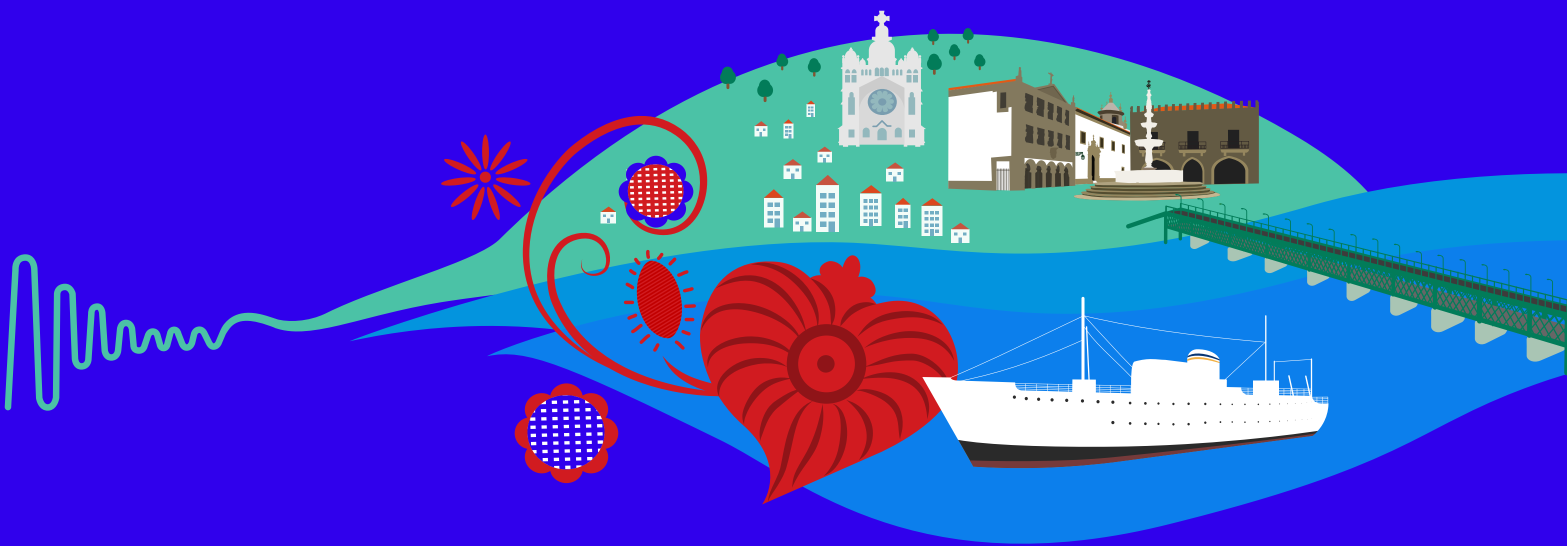
Hands-on Science

Science Education. Discovering and Understanding the Wonders of Nature.



Edited by:
Manuel Filipe P. C. Martins Costa
José Benito Vázquez Dorrío

The Hand-on Science Network

Hands-on Science
Science Education
Discovering and understanding the wonders of Nature

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Foreword

Science Education
Discovering and understanding the wonders of Nature

With our 17th annual Hands-on Science conference, at the very beginning of a new decade that many of us are expecting to be the turning point of a certain civilizational regression we are witnessing at different levels in our societies and world for quite some years already, we decided to celebrate the importance of Science Education to our lives and humankind as a crucial step to *Discover and Understand the* so many *Wonders of Nature*!

And how wonderful remarkable and remarkably varied are all the “faces” of Nature!

Sadly, not all of those “faces” are, always, pleasant to us… and, once more, we were surprised by the amazing power of a sort of molecule… and the COVID 19 pandemic, in a way, turned our lives “up-side-down”. Showing, so clearly, how important is to know and understand Nature… how important it is Science to the survival and sustainable development of our societies and of humankind. And also, and therefore, how decisive it is our role as Science Educators…!

Unfortunately, this year we will not be able to meet in person and share all together a pleasant week enjoying the Nature’ scenery of Viana do Castelo’ mountain river and sea! However, we are together with our common goal, not just in spirit but also *online* profiting from the technological advances Science allowed in the field of telecommunications.

A good number of very interesting and meaningