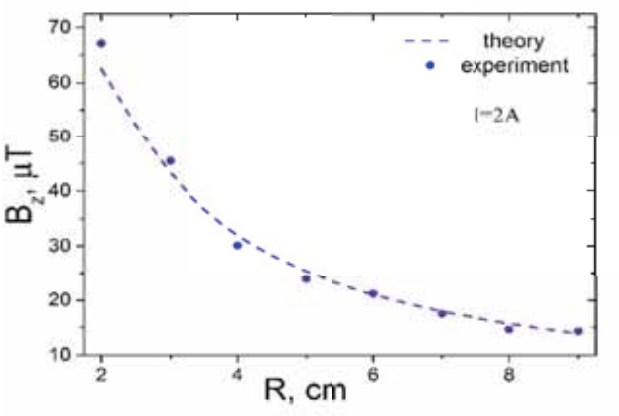
Figure. 5 Data obtained in the presence of current in the conductor

At the same time, the current strength (Figure 6a) and the radius of the circular coil (Figure 6b) changed. It can be seen from the figure that the experimental points fit well the theoretical dependences. The measurement error does not exceed 10%.

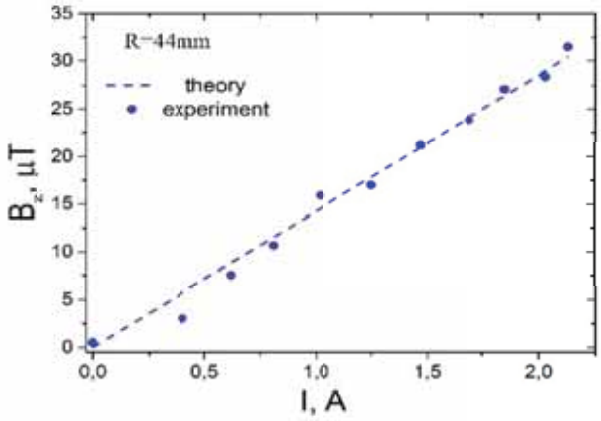
Since the current-carrying and test conductors are located in mutually perpendicular planes, only the projection of the magnetic field induction vector along the z axis is taken into account in the calculations. This allows you to significantly reduce the effect of auxiliary (supply) conductors with current on the measurement process.

The developed setup allows to check the principle of superposition of a magnetic field for closed circuits with a current of various geometric shapes: circular, square, triangular, etc., as well as to investigate the magnetic field created by individual sections of the conductor with current. Check the law of Biot-Savart-Laplace and the principle of superposition of the magnetic field.

It is also possible to connect several closed circuits, which makes it easy to verify the principle of the superposition of magnetic field induction. In this case, the student himself will have to calculate the values of the current strength through the conductors, taking into account their resistance (if there is one conductor, the current strength value will be displayed on the screen). If centimeter divisions are applied to the surface of the tablet, it is possible to investigate the magnetic field of the permanent magnets and determine their magnetic moment.



(a)



(b)

Figure. 6 Experimental verification data of the magnetic field of the superposition principle and the law of Biot-Savart-Laplace

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Experiments with Active Participation of Students

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Abstract. In our contribution we will present various experiments where participants will be actively involved. They will either be part of the experiment as an experimental material, and will examine, for example, their vision, hearing, conductivity, reaction time or they will model different physical processes. We will also show ideas for simple physics competitions and frontal experiments with simple tools.

Keywords. Simple Physics Experiments, Physics Competitions, Physics Tuition.

1. Introduction

In the paper we will focus only on a few selected experiments. We specify what tools are needed to implement them, how to proceed with the demonstration and what`s the physical explanation. We also draw attention to various technical details. This paper is a free continuation of our previous HSci contributions [1-3].

2. Human senses testing

2.1. Measuring the reaction time

2.1.1. Tools

Paper tape with a length of 30 cm approximately and 2 cm wide, crayons, stopwatches.

2.1.2. Procedure

Draw a colour scale on the paper tape, individual colour pieces can have a length of 2 cm. Hold the tape in your fingers. The person whose reaction time is measured prepares his/her fingers (thumb and forefinger) at the bottom part of tape – the fingers are about 2 cm apart. Drop the paper at some time. The second person try to catch it by his/her fingers. Measure the distance between the point where the tape was caught and the lower edge of the tape. You can also measure the time in which the paper tape (falling in the same orientation) drops this distance.

Figure 1. Measurement of the reaction time

2.1.3. Discussion and explanation

Typical value of reaction time is 0.2 s. In our case we did not measure the time, but the distance. It is easier and we do not need the stopwatch for each pair of pupils. The distance of the tape fall is usually about 20 cm.

2.1.4. Pedagogical and technical notes

Students in the classroom can do this simple experiment in pairs. The results can be written on the blackboard and finally you can calculate the average reaction time of the students. Of course, you did not measure the time, but the distance. The distance is 20 cm approximately and you can calculate or measure the adequate time. It is something like 0.2 second.

Figure 2. Searching of the blind spot

2.2. Blind spot
2.2.1. Tools

A sheet of paper, pencil or crayons.

2.2.2. Procedure

Draw a small circle and square on the sheet of paper so that the circle is on the left and the square on the right side. The size of the drawn objects should be about 1 cm and the distance 15 cm. Take the paper in your right hand and stretch it horizontally in front of you. Close your left eye and focus the right eye on the circle (which is at the left side of the paper). Try to see also the square but do not focus on it. Move the paper toward and backward the eye. In a certain position the square suddenly disappears.

2.2.3. Discussion and explanation

There is a small part of the retina called blind spot. When the light falls on this spot, we see nothing. In our experiment the image of the square hit the blind spot.

2.3.4. Pedagogical and technical notes

Students can be told that there is a direction in which we see nothing. We can discuss whether this fact can cause some dangerous situation.

2.3. Moving pictures
2.3.1. Tools

Patterns of pictures, scissors, glue, thread, skewers.

2.3.2. Procedure

Cut out the picture, bend over the marked line and lubricate with glue. In the middle we put either a piece of thread in such a way that both ends overlap, or a piece of skewer, here just to look out one end. Then glue the two parts together. We grasp the image by a thread (a skewer) and rotate it quickly. What will we see? (The sun is laughing; Bob throws the ball and the bat is waving its wings.)

Another variation of moving pictures: Cut out both pump pictures. Put them on each other and snap on the left edge with a stapler. Wrap the top picture onto a pencil. Then swipe it quickly over the bottom image. You see the pumper pumping.

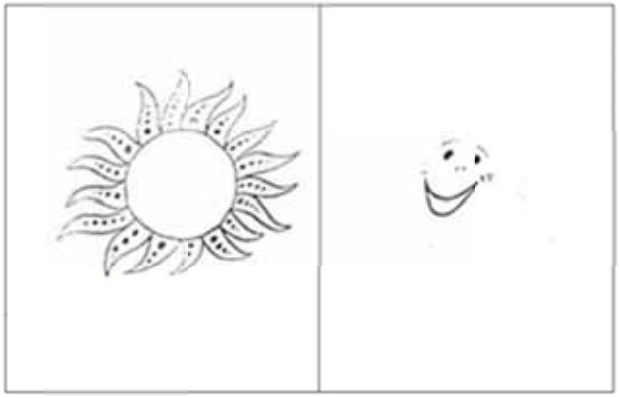

Figure 3a. Moving picture (var. 1)

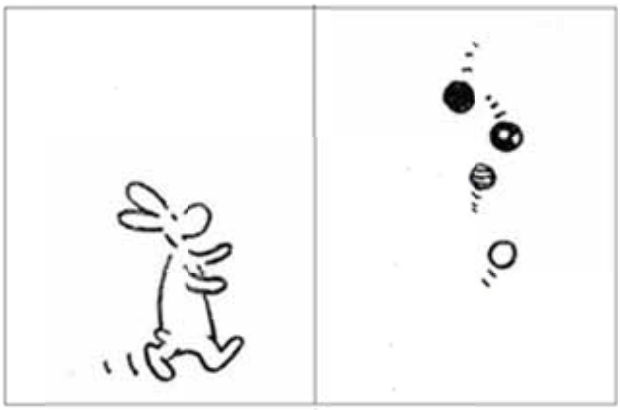

Figure 3b. Moving picture (var. 1)

Figure 3c. Moving pictures (var. 1)

2.3.3. Discussion and explanation

In moving image experiments we used the fact that eyesight has some "inertia". For fast moving images, we are not able to sharply distinguish one from the other, but merge us into a moving image.

2.3.4. Pedagogical and technical notes

Students can be inspired by the pictures we present here and draw their own. Alternatively, the images may be coloured.

Note: Backgrounds for moving images are taken from the Czech Association of Young Debrouillards.

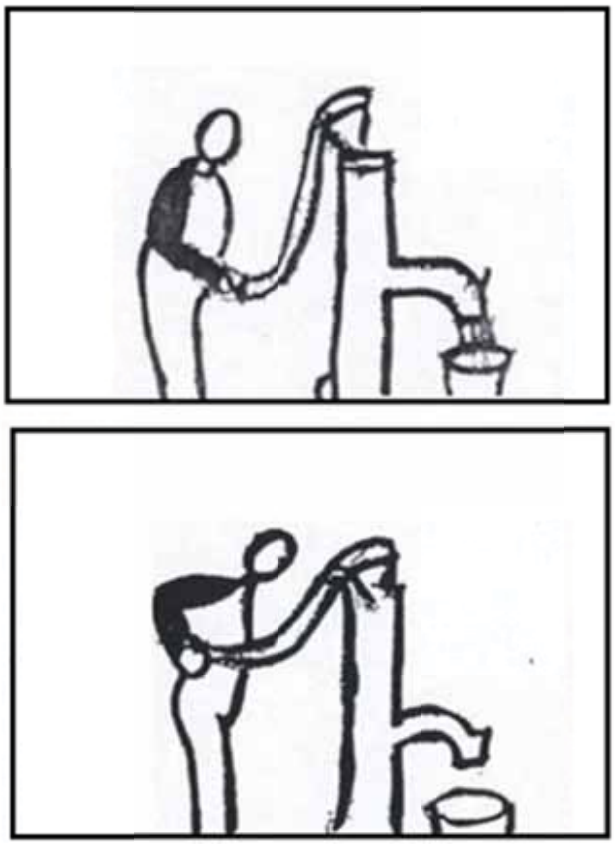

Figure 3d. Moving pictures (var. 2)

2.4. "Blocks" - weight perception
2.4.1. Tools

Two blocks with the dimensions of 10 cm x 10 cm x 5 cm and 10 cm x 10 cm x 2 cm. The bigger one is made of wood the smaller of iron (steel). Both blocks are covered by the same aluminium foil.

2.4.2. Procedure

Let someone hold the blocks so that the wood is underneath. Tell him to remember the weight of the blocks. Then let him hold the metal block itself. Ask what have more weight. Surprisingly, you get the answer that one block is heavier than both together.

2.4.3. Discussion and explanation

This is a kind of illusion. We expect that both blocks have the same density, but in fact the densities are very different. This is the reason, why we expect, that the bigger block is much heavier than the smaller one. But the opposite is true and our senses are confused.

2.4.4. Pedagogical and technical notes

Emphasize, how important measurements are. When we use scales, there is no surprise. On the other hand, our senses tell us something, what is not true.

Figure 4. Magic blocks

2.5. Man as a thermometer
2.5.1. Tools

Three cups (glasses), hot and cold water.

Figure 5. Fingers as a thermometer

2.5.2. Procedure

Prepare three cups. We put icy water in one, lukewarm in the other, and hot in the third (so we can put inside our fingers). Put the forefinger of one hand into the hot water and

the forefinger of the other hand into the icy water. Hold them there for a while and then put them in the lukewarm water. What do you feel when you dip your fingers in lukewarm water? Do they both “indicate” the same temperature?

2.5.3. Discussion and explanation

Fingers don't work as a good thermometer. With a finger in the icy water, we feel a higher temperature (lukewarm water is warmer to it) than with a finger in hot water (lukewarm water is colder to it).

2.5.4. Pedagogical and technical notes

Students should to try this experiment. Be aware that everyone can withstand otherwise hot water, it needs to be individually adapted. It's also interesting to try at home the temperature of hot water which students can tolerate for bathing and then compare the data at school.

2.6. Why we have two ears

2.6.1. Tools

Piece of garden hose (length approx. 1.5 m; diameter approx. 2.5 cm), pencil.

2.6.2. Procedure

We do the experiment in a couple. The one who tests his/her hearing takes the hose, leaves it behind his/her back and puts it to his/her ears. The other of the pair taps with a pencil in different places into the hose. The first of the pair signalizes by raising a finger if the sound came from the right or left side. (See Figure 6).

Figure 6. Taping into the hose

2.6.3. Discussion and explanation

For example, when you tap closer to the left ear, the sound reaches the ear before it reaches the right and the brain registers it.

2.6.4. Pedagogical and technical notes

Take care that students do not knock too much into the hose. The hose transmits the sound very well, and if it is attached close to the ears, a strong tap can be very uncomfortable. It is also necessary to watch over the students not to scream in their ears with help of the hose - this could be very dangerous.

3. What is the capacity of our lungs

3.1. Tools

Plastic or glass bottle (3 - 5 l), bucket (aquarium, bowl), plastic tube, straws, water.

3.2. Procedure

Glue the paper tape on the bottle from the top down, it`ll serve as a volume scale. We gradually pour half a litre of water into the bottle and always mark the water level on the tape (we can make the label directly on the bottle with a marker). Then turn the bottle full of water up into a bucket or other container of water. Insert the end of the plastic tube into the bottle neck (see Figure 7). Blow the air into the bottle after deep breathing and measure the volume on the scale.

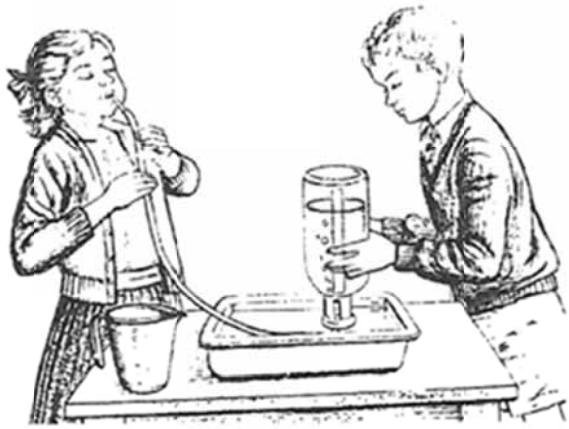

Figure 7. Measuring the capacity of our lungs

3.3. Pedagogical and technical notes

For hygienic reasons, always put a new straw on the end of the tube for each student.

4. Man as an electric source

4.1. Tools

Two pieces of different metal sheets (e.g. copper and zinc), multimeter with supply cables (or demonstration voltmeter).

4.2. Procedure

Connect the voltmeter to the metal sheets. Press the sheets between your fingers. Voltmeter shows voltage. Do the experiment with the multimeter switched to DC voltmeter mode with a range of 2 V or less.

Figure 8. Man as an electric source

4.3. Discussion and explanation

Our body works like an electrolytic solution. Chemical reactions are taking place at the interfaces of the plates and our fingers, which cause an electric voltage between the plates.

4.4. Pedagogical and technical notes

It is possible to make hand-shaped plates, as seen in the Figure 8. We can organize a contest who produces more voltage. When you moisten your hands with salt water or vinegar, you get more voltage.

Figure 9. Hoist from brooms

5. Hoist from brooms

5.1. Tools

Two brooms or longer rods, rope.

5.2. Procedure

Tie one end of the rope to one broom and then thread the rope through the broom handles as shown in the Figure 9. Then invite two strong boys to hold each handle firmly. Ask a slim girl to pull the free end of the rope. The girl easily pulls the two boys together.

5.3. Discussion and explanation

Brooms with a rope work like a hoist. With more rope threading, the number of "pulleys" increases, but friction also increases. We need to find the right balance between both.

5.4. Pedagogical and technical notes

Smooth handles work better for less friction.

6. Physics competitions

6.1. Going through a sheet of paper

6.1.1. Task

Go through a sheet of paper and don't tear it.

6.1.2. Tools

Sheet of paper, scissors.

6.1.3. Procedure

Cut the paper along a thin line. Then spread it and go through the resulting paper window.

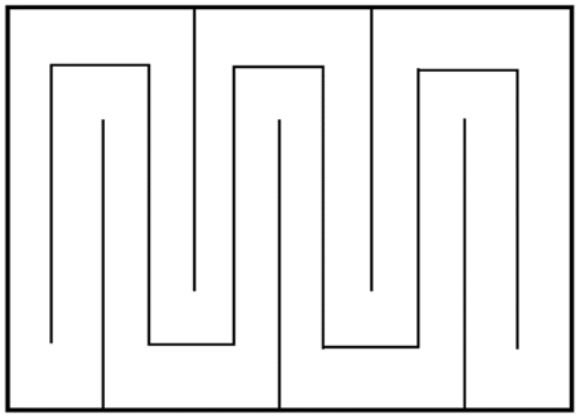

Figure 10. How to cut the paper

6.1.4. Pedagogical and technical notes

You can organize a competition for the largest possible paper window. Who will make a window through which a dog passes? Can anyone make a window for an even bigger

animal? And could an elephant go through the paper?

Figure 11. Dana goes through a sheet of paper...

6.2. Building bridge from a sheet of paper
6.2.1. Task

Build the strongest bridge from a sheet of paper.

6.2.2. Tools

Sheet of paper, weights for strength testing.

6.2.3. Procedure

It is necessary to devise how to adjust and strengthen the paper to bear the greatest load.

Figure 12. Paper bridges

6.2.4. Discussion and explanation

The bridge can be created in a variety of ways. The paper strengthens well, for example, by folding it into an “accordion” or rolling it up (see Figure 12).

6.2.5. Pedagogical and technical notes

The minimal length and width of the bridge must be determined in advance. For example, we can bridge school desks or chairs.

6.3. Immersing paper under water
6.3.1. Task

Immerse paper under water without getting wet.

6.3.2. Tools

Glass, aquarium or transparent plastic container with water, paper towel or napkin.

6.3.4. Procedure

Fill the aquarium or other larger container with water. Squeeze the paper and place it on the bottom of the glass to keep it inside. Then immerse the glass in the container upside down and take it out again.

Figure 13. Immersing paper under water

6.3.5. Explanation

There is air in the glass and prevents the surrounding water to enter the paper at the bottom.

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6.4. Blowing the paper ball into the bottle
6.4.1. Task

Blow the paper ball into the bottle.

6.4.2. Tools

Bottle (plastic or glass), paper (napkin).

6.4.3. Procedure

Make a small paper ball, place the bottle horizontally on the table, put the ball on the edge of the bottle neck and blow it inside the bottle.

Figure 14. Blow the paper ball into the bottle

6.4.4. Discussion and explanation

The ball blows out of the bottle neck if we blow sharply. The bottle is full of air, blowing inside we add more and compressed air escaping from the bottle pushes the ball out. If we want to get the ball into the bottle, it is necessary to blow gently on the ball, so that the air only enters the bottle through the bottom while through the upper part escapes out.

6.5. Pouring out water from the bottle
6.5.1. Task

Pour out water from the bottle as quickly as possible.

6.5.2. Tools

Glass bottle, wash-basin (water bucket), water.

6.5.3. Procedure

Fill the glass bottle with water and pour the water out of the bottle in a variety of ways (see pictures - in the third case, circle several times with the bottle to create the water vortex). In doing so, we measure how long the water flows out from the bottle.

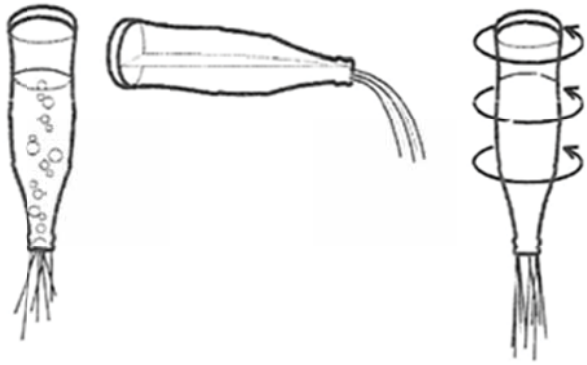

Figure 15. Pouring water from a bottle

6.5.4. Discussion and explanation

When pouring water, air enters the bottle instead it. The incoming air and the outflowing water interfere with each other. When circling the bottle there is a tunnel in the middle, through which the air can easily enter, and the water easily flows out down the walls. If we just turned the bottle, the air gets more difficult inside.

6.5.5. Pedagogical and technical notes

Another spectacular and probably the fastest way to get water from a bottle is to hold the bottle horizontally with throat apart from you and spin quickly. But that"s good to do outside.

6.6. Water tornado
6.6.1. Task

Pour the water as quickly as possible from the upper to the bottom bottle without squeezing it.

6.6.2. Tools

Two identical PET bottles with glued bottle caps in which a 10 - 13 mm hole is drilled in the center, water.

Figure 16. Water tornado

6.6.3. Procedure

Pour one bottle with water and attach the second bottle with the glued caps. We turn the bottles so that the full is up. The challenge is to pour water into the bottom bottle. We do this by swirling the bottles several times to create a water vortex.

6.6.4. Discussion and explanation

When swirling the bottles, a water vortex is created above the hole in the caps. The air from the bottom bottle flows through the water tunnel up to the upper one. The water flows down at the vicinity of the bottle side.

6.6.5. Pedagogical and technical notes

A good way to glue the caps is to roughen them and connect with a hot melt gun. It is still possible to insert glued lids into a piece of tube of suitable diameter for reinforcement. If you use large PET bottles, it is good to reinforce them on the side, with a wooden strip.

6.7. Inflating the plastic sleeve
6.7.1. Task

Inflate a plastic sleeve for as few breaths as possible.

6.7.2. Tools

Long plastic sleeve.

6.7.3. Procedure

You can get a long sleeve by sticking together several smaller parts. You can get suitable plastic packaging e.g. in a copy center. One person holds one end of the sleeve pressed to keep the air from escaping. The other person tries to inflate the sleeve for as few breaths as possible. Try different ways of inflating.

Figure 17. Inflating the plastic sleeve

6.7.4. Discussion and explanation

It is best to open the end of the sleeve end and blow into it from a slight distance. We will use not only the air from our lungs but also the surrounding air.

7. Conclusion remarks

Physics could be studied using various tools. We can use sophisticated and complicated devices as well as simple ordinary things. In this contribution we tried to introduce several hands-on experiments that students can actively participate in. In doing so, they can examine their body and senses. They can then apply their physical knowledge to various physics competitions and games. We would like to recommend also other works deal with similar topics [4-6]. We hope that you will enjoy some of them in your physics lessons.

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Electricity on Paper

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Abstract. The paper proposes a practical cycle of classes on electricity at school. The main goal of these classes is to form students' interest in physics and electronics, as well as acquaint them with the basics of building electrical circuits and their main components.

Keywords. STEM Education, Entertaining Circuitry, Practical Electricity Classes with Schoolchildren.

1. Introduction

Currently, the highest priority is STEM education, which covers the natural sciences, technology, engineering and mathematics [1-2]. The STEM learning space is a combination of new teaching technologies and flexible learning environments, and is designed to arouse children's curiosity and provide them with interesting learning materials. The main difference of the STEM approach is that children use their brains and their hands to successfully study a variety of subjects. Important components are self-preparation and the ability to work in a team.

As part of the implementation of STEM education in elementary school (grades 2-4), a practical cycle of classes in electricity is offered.

2. Practical classes on electricity with students

For classes use notebooks printed in them assembly electrical circuits. There are more than twenty different schemes with a description of the devices in which they can be used, as well as with the description, in a form accessible to children, observable physical phenomena, or phenomena on which the work of the components of the scheme is based. In addition, instructions for work and various clues are placed in notebooks, each work contains test questions and tasks for self-preparation.

In addition to notebooks, before each work, children receive a corresponding set of components used in the circuit, a conductive copper tape, a power source (3 V) and the simplest device for checking the presence of voltage in different parts of the circuit to be assembled. This device consists of a wire, colored needle tips, and an active buzzer that beeps when voltage is present.

On the assembly of one scheme, there are several classes. At the beginning of each lesson, the teacher works with the whole class: talks about a new electrical circuit; discusses issues that arise when assembling circuits; checks the performance of tasks for self-preparation. After this, the class is divided into groups of four people and the practical part of the lesson begins. Children distribute the responsibilities of each of the group members and start work; in the next classes, the duties are redistributed, which allows everyone to express themselves in different types of work.

Assembling the circuit is as follows. Cut off the pieces of copper tape of the required length. One side of the adhesive tape is dielectric sticky, the second is copper conductive. The adhesive side is glued to the paper, the components of the circuit and the power source are fixed on the conductive side, according to the assembly diagram, instructions for work and prompts. Copper tape is also used for fastening. The presence of voltage in different parts of the circuit, during assembly, is monitored by a device with a buzzer.

At the first lessons of this cycle, a galvanic battery GB (3 V) is used as a power source. Subsequently, children are introduced to renewable energy sources - solar batteries, in addition, ionistors (electrolytic capacitors with high capacitance) are proposed to use as accumulators of electrical energy [3].

Children assemble a simple device consisting of solar batteries and connected to them for charging ionistors (10 F). Later in the classroom, ionistors are used, which the children, if necessary, charge and use as a power source.

The proposed schemes in the classroom are arranged in a sequence from simple to complex. Simple schemes are replaced by more complex, in addition, in each work uses a new element in the scheme, with which you can

create more complex devices. For example, Figures 1 and 2 show electric flashlight circuits, the first one uses the usual red LED HL1, the second uses the RGB LED, which can emit different colors: the three primary colors and their combinations depending on the position of the S1 - S3 switches.

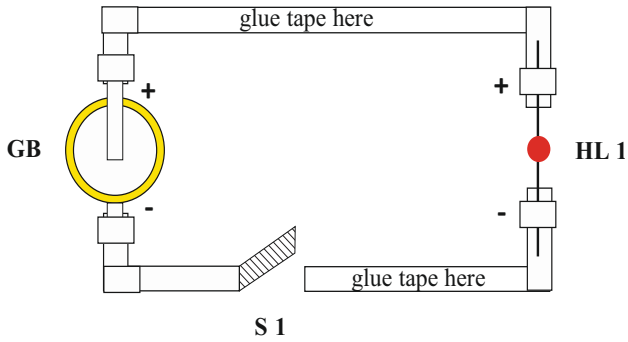

Figure 1. Flashlight

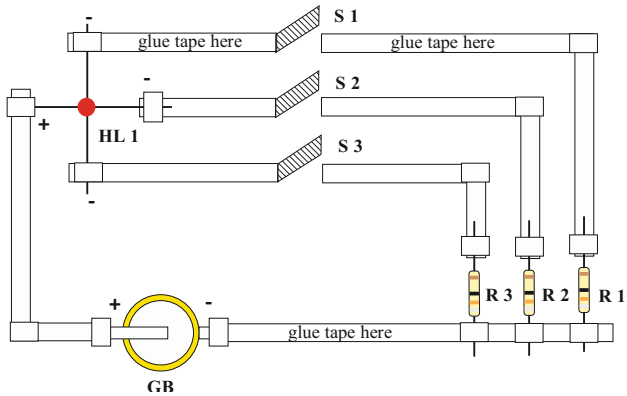

Figure 2. Multicolor flashlight

3. Conclusions

The idea of using copper conductive tape for building electrical circuits is not new, there are similar kits for sale [4]. The originality of this work is as follows:

- it is proposed to use copper conductive tape for assembling electrical circuits in notebooks (electricity on paper) during the practical training cycle in elementary school as part of the implementation of STEM education;
- describes the general algorithm for conducting classes in the classroom, the proposed work of children in groups of four with the distribution of responsibilities and the interaction of group members. This approach is necessary for the development of teamwork skills;
- in the classroom, children use their brains and hands. Developed fine motor skills in children 8 - 10 years old, when working with copper tape; the use of the simplest instrument to check for the presence of electrical voltage develops research abilities;
- renewable energy sources (solar panels and ionistors) are used as power sources in electrical circuits.

The proposed practical cycle of classes in electricity in elementary school is propaedeutic and precedes further activities with children on digital electronics and devices based on them in high school.

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Scientix, the Community for Science Education in Europe

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Abstract. Scientix promotes and supports collaboration among STEM agents (science teachers, education scholars, policymakers and other professionals) in Europe and beyond. The Scientix Teacher Panel includes Scientix Ambassadors that have mainly the mission to promote and inform at national level about Scientix activities, in schools and regional/national on symposiums, conferences and workshops. They can also assist in developing and testing tools and services of Scientix and ensure the pedagogical quality of the Scientix repository. As an example, in this work the experience and results of the activities performed as Scientix Ambassador in Galicia-Spain are presented.

Keywords. STEM, European Schoolnet, Scientix.

1. Introduction

Scientix [1] is an initiative for promoting scientific education and vocation in Europe that now brings together over 7000 teachers after several years in operation. Each particular group related with STEM education can obtain important benefits from Scientix, so [1]:

1. Teachers are able to:

a) Browse through the Scientix resources repository and find inspiration for your classes.
b) Get involved in European STEM education projects via our matching tool.
c) Participate in national and European workshops and professional development courses.
d) Download all presentations, videos and materials from our conferences, and stay tuned for future ones.
e) Participate in online training, webinars or communities of practice.

2. Researchers / project managers can:

a) Find teachers or schools to collaborate with by browsing the Scientix public profiles directory.
b) Browse through the project reports library.
c) Participate in the Scientix networking events for STEM education projects.
d) Co-organise an event with Scientix, increasing your dissemination and participants.
e) Present your project at Scientix conferences.

3. Policy makers are capable of:

a) Use the Scientix Observatory for information about national strategies in STEM education, and to keep up-to-date with the state of play in STEM education research and practice.
b) Get in touch with the STEM education community joining Scientix networking events, screening the public profile directory or using the match-making tool.

2. Structure, resources and activities

Coordinated by European Schoolnet [2], a non-profit organization and network of thirty-one European education ministries, Scientix receives funding from the European Commission through the 7th Framework Program and has contact points in every EU country. In Spain, this role is currently fulfilled by the National Institute of Technology and Professional Development (INTEF) at the Spanish Ministry of Education and Vocational Training (MEFP) [3].

Over the course of the project, Scientix assigns a series of representatives or ambassadors in each country whose aim is to spread the word about its activities among the teaching community throughout Europe, help share knowledge and best practice in science education, and support and improve scientific education in general at a local level. The panel of Scientix ambassadors is one of the three main support groups for the implementation of Scientix activities and support STEM

Education. Spain currently has 58 Scientix ambassadors for the 2016-2019 period, five of whom are linked to different Spanish universities while the others are mainly secondary school teachers. The main task of all Scientix Ambassadors is to support the dissemination of Scientix, to provide ad hoc help in surveys, feedback requests, etc. and to report back to Scientix on their actions. They participate, for example, in activities to raise awareness of the research going on in different science and technology centres not only among the general public but, particularly, among students undertaking training who are likely to find their vocation through direct interaction with labs and research teams. At the same time, the ambassadors present Scientix at education centres, national/regional teachers' associations, congresses and workshops, and they advise other teachers on how to get involved in European STEM collaboration, in the belief that professional development of teachers should include active participation in cooperation and collaboration networks. The ambassadors can undertake assessment and monitoring tasks for projects/tools for teaching innovation at a European level and, at the same time, help not only to publicise the resources, projects and training Scientix offers but also to provide information about periodical events. Scientix Ambassadors are normally involved in the preparation of Scientix Webinars [4], Scientix Moodle courses [5] and in the writing of Scientix blog articles [6].

Scientix currently provides free direct access to over four hundred European educational projects and almost two thousand teaching resources for the classroom, many translated into the 30 official languages of the EU or available for translation by Scientix on the specific request of teachers when the need arises. Around seven hundred resources have already been translated in this way. Scientix periodically offers online training, inviting users to freely access video conferencing programs in twenty-four languages and various formats: Massive Online Open Courses, seminars or workshops, etc.: spaces for learning that are also times and places for sharing and exchanging ideas. For example, in webminars commonly involve up to 200 people at different sites all connecting for an hour with the possibility of interacting with the speaker in some way. In Scientix training actions participants receive a course badge and/or a course certificate upon completion of the activity (Figure 1). For example, recently the 'STEM Is Everywhere!' MOOC offered a selection of resources, tools and strategies for activities for primary and secondary teachers to connect STEM teaching, in an entertaining and an interdisciplinary way, with "real life" and real-world problems" [7].

Figure 1. 'STEM Is Everywhere!' MOOC: course badge

Figure 2. 2nd National Congress of Scientix. Madrid

Of course, it is possible to subscribe to the online newsletter tailored for a specific topic which also gives information on news and events and reminders of upcoming activities, competitions, awards and training possibilities. Meet-ups are held nationally and internationally

– meeting points in the form of seminars or congresses.

In our case, the 2nd National Congress of Scientix was held in Madrid on 2nd-3rd February 2019 and ran during a day and a half. Organized by INTEF and the Spanish Foundation for Science and Technology (FECYT) with the objective to facilitate the exchange of knowledge and practical activities for STEM learning (Figure 2). Near 200 STEM teachers and experts from all over Spain participated in the event that held more than 30 communications, round tables and hands-on workshops with a lot of innovative educational practices, best methodlogical tools and project results [8].

3. Activities as Scientix Ambassador during the 2018-2019 academic year

Usually, it is difficult to change teaching practices in school and it is difficult to show new tools and experiences to teachers with a formal intervention. So in order to show them Scientix possibilities we employ our experience and know-how mainly in their schools, trying to show how new methodologies impact direcly in their pupils. Therefore, during the 2018-2019 academic year the strategies used to spread and share knowledge include face-to-face seminars with students, teachers and the management and departmental teams in high-schools. In our case we use first a motivational talk packed with fun experimental material in the belief that practical experiments and activities can inspire and help the students to develop a conceptual understanding of the ideas in the curriculum and the competences associated with using the scientific method, such as critical thinking, group work, and so on [9].

These seminars aim to show experimentally the relationships between the contents of secondary and pre-university Physics topics and the knowledge needed to study Engineering or a scientific degree – encouraging learners to lose their fear of science, technology, engineering and mathematics and to start seeing them as an appealing option they could dedicate their time to in the future (Figure 3). At the same time, this intervention on their own doorstop in schools means informal collaboration networks can be created with the teachers in the places where they work by providing information about the different tools and resources available through Scientix, encouraging them to take part in the activities, and providing them with updates and news about events. As for example, the STEM Discovery Week 2019, a joint international initiative that invites projects, organisations and schools across Europe and around the world, to celebrate careers and studies in the fields of STEM [10]. During last campaign, around 4700 schools from 40 countries were involved in 7 competitions, with 800 submissions and 162000 participants [10].

Figure 3. Activities as Scientix Ambassador in secondary and pre-university centres during the 2018-2019 academic year

We have also the possibility to spread information about reports coordinated by the Scientix observatory [11], which provides periodically relevant studies on the state of the art of different topics related to science education. In particular the recent reports related with STEM Education Policies in Europe [12] and Education Practices in Europe [13] are recommended for any education professional.

During the 2018-2019 academic year, there have been 23 talks that have taken “Learning Physics by Doing Physics” and the Scientix project to around 1600 students and 150 teachers (Figure 3) [9]. At the same time practical classes and workshops for teachers,

education researchers, policymakers, and other education professionals in the areas of science were presented in regional, national and international symposiums, conferences and workshops (Figure 4) [14-18].

Figure 4. Activities as Scientix Ambassador at University of Burgos (Spain), University of Salamanca (Spain), Pontificia Universidad Católica del Perú (Peru), Universidad Nacional Mayor de San Marcos (Peru), ENCIGA Meeting (Spain), and University of Barcelona during the 2018-2019 academic year

4. Conclusions

Scientix, the community for science education in Europe, promotes and supports a Europe-wide collaboration among STEM teachers, education researchers, policymakers and other STEM education professionals, where we have the opportunity to share their experiences and best practices with peers and start new collaborations. An important way of keeping up with Scientix initiatives is by following the project on social media, where the organisation has over fifteen thousand followers on Twitter [20]/Facebook [21], which are open to collaboration from anyone interested in STEM education. Persons interested in obtaining quick information can also subscribe to Scientix email updates to get all the latest news [22].

5. Disclaimer

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Chornobyl: a History of the Past or a Demonstration. How Science Can Solve the Problems of the Future?!

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Abstract. The possibilities of a well–known historical event as a starting point for teaching various scientific and technical aspects are shown. In particular, it is indicated how, as an example of the Chornobyl disaster, it is possible to elucidate in detail the principles of the work of the nuclear power engineering and the scientific basis of the processes that took place during and after the accident (based on sections of the school course of physics covering nuclear physics). It is also indicated for scientific discoveries and implementation, as well as engineering and technical solutions that were used during the elimination of the consequences of the accident. Thus, one man–made disaster allows us to disassemble this problem from the history of science and technology, physics, chemistry and ecology. Thus, this approach allows us to introduce the aspects of multidisciplinarity into learning, and to point out the interconnections of different types of sciences, which promotes a better understanding of the need for comprehensive development by students, and motivates the study of natural sciences [1–2].

Keywords. Chornobyl, Nuclear Physics, Power Engineering, History of Science, Chemistry, Ecology, Safety and Health, STEM Education.

1. Introduction

The example of the Chornobyl disaster will detail the principles of atomic energy and the scientific bases of the processes that occurred during and after the accident (physics section of the high school program on nuclear physics). Scientific discoveries and implementations, including the use of rapidly evolving alternative energy sources, as well as engineering and technical solutions used to eliminate the "aftermath" of the accident, will be analyzed and discussed (some issues of physics, chemistry and ecology will be considered). An important part of the project is labor protection and civil defense.

2. History

More than 30 years have passed, and the rainy day of the Chornobyl tragedy continues to excite people: both those whom he hooked with his black wing, and those who were later born far from the crippled land. This day did not pass without a trace – an unprecedented scale of tragedy struck the whole world.

The disaster of the Chornobyl Nuclear Power Plant (officially named the Chornobyl Nuclear Power Plant in honor of Vladimir Ilyich Lenin) that occurred at reactor No. 4 On April 26, 1986 is well known to everybody. It has been widely regarded as the worst accident in the history of nuclear power. It was the reason of large restricted area known as the Chornobyl Exclusion Zone appeared. Pripyat city and several other settlements were abandoned.

Due to the Decree of the Council of Ministers of the USSR of September 29, 1966 on the commissioning of energy capacities was planned to generate 11.9 million kW of power. After this Decree 8 million kW was planned to be generated by nuclear power plants. In the southern part of the USSR was planned to build a nuclear power station, which should provide electricity to the Central Energy Region – 27 regions of the Ukrainian SSR and Rostov Region with a total population about 53 million people.

It was taken into account that the most economically feasible radius of power supply is about 350–450 km. After the survey of 16 construction sites it were proposed two of them: near the village of Ladyzhiny, Vinnytsia region, and the village of Kopachi, Kiev region. The first name of the station was "Central Ukrainian NPP". The well–known Chornobyl Nuclear Power Plant in honor of Vladimir Ilyich Lenin appeared later.

On August 15, 1972, the first cubic meter of the main building concrete was laid. On September 26, 1977, the first Ukrainian nuclear power plant was run. The first power unit of the

Chornobyl nuclear power plant consisted of two RBMK–1000 reactors. The third and fourth power units with similar reactors were finished by the end of 1983. It was planned to run the fifth and sixth power units with the same reactors. But after the accident at the fourth power unit all constructions were stopped.

Directly in the Pripyat river valley to the south–east of the NPP site in order to provide cooling for turbine condensers and other heat exchangers of the first four power units, a 22 km² bulk pond cooler was built. It was planned to use cooling towers built near the fifth and sixth blocks under construction to ensure the cooling of heat exchangers. But the disaster happened earlier.

The accident at Unit 4 of the Chornobyl nuclear power plant occurred on April 26, 1986 during the safety systems tests. Two situations were simulated. The first was connected with complete loss of power supply to nuclear power plants, including main circulation pumps (MCP) and pumps for emergency reactor cooling system. The second test simulated the accident, in which considers the reactor circulation loop large diameter pipeline rupture.

The project provided that when the external power was turned off, the electricity generated by the turbo–generators due to run–out is supplied to start the pumps included in the emergency reactor cooling system, which would ensure guaranteed cooling of the reactor. It was the only attempt to do such experiment with RBMK – 1000 reactor from the time them were putted into operation.

Tests were scheduled to be held in the afternoon of April 25, 1986 on the basis of the reactor No. 4. The reactor thermal power at that time should be 700 MW, after which it was planned to shut down the reactor for scheduled repairs. Thus, the tests should have been carried out in a reduced power mode, which is characterized by an increased (relative to the nominal) flow rate of the coolant through the reactor, a slight heating of the coolants to the boiling point at the entrance to the core and minimum vapor content.

Tests began at 1:23:04. The four main circulation pumps began to work from the residual rotation of the turbogenerator. That leads to the decreasing of water flow and increasing steam content.

At 1:23: 43 a great increasing of power began. The three explosions sounded immediately. The reactor was destroyed, and huge volumes of radioactive substances came into the atmosphere. Reactor No. 4 was in fire.

The liquidation of the consequences began at the same night. Within a few hours after the destruction, firefighters and Chornobyl personnel were able to eliminate numerous fires, which prevented the threat of fire spreading to other power units. The risk has been huge because the 3rd power unit was located in the same building as the 4th.

On April 27, helicopters began to drop the protective materials into ruined building. After the two weeks of deadly work, the materials covered the central hall with a ball from 1 to 15 meters thick, isolating the reactor from the environment. At present, a new sarcophagus over the emergency 4th power unit has been commissioned. The new sarcophagus (called the “New Safe Confinement” (NSC)) was pushed into its design position in November 2016. The project was completed in May 2018.

3. Nuclear reactor physics

A nuclear power plant differs from a thermal one only in that the steam for turbines is heated by the energy of a nuclear reaction – the fission of uranium nuclei into two (occasionally three) large fragments. This process attracted the attention of physicists primarily because it can self–sustain, since it belongs to the chain.

Such a well–known chemical reaction as combustion goes on its own – it only needs fuel, an oxidizing agent and initial heat input. The “burning” of nuclear fuel is more difficult to ensure: for the nuclei to be divided, a personal match must be brought to each of them – a neutron. But nature provided this opportunity – during the decay of a nucleus several neutrons with an energy of about 2 MeV fly out. The chain reaction will continue if at least one of these neutrons, absorbed by the new nucleus, causes its fission and the appearance of the next generation neutrons. The ratio of the number of neutrons participating in a certain stage of a nuclear reaction to the number of neutrons of the previous generation at the same stage is called the multiplication coefficient K. This quantity completely determines the dynamics of the chain process:

at K = 1, the reaction proceeds at a constant speed, at K> 1 it accelerates, at K <1 goes out.

It would seem that since fission of one nucleus releases two or three (on average 2.3) neutrons, it does not cost anything to achieve an accelerated or at least stationary reaction. In fact, this is not easy at all, because for many reasons neutrons are eliminated from the game.

Having flown out of a split nucleus, a neutron can simply go beyond the limits of the reactor core. To reduce the likelihood of such a loss, the reactor is made large enough, and the core is surrounded by a reflector – a substance whose nuclei do not react with neutrons, but play the role of a barrier preventing their rapid leakage. If the neutron remains in the core, another danger lies in wait for it – entrapment of an impurity or structural material by the nucleus. Suppose this did not happen. Then, sooner or later, the particle will be absorbed by the nucleus of one of the uranium isotopes – 238U or 235U. When fast neutrons are absorbed in 238U, fission occurs only in 5 cases out of 100, and in the remaining 95, 239U is formed, and the neutron falls out of the multiplication chain. The nucleus of 235U will split in 85 cases out of 100, and only 15 neutrons will be uselessly spent on the formation of 236U. Natural ores contain 99.3% of 238U, while 235U contains only 0.7%, and in addition, the probability of capturing fast neutrons by the heavy isotope of uranium is much higher than light. Therefore, in pure natural uranium, a self–sustaining chain reaction does not occur.

If the neutron is not captured immediately by uranium, it wanders for a while inside the core, colliding with different nuclei and losing speed. In the end, its energy drops to 0.025 eV – the average energy of thermal motion and does not change anymore. Such slow, or thermal, neutrons are no longer able to cause 238U fission and, when absorbed by this isotope, will inevitably be lost for the reaction. But thermal neutrons can lead to fission of 235U nuclei — moreover, they are captured by a light isotope much more often than by a heavy one. But, slowing down in collisions, neutrons inevitably pass through the region of intermediate energies (1–10 eV), in which the probability of capture by 238U nuclei reaches a maximum. Therefore, if you do not take special measures, most fast neutrons simply do not have time to turn into thermal ones.

The solution was found in the use of a moderator – a substance, when moving in which neutrons are not captured, but quickly lose energy. Usually, uranium is placed in a moderator in small portions at a certain distance from each other. Fast neutrons arising from the fission of uranium in one of these parts, fly out of its limits in the moderator. Here the particles reduce the speed to thermal and then can travel for a long enough time until they again fall into uranium. Now they will almost certainly be absorbed by the nuclei of the light isotope and cause new fissions. The chain reaction goes further.

We touched on only a small part of the problems arising in the development of a nuclear reactor. Scientists and designers have to take into account many different factors, and most importantly, take into account that each of them can change over time, and take care that no changes can interfere with confident control of the reactor.

4. Power engineering

The traditional system of training high school students and then specialists in our country's technical colleges includes their theoretical and practical training in specific educational programs and curricula. It is mainly based on the transfer of scientific and technical knowledge to students and students and practically does not prepare them for those realities of life that the future specialist will encounter when it comes to production.

This problem becomes most urgent when it comes to preparing future specialists at the universities of the country for those industries that work with some risks to human life and the environment. These industries are, in the first place, first and foremost – large, sophisticated technical systems with many different objects and connections between them. These industries include, first of all, energy, metallurgy, the chemical industry, enterprises serving the military and space complex, and others. Confirmation of the extreme importance of this problem is the increasing number of technical (man–made) accidents and catastrophes in all countries of the world. Suffice it to name the accidents at the Three

Island nuclear power plants (USA), Chornobyl (Ukraine), Fukushima (Japan), the Sayano–Shushenskaya hydroelectric power station (Russia), the devastating accidents at the Baosian hydroelectric plants (China), the explosions and the fires at the plants, producing ammunition, serious transport accidents, offshore drilling rigs. They are all related not only to huge material losses, but also to human casualties, which are estimated by hundreds and thousands of people.

Numerous commissions investigating such at the technical sites, in the end, made the same conclusion: the cause of all these accidents, in the vast majority of cases, was the "human factor", i.e. the mistakes of people at different stages of the technical life facility or system, those people who designed these facilities, installed them, repaired the equipment, or engaged in their operation.

Therefore, the development of methods, techniques and skills that would help high school teachers and technical colleges, against the background of transferring scientific knowledge, to form in the students the professional skills they need for further practical activity, which would eliminate possible mistakes in design, montage and the operation of technical facilities and reduced the likelihood of accidents on them.

Based on the above, part of the teacher training program will be related to the study of the basics of building energy facilities and systems, environmental and energy security of the country and the principles of safe operation of Ukrainian energy facilities.

5. Chemistry

5.1. Immediately chemistry: three main problems of Chornobyl

After the 4th power unit explosion 3 main problems immediately appeared. In this case chemical engineers were needed to solve them. The first was to extinguish the reactor without using water, the second was dust suppression, because the main environmental pollution was caused by the emission of huge amounts of radioactive dust into the atmosphere. The third was the decontamination of buildings, roads and equipment. Unfortunately, there were no prepared action algorithms in these conditions.

In order to solve the first problem scientists decided to drop bags of sand, dolomite and lead (plumbum) from helicopters directly into the burning reactor. But this could only be done from a height of 200 m due to the difficult radiation situation (Figure 1).

Figure 1. A helicopter over sandbags with dolomite and parachutes with boric acid and liquid rubber [3]

The complexity of the work was explained by the necessity to hit the bags into the target. Lead was used in order melt to decrease the temperature of the hot radioactive fuel. At the same time a lead film is formed and reduces the radiation background. In addition, dry boric acid was also dumped into the burning reactor for efficient neutron absorption. Of course such activity caused dust formation which could not be allowed. At this time a chemical mini–workshop was immediately built to create special compositions that could quickly polymerize on the surface, forming insoluble films. Chemists on the spot improved these solutions, using combined polymers, phosphate compounds.

To solve the problem of dust suppression, liquid rubber was first used. It also was dumped directly on hot fuel. In addition to its main purpose, it reduced the temperature inside the burning reactor. After that vinyl–acrylic and bitumen–water emulsions were used (Figure 2).

Figure 2. Helicopter sprays dust suppression reagents [3]

The difference between them is that bitumen–water emulsions can collect dust particles into agglomerates and do not form a solid film like acrylic copolymers. These methods of dust suppression are the most effective and used all over the world. Such components were also used for the treatment of dirt roads on the territory of the Chornobyl nuclear power plant.

After the reactor explosion a radioactive cloud got into the air. The most active isotopes which are short–lived (the half–life is only eight days) were the most dangerous. First was iodine. The problem was in his high activity and ability to digest by living organisms and accumulated in the body which is the worst. Therefore, doctors spoke most of all about iodine, prohibited the greens from eating, checked milk very carefully and provided all workers with respirators to prevent thyroid glands from iodine penetration.

A month later radiochemists shifted their attention on plutonium when the biggest part of the radioactive iodine decayed. It is known as long–lived and toxic. Its accumulation even in small doses is quite dangerous for lungs.

Surfaces of buildings, equipment, and special vehicles were deactivated by different physicochemical methods from pollution of a mixture of fission products of uranium, radioactive isotopes and plutonium. All of them were based on washing surfaces with special solutions (Figure 3).

Figure 3. A helicopter sprays decontamination solutions [3]

Figure 4. Deactivation of the territory and vehicles [3]

These reagents either dissolve or combine radioactive isotopes into complex compounds that have to be removed in the end. For this purpose, chemists used surfactant solutions (gardinol, sulfonol, wetting agents OP–7, OP–10) and complexing agents. These substances significantly increase the deactivating ability of surfactant solutions, forming complex compounds with many metals (products of a nuclear explosion) that are quite soluble in

water. When these compounds appear, the bonding forces of the radionuclides with the surface weaken. As a result, they can be easily removed from the contaminated surface. In order to maximizing efficiency of the decontamination process, solutions were prepared no late than a day before the use.

The treatment of equipment consisted of three stages: washing under high pressure, treatment with deactivation solutions and its subsequent washing off under high pressure (Figure 4).

5.2. Immediately chemistry: solution of radioecological problems

Even three decades after the Chornobyl disaster, in modern Ukraine, the development of effective sorbents for the extraction of radionuclides from aqueous solutions and soil is relevant because of the importance of radioecological problems caused by the accumulation and spread of radioactive contamination in the environment. The spread of radionuclides is facilitated by their high migration ability (especially strontium, cesium, uranium and technetium).

Solving these kinds of problems requires the combined efforts of scientists and developers working in various fields – environmentalists, chemical technologists, agrochemicals and biotechnologists.

Of particular interest in this regard are sorbents of natural origin, modified by artificial chemicals that combine sorption efficiency with harmlessness (and preferably – with benefit) to the environment, in addition, their use should have an economic effect.

All these requirements are fully met by humic and humic acids extracted from peat and lignite of Ukrainian deposits and sorbents made on their basis. These bioorganic substances exhibit high sorption capacity against radionuclides, heavy metals and other ecotoxicants, irreversibly linking the latter to chemical complexes. This property is especially valuable and relevant in conditions of high technogenic load, when in the form of dust and ash fall harmful compounds during the work of large industrial enterprises, as well as the level of radiation pollution. The introduction of humic preparations promotes the formation of insoluble sedentary complexes, which are derived from the circulation of substances in the soil. Thus, the products produced on such soils are much more environmentally friendly [4–5].

Due to carboxyl, hydroxyl, carbonyl groups and aromatic fragments humic acids enter into ionic, donor–acceptor and hydrophobic interactions, i.e. humic substances are able to bind different classes of ecotoxicants, which, together with their ecological properties, are natural, effective and natural which fully comply with the principles of green chemistry [6–7].

The heterogeneity of the structure of carboxylic acids on the one hand, gives an extremely wide range of properties, and on the other – nonspecificity of action. This can significantly complicate the process, so the task of creating humic substances with a more directional action does not lose relevance.

Modifications should be made to enhance the reducing properties (to neutralize oxidized actinides, such as plutonium). Phenol–formaldehyde condensation of hydroquinone and humic substances makes it possible to create a fairly environmentally friendly and effective reducing agent.

The sorption capacity can be increased by tying the gum to the mineral matrix. Given that the major constituent of natural minerals is silica, the most convenient way is to form a Si–O–Si bond between the humic substance and the mineral matrix. Then it is possible to obtain a powder with surface–active groups, which, upon dissolution in the reservoir, will adhere to the mineral surface.

By changing the degree of modification of humic substances, you can control the properties that will have a humic film, reaching the maximum degree of extraction of radionuclides.

Thus, on the example of sorption purification from soil radionuclides and natural reservoirs contaminated as a result of the Chornobyl disaster, as well as the reclamation of the affected territories, students of different specialties can be trained in solving technical and environmental problems at the intersection of sciences.

6. Ecology

Despite the fact that the Chornobyl nuclear power plant is located in Ukraine, Belarus suffered the most after the accident, about 60% of the emissions fell on its territory, and some of the radioactive dust settled on the lands of European countries (Sweden, Finland and Austria).

As a result of the accident, radioactive fallout contaminated more than 200 thousand square kilometers of Europe. Over 1 million people turned out to be in dangerously contaminated territories. Pollution of more than 1 Ci per square kilometer spread to 9% of the territory of Ukraine, among which 18 out of 25 regions of Ukraine with a total area of 42 thousand square kilometers. 5 million hectares of land were withdrawn from agricultural practice.

As a result of radioactive decay, exposure to rain and wind, human activities and countermeasures, the surface contamination of urban areas with radioactive material was significantly reduced. However, as a result of the decontamination of urban areas, significant volumes of low level radioactive waste were generated, which, in turn, created the problem of their disposal.

After the Chornobyl accident, the highest levels of absorption of radioactive cesium were recorded in forest vegetation and in animals living in forests and hills. In Western Europe, a number of countermeasures are still being applied to livestock products raised on higher elevations and in wooded areas due to the high and sustained absorption of radioactive cesium by the affected extensive farming systems.

The environmental response to the Chornobyl accident was a complex interaction of factors such as the accumulated dose, dose rate, and its temporal and spatial variations. Both individual and group effects caused by radiation–induced cell death were observed in plants and animals as follows:

a) increased death of conifers living in the soil of invertebrates and mammals;
b) loss of reproduction in plants and animals;
c) chronic radiation syndrome in animals (mammals, birds, etc.).

The use of wood and wood products makes only a small contribution to the dose of the population, although the ash may contain large 137Cs activities and potentially lead to higher doses than with other uses of the tree. Forest fires increased the concentration of radionuclides in the air in 1992 and represent the danger of the involvement of radionuclides in the circulation of substances to this day.

High concentrations of radioactive substances in surface waters immediately after the accident quickly declined, and at present, the concentration of radionuclides in drinking water and in irrigation water is very low. However, the groundwater in the region of the accident is close to the surface, so the Chornobyl radionuclides in the coming years after the accident ended up in the groundwater of other European countries. Bioaccumulation of radioactive cesium in the aquatic food chain has led to significant concentrations of radionuclides in fish in the most affected areas, as well as in some lakes located at a great distance, for example, in Scandinavia and Germany.

7. Labor protection and civil defense

An important part of the Chornobyl curriculum is related to the study of some issues on the basics of occupational safety and health. A comprehensive and consistent set of safety requirements sets out the mandatory requirements that must be met to protect people and the environment at present and in the future. Such requirements are governed by the objectives and principles of the security framework. If the requirements are not met, steps must be taken to achieve or restore an adequate level of security. The format and style of the requirements form the basis of a national security regulatory system. The requirements are defined by the relevant parties such as: – State, legal and regulatory basis for security; – Safety management and management; – Radiation protection and safety of radiation sources; – Assessment of the safety of nuclear installations and their operation; – Management of radioactive waste before long–term storage; – Decommissioning and decommissioning of nuclear facilities; – Emergency preparedness and response, etc.

The designs of many existing nuclear power plants, as well as the designs of new nuclear

power plants, have been refined by incorporating additional measures to mitigate the consequences of complex accident scenarios, including dependent failures and severe accidents. Many existing NPPs have been additionally equipped with additional systems and equipment with new functionalities designed to help prevent severe accidents and mitigate their effects. According to the requirements of the International Atomic Energy Agency (IAEA), full–scale simulators were created at all Ukrainian NPPs with mathematical modeling of processes, including emergency ones, where operational personnel are trained and tested. New NPP projects now directly include analysis of severe accident scenarios and strategies for managing such accidents. The design of nuclear power plants is also guided by the requirements relating to the state system of accounting and control of nuclear materials and the requirements related to ensuring physical security.

In order to achieve the highest possible level of safety in the NPP project, it is necessary to provide for such measures that meet national and international criteria and security objectives for:

a) the prevention of accidents with adverse effects resulting from the loss of control of the reactor core or other sources of radiation, and the mitigation of any accidents in the event of their occurrence;
b) ensuring that any radiological consequences of any accident involved in the design of the installation are below their respective limits and kept at a reasonably low level;
c) ensuring that the likelihood of an accident with serious radiological consequences is extremely low and that the radiological consequences of such an accident are mitigated as far as practicable.

8. Alternative energy

After the world felt the whole danger of nuclear energy and became infected with the idea of getting energy from alternative sources, such as sunlight and wind, a river of funding surged in that direction.

But what are alternative energy sources? And why are they called alternative? Is it all cloudless on the horizon of owners of miracle equipment capable of giving free energy? A whole series of issues related to the use of alternative energy technologies more and more often arises in a simple person who is thinking about abandoning traditional sources of energy. After all, it would seem how cool it is to completely switch to an inexhaustible natural resource and forget about gasoline exhausts under the window, endless bills and dependence on a thousand and one companies sending these bills! However, in any serious business, there are pitfalls, and it would be nice to identify them in advance, before setting sail.

Alternative sources of energy are called methods of generating heat and electricity using inexhaustible natural resources – sunlight, wind and other gifts of nature.

One of the most common ways to use natural energy is solar panels, replenishing your charge from the rays that hit them. Enterprising representatives of the human race have learned to embed such batteries not only in electrical appliances, but also in tiles, fountains, portable chargers, car roofs, road surfaces and even aircraft. One of the main advantages of solar energy is its environmental friendliness. True, silicon compounds can cause little harm to the environment, but compared with the consequences of burning natural fuels, such damage is a drop in the ocean.

Semiconductor solar cells have a very important advantage – durability. Despite the fact that caring for them does not require especially great knowledge from the staff. As a result, solar panels are becoming increasingly popular in industry and everyday life.

A few square meters of solar panels may well solve all the energy problems of a small village. In countries with a large number of sunny days – the southern part of the USA, Spain, India, Saudi Arabia and others – solar power plants have long been operating. Some of them reach quite impressive power.

Today, projects are already being developed to build solar power plants outside the atmosphere – where the sun's rays do not lose their energy. Radiation trapped in the Earth's orbit is proposed to be transferred to another

type of energy – microwaves – and then sent to the Earth. All this will be memorized fantastically, but modern technology allows such a project to be implemented in the very near future.

Geothermal energy is a method of generating electricity by converting the Earth's internal heat (the energy of hot steam–water sources) into electrical energy. This method of generating electricity is based on the fact that the temperature of the rocks increases with depth, and at a level of 2–3 km from the Earth's surface exceeds 100 ° C. There are several schemes for generating electricity at a geothermal power plant. Direct scheme: natural steam is piped to turbines connected to electric generators. Indirect scheme: steam is preliminarily (before it enters the turbines) cleaned of gases that cause the destruction of pipes. The cost of the “fuel” of such a power plant is determined by the cost of productive wells and a steam collection system and is relatively low. The cost of the power plant itself is low, since it does not have a furnace, a boiler plant and a chimney. The disadvantages of geothermal electrical installations include the possibility of local subsidence of soils and the awakening of seismic activity. And the gases escaping from underground can contain toxic substances.

Wind energy is a branch of energy specializing in the use of wind energy (kinetic energy of air masses in the atmosphere). Wind farm – a facility that converts the kinetic energy of the wind into electrical energy. It consists of a wind turbine, an electric current generator, an automatic device for controlling the operation of a wind turbine and a generator, facilities for their installation and maintenance. To obtain wind energy, different designs are used: multi–blade “daisies”; propellers like airplane propellers; vertical rotors, etc. The production of wind power plants is very cheap, but their power is small, and their work depends on the weather. In addition, they are very noisy, so large wind farms even have to be turned off at night.

Wave energy is a method of generating electrical energy by converting the potential energy of the waves into the kinetic energy of the pulsations and arranging the pulsations into a unidirectional force that rotates the shaft of the generator. Compared to wind and solar energy, wave energy has a much greater specific power. So, the average power of the waves of the seas and oceans, as a rule, exceeds 15 kW/m. With a wave height of 2m, the power reaches 80 kW /m. That is, during the development of the surface of the oceans there can be no shortage of energy. Only part of the wave power can be used into mechanical and electrical energy, but the conversion coefficient for water is higher than for air – up to 85 percent.

Tidal energy, like other forms of alternative energy, is a renewable source of energy. This type of power plant uses tidal energy to generate electricity. For the construction of a simple tidal power station, a pool is needed – a bay covered by a dam or a river mouth. The dam has culverts and installed hydraulic turbines that rotate the generator. During high tide, water enters the pool. When the water levels in the basin and the sea become equal, the gates of the culverts are closed. With the onset of low tide, the water level in the sea decreases, and when the pressure becomes sufficient, the turbines and the electric generators connected to it begin to work, and the water gradually leaves the pool. It is considered economically feasible to build tidal power plants in areas with tidal sea level fluctuations of at least 4 m. The disadvantage of tidal power plants is that they are built only on the shores of the seas and oceans, and besides, they do not develop very large capacity, and tides are only twice a day.

Biomass energy. When rotting biomass (manure, dead organisms, plants), biogas with a high methane content is released, which is used for heating, generating electricity, etc. There are enterprises (pigsties and cowsheds, etc.) that themselves provide themselves with electricity and heat due to that have several large "tanks", where large masses of manure from animals are dumped. In these sealed tanks, the manure rots, and the gas released goes to the needs of the farm. Another advantage of this type of energy is that as a result of the use of wet manure for energy, the dry residue from manure remains, which is an excellent fertilizer for fields. Also, fast–growing algae and some types of organic waste (stalks of corn, reed, etc.) can be used as biofuels. Such alternative sources have several advantages over traditional methods of energy production:

a) environmental friendliness; when using the equipment there are no emissions of harmful substances polluting the environment;
b) noiselessness (this item does not apply to the version with windmills);
c) the ability to install in remote places of the planet, not equipped with power lines;
d) free energy.

Given all the expected costs, the use of an alternative energy source in private ownership is often unprofitable and represents economic benefits only for large enterprises.

Progress does not stand still – polymer solar panels have already been invented, the production of which is several times cheaper. But this does not mean that homeowners should abandon the idea of using alternative energy sources. After all, progress does not stand still – polymer solar cells have already been invented, the production of which is several times cheaper than the manufacture of traditional silicon. And the appearance on the market of new, more economical, models of generators and additional equipment, a change in electricity tariffs gives reason to think that in the near future this practice will still be universally recognized.

9. Conclusions

The educational project aims to motivate senior students to study natural sciences.

To prevent and solve such problems, a large number of qualified specialists of engineers, technologists, and designers are required whose knowledge is based on mathematics, physics, chemistry and other natural and technical sciences. Nowadays, such specialists are becoming less and less every year.

The main objective of the project are:

a) popularization and motivation to study in the natural–mathematical and engineering technical sciences and specialties;
b) preparing a new generation capable of accepting the challenges of the future and creating new safe technologies not only in the energy sector, but also in other areas.

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Eliminating the Misconceptions of the 5th Grade Students in the Subject "Fraction" by Using Concept Maps

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Abstract. This research was carried out in order to determine the misconceptions of the subject "Fractions" in 5th grade math class and to eliminate these misconceptions by using concept maps. The data were collected through the focus group interview technique, semi-structured questions and the teacher's diaries that were kept in application process. For every question, codes and themes were determined by systematically examining the notes that were computerized. The codes and the themes were compared by using co-observer technique and the reliability of the application was found %93. After the application school was determined, four students were chosen with the maximum diversity sampling. 1st, 2nd, 3rd and 4th Action Plans were prepared to eliminate students' misconceptions with using concept maps. The themes which were determined for the questions asked in the interview in the light of the data collected from the students after the application were shown in the Findings part to support students' answers. As a result, after reviewing the collected data, it was found that using concept maps to eliminate misconceptions of the students was effective, it made students eager to lesson and made them like Math and at the same time, while it made it easier to understand for the students who have understanding difficulty, it made the students who were good at Math get bored. Moreover, the using of concept maps caused some of the students get confused.

Keywords. Misconceptions, Concept Maps, Students, Views.

1. Introduction

Teaching material is an important element of the learning-teaching process. Instructional materials are important to facilitate learning in the learning-teaching process, to increase productivity in learning and to provide cost-effectiveness. One of the instructional materials, which are an important element of the educational situation, is concept maps [1]. The human mind finds the common aspects of various objects, events, ideas and behaviors and classifies them into categories. Concepts are the abstract representatives of the classifications of objects, events, ideas and behaviors with common characteristics [2]. Baki (1999) defines misconceptions as the behaviors as a result of experiences of the students [3]. Identifying the misconceptions among the students is important to ensure the understanding of the learners. In the scope of the research literature survey has been conducted to determine the misconceptions about the fractions in the mathematics course. It has been concluded in these research that students have difficulties in dealing with fractions [4]. The use of concept maps in the teaching process has resulted in permanent learning [5]. The aim of this study is to solve the conceptual misconceptions of "Fractions" in the mathematics lesson of the 5th grade students of secondary school with concept maps. The research has benefited from the use of concept mapping techniques to solve the misconceptions of "fractions" in students.

2. Methods

In this section the research design, sample, and the research process.

2.1. Research Design

In the study conducted, an action research one of the qualitative research designs has used. Action research is a systematic intervention process in which people conduct research on their own professional activities and on the basis of action for change [6].

2.2. Participants

The study group of the study is composed of students in Bilecik in the fall semester of 2017-2018 and fifth grade students in Atatürk secondary school in Osmanlı. Students are given A, B, C and D codes. A total of 4 students, 3 girls and 1 boy, have participated in the research. Students participating in the research; a hardworking student (D); (B) is a student who does not like a lesson, a mainstream student (A) and a student, even s/he likes the lesson cannot get good grade (C). The school in which the study was

conducted consists of pupils of parents with moderate and good socioeconomic status.

2.3. Data collection and Analysis

The students in the study group were implemented in the 1st Action Plan "pre-tests of fractions" to identify deficiencies in the preliminary knowledge of fractions as a means of collecting data by the practitioner. "Fractions pre-test" consists of 7 questions. The first question is about "acquire the fractions varieties", the second and third questions are about the "convert fractions to each other", the fourth question is about "write the reading of fractions", the fifth question is about "abbreviation and equivalence in fractions" and the 7th question 'shows the fraction on numerical axis' objectives. The findings are coded as S1, S2, S3, S4, S5, S6 and S7. The fractions pre-test consisting of 7 questions and requiring a written answer in order to understand what the mistakes are made and where they originate are prepared together with 5 teachers who are experts in the field. Before preparation of the pre-test, the mistakes in the second math exam have been evaluated. The validity and reliability of the success test prepared before the start of the study have been determined (α = 0.43). In addition, for each item that constitutes the pre-test of fractions, the item total score correlation has been calculated. A questionnaire created by using the misconceptions of the students has been also used as a data collection tool. At the next stage, questions for the each misconceptions to determine whether the students have misconceptions or have made mistakes by detecting the mistakes made by the students in the examination which has been applied to measure the foreknowledge. In the study, participants have been interviewed and the teachers' diary in which the teachers' observation are have been used to collect data.

3. Findings

When students' opinions have been examined, the use of concept maps is positive for students. The teacher has changed the way students view mathematics lessons and help them to like mathematics. However, the use of concept maps is negative in terms of students in some parts of the subject "Fractions" in mathematics. It is useful for the students that teacher use this kind of method. Students also support the attending of mathematics classes with concept maps in the same way. When students' opinions have been examined, they have stated that they have experienced problems during the use of concept maps on "Fractions" in mathematics class. The students have pointed out that they cannot understand the some parts and have difficulties in constructing the concept maps. All the students have stated out that learning the fraction by concept maps is useful and helps them to construct meaningful learning.

4. Results and Discussion

In the study, the effects of the concept maps used for solving the misconceptions on the subject of "Fractions" in the Mathematics course of the 5th grade students have been examined. When the results of the observation in the teacher's diary are examined after the implementation of the second action plan, it has been found that the students have misconceptions about the reading of fractions, the conversion of fractions to each other (compound fraction integer and integer fractions), misinterpretation and comparison of fractions, fractions on number lines, simplification in fractions. The concept maps prepared by the practitioners are displayed to the students and the topic is explained again in order to solve the misconceptions that are determined in the students. When the results of the observation in the teacher's diary are examined after the implementation of the third action plan, the course is taught with the concept maps prepared for the fraction types, the reading of the fractions, the transformations in the fractions (compound fraction integer and integer fraction), fractions simplification and ordering. At the end of the course it is seen that when the students are asked again questions about the objectives, the students give correct answers to the questions about the reading of the fractions, conversion in fractions, comparison and sort of fractions and showing the fractions on the number line, and concept maps are effective. It is stated in the literature that concept mapping techniques are important in improving their reading comprehension skills [7]; it leads the meaningful learning that activities based on the use of mind maps and concept cartoons are beneficial to the academic achievements of learners and to the development of the perceptions of questioning learning skills [8-9]. It has been concluded that

the concept maps are not effective in simplification and equivalent in fractions. When the results of the observations in the teacher's diary are examined after the implementation of the 4th plan, it has been found that students have been able to create their own concept maps. In the process of preparing concept maps, the practitioner is challenged and some of the concept maps prepared for the learners are complicated by the students because the process of preparing the concept maps is not known exactly. It has been also found that the students have difficulties when they are asked to create a concept map.

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The Effect of the Vee Diagram Use on the Nature of Scientific Knowledge

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Abstract. The purpose of the present study was to investigate the effect of the use of Vee Diagram in inquiry-based science lab on the fourth grade science pre-service teachers' understanding on the nature of scientific knowledge. In the study, a quasi-experimental design was used with pre-test and post-test control group. In this scope, two sections were selected from the fourth grade pre-service science teachers as one experimental group (n=32) and one control group (n=32). While the pre-service science teachers in the experimental group performed the testing of hypothesis used in the inquiry-based science labs, the ones in the control group carried out closed-ended experiments. While the students in the experimental group prepared their experiment reports according to the Vee diagram, the students in the control group prepared their experiment reports according to the traditional laboratory report. Before and after the experimental application, the "Nature of Science Knowledge Scale" developed by Rubba and Anderson [1] and adapted to Turkish by Kılıç, Sungur, Çakıroğlu and Tekkaya [2] was applied to both experimental and control groups. The results of the current study revealed that the use of the Vee diagram in inquiry-based science lab had a positive effect on the pre-service science teachers' understanding about nature of scientific knowledge.

Keywords. Vee Diagram, Inquiry-Based Science Lab, Pre-Service Science Teachers, Nature of Scientific Knowledge.

1. Introduction

Science courses are designed to allow the students to explore, to query, to mount an argument and to design a product. In this context, it is expected that science teachers should be in the role of a guide who shares the importance and value of science and the responsibility and enthusiasm of achieving scientific knowledge as well as guiding the research process in the class [3]. Therefore, teachers have great responsibilities. As it is known, laboratories are an irreplaceable part of science education [4]. Students who carry out an experiment in labs communicate more with their peers and take responsibility so they feel more comfortable. Thus, it can be said that laboratories are the heart of science education [5]. It is also known that the attitudes and achievements of the students who carry out experiment in the laboratories are more developed [6]. Therefore, students are often advised to carry out experiment.

It is known that the experimental techniques used to achieve more objectives in the science labs are quite important for students. In this context, the objectives of the inquiry-based labs where students carry out open-ended and hypothesis-testing experi-ments rather than close-ended experiments (traditional science experiments) are multidimensional and meaningful [7]. Thus, it is suggested that inquiry-based science laboratory that students will be more active should be frequently included. It is known that Vee diagrams are an important tool in the effectiveness of science laboratories [7]. Vee diagrams were used for the first time in the 1970s by Gowin and his students [8]. Vee diagrams are one of the most frequently used subjects in science education in recent years and are often among the effective tools to facilitate concept teaching [9]. In this context, it is very important to prepare the reports in the Vee diagram format in the experiment group of hypothesis testing experiments. The purpose of the present study was to investigate the effect of the use of the Vee Diagram in inquiry-based science lab on the fourth grade science pre-service teachers' understanding on the nature of scientific knowledge.

2. Method

2.1. Research Design

In the study, a quasi-experimental design was used with pre-test and post-test control group.

2.2. Study Group

The study group involved in the present research was 64 fourth year students (32 experimental group and 32 control group) studying in the Department of Science

Education of a state university in the 2017-2018 academic year.

2.3. Data collection process

While the pre-service science teachers in the experimental group performed the testing of hypothesis used in the inquiry-based science labs, the ones in the control group carried out closed-ended experiments. While the students in the experimental group prepared their experiment reports according to the Vee diagram, the students in the control group prepared their experiment reports according to the traditional laboratory report. In this study conducted within the scope of the Science Laboratory II module, experiments were conducted using worksheets based on the use of the Vee Diagram in inquiry-based science lab for the experimental group while close-ended experiments were conducted for the control group. In the implementation stage of the research, each group conducted eight experiments.

2.4. Data Collection Tools

Before and after the experimental application, the "Nature of Science Knowledge Scale (NSKS)" developed by Rubba and Anderson [1] and adapted to Turkish by Kılıç, Sungur, Çakıroğlu and Tekkaya [2] was applied to both experimental and control groups. The NSKS has 48 items in six sub-themes (Amoral; Creative; Developmental; Parsimonious; Testable and Unified). Cronbach alpha value of the NSKS was calculated as 0.74 by Kılıç et al., [2]. Cronbach's Alpha value of the NSKS was calculated as 0.86 by researcher.

3. Findings

In order to test whether the data were normally distributed, Skewness and Kurtosis coefficients were examined, and Shapiro-Wilk test was performed. Skewness and Kurtosis values of the NSKS are presented in Table 1.

If the values of the Skewness and Kurtosis are each divided into standard error and these values are between -1.96 and 1.96, the data show normal distribution. Moreover, the p (sig.) values of the Shapiro-Wilk test greater than 0.05 mean that the normality of the data is provided [10].

Table 1. Skewness (S) and Kurtosis (K) Values of the NSKS for Scale/Sub Dimensions (S/SD): (1) Amoral; (2) Creative; (3) Developmental; (4) Parsimonious; (5) Testable; (6) Unified. Experimental (pre-test/post-test): E_{pre}/E_{pos}; and Control (pre-test/post-test): C_{pre}/C_{pos} Groups (G); Statistic (Stat.); Standard Error ($Std._{Error}$)

S/SD	G		Stat.	$Std._{Error}$	Shapiro-Wilk Stat.	df	Sig.
(1)	E_{pre}	S	0.749	0.414	.939	32	.072
		K	0.073	0.809			
	C_{pre}	S	-0.906	0.414	.924	32	.027
		K	2.196	0.809			
	E_{pos}	S	0.537	0.414	.951	32	.158
		K	-0.237	0.809			
	C_{pos}	S	-0.220	0.414	.963	32	.336
		K	0.785	0.809			
(2)	E_{pre}	S	-0.082	0.414	.986	32	.937
		K	0.219	0.809			
	C_{pre}	S	-0.844	0.414	.913	32	.013
		K	0.191	0.809			
	E_{pos}	S	-0.800	0.414	.945	32	.102
		K	1.102	0.809			
	C_{pos}	S	-0.904	0.414	.922	32	.023
		K	1.026	0.809			
(3)	E_{pre}	S	-0.300	0.414	.961	32	.291
		K	1.557	0.809			
	C_{pre}	S	-1.394	0.414	.866	32	.001
		K	2.861	0.809			
	E_{pos}	S	0.367	0.414	.961	32	.292
		K	-0.308	0.809			
	C_{pos}	S	-2.064	0.414	.830	32	.000
		K	7.565	0.809			
(4)	E_{pre}	S	-0.027	0.414	.973	32	.574
		K	-0.475	0.809			
	C_{pre}	S	0.053	0.414	.968	32	.454
		K	-0.175	0.809			
	E_{pos}	S	0.202	0.414	.937	32	.062
		K	-0.142	0.809			
	C_{pos}	S	-0.440	0.414	.943	32	.092
		K	-0.556	0.809			
(5)	E_{pre}	S	-0.770	0.414	.937	32	.061
		K	0.341	0.809			
	C_{pre}	S	-2.037	0.414	.768	32	.000
		K	4.430	0.809			
	E_{pos}	S	-0.363	0.414	.953	32	.179
		K	0.847	0.809			
	C_{pos}	S	-0.919	0.414	.924	32	.026
		K	0.466	0.809			
(6)	E_{pre}	S	0.084	0.414	.964	32	.359
		K	-0.643	0.809			
	C_{pre}	S	-1.136	0.414	.893	32	.004
		K	0.884	0.809			
	E_{pos}	S	-0.135	0.414	.936	32	.058
		K	-1.244	0.809			
	C_{pos}	S	-1.130	0.414	.920	32	.021
		K	2.704	0.809			
NSKS	E_{pre}	S	0.293	0.414	.976	32	.688
		K	-0.386	0.809			
	C_{pre}	S	-1.855	0.414	.776	32	.000
		K	-3.208	0.809			
	E_{pos}	S	0.491	0.414	.955	32	.206
		K	-0.659	0.809			
	C_{pos}	S	-2.249	0.414	.807	32	.000
		K	9.693	0.809			

In this context, it can be said that some of the data show normal distribution while others do not show normal distribution (see Table 1). A parametric test was used for the normal distribution data whereas a non-parametric test was used for the non-normal distribution data.

Independent samples U-test and t-test results of pre-test scores of the NSKS between experimental and control groups are presented in Table 2.

Table 2. Independent samples U-test and t-test results of pre-test scores of the NSKS for Scale/Sub Dimensions (S/SD) [(1) Amoral; 2) Creative; 3) Developmental; (4) Parsimonious; (5) Testable; (6) Unified] between Experimental: E; and Control: C Groups (G). Mean Rank (MR); Mean (M); Sum of Ranks (SR); Standard Error (Std.$_{Error}$)

S/SD	G	MR	SR	U	p
(1)	E	30.16	965.00	437.000	0.311
	C	34.84	1115.00		
(2)	E	28.02	896.50	368.500	0.053
	C	36.98	1183.50		
(3)	E	29.64	948.50	420.500	0.217
	C	35.36	1131.50		
(5)	E	31.19	998.00	470.000	0.571
	C	33.81	1082.00		
(6)	E	33.19	1062.00	490.000	0.767
	C	31.81	1018.00		
NSKS	E	28.78	921.00	393.000	0.110
	C	36.22	1159.00		
S/SD	**G**	**M**	**Std.$_{Error}$**	**t**	**p**
(4)	E	25.43	3.67	-0.186	0.853
	C	25.59	3.03		

As it can be seen in Table 2, it is found that there is no significant difference between experimental and control groups pre-test scores (U:437.000, p>0.05; U:368.500, p>0.05; U:420.500, p>0.05; U:470.000, p>0.05; U:490.000, p>0.05; U:393.000, p>0.05; and t:-0.186, p>0.05).

Independent samples U-test and t-test results of post-test scores of the NSKS between experimental and control groups are presented in Table 3.

As it can be seen in Table 3, it is found that there is no significant difference between experimental and control groups post-test scores (U:503.000, p>0.05; U:493.500, p>0.05; U:481.000, p>0.05; U: 478.000, p>0.05; U: 488.500, p>0.05; t:0.132, p>0.05; and t:0.306, p>0.05). Paired samples t-tests results of pre-test and post-test scores at the NSKS of the experimental group are presented in Table 4.

Table 3. Independent samples U-test and t-test results of post-test scores of the NSKS for Scale/Sub Dimensions (S/SD) [(1) Amoral; 2) Creative; 3) Developmental; (4) Parsimonious; (5) Testable; (6) Unified] between Experimental: E; and Control: C Groups (G). Mean Rank (MR); Mean (M); Sum of Ranks (SR); Standard Error (Std.$_{Error}$)

S/SD	G	MR	SR	U	p
(2)	E	32.78	1049.00	503.000	0.903
	C	32.22	1031.00		
(3)	E	33.08	1058.50	493.500	0.803
	C	31.92	1021.50		
(5)	E	31.53	1009.00	481.000	0.676
	C	33.47	1071.00		
(6)	E	33.56	1074.00	478.000	0.647
	C	31.44	1006.00		
NSKS	E	31.77	1016.50	488.500	0.752
	C	33.23	1063.50		
S/SD	**G**	**M**	**Std.$_{Error}$**	**t**	**p**
(1)	E	29.06	4.04	0.132	0.896
	C	28.90	5.34		
(4)	E	26.56	3.16	0.306	0.761
	C	26.81	3.37		

Table 4. Paired samples t-tests results of pre-test and post-test scores at the NSKS for Scale/Sub Dimensions (S/SD) [(1) Amoral; 2) Creative; 3) Developmental; (4) Parsimonious; (5) Testable; (6) Unified] of the Experimental (pre-test/post-test): E_{pre}/E_{pos} Group (G). Mean (M); Standard Deviation (Std.$_{Dev.}$) *p<0.05

S/SD	G	M	Std.$_{Dev.}$	t	P
(1)	E_{pre}	27.53	3.56	-2.514	0.017*
	E_{pos}	29.06	4.04		
(2)	E_{pre}	28.78	4.57	-2.440	0.021*
	E_{pos}	30.87	4.88		
(3)	E_{pre}	29.31	4.26	-1.993	0.055
	E_{pos}	30.40	3.67		
(4)	E_{pre}	25.43	3.67	-1.523	0.138
	E_{pos}	26.56	3.16		
(5)	E_{pre}	31.93	4.20	-1.365	0.182
	E_{pos}	32.81	3.75		
(6)	E_{pre}	32.43	3.11	-1.250	0.221
	E_{pos}	33.25	3.84		
NSKS	E_{pre}	175.43	13.92	-3.863	0.001*
	E_{pos}	182.96	15.90		

As it can be seen in Table 4, it is found that there is a significant difference between pre-test and post-test scores at *"Amoral"* sub-dimension of the experimental group (t: -2.514, p<0.01), and this difference is in favor of post-test scores. Moreover, it is found that there is a significant difference between pre-test and post-test scores at *"Creative"* sub-dimension of the experimental group (t: -2.440, p<0.01), and

this difference is in favor of post-test scores. Finally, it is found that there is a significant difference between pre-test and post-test scores at the *"NSKS"* of the experimental group (t: -3.863, p<0.01), and this difference is in favor of post-test scores. Paired samples Wilcoxon signed ranks test and t-test results of pre-test and post-test scores at the NSKS of the control group are presented in Table 5.

Table 5. Paired samples Wilcoxon signed ranks test and t-test results of pre-test and post-test scores at the NSKS for Scale/Sub Dimensions (S/SD) [(1) Amoral; 2) Creative; 3) Developmental; (4) Parsimonious; (5) Testable; (6) Unified] of the Control (pre-test/post-test): C_{pre}/C_{pos} Groups (G). Mean Rank (MR); Sum of Ranks (SR); Mean (M); Standard Deviation ($Std._{Dev.}$)

S/SD	G	MR	SR	z	p
(1)	C_{pre}	11.06	88.50	-1.76	0.078
	C_{pos}	13.22	211.50		
(2)	C_{pre}	12.00	120.00	-0.211	0.833
	C_{pos}	11.08	133.00		
(3)	C_{pre}	9.79	137.00	-1.200	0.230
	C_{pos}	12.17	73.00		
(5)	C_{pre}	9.46	123.00	-0.263	0.793
	C_{pos}	13.50	108.00		
(6)	C_{pre}	9.88	79.00	-1.547	0.122
	C_{pos}	12.43	174.00		
NSKS	C_{pre}	13.59	149.50	-0.950	0.342
	C_{pos}	14.28	228.50		
S/SD	**G**	**M**	**$Std._{Dev.}$**	**t**	**p**
(4)	C_{pre}	25.59	3.03	-1.976	0.057
	C_{pos}	26.81	3.37		

As it can be seen in Table 5, it is found that there is no significant difference between pre-test and post-test scores of the control group (z:-1.76, p>0.05; z:-0.211, p>0.05; z:-1.200, p>0.05; z: -0.263, p>0.05; z:-1.547, p>0.05; z:-0.950, p>0.05; and t:-1.976, p>0.05).

4. Conclusion and Discussion

The first result of the current study showed that there was no significant difference between experimental and control group pre-test scores.

The second result of the study showed that there was no significant difference between experimental and control group post-test scores.

The third result of the study showed that there was a significant difference between pre-test and post-test scores at *"Amoral"* sub-dimension of the experimental group, and this difference was in favor of post-test scores. Furthermore, it was found that there was a significant difference between pre-test and post-test scores at *"Creative"* sub-dimension of the experimental group, and this difference was in favor of post-test scores. Finally, it was found that there was a significant difference between pre-test and post-test scores at the *"NSKS"* of the experimental group, and this difference was in favor of post-test scores. Similarly, some studies reported that Vee diagrams have a significant effect on student success [11-12]. Accordingly, it can be argued that inquiry-based laboratory implications based on Vee Diagram in are more effective than laboratory activities conducted with the use of close-ended experiment in terms of understanding on the nature of scientific knowledge of pre-service teachers.

Finally, result of the study showed there was no significant difference between pre-test and post-test scores of the control group.

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Examination of Inquiry Learning Perception of Secondary School Students in Science

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Abstract. The purpose of this study in which the general screening model of quantitative research methods has been employed is to examine the inquiry learning perception of secondary school students according to the various variables. For this purpose, 'Inquiry Learning Perception in Science Scale' which consists of 3 sub dimensions and 22 items has been applied to 266 secondary school students selected by using simple random sampling. The normality test has been used to decide which analysis would be carried out and it was decided that the data are not normal. For this reason, it has been decided to use Kruskal-Wallis and Mann Whitney U. It has been concluded that the students have a high level of inquiry learning perception and the gender is a significant variable on inquiry learning. Female students have a higher perception about inquiry learning. It has been also concluded that the parents' educational statue plays an important role on the inquiry learning perception. The students with a parent who has a university degree have a higher perception than the other students. The results have also showed that the occupation of the mother is another important variable on inquiry learning perceptions. The students whose mother works in a state job as an officer have a higher perception on inquiry learning. The last finding of the study has revealed that the income of the family is an important variable, as well and this result is also related with the students private lesson statue as it has been concluded the students who has private lessons have higher perceptions about inquiry learning.

Keywords. Inquiry learning, Perception, Secondary School, Students.

1. Introduction

The rapid development of technology and science in our time has changed the teaching activities, that is knowledge transfer, of classical education systems. Today's education systems place more emphasis on student-centered approaches than teacher-centered approaches. At the basis of such approaches, instead of passively passing knowledge on to learners, it aims to involve students in the process, to teach them how to access information, and to make them scientific literate individuals. These approaches are aimed to provide students with the attitudes and skills necessary to solve the problems related to science that students will encounter in school and after school life, not memorizing the information in the science courses. Individual attitudes are closely related to how they will behave in different situations. Individuals with scientific attitudes are expected to have a researcher and critical personality and to stay away from prejudices. The high attitudes of students towards science courses will have a positive impact on the lifetime of learning and the development of a researcher and a critical personality. The Science curriculum that is being used in our country has also been developed and put into practice on the basis of that students will construct the knowledge in their minds, that is students are in the center of the learning activity. The aim of the curriculum is to make the students acquire the skills of learning by doing and living, questioning and rationalizing. The curriculum aims to improve students' inquiry learning skills as well. Inquiry learning will encourage learners to learn according to constructivist approach by encouraging students to ask, create, discuss and reflection skills.

Science is a field in which individuals are curious about other creatures, occurrences, developments and cause-and-effect relationships in the environment they live in, and try to understand, examine and make meaning, and use them in the direction of their own needs [1]. The lectures in the field of science aim to provide individuals with the skills such as perception and scientific thinking while providing guidance on finding answers to these searches [2]. In line with these objectives, the curriculum implemented in the field of science have been developed as student centered by adopting the constructivist approach. The main reason for this is that students are highly influential in facilitating the learning of the logic of scientific research to individuals rather than memorizing the concepts and rules of science [3].

Science and Technology curriculum developed in 2004 following the reform studies carried out in the educational programs aims to educate all individuals as science literate. In educating of individuals with these features, it is undoubtedly necessary to adopt contemporary approaches. As in the whole education field, contemporary approaches to science teaching have also indicated that questioning in science learning has a great influence. The inquiry was influenced by John Dewey, the constructor philosophy and the philosophy of Socrates [4]. The current approaches in science teaching suggest the necessity and importance of students' learning by inquiry of science [5], and that the definition of science teaching could be done in a single word, and that would certainly be inquiry.

Inquiry-based learning emphasizes the process of collecting information rather than a product producing and problem solving [6]. According to [7], students are experiencing an educational experience in which they learn about the world like a scientist by inquiry. In this lifelong process, students work on a real life problem, formulate the problem, create probabilistic solutions, establish causal relations by conducting various investigations, and reach learning. İnquiry learning is a method in which individuals find themselves in various activities, with effective learning, information organization, and improvement of knowledge circulation [8]. Despite the fact that the studies on inquiry-based learning are based on the 20th century, it is seen that the studies related to this field in our country have been started in the 21st century and accelerated with the education reform in 2004 [9]. Studies on inquiry-based learning show that this method has positive effects on many variables such as motivation, attitude and academic success of the students. [10] have concluded that inquiry-based learners have developed positive attitudes among students and that they have created higher interrogation skills, but have not had an impact on the students' scientific performances. As it is stated in the literature inquiry learning essential for students to gain the skills in our modern time. Therefore, it is important to examine the level of the inquiry learning perceptions of the students. In this context, the purpose of this study is to investigate the level of the inquiry learning perception of secondary school.

2. Research Problems and Subproblems

In this study, the following research questions are investigated:

1) What is the level of student inquiry learning perception?
2) Is there a significant difference in the level of inquiry learning perception of the students according to:
   a) Gender variable?
   b) Parents' education statue variable?
   c) Parents' occupational statue variable?
   d) Parents' income level variable?
   e) Private lesson statue variable?

3. Method

In this section, the study sample, the process of development of the scale and the analysis of the data are explained.

3.1. Research Model

In this study, the general screening model which is one of the quantitative research methods has been employed to examine the inquiry learning perception of secondary school students according to various variables.

3.2. Participants

The participants of the study compose of 266 (112 Male, 154 Female) secondary school students studying in Afyonkarahisar in 2016-2017 and have been selected by using simple random sampling.

3.3. Data Collection Tool and Data Analysis

'Inquiry Learning Skills Perception Scale' developed by Taşkoyan (2008) has been used as the data collection tool. The scale consists of 3 subdimension and 22 items. Cronbach's Alpha value of the scale is.84.

Before analyzing the data, the normality test has been used to decide which analysis would be carried out and it was concluded to use Kruskal Wallis and Mann Whitney- U.

4. Findings

The findings of the first research problem

'What is the level of student inquiry learning perception? is given in the Table 1.

Table 1. The level of the inquiry learning perception of the secondary school

Subscale	X	ss
Positive Perceptions	3,89	.692
Negative Perceptions	3,44	.742
Inquiry the truthness	3,78	.836
Total	3,73	.575

As it can be seen in Table 1., it was found that the level of inquiry learning level of the students is moderate, but near to the high level (X=3,73, ss=.575).

The findings of the second research problem 'Is there a significant difference in the level of inquiry learning perception of the students according to gender variable? is given in the Table 2.

Table 2. Mann Whitney-U results according to the Gender (G: 112 Male, 154 Female) for Subscales (SS): (1) Positive Perceptions; (2) Negative Perceptions; (3) Inquiry the truthness; (4) Total. Mean Rank (MR); Sum of Ranks (SR)

SS	G	MR	SR	U	p
(1)	M	122,04	13668,00	7340,00	.038
	F	141,84	21843,00		
(2)	M	154,19	23746,00	5437,00	.000
	F	105,19	11765,00		
(3)	M	113,78	12743,50	6415,00	.000
	F	147,84	22767,50		
(4)	M	115,86	12976,00	6512,00	.001
	F	146,33	22535,00		

As it can be seen in the Table 2, the gender variable plays an important role on inquiry learning level of the students. There is a significant differences in the favour of female in the positive perception (U=7340,00, p=.038), in the inquiry the truthness dimension (U=6415,00, p=.000) and in the total of the scale (U=6512,00, p=.001). There is a significant difference in the negative perception dimension for male students (U=5437,00, p=.000).

The findings of the third research problem 'Is there a significant difference in the level of inquiry learning perception of the students according to Parents' education statue variable?? is given in the Table 3.

Table 3. Kruskal Wallis results according to the Parents´ Education Statue (PES) [Primary School (PS); Secondary School (SS); High School (HS); University (U)] for Subscales (SS): (1) Positive Perceptions; (2) Negative Perceptions; (3) Inquiry the truthness; (4) Total. Number (N); Mean Rank (MR); Difference (D)

SS	PES	N	MR	x2	p	D
(1)	PS	15	119,30	22,438	.000	4-1
	SS	133	118,00			4-2
	HS	100	143,75			4-3
	U	18	202,89			
(2)	PS	15	121,20	2,823	.420	
	SS	133	127,40			
	HS	100	140,72			
	U	18	148,72			
(3)	PS	15	153,70	6,089	.107	
	SS	133	122,16			
	HS	100	143,05			
	U	18	147,42			
(4)	PS	15	133,63	9,743	.021	4-1
	SS	133	120,98			4-2
	HS	100	143,10			
	U	18	172,58			

As seen in the Table 3, there is significant difference both in the first dimension of the scale and the total of the scale (p<.05). Therefore, post hoc test was used to determine among which group the difference occur. The students with a university graduated mother have a higher level of perception than primary school, secondary school and high school graduated mother.

The same test was used for the father education level variable but it was concluded that there was no significant difference between groups.

The findings of the third research problem 'Is there a significant difference in the level of inquiry learning perception of the students according to Parents' occupational statue

variable? is given in the Table 4.

Table 4. Kruskal Wallis results according to the Parents´ Occupational Statue (POS) [Unemployed (U); Private (P); Officer (O)] for Subscales (SS): (1) Positive Perceptions; (2) Negative Perceptions; (3) Inquiry the truthness; (4) Total. Number (N); Mean Rank (MR); Difference (D)

SS	POS	N	MR	x2	p	D
(1)	U	223	131,93	17,065	.000	2-1
	P	31	112,05			3-1
	O	12	218,00			3-2
(2)	U	223	133,44	5,883	.053	
	P	31	116,16			
	O	12	179,38			
(3)	U	223	138,20	13,196	.001	3-1
	P	31	88,52			3-2
	O	12	162,38			1-2
(4)	U	223	135,55	20,454	.000	1-2
	P	31	90,68			3-1
	O	12	206,00			3-2

As seen in the Table 4, there is significant difference in the first and third dimensions of the scale and the total of the scale (p<.05). According to results of the post hoc test, students with a mother who works as an officer have a higher level of inquiry learning perception. The same test was done for the father occupational statue, but it was concluded that there was not any significant difference between groups.

The findings of the third research problem 'Is there a significant difference in the level of inquiry learning perception of the students according to Parents' income level variable? is given in the Table 5.

As seen in the Table 5, there is significant difference in the all of the dimensions of the scale and the total of the scale (p<.05). According to results of the post hoc test, students from a higher income family have a higher level of inquiry learning perception. The same test was also done for the students private lesson statue and it was concluded that the students who get private lessons have a higher level of inquiry learning.

Table 5. Kruskal Wallis results according to the Parents' Income Level (PIL) [(a)<1499€; 1500€<(b)<2499€; (c)>2500€] for Subscales (SS): (1) Positive Perceptions; (2) Negative Perceptions; (3) Inquiry the truthness; (4) Total. Number (N); Mean Rank (MR); Difference (D)

SS	PIL	N	MR	x2	p	D
(1)	(a)	47	137,62	14,121	.001	
	(b)	94	110,28			
	(c)	125	149,42			
(2)	(a)	47	118,53	6,622	.036	
	(b)	94	124,12			
	(c)	125	146,18			
(3)	(a)	47	144,84	24,168	.000	
	(b)	94	102,45			
	(c)	125	152,59			
(4)	(a)	47	138,40	17,876	.000	
	(b)	94	107,29			
	(c)	125	151,37			

5. Results

The first results of the study showed that the students have a moderate level of inquiry learning perception but it is close to the high level according to the descriptive analyses. The second results of the study showed that the parents' education level, mother education level has an important effect on the students' inquiry learning perception level. The third results of the study showed that parents occupational statue played an essential role on the level of inquiry learning perception of the students. The last results of the study revealed that both the income of the family and students' private lesson statue are effective on their inquiry learning perception level. The students from higher income family and getting private lesson have a higher level of inquiry learning.

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Examination of 'Canım Kardeşim' Cartoon in Terms of Preschool Values

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Abstract. Cartoons are used for children's learning, fun, amusing education as well as social values. Cartoons have great importance in teaching human values. In this study, the values in the cartoons 'Canım Kardeşim' were examined in terms of the values in the pre-school education program. The data were obtained with notes taken during the monitoring of the videos. The model of the research was determined as a document review. Descriptive and content analysis were used in analyzing the determined values. As a result of the analysis made, some values such as helping in cartoon, love, respect, kindness, responsibility, patience, friendship, business association and honesty are reached. The common values of the skills, values and achievements in the pre-school level were taken from the values in the 'Canım Kardeşim' cartoon and it was reached that the values in cartoons can be determined and used in the education process of the pre-school child.

Keywords. Cartoons, Education, Value.

1. Introduction

Cartoons have an important place in children. a variety of cartoons are being broadcast on weekdays in the morning hours and on weekends both in the morning and during the day, when children are more likely to face the television in the national and international channels in Turkey. In addition to this, there are channels that broadcast via satellite only for children such as "Cartoon Network, TRT Child" and channels that broadcast cartoons almost every hour of the day. Cartoons display is not limited to TV channels only. Today, when it is common to use the internet environment, we have access to many things we want at any moment. Children are also able to watch cartoons whenever they want with the internet. Children who spend a large percentage of the day in cartoons have a great deal of education from cartoons. Cartoons are stronger in teaching social values than family, school or religious institutions [1]. Pre-school education for children's development is at least as important as the schooling period they will be at other ages. Pre-school education is the period when children first meet with the concepts of education, teacher and school [2]. The development of children in the social and emotional way shapes their personality. One of the main objectives of pre-school education is to educate citizens who have certain values and can take responsibility. It is generally accepted that there is a process of corruption in values. This corruption process, which takes place in values, also puts the educational institutions in a difficult situation such as violence. Therefore, the values that are tried to be given in the curriculum should reach the objectives [3], the adequacy of values for children and cartoons which are important elements for the development of children should be watched in terms of values. The purpose of this research is to determine the extent to which the values are included in the "Canım Kardeşim" cartoon broadcasted on TRT Çocuk channel and examine it in terms of skill, value and objective before the school.

2. Method

Document analysis, which is one of the qualitative research designs, has been employed. In the document review, printed or electronic documents are examined and evaluated systematically [4]. In this study, importance has been given to the age group in the selection of cartoons in terms of preschool values, it has been decided to analyse the cartoon named 'Canım Kardeşim' which is suitable for preschool age group.

2.1. Sample/ Analysed Documents

Canım Kardesim is a Turkish cartoon which is broadcasted on the TRT Çocuk channel. The characters are a primary school student Müge, her younger sister Mine, their mother Lale, their father Galip and their cat Mıncır.

2.2. Data Collection

Cartoons broadcast on children's channels have been examined for the collection of the data. It has been decided to investigate the 'Canım Kardeşim' cartoon according to the rate of watching on the internet and the cartoons

that children can reach. The values which are detected in the cartoon have been examined according to the preschool student age. All the episodes of the cartoon, 109 episodes, have been watched and the episodes (71 episodes) which are about a value or a group of value have been analysed by taking notes. The archive of TRT Çocuk have been examined and it has been decided that the cartoons have such values as friendship, cultural objectives, learning and imagination. Notes have been taken during watching of the episodes. The cartoons with the values have been also noted, and the codes and themes were determined. The videos that have watched can be reached from [5-7].

2.3. Data Analysis

The data in this study were evaluated using both descriptive and content analysis methods. This study also use content analysis as it attempts to reach concepts and relationships that can explain the collected data. Content analysis tries to identify the data and reveal the facts that may be hidden within the data. Content analysis is to bring together similar data within the framework of certain concepts and themes and to interpret them by organizing them according to a form that the reader can understand [8]. The collected data have been organized on the computer. After this process, the data are coded and divided into categories. The selected episodes have been watched three times by the researcher and re-watched by the intercoder to improve reliability.

3. Findings

Episodes have been watched and values have been noted. The cartoon consists of 109 episodes in total. The 71 episodes where the values are found have been reviewed. A total of 20 values have been found in 71 episodes have been examined. Some episodes have more than one value. Miles and Huberman formula have been used to calculate the reliability. The reliability has been calculated as 78.01%. The values which have been found in the cartoon are listed as: " Family Union, Friendship, Diligence, Courtesy, Honesty, Empathy, Brotherhood, Business Association, Happiness, Courtesy, Sharing, Holding, Being Healthy, Love, Respect, Responsibility, Cleaning, Patriotism, and Helping ". It has been concluded that the values which have been detected in the cartoon are in accordance with the preschool curriculum.

4. Result and Discussion

It is aimed to determine the values given in cartoons for the pre-school curriculum in the study conducted. Values have been determined in the direction of pre-school skills, values and objectives. The values in the study have been related to the pre-school curriculum and the document analyis has been used in order to increase visuality in education. The Canım Kardeşim cartoon, composed of 109 episodes broadcasted on TRT children's channel, has been watched twice and notes have been taken. 71 episodes which include at least one value have been included in the study. The reliability have been found as 78.01 %. When we look at the frequency of passing values in the cartoon, we find that values of "courtesy, help, love" are values in almost every episodes and that "patriotism and family union" are values in lesser parts than other values. It has been concluded that the values in the cartoon are closely related with values in the preschool curriculum.

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The Development of the Curriculum Fidelity Scale

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Abstract. The purpose of this study is to develop a five point likert scale called 'Curriculum Fidelity'. For this purpose, a draft scale consisting of 65 items have been represented to the field experts and it has been decided that 15 items should be excluded. The remaining 50 items have been given to 249 teachers and the maximum likelihood has been used in the exploratory factor analysis of the scale in order to examine the structural validity. The remaining 28 items have been grouped into 3 factors. The explained variance is 62,753 of the total variance. The Cronbach's Alpha value is 0.94. Furthermore, item-total, item-remaining and item discrimination have been found significant. After exploratory factor analysis, it has been found that goodness of fit indexes are acceptable according to the results of confirmatory analysis (RMSEA= .075; CFI= .90; RMR= .08; GFI= .79; AGFI= .76; NNFI= .89).

Keywords. Curriculum, Fidelity, Teachers.

1. Introduction

There are different definitions about curriculum in educational resources as it is comprehensive and multidimensional. Differences in the definition of the curriculum are based on the understanding of the scientists; as they consider different dimensions of educational practices or they emphasize different dimensions of an approach. the curriculum is defined as a plan that shows all the activities that are carried out in order to create a behavioural change in the individual and all activities which are to carry out the aims of the national educational in an education institution for children, youth and adults. In addition to these curriculum definitions, Eisner (1985) [1] focuses on the existence of several different curriculum, which are actually formal, implicit and neglected curriculum. While the curriculum prepared by the official institutions and sent to the related institutions is the official curriculum and the curriculum to be followed, the effect of many variables such as teachers' practices differences, school sub-structures, student differences cause differentiation of curriculum implementation, that is, Eisner's expression of functional curriculum and neglected curriculum.

In the formation of different curriculum, the influence of what teachers are attached to the implementation of the formal curriculum is untenable. For this reason, in the 1970s, it became important to examine the concept of curriculum fidelity in the United States [2]. Curriculum fidelity is defined as the extent to which the implementers are faithful to aims of the curriculum developer [3-4], and to the extent to which the curriculum is implemented compared the original curriculum design [5]. Curriculum fidelity is defined and measured with five different dimensions [6-7] such as adherence, dose/duration, quality of curriculum delivery, participant response-veness, and curriculum differentiation. While it is notes that each of these dimensions are to be measured [3], there are other studies which note that there is no need to measure them separately.The need to measure curriculum fidelity [8] is the main reason for understanding curriculum implementation, testing theoretical assumptions, interpreting findings, and ensuring feedback [3-4,9]. In this way, feedback can be provided to the curriculum evaluation studies, as well as to the formative evaluation. From this point of view, it is very important to determine the level of curriculum fidelity of the teachers.

2. Method

In this section, the study sample, the process of development of the scale and the analysis of the data are explained.

2.1. Sample

The study sample consists of 249 teachers who have been working in the Aegean Region of Turkey during the academic year of 2017-2018. There is different information in the literature about sample selection in scale development studies, a sample of 100 individuals may be sufficient [10].

2.2. Scale Development Process

At the beginning of the creating the item pools, the studies on the curriculum fidelity

have been examines and the four open-ended questions have been created based on the literature. The questions have been asked to five teachers from different branches (2 English Language Teachers, 1 Classroom Teacher, 1 Science Teacher, 1 Technology and Design Teacher) selected randomly and to the three Phd candidate in Curriculum and Teaching. Analysis of responses to open-ended questions and a review of relevant literature have revealed a total of 65 items expressing the curriculum fidelity. The five point likert type instrument has been presented to expert in terms of scope validity and a total of six items with narrative impairment, not related to curriculum fidelity have been excluded from the scale. After the necessary correction the remaining items have been applied to the 14 teacher eight of which works in Afyonkarahisar, Turkey, and the others have been reached through the internet on a voluntary basis, and it has been decided that nine items have been excluded from the scale. After all the corrections, the remaning 50 items have been applied to 249 teachers working in Afyonkarahisar, Turkey.

2.3. Findings of Exploratory Factor Analysis

Kaiser Mayer Olkin (KMO) .941 and the Bartlett Test value of .000 ($p < .05$) have been found to be appropriate for factor analysis. In the exploratory factor analysis applied to the data obtained after pilot implementation of the draft scale, maximum likelihood has been used as a factorization technique. The item load value has been decided as 40 to exclude the items. When determining the factors in the exploratory factor analysis, the eigen value [11] and the screen plot [12] are used. In this study, 3 factors with more than one eigenvalues have been determined when deciding on the number of factors. As a result of exploratory factor analysis, 22 items were excluded from the scale and a scale consisting of 3 sub-dimensions named as 'Curriculum Fidelity' has been developed with 28 items. The Cronbach's Alpha value of the scale has been calculated as $\alpha = .944$. The three factors explain 62,753% of the total variance. As a result of the Pearson Moments Correlation analysis performed for item total and item remaining analysis, it has been concluded that all the items in the scale have a significant correlation with the total score at 0.01 level, and item discrimination tested by t-test to the bottom and top 27% is also found significant.

2.4. Confirmatory Analysis

After the model of 'Curriculum Fidelity Scale' and its subdimensions, have been created, the model has been tried to be confirmed by confirmatory factor analysis. It has been decided that the subscales measure 'practices, awareness and external factors' respectively. It has been found that all the parameter estimations are significant at the level of .01. It has been found that goodness of fit indexes are acceptable according to the results of confirmatory factor analysis (RMSEA= .075; CFI= .90; RMR= .08; GFI= .79; AGFI= .76; NNFI= .89).

3. Results

A scale to measure teachers' curriculum fidelity level has been created at the end of the study. For this purpose, a 5-point likert-type scale consisting of 65 items has been prepared based on the answers of open-ended questions related to literature, expert opinion and teachers. This prepared draft scale has been first presented to the expert opinion and 6 items have been excluded in the direction of the feedbacks from the experts. Nine items have been excluded from the scale, which have not been understood through a pilot application with the remaining items or decided not to serve for scale purposes. With the remaining 50 items, studies on the structural validity of the scale have been carried out. Firstly, exploratory factor analysis has been carried out in the study. As a result of the exploratory factor analysis, KMO value (.941) and Barlett test result ($p < .05$) have showed that the data have been appropriate for factor analysis. The load values of the items have been determined to be .40, and it has been decided to remove the items under this value. A total of 22 items that have not complied with the relevant criteria have been excluded from the scale and the scale has been composed of 3 separate factors and explained 62,753% of the total variance. Furthermore, item-total, item-remaining and item discrimination have been found significant. As a result of confirmatory factor analysis, good fit indexes of scale $\chi 2$ / df = 2,12; RMSEA = .075; CFI .90; RMR = .08 and GFI = .79 respectively. Although the good fit indexes of the scale do not show perfect fit, the results are

within acceptable limits and close to acceptable limits.

4. Acknowledgements

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Popularization of Science among International Students in Ukraine

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Abstract. The purpose of the article is to identify and substantiate the pedagogical conditions for the forming a model of a modern technical specialist with a high level of professional skills, and skills of transforming scientific data, incomprehensible to the ordinary people into interesting and understandable information that will promote greater attraction from young people to scientific problems. The necessity of forming a professionally oriented world outlook for international students in their future scientific and technical activity by using interactive pedagogical technologies of science's popularization such as: distance courses of science popularization; integration of the academic subjects and extracurricular activities in a technical university with creating a learning environment aimed to a modern technical specialist forming, is substantiated.

Keywords. Integration Training, Model of Modern Technical Specialist, Pedagogical Conditions, Popularization of Science.

1. Introduction

The interest in scientific work and engineering professions has significantly decreased in recent years. This situation is typical for many countries, and, of course, for Ukraine. All over the world, scientists and researchers are trying to solve the problem of "science popularization", to encourage young people in obtaining scientific knowledge and conducting scientific research, forming scientific skills. Scientific festivals and theaters, Internet conferences, online interviews of scientists, news, magazines, books, radio and TV programs and many others are used to solve this problem.

Stephen Hawking emphasized the fact that it is very important to create public interest at least about those scientific areas that are very interesting to study [1-4]. He noted that science is often taught in not very interesting form. Young people do not see the connection between science and the world around them; they learn only to pass the exams. Hawking also said that teachers should actively promote science among students and schoolchildren, underlining that the development of science and technology is possible only if the interest in society in these areas of activity is high enough [5]. It is advisable to use the whole arsenal of modern means, in particular, the Internet, mobile communication opportunities, advertising, etc.

2. Recent research and publications analysis

Nowadays Europe builds a knowledge-based economy, because Europeans understand that progress is impossible without implementing scientific research. The world has reached such a degree of development, when society absolutely needs a threshold of knowledge that guarantees security and a new quality of life [6]. That's why there are many programs for increasing interest in science by the public. One of the most popular is the Horizon 2020 program with a budget of 17.5 billion euros. Moreover, the European and American Funds of Science conducted a joint study to analyze the problem of popularizing science in different countries of the world. The results showed that in the United States scientific popularization has been put on a very high level [7].

In addition, the United Kingdom also should be noted as the state provides significant support for popularization of science: a special commission whose purpose is to explain to people why science is important and a special TV channel, which deals exclusively with the promotion of scientific knowledge, were created. The European Center for Science and Art named Alpha Galileo Press was organized [8]. Among many popular European publications, it should be noted British Journals Nature and New Scientist, which provide information about scientific achievements, and even the only publication in these journals is often considered more valuable for scientists than dozens of articles in other editions [9-10]. As a result, the interest of great part of British youth is directed toward the natural sciences.

Scientists all around the world propose to follow some basic principles of effective

science promotion. Among them are the following:

- Adaptation of a complex scientific phenomenon to some essential formula depending on the audience.
- Using the principle of analogy like comparing the scientific phenomenon with everyday life, so that the first became clear.
- Making messages about scientific phenomenon with emotional attitude.
- Clear balance of depth of detail and calculation of the uninformed reader, rigorous dosing of the message logic.

3. Objective

A large number of students from more than 148 countries study in Ukraine. An important condition for improving the popularization of science among international students is their awareness, possibility of access to specific scientific information adapted for them especially in the first stage of studying. Scientists of Ukraine are exploring the effective ways of solving the problem of science popularization among international students, but, unfortunately, these issues still require careful attention from researchers and teachers.

The objectives of the paper are as follows:

- providing foreigners with systematic knowledge of the famous scientific inventions both in Ukraine and all over the world;
- acquaintance with the peculiarities of educational process associated with various scientific areas and scientific research;
- development a comprehensive psychological and pedagogical program for the science popularization as a tool for increasing the effectiveness of international students' adaptation to new living conditions, as well as the prevention of extremism and xenophobia.

Due to the program's implementation, a concept of educational material was formed; a methodology for presenting scientific information was prepared; a technology of its implementation was developed; a pedagogical experiment was conducted as a logical continuation of theoretical research and checking their reliability, assessing the effectiveness and practical significance of the program.

4. Program of science popularization for international students

For many decades, NTU "KhPI" pays great attention to the popularization of science among international students. Thus, international students are given the maximum timely assistance in adapting to a new socio-cultural environment in order to achieve comfortable integration into the Ukrainian scientific and educational environment, as well as in assimilating new methods of obtaining scientific knowledge.

Most foreign citizens have a low level of awareness of science in general and scientific activity in Ukraine, in particular. Therefore, at the first stage of the program's implementation, special conditions for the elimination of the above-mentioned complexities should be provided.

It is well-known that due to differences in cultures and national mentality, there specifics in different spheres of life, including the perception of the scientific research significance. In addition, some differences in people interaction, manner of communication, and doing business in scientific area are reflected in all life spheres, so knowledge of these differences significantly affect the success of the popularization of science among foreigners.

In our opinion, the program of science popularization for international students should begin immediately after their arrival in Ukraine.

That's why, "Acquaintance Lessons" were created by professors of the Department of Natural Science of NTU "KhPI". There are acquaintance with the most important scientific objects of NTU "KhPI" and other Kharkiv universities; special classes in English, French and other languages for informing about

Ukrainian higher educational establishments, research organizations and programs for supporting foreigners in their further scientific and educational activities. Moreover, foreigners-freshmen are invited to the educational-adaptation course “Peculiarities of scientific research”, which aims to provide international students with key knowledge about modern scientific developments of NTU “KhPI” with real practical effect, and, at the same time, familiarity with the system of scientific research in Ukraine.

To determine the effectiveness of the presented program, a pedagogical experiment was conducted. Two groups of international students took part in the experiment: one of them was an experimental (with the program of popularization of science learning) and the other was a control group (without the proposed program learning).

The pedagogical experiment was conducted for two years and consisted of three stages: establishing, forming and comparative.

208 international students and postgraduates from NTU “KhPI” were involved in various types of research and experimental work. Due to the establishing experiment, the problems related to the latest information technologies, environmental problems, and globalization of the economy were systematized; the level of students’ awareness in engineering activities was determined. To solve these problems, a website for online forums, where students and experts could express their views on the issues listed above, was created [11].

The toolkit for research was questionnaires and surveys. The essence of the questionnaire developed specifically for international students, was to clarify their level of awareness of and willingness to participate in scientific and technical activities in Ukraine and in other countries.

The questionnaire contained 28 questions specified the attitude of foreigners to the following problems: 1) necessity of science popularization among foreigners in Ukraine; 2) knowledge in different areas of engineering activities for choosing future speciality in Ukrainian university; 3) dependence between the effectiveness of technical activity and professional ethics norms; 4) necessity in training courses “Science in Ukraine” and “Science at NTU “KhPI” and others. Respondents had to choose one of the four response options: “Yes”, “No”, “Sometimes”, “I do not know”. The analysis of the answers is shown below (Table 1).

Table 1. International students’ answers

№	Issue	Respondents’ answers (%)			
		Yes	No	Some-times	I don’t know
1	Necessity of science popularization among foreigners in Ukraine.	28	10	46	16
2	Knowledge in different areas of engineering activities for choosing future speciality in Ukrainian university.	20	25	15	40
3	Dependence between the effectiveness of technical activity and professional ethics norms.	10	20	55	15
4	Necessity in training courses “Science in Ukraine” and “Science at NTU “KhPI”.	62	8	10	10

The given structure of responses testifies that international students consider that receiving more profound information about scientific achievements and science while their university training is very important. However, they do not have a complete idea and integral concept about the importance of science popularization. The analysis of the answers to the proposed problems confirms the relevance of the development of methodological issues on the promotion of science in Ukraine, whose research is being carried out by an increasing number of scholars.

At the stage of the establishing experiment, the students' opinion was also clarified about following issues: “What additional training courses do you consider useful for studying in the process of training at the university”: “Science in Ukraine”, “Science at NTU “KhPI”, “The phenomenon of Ukrainian scientists”, “Prospective specialties in NTU “KhPI”, “Your proposal”. These questions caused some difficulties for international students, although the answers were rather monotonous: 22% of students supported the course “Science at NTU “KhPI”, 20% – the course “Prospective specialties in NTU “KhPI”, 20% – the course “Science in Ukraine”, 16% – the course “The phenomenon of Ukrainian scientists”, 22% – did not give any preferences for any course (Figure 1).

The results of the analysis of the establishing stage allowed making conclusion about little awareness of international students' regarding achievements, problems and significance of scientific research.

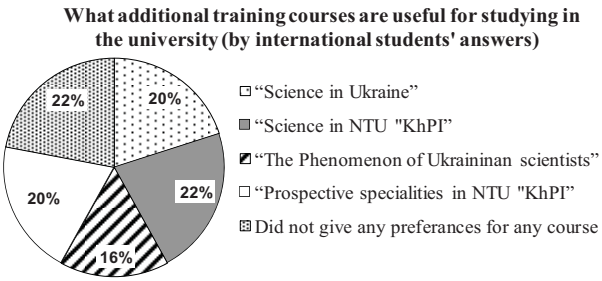

Figure. 1. Answers of international students of NTU "KhPI" to the question "Which additional training courses you consider expedient to study in training technical specialists at the university"

The next stage of the study was the forming experiment. The tasks of the forming stage of the pedagogical experiment were as follows: acquaintance of international students with the basic concepts of international scientific research; analysis of the main theoretical positions on the science popularization, developed both on foreign and Ukrainian base; identification of appropriate variants of science popularization among international students in Ukraine. To conduct the forming stage of the experiment, interactive courses "Features of scientific research", "Science in Ukraine" and "Science in NTU "KhPI" were developed, the educational tasks based on investigation real science issues were formed.

Educational material was developed in the form of interactive lectures and cases. Students received information about the history of the certain technical devices invention, as well as about the actual problems that modern scientists are trying to solve.

The material of the lectures and cases was not burdened with formulas and specific scientific terms; the process of creating a certain technical tool was based on a statement of what key scientific problems existed at each stage and whom and how they were solved. All these were contributed to raising the interest of the audience to science popularization. In addition, some lectures and practical classes were conducted in the form of "round tables" with participation of international postgraduate students of NTU "KhPI" and other higher educational Ukrainian institutions.

At the stage of the forming experiment, the following events were also carried out:

a) international students' conferences with discussion of modern scientific developments' practical significance;

b) meeting with well-known scientists who have made a significant contribution to the development of science;

c) excursions to the Kharkiv scientific museums;

d) excursions to the leading departments of the NTU "KhPI" with demonstration of their scientific achievements.

The NTU "KhPI" international students' scientific community was created, and foreigners from Ukrainian higher educational institutions have possibility to share their experience of training, answer questions, provide consultations etc. through the Faculty of International Education NTU "KhPI" Facebook [12-13].

The final stage was a comparative experiment, the essence of which was the attitude of learning outcomes in experimental and control groups. The instrumental tool of the comparative stage of the experiment was psychological and pedagogical diagnostics, which was conducted before studying the course in experimental groups and after its completion. International students gave answers to the same key problems associated with the popularization of science, which were offered to them for analysis at the stage of an establishing experiment.

According to the plan, two diagnostic sections in two groups of respondents were conducted: before and after completion of the pedagogical experiment. At the beginning of the experiment, the groups did not differ much in terms of cognitive activity: one third of students had low levels of educational activity, demonstrated passivity and apathy, and reluctance to leave the hostel. After implementation the proposed program in the experimental group, the percentage of international students with a high level of activity increased from 17 to 33%, the

percentage of international students with an average level of activity increased from 47 to 62%, and the percentage of international students with a low level of activity decreased from 36 to 5%. The situation in the control group remained almost unchanged.

The obtained results of the experiment indicate that the program of popularization of science among international students contributes to increasing their level of educational activities, and acceleration of the process of adaptation to new conditions.

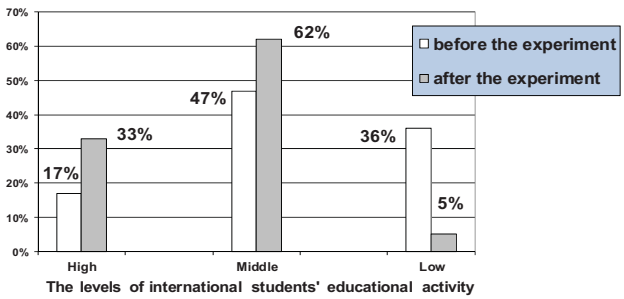

Figure 2. Comparison of the experiment's results before and after the program of popularization of science implementation

5. Conclusions

A program of popularization of science among international students will be useful for solving following tasks:

- increasing the number of international students who will be actively engaged in postgraduate and doctoral studies;
- international students' involvement in further scientific activity and continuation of appropriate training;
- promoting education at Ukrainian universities for those young people who are just about to come to Ukraine to study;
- increasing an intercultural competen-ce of all participants.

Teachers, sociologists, specialists in technical and natural sciences should be involved in activity regarding preparing educational materials for the program of science popularization implementing. Furthermore, there is a strong necessity to study the forms and methods of science popularizing used in world practice. Technologies of implementation the proposed program provide several areas of preparatory work: development of the necessary training materials, teachers' training, and using different forms of multimedia presentation and computer simulations.

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Scientific Student Associations, as a Way to Popularize and Develop Science

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Abstract. The analysis of the prospects of attracting scientific student communities for the development and popularization of science among young people, as well as their role in the STEM education program, has been carried out. The results of the work of the student scientific association "Electrolium" are presented. The evaluation of the effectiveness of the functioning of informal student associations in the popularization of science in the conditions of the modern higher school of Ukraine. Positive changes are demonstrated not only in the current progress of students who are participants in a student scientific association, but also in their personal characteristics.

Keywords. Competence, Knowledge Generation, Research Work, Student Association.

1. Introduction

Under the conditions of reforming the system of higher education in Ukraine, scientific student associations are acquiring special urgency, since the integration of research work into the process of professional training of future specialists allows improving the quality of education. The current world trend is the increase in the number of student associations and their members, the expansion of activities, as well as the effectiveness of their influence on the formation of skills and competencies of participants in such associations [1-2].

The creation and functioning of scientific student associations will allow to reveal the creative abilities of each student, to form additional knowledge, professional and scientific skills, to develop positive personal qualities and communication skills in modern society [3]. This will enable students to better prepare for future professional activities in the competitive world, which is one of the necessary components of modern education. In addition, the effective work of scientific student associations provides opportunities for the development of science in the environment of modern higher education institutions, involvement of young people in science, as well as popularization of science in modern society.

Thus, the study of the peculiarities of the functioning of scientific student associations and their influence on the formation of students' competences in the conditions of the modern higher school of Ukraine is an important and timely task.

2. History of creation and modern student community

The history of the creation of student communities dates back to the creation of universities. Virtually every university in the world has its own student councils, fraternities, nursing or committees. And if we have heard about fraternities in the United States from famous films and TV shows, then we know much less about student organizations in European countries [4]. However, this does not detract from their merits and the benefits that any student gets thanks to them [5]. After all, membership in student communities is often an important (significant) factor for employers and business leaders, in which a university graduate intends to work.

In the USA, the “student organization of Greek letters” has achieved more success [4]. That is, brotherhood and sisterhood, taking for the names of the letters of the Greek alphabet. The first such organization was (Phi Beta Kappa), formed on December 5, 1776, in the year when the United States gained independence, at the College of William and Mary (Virginia). Despite its semi-official foundation, this organization is the oldest in the United States and around the world.

The first officially registered student association was (Chi Phi), which opened its doors to students at Princeton University on December 24, 1824. However, the fraternity was completely masculine (which is why fraternity was called), since at that time women were not accepted into higher education institutions not only in the USA, but practically all over the world.

On April 25, 1867, the world's first sisterhood began to function - the organization L.C-sisterhood (Phi Beta Pi). It was the first women's student organization.

An interesting fact is that almost 22% of the US government is from student fraternities and sisterhoods. Many managers and media workers have also gone through a similar experience.

In Germany, the development of student fraternities began in the days of the Austrian Empire [4]. Only members of aristocratic families or people from the wealthy class of merchants and the middle class could enter universities in Europe. Thus, in the universities of Germany (for example, at the Heidelberg University) the first student fraternity was founded by aristocrats and received the name "Corps" (Corps). Burschenshaft is a fraternity founded much later, during the time of the German Empire. Burshenshaft adhered to conservative right-wing nationalist views and were the most widespread among students, since they accepted members to themselves, regardless of class or financial position.

Also in Germanic universities there were such student communities as Landsmanshafta (members of such a fraternity should belong to the same geographical region), Turnershaft (sports fraternity), Zingsherftah (singing societies), and various religious communities.

Today, student Germanic fraternities are divided by interest group. The most popular youth council in Germany is the “Vanderfogel” (migratory bird) - a fraternity advocating for individual freedom.

Italy from the Middle Ages suffered from the dictatorship of the Papacy, as well as a significant number of clergy who participated in the leadership of the country (more than 50%) [4]. That is why the freedom-loving students in Italy and began to create fraternity - in protest against control and dictatorship. This is how the secret communities of "rowdy" or Golardias appeared, many of which still exist today. Modern Gollardias are built according to this principle - the head of the organization is in every city and university, and each of them has a name fixed by tradition: in Perugia it is called the Griffin, in Turin - the Pontiff, in Pavia - the Tower, and so on. Traditions that existed in Gillardii has long been maintained now.

In Ukraine, student fraternities began to be created during the Russian Empire, when most of them were banned. A striking example of such a student society was the Cyril and Methodius Brotherhood, which included Taras Shevchenko and several other famous graduates of the Kiev-Mohyla Academy.

Today, student communities are established and operate in many universities of Ukraine: fraternity in Lviv Polytechnic, National University Ivan Franko, the brotherhood of the Karazin University and many others.

Ukrainian student communities are often very similar to student parliaments and councils, they mostly do not have a specific name. Membership in student communities today is an essential basis for cultivating responsibility, self-discipline, as well as leadership qualities.

3. Analysis of the student scientific community “Electrolium” work

The student scientific community “Electrolium” was established at the National Technical University “Kharkov Polytechnic Institute” in September 2016 and it included more than 30 students from three departments: “Electric Power Transmission”, “Electric Power Plants”, “Automation and Cybersecurity of Energy Systems”. These were mostly 4th and 5th year students. During 2019, two graduate students entered the team. The leaders (tutors) are 4 teachers. It should be noted that graduates of NTU "KPI", who were part of the student scientific community “Electrolium” continues to keep in touch with the active participants, which allows not only to ensure continuity in the community’s activities, but also ensures that its participants communicate with representatives of the professional environment in which students later have to work. This fact allows us to provide a focus on the needs of modern energy enterprises.

The dynamics of changes in the number of participants in the student scientific community "Electrolium" is presented in Figure 1. Data analysis Figure 1 indicates an increase in participants.

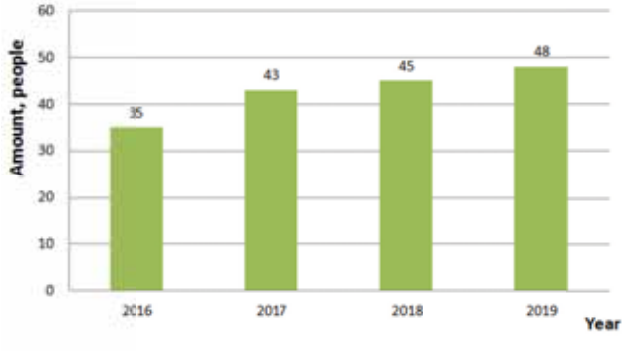

Figure 1. Dynamics of change in the number of participants in the student scientific community "Electrolium"

The characteristic by categories of participants of the student scientific community "Electrolium" for June 2019 is presented in Figure 2. and shows that the community is represented mainly by senior students, which is associated with a conscious choice, as well as the practical utility of the functioning of such communities. The participation of high school students confirms the popularity and relevance of creating such scientific communities.

The purpose of the activities of scientific student associations is the development of creative and scientific abilities of the participants, the realization of creative potential in accordance with their abilities and needs, the enhancement of their professional and general cultural competences in the field of scientific activity.

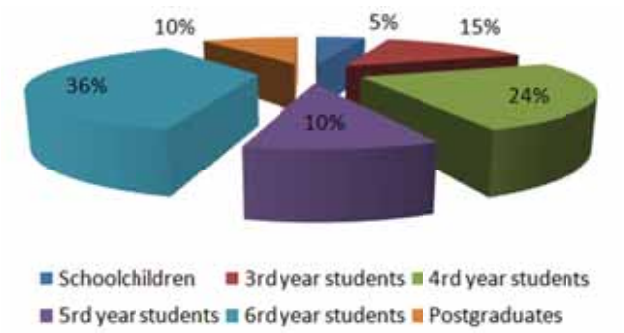

Figure 2. Categories of participants in the student scientific community "Electrolium" for June 2019

Among the main activities of the student scientific community "Electrolium" should be noted participation in events to popularize science, in competitions of scientific works, tournaments and competitions of engineering projects, in publishing articles, participating in scientific conferences, as well as social projects.

Thus, members of the student scientific community "Electrolium" participated in such events to promote science:

- organization of events in the framework of the international educational project for the popularization of science "Night of Science" (the total number of visitors is more than 2500), where the work of high-voltage equipment in a large high-voltage hall was demonstrated;
- a series of special events "Vacations with the Polytech" and "Saturdays with the Polytech" (the total number of visitors is more than 2500);
- organization of an open laboratory zone within the framework of the "Unusual Open Day" of NTU "KPI" with the participation of 2000 students and students;
- summer and winter STEM schools;
- festival of popularization of science in Ukraine "Scientific picnics";
- in the science festival "SCIENCE IS FUN" 2019;
- thematic research projects of the Arsenal of Ideas of Ukraine;
- scientific meetings with students in the high-voltage room National Technical University «Kharkiv Polytechnic Institute» (in the Tesla laboratory or Electrolium).

Among the scientific events in which members of the student scientific community "Electrolium" took an active part, it should be noted:

- International, All-Ukrainian and regional scientific and practical conferences;
- International and All-Ukrainian competitions of student research papers;
- All-Ukrainian Student Physics Tournament
- a scientific project Ukrenergo Laboratories - 2017, organized by the National Energy Company "Ukrenergo", which won first place;

- the 2nd All-Ukrainian Festival of Engineering Talents "Future of Ukraine 2019" with the participation of Progrestex-Ukraine, Tukana Engineering Ukraine, Boeing Ukraine, whose main goal is to promote engineering education, popularize the engineering profession, search, promote and support creative, talented youth, who plans to link their future with engineering activities.

Among the most important social projects in which members of the student scientific community “Electrolium” took part should be noted:

- the festival of social youth initiatives of the UPSHIFT Ukraine 2019 program, organized by the Professional Development of Kharkiv Foundation and dedicated to solving social problems through innovative projects;
- the Red Bull Basement University - 2018 project, in which students make positive changes on their campus and implement ideas for changing their university space.

Information on the main results of the work of the student scientific community "Electrolium" is presented in Table 1.

Table 1. The results of the work of the student scientific community "Electrolium"

Name	Number
Publication of articles	> 10
Abstracts of conferences	> 50
Scientific papers presented at international and All-Ukrainian competitions	7
Science projects	2
Social projects	3

The involvement of students and their active work in the student scientific community "Electrolium" contributes to:

- the formation of a number of competencies (professional, research, communication, social, organizational), allowing to improve the level of training and general competence of future specialists (bachelors and masters) [6];
- improving the academic performance of the scientific community;
- development of communication skills in various academic, scientific, social and social groups;
- formation of personal qualities of community members, allowing them to fully (or maximally) realize the potential of their development in scientific and public life.

Formation of professional skills of students when working in the student scientific community "Electrolium" is carried out:

- deeper and more detailed acquaintance with the most pressing problems of the electric power industry;
- the use of modern means and methods for solving tasks;
- development of skills for working with high-voltage equipment;
- practical experience in performing experimental studies and processing the results obtained.

Research competencies are formed among members of the Electrolium student scientific community as a result of:

- the ability to independently formulate and solve the problem;
- the ability to independently acquire new knowledge;
- the ability to independently find possible solutions and justify their correctness;
- the ability to represent and protect the results of research.

The formation of communicative competences of students when working in the student scientific community "Electrolium" is carried out with:

- ability to work in a scientific team;
- awareness of their personal role in the team of researchers (the generator of ideas, critic, performer, organizer, moderator, etc.).

Social competences are formed by students of the student scientific community "Electrolium" due to:

- the ability to adapt the scientific results obtained to solve various social problems;
- the formation of skills of participation in social projects;
- develop communication skills with various social groups and their elements;
- the ability to present the results of work in various social groups.

Organizational competences of students of the student scientific community “Electrolium” are formed due to:

- the ability to form a sequence of solving the task and identify the main stages of its solution;
- the ability to formulate and provide the basic conditions for obtaining a result.

Analysis of the results of the academic performance of participants in the student scientific community “Electrolium”, which are presented in Table 2, allows us to conclude that the performance of participants in the student scientific community “Electrolium” is higher than in other students of academic groups.

Such results confirm the fact of strengthening the connection between scientific and educational processes in the specialists training higher education.

Observing the participants of the student scientific community “Electrolium” for several years, it should be noted that they have developed such qualities as discipline, responsibility, education, sense of duty, decisiveness, initiative, practical thinking, technical fantasy, ability to criticize and self-criticism, concentration of the problem to be solved, perseverance in obtaining a result, perseverance in the performance of tasks, the ability to work with information, the ability to defend their point of view, the ability to make deliberate and rational decisions, communication skills in teamwork. All these qualities are necessary and important for students for a successful professional career. This testifies to the positive influence of creative and scientific activity on the formation of both basic research skills in the specialists training higher education and personal qualities for building a successful professional career.

In general, the results confirm the positive impact confirms the positive impact of the creation and functioning of the student scientific community "Electrolium" on its members.

Table 2. The results of the academic performance of participants in the student scientific community "Electrolium" for the 2018/2019 academic year

COURSE	Students category in an academic group	Session average score	
		Fall semester	Spring semester
3	Members of the scientific community	86	91
	Non members of the scientific community	83	82
4	Members of the scientific community	91	94
	Non members of the scientific community	88	90
5	Members of the scientific community	93	96
	Non members of the scientific community	89	92

4. Conclusions

Analysis of the results of the work of the student scientific community "Electrolium" allows to draw conclusions about the overall positive results of the community: increasing academic performance of students who are members of the student scientific community "Electrolium", increasing the level of knowledge and skills, the formation of professional skills and general competence, development of personal qualities, as well as sociability. Thus, the integration of research into the process of professional the training of future energy industry specialists allows to improve the quality of education of students, as well as contributes to the popularization and development of science in higher education.

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STEAM Project: «Zodiac constellations»

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Abstract. The main goal is to acquaint pupils with zodiacal constellations, to continue forming a scientific outlook, to develop a cognitive interest in the natural sciences, to cultivate a sense of responsibility and ability of cooperation in a team; to improve knowledge about the etymology of names and the mythology of zodiacal constellations with their subsequent realization in practice; to learn how to collect data in different ways, to analyze and organize them; to make a zodiac circle, models of zodiacal constellations in various techniques of decorative and applied arts; to analyze the digital RGB code of stars, to deepen the knowledge of foreign languages through the studying new vocabulary based on the introduction of grammatical structures.

Many people do not even realize that the Zodiac constellations control the laws of human lives, both from the outside and inside parts of the world. People usually turn to the zodiac for help with financial affairs, travelling, career, the date of marriage and military strategies. And they also argue that the zodiac signs of their birthdates may determine their features of character, temperament, ability, appearance and other peculiarities.

Keywords. Astronomy, Hands-on Activities.

1. Introduction

The Earth is one of the innumerable celestial bodies. In order to study the Earth more properly, it is necessary to find out what exactly is happening around it [1]. The human life mostly obeys to the "heavenly" schedule.

Therefore, the zodiac signs constantly continue playing an important role in lives of many different people. Even those who do not trust the horoscope may occasionally appeal to it for fun or curiosity. However, some of the pre-emptive astrologers can occur. But does it mean that looking for the information about stars is rational? Do the zodiac constellations affect on humans and their lives? What type of temperament do people have due to zodiac signs? What materials can you use to make models of the constellations? Is there any dependence between the wave length of the light and the RGB code?

For this project you need: a telescope, some hardware (a computer and a projector), software (Microsoft Office software package), fiber board, aerosol paints, LEDs, lithium battery – 2032, various secondary raw materials, natural materials, textile materials.

2. The algorithm of work with pupils

2.1. The general theoretical information about zodiac constellations

While the sun is setting beyond the horizon and the night comes, everyone can enjoy with the divine masterpiece – our night starry sky.

We all love to observe these countless brilliant points, which the sky is filled with. A person has dreamed of the sky for a long period, even he called the constellations with human names.

For better distinguishing the stars, in ancient times astronomers grouped them together thousands of years ago, as if they were points of an imaginary figure: a lion, a snake, weights or other objects or mythological creatures.

In the original Greece zodiacal constellations were divided into a special group, and each of them was assigned its sign. In the past more than 2000 years ago, the zodiac signs were shifted so that concerning between the coordinates of constellations and symbols does not. So there`s no correspondence between the dates of the Sun entry into the zodiacal constellations and the appropriate zodiac signs. Modern boundaries of the zodiacal constellations do not correspond to accept in the astrology ecliptic division into twelve equal parts. They were established by the General Assembly of the International Astronomical Union (IAU) in 1928.

And, as a result, at the present time, the ecliptic also crosses the constellation of Serpent Bearer (however, it is traditionally that Serpent Bearer is not considered as the zodiacal constellation), and the limits of finding the Sun within the constellations can range

from seven days (the constellation of Scorpio) to one month sixteen days (the constellation of Virgo).

The constellations of Fish and Capricorn are fully visible in the southern regions of Ukraine, the rest constellations - throughout its territory.

2.2. Practical skills and the first stages of work on the topic – the creating a zodiac circle

It is necessary to prepare patterns of constellations on paper and to transfer them to the fiberboard, then cut out and set the illumination of the main constellation stars [2-3]. This task is made by pupils of the 8-9 forms. So the pupils need to complete the following points:

- find images of the constellations through the Internet;
- transfer to the fiberboard from the paper using a multimedia projector;
- cut by contour with a jig saw;
- paint the billets;
- drill some holes for the main stars position;
- install LEDs with polyamide glue;
- split according to the parallel connection principle;
- install power sources - light batteries, voltage 3 V;
- balance the load on the various shoulders of the electric circuit with the help of coal-ceramic resistance.

2.3. Production of constellation models

Make models of constellations from different materials and in different techniques (this task for primary school pupils). Students should take steps such as:

- determine the technique of making models;
- prepare materials and tools;
- make templates;
- transfer the template onto the material;
- produce a model.

2.4. Study of the spectrum of the star's glowing through the RGB code

To investigate the spectrum of constellation stars glowing using RGB codes it is needed to find the answer to the following questions:

1. What constellations and when exactly can be seen in our area?
2. Is there a dependence between the wavelength of the light and the RGB code?

After that, students begin to complete their tasks:

- find an opportunity to capture the image of the field of view of the telescope;
- find a way to determine the RGB encoding for the light of the main constellation stars;
- create a wavelength and the RGB code matching table.

2.5. The investigation of the zodiac constellations effect on human life, character, fate, ability, doing business and fashion trends. The extending knowledge about zodiac constellations and explore their impact on people

Pupils should answer the next questions:

- How do zodiac constellations affect people's lives?
- What is the etymology of the constellations names?
- What are the ancient myths about the constellation?
- Does the constellation affect the business?
- What kind of temperament do students have due the signs of the zodiac?
- Do they need to choose clothes according to the zodiac sign?
- How are zodiac constellations represented in art?
- How are constellations located on the coordinate plane?

So, it is evidently the chosen theme of the project is a burning issue because our character, our destiny and activity are quite directly dependent on a certain zodiac sign.

Changing the hairstyle, haircut or make-up we can significantly draw our luck and success.

3. Conclusions

Congratulations!!! You have created the ideal zodiac circle, produced magnificent models of the zodiac signs, investigated their effect on life, destiny, character, type of temperament, people's abilities and behavior, doing business and fashion trends; studied constellations from different points of view in the closed interaction with other school subjects.

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A Science Club in Perú: Light, Optics, Action!

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Abstract. Hands-on/minds-on experiences are one solution for effective science education, creation of scientific literacy and even life-long learning. They can be employed in formal, non-formal and informal scenarios not only to create an interactive and fun environment but also promote the connection between science concepts to Nature. We set up a Science Club in Peru related to Optics where high school and undergraduate students were in touch with a lot of hands-on experiments designed with easily obtained materials. Although the objective of a Science Club is not complementing the science teaching in the public schools these activities provide important experiences that can be transferred to formal education, since low-cost experiments can be replicated at home or at the schools. In this work, the structure, resources, activities, and results of this experience are presented.

Keywords. STEM, Science Club, Hands-on Activities, Applied Optics, Research.

1. Introduction

Two years agoago a group of Peruvian scientists around the world created *Clubes de Ciencia Perú* (Science Clubs Peru - SCP), a non-profit organization established in an effort to promote science and technology in Society that pursues to inspire high school and undergraduate students in Peru to follow STEM (Science, Technology, Engineering, and Mathematics) careers. Since 2017 during the summer different SCP are carried out in multiple Universities of Peru in partnership with important institutions [1]. The program is related mainly with an intensive hands-on one-week workshop (five full days with 7 hours per day and a summary day in which each club present results to other clubs) that links previous knowledge of the participants with theoretical and practical aspects at the frontier of a specific subject. Usually, each SCP has 20-25 participants, 2-3 volunteer assistant students, an instructor connected with an international organization and a national co-instructor. This project allows participants to explore cutting-edge scientific topics while participating in social activities and networking opportunities for the future. It is also realized with a similar structure in other countries in Latin America (Bolivia, México, Paraguay, Colombia, Brazil, …). SCP is part of *Clubes de Ciencia* created in 2016 [2]. These projects are important tools to bridging the gap between STEM careers and Society, as one of the purposes of Science outreach, is to make these topics understandable and enjoyable to the public in general and in particular to high school and undergraduate students. In this work, we present our experience with an SCP related to our teaching and research in Applied Optics taught at the *Pontificia Universidad Católica del Perú* (PUCP).

Figure 1. Light, Optics, Action! [1]

2. Light, Optics, Action!

In 2018 our SCP (Light, Optics, Action!) was one of the eleven selected workshops in that edition (Figure 1). The program, that adopts the

theory and practice of inquiry-based science learning, was developed by personal of the PUCP and the University of Vigo with the idea of linking our research in Optics and Photonics with real-life experiences and high school and undergraduate curriculum based on our previous experience in training and teaching in Optics [2-11].

Figure 2. Hands-on activities in workshops

Different concepts were learned by students themselves about Optics and Optical Engineering through problem-solving, hands-on activities and discussion with peers with a lot of experiments with everyday materials on topics such as [3-11]: the nature of light and its properties including coherence and polarization, frequency and wavelength for different sources of light (incandescent bulbs, lasers, LED lamps, UV lamps, …); calculation of speed of light and refractive index; the basic principles of geometric optics and optical instrumentation in lens, mirrors, windows, telescopes, …; interference with white light and lasers; diffraction in gratings, CD, DVD, spectrometers, …; optical fibres and waveguides; colour and vision; etc… that are supposed to increase curiosity and desire to discover, experiment and explore more (Figure 2). Finally, participants visited the Optical Laboratories of the Physics Department at PUCP in order to experience the world of research in Applied Optics (Figure 3).

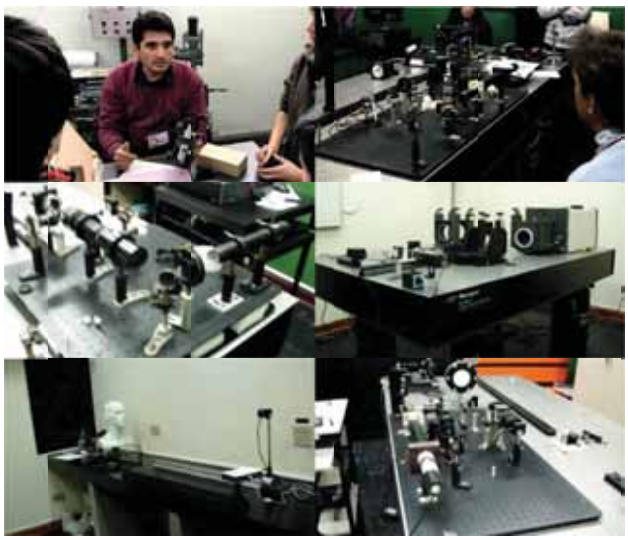

Figure 3. Hands-on activities in research laboratories

3. Learning Objectives

Different open problems were presented in a collaborative framework by implementing a combination of experimental and theoretical hands-on/minds-on activities, based on the idea that Optics and Engineering Optics can be joyful and accessible for everybody, transforming the way that participants interact with concepts and materials from their curriculum and that, at least, involves asking questions, making observations, building something, testing ideas, … With our SCP students would be able to:

a. Recognize the importance of light and light-based technologies;
b. Perform basic experiments in Optics combined with on-line simulations;
c. Identify the importance of learning through dynamic and participatory hands-on way;
d. Encourage the development of problem-solving, communication creativity and thinking skills

4. Results and Conclusions

As instructors, the experience can be considered as very satisfactory. To analyze the impact of the SCP, a survey, on a numerical five-point scale was provided. 100% of the participants took part. The most relevant aspects were taken into account and results show that students appreciated the

methodology since rated very high (with scores of near 4.5) our SCP with respect to its organization and general planning; prior dissemination; timetable; instructors and volunteers; hands-on experiments; match expectations; the degree of satisfaction; ... They also would recommend their friends to participate in SCP. The positive reply of participants as indicated in the survey results reiterates the success of the proposal. It was clear from the survey results that the students generally agreed that the SCP was more interesting than typical masterclasses or conferences. We think that SCP enables students to look at the world of light in a different way after the participation since, in most cases, they saw activities that they have never seen before and made experiments that they had never made before.

5. Disclaimer

We would like to thank participants, organizers and sponsors of “Clubes de Ciencias Perú”; Dr. María del Rosario Sun Kou (Head of the Department of Science at PUCP); Andrés Martínez Rodríguez, Claudia Parisuaña Barranca and Vladimir Calvera Cigueñas (volunteer assistant students); and Miguel Asmad, Rubén Sánchez and Guillermo Baldwin (members of the Applied Optics Group at PUCP) for their support and encouragements.

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Historical Experiments as Tool to Enhance Learning of Concepts and Electrostatics Phenomena: a Case Study of Grade 11th Learners in Mozambique

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Abstract. The world around us is in constant changes, implying a change in the educational paradigm that is geared towards the development of competences. These competences are linked to the knowledge of the nature of science, scientific literacy and scientifc argumentation including the knowledge about technology [1]. Recognizing the role of history and philosophy of science in teaching, defended by Ernest Machin 1887, Michael R Matthews in 1989, Pierre Duheimin 1906 and John Dewey in 1920 many researchers in Physics Education have chosen this method to make teaching science more graceful, which is a consensus option.

The practice has shown that the experimental component is being neglected, although it is implicitly linked to history and philosophy of science. The purpose of this study is to describe the learning environment of electrostatics in grade 11th in the traditional way. Later is also analyzed the students learning through the integration of electrostatic historical experiments as a didactical tool in the classroom. Other objective of this research isto evaluate through the historical view, the potential of developing new perspectives of teaching and learning physics in Mozambique.

The reason of selecting electrostatic is because the contents taught are merely abstract and they play a role to the explanation of electrodynamics concepts such as electrical current, voltage, concepts and laws related to generation, transport, conservation and distribution of electricity. The concepts of electrostatic and electrodynamics are all related to the operation principle of different electrical appliances and also the foundation of technology.

The experience shows that when learners are asked to show their creativity in terms of building Physics experiments, they tend to electricity among other fields of Physics in the secondary school such as Matter structure, Mechanic (Kinematic, Dynamic and Static), Work and Energy, Thermal phenomena, Solid and Fluid Statics, Geometrical Optics, Electricity and Magnetism, Electromagnetic Waves, Black Board Radiation, Atomic Physics, Nuclear Physics, Fluid Mechanic, Hydrodynamic, Gas and Thermodynamic, Oscillations and Mechanic Waves.

So in this research is considered that the learner's enjoyment is to understand the concepts of electricity which starts from the knowledge of electrostatics, the main focus of this study. Whereas, physics is an empirical science, where the observation and experimentation play a crucial role in the treatment of contents. Therefore, the goal of this research is to analyses the effect of historical devices of electrostatics in learning electrostatic concepts and phenomena, including building the nature of science and improve academic literacy to grade 11th learners in Mozambique.

Historical devices were built by the scientists in the past and played an important role for design, development of theories, concepts, and laws actually accepted. In this research, Historical experiments are applied to teach the electrostatics concepts such as electric charge and its proprieties; electric field and its proprieties, electrical potential to grade 11th learners. Is important to refer thatthis approaches is also emphasized in the Physics teaching program of Mozambique when it consider that with the inclusion of some elements of historical focus in the programs, it is intended, in particular, that students know aspects of the life, work, activity and points of view of eminent scientists and develop appropriate moral values [2].

These concepts are raised from the historical view through the use of electrostatics experiments, worksheets, posters and short historical videos about electrostatics. When the learners are passive in the learning process, then the learning is called traditional. In this process the learners do not build their own understanding of science. The teacher's activities are based on delivering the content by

exposing in the board or by dictating. The most prevalent VAK, teaching style in the traditional methodology is auditory.

The common didactical resources used in the traditional style are based on chalk, black board, rulers, test books, exercises books and exercise sheets for students. Sometimes it is possible to find some experimental materials for demonstration where students observe and try to describe phenomena, but they do not use worksheets. In addition, the common activities of students in the class are related to write notes and solve exercises based on data replacement. Through these elements is possible to say that there is rote or mechanic learning of Physics contents.

To integrate this approach in the classroom will be applied the theoretical framework of Model of Education Reconstruction (MER) [3] and the Cognitive-Historical Reconstruction (CHR) [4]. MER is composed by three core elements (1) Design and evaluation of teaching and learning environment in this case about electrostatics, (2) Research on teaching &learning (3) Clarification and analyses of science contents. Nevertheless, CHR is also composed by two core elements such as [5] contemporary model related to conceptual structure and [2] historical model relate to cognitive process.

To fulfil the application of this model a course of 13 lessons is designed where material are provided by the researcher. Two schools in the rural area of Sofala Province were selected as the population and sample of (N=400).The selected sample is divided in control and experimental group and the methodology of Pre-test, intervention and post-test is applied. The Pre is divided into 2 parts, the first is motivation test of 25 questions SMQ II of reliability α=0.92 [1] measuring 5 factor analyses elements (intrinsic motivation, career motivation, self-determination, self-efficacy and grade motivation).

The second part is learning outcome test, measuring the common misconceptions of the students about electrostatics. The results of this step allow to the researcher to design materials and lesson plans for intervention. In this pre-test and post test period both groups control and experimental group is assessed in the same way. The only difference will be in the intervention, where the experimental group the 13 lessons course will be designed while for the control group the activities will be the chalk based and all normal activities of the lessons. For this, the sample will be randomized to create an experimental group (200) and control group (200), assisted by two teachers T(1) and T(2). Semi-structured interview for Physics teachers took place to diagnose their PCK regarded to electrostatics contents. The first step of this research is the validation of the instruments learning outcomes test and guide of interview for Physics teachers. The results to be presented in this conference are regarded to analyses the level of motivation of the students through the traditional methodology, the learning outcomes of the students after learning electrostatics in the traditional methodology, also the PCK of the teachers in electrostatics contents.

The experiments to be integrated are based on previous works [6-7]. Also plays crucial role in this research the ideas of reconstructing historical experiments [4-5, 8-10]. The data of the questionnaire are categorized and analyzed by SPSS 21.0 program inferring complex linear modeling through, T Test, analysis of moment structures (AMOS) and WILCOXON.

These results are strongly considered in preparation of lesson plans, learning materials and environment of the classes. The PCK is assessed here to see the reason of some learner's misconceptions. While the learning outcome instrument is used in the reflection of which aspects to considerer when planning the activities for intervention second stage.

Keywords. Model of Didactic Recons-truction, Historical Experiments, Replication Method, Learning Concepts, Motivation, Electrostatics Learning Outcomes.

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Learning Platform as One of the Ways to Improve the Professional Qualification of Mathematical Disciplines Teachers at Higher Technical Educational Institutions

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Abstract. The concept of developing the 'For Higher School Mathematics Teachers' learning platform, the use of which can promote raising of the qualification of both young and experienced teachers of mathematical disciplines in a higher technical educational institution, is presented. The relevance of the research is proved by the analysis of modern studies into the issues of higher school teachers' further training, improving personalized teaching, upgrading educational resources quality, improving the training and teaching monitoring process. The rationale for the structure of the platform, its main sections and content is provided. To define the content of the sections, the results of the questionnaires, the proposals from teachers in higher technical educational institutions and graduate students studying in 014 'Secondary Education (Mathematics)' speciality were used. In addition, the results of the analysis of the content of the existing educational resources were taken into account.

Keywords. Mathematical Education, Higher Technical Educational Institution, Qualification Raising, Learning Platform.

Training of highly-qualified mathematics teachers is one of the topical international educational problems. Ukraine makes here no exception. We can observe the lag in the worked-out methods used by mathematics teachers at higher educational institutions from the advancements in modern technology. In particular, this applies to the technologies that are disseminated through learning platforms. As a result, both young and experienced teachers at HEIs have no possibility to access such online environment that should help in raising their qualification and promote their careers in education. This is exactly what predetermines the relevance of studying the problems of finding ways to further education for a modern mathematics teacher.

The development of the "For Higher School Mathematics Teacher" learning platform [1], was the result of the long study and analysis of modern research on the issue of raising the qualification of higher school teachers [2], improving of personalized teaching [3], upgrading the quality of resources [4], improving of training and teaching monitoring [5].

We took into consideration the results of the questionnaires and proposals from the teachers and graduate students who among the other ways of efficient training of mathematics teachers at higher technical educational institutions chose the development of a learning platform. The expediency of developing the platform was pointed out by 76 % of the interviewed technical HEI teachers. They mentioned that the existence of the online environment would significantly contribute to the improvement of the level of their preparation for teaching. The expediency of developing the platform was pointed out by 81,8 % of the graduate students. They noted [6] that the accessibility and mobility of the corresponding online environment were seen as an important requirement for a present-day student who learns in the midst of mobile devices.

The analysis of the existing educational resources [7] helped to come up with the development environment, platform concept and sections.

The developed "For Higher School Mathematics Teacher' learning platform has the form of a web-based system with two subsystems: users' subsystem (web site) and

administrating subsystem (content management). To be in line with the current trends in the existence of the web-based systems, the online platform meets the following requirements:

- accessibility, reliability and security which involve posting content on a modern, technically equipped server, or hosting;
- data security which involves the use of present-day web development, anti-hacking and anti-malware tools;
- user-friendly adaptive interface which allows the users and administrators to work fast on stationary and mobile devices.

Users' materials are to be provided in English and Ukrainian. The main page of the platform is presented in Figure 1.

Figure 1. The main page of the 'For Higher School Mathematics Teachers' platform

The Syllabi section focuses on reviewing engineer training programs that are constantly improving. The analysis of the regulatory documents will make it possible to implement mathematical reforms and increase opportunities for those students who are on the way of their professional development under the Master's Degree program.

The materials in the Mathematical Courses section will offer directions for their modernization, as well as materials for testing. A separate section will consider the issues of motivation in mathematical education. The methodology for using educational innovations will be provided in the Teaching Tools tab.

The content of the Project on Mathematics section will help to focus teachers' activities on the essence of the 'Mathematics for Engineers' idea. In our research we pay considerable attention to the issues of forming professional competencies of technical specialties students. That is the reason why we consider it necessary to engage them in the development of mathematical projects. The efficient use of additional resources and chats will stimulate interest in successful engineering achievements, in particular, in the field of promoting STEM-technologies that help bring math to practical engineering research.

During the analysis of modern monitoring technologies it will be determined which of them involve using computer and facilitate teaching planning.

The purpose of the Teachers' Forum is continuous learning, based on constant feedback between the users and the developers. Interactivity is to promote the development of students' discussion groups. The section is also slated to highlight the international library of pedagogical practices, the experience of applying STEM technologies by the countries that have achieved greater success in solving this problem. Acquiring better knowledge of academics' practical experience will help to create a community of practitioners and support their willingness to cooperate.

The concept of developing the platform was discussed at the international scientific and methodological conference 'Problems of Mathematical Education' in Cherkasy, April 11-12, 2019. [8].

The moderators of the platform are the team of lecturers of the Donbass State Engineering Academy, Donbas National Academy of Civil Engineering and Architecture, The Institute of Chemical Technologies (the town of Rubizhne) of the East Ukrainian Volodymyr Dahl National University, Kryvy Rih State Pedagogical University, Cherkasy State Technological University.

We welcome all interested teachers and students to join in our project on order to develop and improve mathematical education for technical specialties students.

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Nanotechnology, Bionics and Scientoonics: a New Hope to Change the World

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Abstract. Nanotechnology is a field of applied science and technology covering a broad range of topics. The main unifying theme is the control of matter on a scale below 100 nanometers, as well as the fabrication of devices on this same length scale. Richard Feynman described the concept of 'building machines" atom by atom in his talk titled "There is plenty of room at the bottom".

Bionics some times called Biomimetics or Biomimicry [1], basically biologically inspired engineering is defined as a “New science that studies nature's models and then imitates or takes inspiration from these designs and processes to solve human problems". Prof. Janine Benyus suggests looking to Nature as a "Model, Measure, and Mentor" and sustainability as an object of bionics. Bionics looks to nature and natural systems for inspiration. After millions of years of tinkering, Mother Nature has worked out some effective processes. In nature, there is no such thing as waste — anything left over from one animal or plant is food for another species. Human engineers and designers often look there for solutions to modern problems.

Sea shells are safe havens for the inhabitants providing protection against any predator and harsh environmental conditions as they are very strong. Sea shells are made up of chalk a brittle material so what makes them strong? By studying the nano structure of shells which are made in several years we can make high strength ceramics which are light yet very powerful. We can design turbine blades and engines. Tropical Morpho butterfly (*Morpho sulkowskyi)* found in Colombia, Peru and Ecuador and is famous for their stunning colours but these colours are changed in response to any change in the vapours. This is caused by the nanostructure of the wings scale which is capable of reacting and detecting to the gases in the atmosphere. This will help us to build more sensitive and selective sensors which can be used in metros, subways, stadium, sports arena, public concerts and gatherings for catching terrorists. Development of nano clothes to the paint which doesn’t allow settling dust on the walls, inspired by lotus flower and peacock feather are the best example of how Bionics uses nanotechnology.

What is most important today is that people are not aware of the promises Nanotechnology and Bionics holds for the future as they are complimentary to each other. In Bionics many of the models of nature are perfect example of nanotechnology done by the nature. Author who has started a novel concept of science communication called scientoon (a new class of cartoons based on science to understand, learn and enjoy science [2]) and has coined a new science called Scientoonics, will deliver a unique lecture using every slide as scientoon to create awareness about Nanotechnology and Bionics as what enormous future these two sciences hold together specially in the area of medical, pharmaceutical sciences, water conservation to climate change and thus helping in the sustainable development for a better world.

Figure 1

Keywords. Nanotechnology, Scientoonics, Scientoon.

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Science Festivals: For Science Communication in Tribal Area of India

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Abstract. India is a country of unique Social and cultural structure. Schedule Tribes are very specific community of the country. A substantial list of Scheduled Tribes in India are recognised as tribal under the Constitution of India. According to the census 2011 Tribal people constitute 8.6% of the nation's total population which is more than 104 million people. This section of the society is one of the most deprived sections of the population in the Indian society. Despite of various kinds of policies and programmes of the uplifment of the community they are still on margin especially in the field of science and Technology. Tribal children are not exceptions for this. With the objective of inculcating scientific temperament among the tribal students and to provide them an enabling and enjoyable experience of learning the fundamentals of science and mathematics through fun science festivals are being organized by Vigyan Prasar (VP) since 2016-2017 for tribal children in selected states of the country. (Gujarat, Jharkhand, Himachal Pradesh, Uttrakhand, Maharashtra, Telangana, Andhra Pradesh, Tamilnadu, Rajasthan, Orissa and Chhattisgarh) since 2016. The key point of the Science festivals is to take effort to understand the science on basic level and children can opt the science for further studies.

To explain science in easy method among the tribal children it is necessary to make the topic interesting as well as make the involvement of the children. Science Festivals provide a space to children to learn science with fun. Festivals are being organized on the basis of do yourself activity, (DIY) in which all the resource material provide to the children and ask them to do activities.

Science festivals are the innovative method to introduce the scientific information for the children of various age groups. With the help of this science festival Vigyan Prasar caters more than two thousands tribal children every year.

During the programme resource person (Subject experts) discuss the activity provide the time to the activities and discuss the science behind it. After the programme children discuss and ask their queries with the resource person and also these children give the training to other groups. And motivate to others to participate in the programme and share their scientific talent.

Except making the models children are doing their own efforts and make new models and ask their quires with the resource persons. VP received overwhelming responses from the children for the programme. Every year VP organizes more than 100 children science festivals at tribal area of the country to understand the science in easy manner.

Keywords. Census, Resource Person, Science Festival, Tribal.

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Perceptions of Science in Ukrainian Society and STEM Education

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Abstract. A promotion of science education is very important in the modern world. It is especially true for Ukraine. As a typical post-Soviet state, Ukraine was famous for powerful science, engineering and technical education system. After Ukrainian independence for over 27 years, the popularity and prestige of natural and scientific education has gradually declined. Despite the general trend of the world to reduce the popularity of the natural sciences due to their complexity in the study, insufficient assessment of the work of scientists and specialists in the field of natural sciences and technologies, the negative image of scientists in general, in Ukraine there are several specific points.

Table 1

	Number	Physics	Chemistry
2012	324,139	67,555	46,727
2013	315,858	69,763	50,423
2014	290,655	66,692	49,208
2015	267,394	51,463	39,730
2016	267,172	35,892	30,799
2017	239,945	26,491	24,811
2018	333,171	23,405	21,978
2019	349,365	23,485	15 476

The first one, there is an economy and political crisis of 1991-1995, which led to the destruction of the industrial sector of the economy, unemployment among scientists and engineers, and large industrial cities decline. That time graduates of scientific and technical faculties could not find a job. All of this consolidated for a long time idea that the scientists and engineers are not demanded in the Ukrainian labour market.

The second one, interest in science and technology in high school students are unbelievably falling today in Ukraine. This reflection can be seen in the number of students who choose the technical subjects and sciences for the compilation of external testing. The comparison in 2012 -2019 shows that the number of pupils in Ukraine who choose physics has decreased from 67,000 to 21,000, and chemistry from 42,000 to 14,000 (Table 1). The next indicator is the results of the receiving company. Figure 1 show very low interest in mathematics, physics and chemistry.

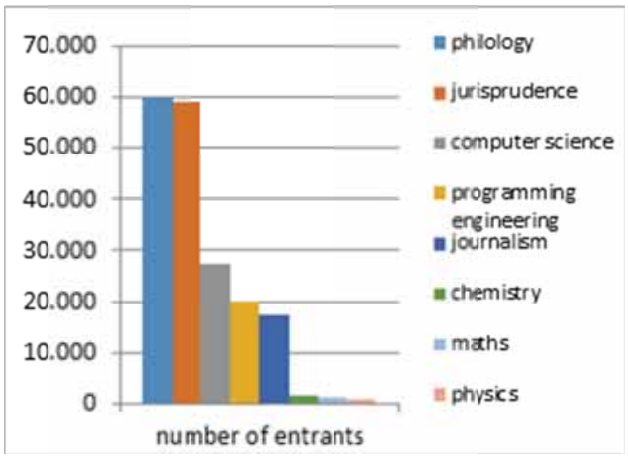

Figure 1

Development of science education is very important for Dnipro. This city is an industrial center of Ukraine. STEM-education is a way for solving this task.

The European Schoolnet Academy [1] experts' state that national strategies for the introduction of STEM as innovation should be aimed at: creating a positive image of science, increasing the population's scientific literacy, improvement in the state of teaching and academic achievement at school, increasing students' interest in science, its popularization, overcoming gender stereotypes and achieving gender balance. Current global STEM education models are based on the following common factors: reforming curricula, changing educational standards, establishing partnerships between schools, universities and employers, creating research centers for youth, innovation parks, STEM centers, STEM-ambassadress, STEM-laboratories

According to the Order of the Education and Science Department of Dnipropetrovsk Regional State Administration, No 881/0/212-16 dated 16th Dec 2016 "On conducting experimental research on the topic "Scientific and methodological principles creation of an innovative STEM-education model" created STEM-schools network, which involves 45

educational centers in Dnipropetrovsk Region (secondary schools, scientific and technological lyceums, gymnasiums), STEM educators and partner organizations, representing regional industry. The main task of this STEM community is to build a unique regional innovative STEM education model, to develop young people's interest in STEM education and careers.

Today, each partner creates its own innovative model of education. There are three types of model: communicative model of education system, infrastructural model and content one.

Keywords. STEM Education, Science, Innovative Model of Education.

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Searching for Chemical Elements: a Multidisciplinary Activity in the 150th Anniversary of the Periodic Table of Chemical Elements

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Abstract. 2019 is the 150th anniversary of the Periodic Table of Chemical Elements and has therefore been proclaimed the "International Year of the Periodic Table of Chemical Elements (IYPT2019)" by the United Nations General Assembly and UNESCO [1].

A working tool very useful to various professionals and in diverse scientific areas, this table would not exist if someone had not distributed and ordered the chemical elements according to the value of their atomic weights. The father of the Periodic Table, the Russian chemist Dmitri Mendeleev (1834-1907), was so visionary that his Table allows housing not only the known chemical elements at that time but also the ones still unknown that came to be discovered or synthesized.

When we come across this Table, with so many chemical elements, we ask ourselves how we use them and where we can find each of them, in our real world!

The outreach project Scientia.com.pt has been implementing regularly hands-on activities for children from 6 to 10 years under the name “Ciência p’ra que te quero” [2], since 2014. Each month, from October to July, in a public library, the Biblioteca Lúcio Craveiro da Silva (BLCS) in Braga, a set of 5 – 6 simple and small hands-on multidisciplinary experiments are offered to a group of approximately 15 children.

Such project, “Ciência p’ra que te quero”, was recently distinguish by the Portuguese Environmental Fund and awarded with the “Good practice award for Municipal Public Libraries 2017”. The success of the initiative boosted another edition in the academic year 2018-2019, with a renewed image and logo, the “Ainda mais… Ciência p´ra que te quero”

This work aims to describe "Searching for Chemical Elements”, the session of “Ainda mais…Ciência p’ra que te quero” that occurred in May. It consisted of a set of didactic activities whose main goals were:

i. to make the Periodic Table of Chemical Elements more familiar,
ii. to highlight its applicability in our daily life,
iii. to show its chemical elements and the objects/ places where we can find many of them,
iv. to promote multidisciplinary and transversal skills
v. to develop science education among 6–10 kids who are interested in playing extracurricular activities closely linked to their scientific curiosity.

The session "Searching for Chemical Elements” included:

1. a short initial presentation to the children about the Periodic Table of Chemical Elements, in order to contextualize the topic, making children familiar with some terms and definitions while understanding the practical activities they will be enrolled on;
2. the construction of a "Periodic Table Alphabet" allied to a peddy-paper;
3. the naval battle game adapted to the Periodic Table and, finally;
4. a demonstration of the coloured “firework” that can be made with some chemical elements.

At the end of each session, children were asked to fill a questionnaire regarding their opinion about the session. The vast majority of children liked the peddy-paper activity related with the "Periodic Table Alphabet", except one child who did not like it. The "Coloured firework" was also very appreciated by all the kids. Although the "Naval Battle" game was not experienced by all the children, the four participants stated that they had "really enjoyed" playing the game. Overall, the majority of children rated the three activities very positively.

Keywords. Chemical Element, Hands-on Activities, Multidisciplinary Activities, Periodic Table of Chemical Elements.

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IT-Assisted Teaching Microbiology to Hearing Impaired Students

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Abstract. The Law on Inclusive Education in Ukraine which determines the educational terms and conditions for students with special needs was carried out into effect on October 13, 2018. Deaf students at the Institute of Nursing and Laboratory Medicine in Lviv are offered a program on Laboratory Medicine. Upon successful completion of a course, they are awarded an associate degree in laboratory diagnostics.

Communication and instruction with this student population can be enhanced through building a visually rich learning environment because “most students who are deaf are primarily visual learners” [1]. General instructional aids include the assistance of a sign language interpreter and multimedia projectors. Alongside with these traditional forms of teaching, instruction makes increasing use of advanced technology-based approaches.

While studying laboratory diagnostics students do many microscopic analyses. A digital camera attached as an ocular camera to a microscope allows taking microscopic images which are then uploaded to a computer using image acquisition software. Displaying microscopic images on a big screen makes possible a group work and helps a teacher and a sign language interpreter to provide comments. Also students can create personal libraries of microscopic images.

Mobile devices have become a particularly useful tool, for example, for studying bacterial morphology. At the Institute of Nursing and Laboratory Medicine, hearing impaired students download “Bacteria interactive educational VR 3D” software [2] to their smartphones to explore bacteria with 3D animations which also contain captions.

Combination of traditional sign, fingerspelling and lip reading with innovative technology-based strategies is usually the best choice.

Keywords. Hearing Impaired, Ocular Camera, Mobile Device, Interactive 3D Animation, Education App, Image Acquisition Software.

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Science and Technology Educational Programs: Promoting Talent Beyond Curriculum

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Abstract. The level and standard of education and research in a country are prime determinants of the innovation capacity of a nation, and crucial for economies to move up. Countries increasingly recognize talent as a vital source of competitive advances and thus make education and research a core component of their innovation strategies. In the present, where science and technology are changing rapidly, the development of more specialized capabilities has become imperative. Catalonia, with Barcelona as its capital, currently stands as one of the main research and innovation hubs of all Europe, also becoming a reference worldwide. A privileged environment rich of universities, research centers, innovation hubs and scientific start-ups, big enterprises, and private and public institutions devoted to science advancement are settled all over the country. Over the last decade, Catalunya La Pedrera Foundation (*Fundació Catalunya La Pedrera*) [1] has been committed with promoting scientific and technology vocations amongst the youth through the programs *Youth & Science*, *Crazy about Science*, and *Barcelona International Youth Science Challenge (BIYSC)*; being the first two for Catalan local students and the latter for international students at a pre-college level. All these programs actively engage students through an inquiry approach using both sci-tech experimentation and critical thinking skills as they seek answers to their own questions. Innovative models of education based on hands-on multi-disciplinary research are applied, in cooperation with local and international research centers and institutions. The following fundamental values have been achieved for all projects: to identify talented students through the collaboration of school teachers, to apply a rigorous selection process methodology, to implement innovative research training through real scientists mentorship, to promote multidisciplinary and transversal skills, and to engage researchers to play a key role in the dissemination of science in the youth. Therefore, by gathering education and research, indispensable conditions for innovation to take place, these programs expect to help improve employability, productivity, innovativeness and entrepreneurial potential of tomorrow's working population, both in Catalonia and the world.

Keywords. Scientific Vocations, Excellence, Talent, Science, Technology, Innovation, STEM, Education, Research, Science Educational Projects, International, Innovative Education, Hands-on Education, Research Training, Multidisciplinary, Dissemination of Science, Youth & Science, Crazy about Science, Barcelona International Youth Science Challenge, BIYSC.

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Using ICT for Teaching Mathematics in Primary Education

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Abstract. Erasmus+ E-M@TI-ON project [1] was implemented the last three years (2016-2019) at six primary schools from six European countries. The basic objectives of the project were the improvement of pupils' mathematical competencies, ICT abilities, and English language skills, sharing good practices etc. During the last three years involved teachers used ICT as a tool to teach mathematics. In particular, Scratch programming environment [2] and robotics (Lego Wedo, Lego Mindstorms) were used from teachers to create projects in order to better explain mathematical concepts like division, multiplication, geometry, problem solving etc. On the other hand, pupils, under the guidance of the ICT teachers used programming and robotics to solve mathematical problems. This approach helped students to better understand mathematics, improved their ICT and English skills. Involved teachers changed their methodology on teaching mathematics and began to cooperate more with their colleagues. Robotics projects helped teachers and pupils to be more active and creative in the class and improved their problem solving abilities.

During the last three years, Edmodo was also used to implement flipped classroom strategy [3] to primary school pupils. Pupils' parents became members in learning procedure and they were able to watch the progress of their children. This approach was new for the pupils and helped them to be more confident, autonomous, active and creative. A lot of math lessons, math games, and worksheets were created during the last three years and they are all available in the project's web page [1].

Keywords. E-M@TI-ON, Robotics, Mathematics, Flipped Classroom.

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Summary of Categories of Play for STEM

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Abstract. Play is not of one kind nor is it constant from birth to whenever. Goldschmeid and Jackson [1] identified heuristic play. She named the phenomenon of babies finding out for themselves about artefacts usually constructed by humans but also of naturally made bio facts such as a vegetable or geofacts like pebbles that they find. She suggested providing a selection of such in a basket or other container (a treasure basket). Children explored the properties of materials, through touch, and manipulation for example. Goldschmeid and Jackson [1] introduced the 'treasure basket' where items were placed in basket or other container for the non-mobile child. However, once mobile, any environment in which children are becomes a site and opportunity for children to indulge in heuristic play.

From a science point of view this is Inquiry based learning. In any structured play whether children are left alone to choose what they do and how they use provided items or rules, children will " Do it their way", not as adults who designed the items and coated and would expect them to be used. Instructional play is a remedy to this tendency of a child employing their natural way of finding out, inquiry, it's self-will! Free choice play is similar to the process of STEM inquiry. Observations trigger questions and a strategy is planned, reflecting previous knowledge and understanding and requiring organisation logistics of items needed for investigation and action a plan, together with assessing the outcome. Watch children working through this process!

Distinct types of play are: unstructured and structured. I prefer to subdivide them into free choice and unstructured play. In such there are no toys or other artefacts or systems signed for children (or adults with which to interact).

Hence:

1. Free choice unstructured play, where there are no 'toys', only resources that you can find outside, or/and inside: This is free choice heuristic play.
2. Structured play is when artefacts are purposely available. These may be everyday items as in classic heuristic play or they may be artefacts, such as toys, or play equipment , designed by adults for children, who do not necessarily use them as 'they should', but utilise them as they feel right for them. Designed by grown up wish their ideas- not by children with theirs re-enactment artefacts are often available, small simpler versions of adult items such as cooking utensils, other tools and items such as cookers.
3. Mediated play when toys are available and the children choose with what they are 'playing', moving often from one to another.
4. Facilitated play when specific items are made available and the child is expected to 'play' with, but in fact often adapts the items for their own exploration.

Instructional play, where the aim is for the child to try an activity or artefact and lead into developing some specific skills.

Keywords. Play Types, Heuristic, Structured, Unstructured.

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20 000 Leagues Under the Sea

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Abstract. "The main goal of Education in Science, as part of students' global education, is prepare them to life in the XXI century" [1].

"In Primary School, School must offer students more than traditional reading, writing and counting activities. It is essential to take students to perform experiments. Learn about Science and Technology is to acquire a passport to understand the world you live in and, therefore, adapt furthermore to it. "The sooner that happens, the better." [2].

By implementing and developing this project, planned, tested, applied and produced a complete Learning Project, using Inquiry methodology, aimed at Pre School and Primary School Students, about Earth's Oceans. Students travel along with the characters of the homonym book by 3Jules Verne, trough Earth's oceans, discovering its animals, plants and main difficulties they have to deal with. Students also investigate where water comes from, local river courses, its problems and consequences on the beaches where they end, especially pollution issues. This way we expect to widen students learning horizons and motivate them to protect our planet's natural marine resources. It's also our main goal to enable students to overcome learning difficulties and cultural backgrounds which lead to poor school performances, by opening windows to a different world of opportunities and providing the chance to learn along with peers from a different country.

The experiments planned are in a growing difficulty level, aimed at the students' level and acquired competences, along the STEM curriculum and applying Inquiry methodology.

Students are required to perform activities using their smartphones, in a BYOD point of view, in order to bring real life situations and resources into the classroom, allowing the use of virtual resources in the real world.

Keywords. Science, STEM, Hands-on, Robotics, Augmented Reality, Virtual Reality.

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Abstract. A mystery to the ancients and a marvel to Einstein, electromagnetism is inextricably linked to the operation of motors and generators, the functioning of radio, television and computers, and our understanding of the universe. From the Greeks, who may have been the first to study electricity to Einstein who, as a child, was captivated by the mysterious properties of magnets, humankind's fascination with the electromagnetic force has never stopped. Your students are certain to feel the same sense of mystery and wonder as they probe this fundamental force of nature.

The strengths of hands-on, inquiry-based education are that a student's own curiosity and questions drive the learning. With that in mind, the activities presented in this program are meant to serve as examples of ways to engage students in the investigation of electromagnetism.

Keywords. Electricity, Electromagnetism, Generator, Hands-on Learning, Induction, Motor, Magnetism.

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Discovering Light. Introducing Interference and Diffraction

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Abstract. Light plays a fundamental role in our lives and optics and photonics have a huge and ever increasing importance in a wide range of industries and impact in our modern societies. It is therefore essential that a solid knowledge on this subject is acquired as early as possible, right from primary school or even at kindergarten, in a process of active and participated discovery by the pupils themselves who naturally have an empathy, interest and special curiosity for this Light and Optics subject as it directly relates to vison, one of our major senses. We will briefly explore in a very basic and introductory way two important phenomena on physical optics: diffraction and interference. Simple demonstrations and hands-on experiments will be explored.

Keywords. Hands-on Optics, Interference, Diffraction, Elementary Optics, Teacher Training.

How Water Works…

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Abstract. This work was planned in a cross curricular view, articulating collaborative work between students of different levels, from Primary to Secondary School. It can be replied either in a progressive level of difficulty approach or each level individually. Starting from computational thinking approach, trough programming in SCRATCH [1], programming robots and an ecological house, nothing will be uncovered regarding "How Water Works".

This project is all about water, its role in our life and our role in its preservation. Divided into 3 different levels (easy, for primary school students, intermediate for middle school students, and advanced for secondary students), this project is adjustable for collaborative work in different school levels and cross curricular activities. Students get very motivated, as they are always connected with each other, sharing ideas and presenting results. In the easy level, students are challenged to research where water comes from. The teacher poses some questions, to tease students' curiosity and then… The adventure starts! Students are led to research, learn and share findings with school colleagues. At the same time, students start learning computational thinking, through easy challenges, which lead them to learn how to program simple bots.

After finishing their researches, students start working in small groups, building some beginners' projects using the demo modes of the We Do 2.0 APP, with special emphasis on water related projects. Then Students must build an ecological solution, using any bricks or set they want, in which they must present an innovative solution to save water. In the example presented, students built an ecological house (SET 31068) and combined it with some extra bricks plus the We Do 2.0 set. Then students built a rain water collector, which was connected to a filter (coded by the Lego APP), that led the water into the farm, so animals could drink fresh water. In the intermediate level, students aim at a dam cleaning project, which is centred in a robot that goes through the water shores in the dam, detecting solid garbage. This project has two versions, using two different robots, the LEGO version uses the EV3 LEGO Education kit. In the Arduino version, the work base is a Portuguese robot, developed by the Portuguese Association of Computer Sciences Teachers, ANPRI, which can be printed in a 3D printer, then assembled and onto which is attached an Arduino microcontroller and its accessory range.

Finally, in its advanced level, the main goal is for students to achieve conscience of water (river/dam) pollution. Students must program, in SCRATCH, games that stimulate others to help preserve the water and thus alert people to not throw garbage in any form of water.

The experiments planned are in a growing difficulty level, aimed at the students' level and acquired competences, along the STEM curriculum and applying Inquiry methodology.

Students are required to perform activities using their smartphones, in a BYOD point of view, in order to bring real life situations and resources into the classroom, allowing the use of virtual resources in the real world.

Keywords Science, STEM, Hands-on, Robotics, Water; Image Processing, Data Acquisition, Microclimate, Robots.

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[1] https://scratch.mit.edu/

Problems Implementing 5E Instructional Model: an Action Research

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Abstract. In this study, an evaluation of the process and outcome of a science lesson realized by employing 5E model which is one of the teaching models suited to the principles of constructivist approach. The study is an action research carried out with classroom teacher candidates taking science methods course pursuing their 3rd year at Faculty of Education. The course is about simple electric circuits and the internal structure of a light bulb. First step of the 5 E method aims to draw attention of the students to the subject and to determine their previous knowledge of the subject. For this purpose, pre-service teachers presented a story and posed questions at the end of the story which they needed to have information about basic electric circuits to answer them. The answers given at this stage showed that most of the pre-service teachers had previous knowledge about the subject.

The second stage is the exploration step. In this step, the students were given the materials they would use for the activity in order to construct the knowledge of the subject to be taught and gain the related skills. The question at this stage was: how to light the bulb using a battery, a bulb and a conductive wire. Here, it is necessary to use conductive wire in one piece. Students were asked to draw the circuits which they believe the bulb will light when they set it up. Then, they made to construct the circuits which they designed with the material on their hands and observe that whether the bulb light. In this exploration stage, students were asked how they should set up the circuit, but they were not given the answers, they were guided only by posing questions. Most of the students' designs did not work and they have observed that the bulb was not lit. Although some students have set up the circuit correctly, it was observed that they did not construct the desired knowledge in their minds, they found the correct answer by trial and error. The designs of the students showed that there were some deficiencies and misconceptions about the circuit. It is also understood from their explanations, although some of the students have correctly set up the circuit, they held some incorrect ideas. Information on this stage and examples of student ideas will be presented in full text.The next stage is the stage of explanation. Students are required to disclose their knowledge in the exploration process. At this stage it is understood that the student information is inadequate. Since both the descriptions are insufficient and this step of the 5E model requires this, the instructor explained the internal structure of the light bulb and the working principle of simple electric circuits. For the bulb to light, the current must flow through the two conductor wires of the bulb and the characteristics of the closed circuit are explained. However, each and every situation in which bulb will light was not described one by one. Here the lecturer criticizes herself for failing to help students to fully reveal the ideas in their minds. (Because the evaluation at the end of the lesson, it was seen that students thought that the bulb will light only one way). Hence, the explanation process was although proper, it was failed since it did not address the misconceptions of the students.In the next stage of elaboration, students were asked to look at which objects transmit electricity. They found this stage fun and looked at the conductivities of various materials around them.

Final stage is the evaluation phase, students were distributed 2 worksheets and asked to indicate whether the bulb will light up in different circuits and if not light, explain why it does not light. In one of the worksheets, the circuits are constructed with one battery and the bulb, and in the other, with the two bulbs and two batteries, it was asked in which circuits the bulb will light. There is also a section that requires students to draw the conductor wires in the light bulb.Results of the final exam 2 weeks after the lesson revealed that about 50 percent of the students reached the correct concepts,. However, the others held some misconceptions. The lecturer evaluates this practice as a failure on her side and finds it appropriate to make certain modifications in the lesson plan, especially in the explanation and exploration phases.

Keywords. Action Research, Simple Electrical Circuits, 5E Instructional Model, Pre-service Primary Teachers.

A Useful and Active Learning Method for Teaching Interaction of Light and Matter Using a Hands on Activity

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Abstract. Hands-on science is defined mainly as any instructional approach involving activity and direct experience with natural phenomena or any educational experience that actively involve students in manipulating objects to gain knowledge or understanding. So using hands on activities in teaching of the abstract concepts may be resulted to getting a deep understanding of the concept.

The particulate nature of matter and atomic structure are important concepts that have been emphasized as critical concepts in the secondary school science curriculum. A plenty of learning difficulties have been reported in many studies in this case because of it's abstract nature. Interaction between matter and light have been presented a lots of clue in understanding of atomic structure. Therefore, I report here a useful hands on activity that in which students first make a simple spectroscope and then observe some spectra. Actually they will have their own personal experiences on interaction of light with matter. Indeed, they observe continuous spectrum of sun light and Flashlight with incandescent bulb and also many linear spectra of different light like LED, mercury, neon and fluorescent lamps. Finally they make results and their own knowledge with comparison of these spectra.

Keywords. Light, Matter, Spectroscope, Hands on Activity, Linear Spectrum, Continuous Spectrum.

An Innovation Challenge

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Abstract. Over the past twenty five years children from age 13 upwards have participated in an annual science challenge, with some 600 youngsters involved in teams of up to six participants. The challenges take place in heats, followed by a final where the ten best teams from each heat compete against each other in a different challenge. All the judges participate in a training competition themselves so they understand the issues involved.

In Kharkhiv, it is suggested that participants make small teams of 2-6 people, these can be teachers, lecturers or students. Each team is given a pack of resources and instructions to build a specific structure within the time given. Points are awarded as teams progress and at the end to see which team's innovative structure complies best with the criteria given at the beginning. The challenge involves science ideas but using them innovatively. It will be interesting to see how adults cope!

Keywords. Challenge, Using Scientific Concepts, Team Work.

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Meaningful Teaching of Intermolecular Forces by Doing Fun Experiments

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Abstract. Intermolecular forces are responsible for physical properties of matter such as solubility, boiling point, and so on. Formation of a solution or mixture depends to the magnitude of these forces between solvent and solute. If the interaction between particles of a solvent and solute in comparison of interaction between particles of solvent and solute are of similar magnitude so the two substances are soluble in each other in all proportions. Otherwise, an heterogeneous mixture is formed.

Students have often misconceptions of understanding of intermolecular forces and comparison of their magnitude. In order to teach properly these concepts, we report a useful lesson plan. According to this lesson plan, students do some interesting fun experiments as the following:

First, add 5 ml of acetone, 10 ml of water in a test tube, then pour a few drops of the beta-dine solution (a disinfectant)in the test tube and observe what happens. After that, add a teaspoon of salt or more to the solution and again write your observation. Students do this experiment with different available and safe chemicals. Finally they build their understanding and knowledge according own personal experience. As a result student will learn that the strength of intermolecular forces between different substances, may vary in a somehow extent.

Keywords. Intermolecular Force, Acetone, Fun Experiment, Solvent, Solute, Solubility, Solution.

An Edible Periodic Table

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Abstract. The purpose of this paper is to introduce the periodic table in an innovative way, which may help students remember some of the elements, their atomic numbers and symbols. The participants pick a card, which identifies an element. Everyone ices the name of their element on a biscuit and places it in the correct position on a periodic table chart. Hopefully enough people will take part to complete the table. This innovative idea has worked with children aged 8 upwards and provoked new interest and discussion in the elements themselves and the periodic table.

Keywords. Discussion, Elements, Fun, Periodic Table.

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Utilization of Time-Lapse Microscopy for Understanding Cancer Cell Growth and Effects of Anti-Cancer Drugs

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Abstract. The number 1 cause of death in Japan is cancer and about 370,000 people die of cancer every year. Cancer is a major challenge for humans and a lot of energy and resources have been being invested to overcome the major cancers such as lung, stomach and colon cancers. Brain cancer is a rare cancer (about 0.4% of total cancer death) and being poorly invested in terms of exploring potential cures. But it is the 2nd major cancer for children (under the age of 14) and has the worst survival rate. We have been focusing our attention on triterpenoids and isothiocyanates from plants as multifunctional agents for the prevention and treatment of cancer. However, it is not an easy task to visually demonstrate how cancer cells grow and show the effects of the candidate agents for treatment of cancer. In the presentation, the anti-proliferative effects of glycyrrhetinic acid (GA) from licorice and 6-(methylsulfinyl)hexyl isothiocyanate (6MITC) from wasabi on the brain cancer cells U-251 will be demonstrated, utilizing time-lapse microscopy.

Keywords. Microscope, Time-Lapse, Cancer, Cell Growth.

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3D Images and Holography. A Brief Introduction

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Abstract. The tridimensional visualization of images is getting very important our day with applications of upmost importance in medicine and a wide range of industries and business. As well it plays a major role in virtual reality that appeals strongly to the young generations. In a simple hands-on explorative way we will make a brief elementary introduction to the concepts of 3D image and holography applying basic concepts of geometrical optical and of interferometry and diffraction and the properties of light in general.

Keywords. Hands-on Optics, 3D, Holography, Reflection, Coherence, Interference, Diffraction, Teacher Training.

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AUTHOR INDEX

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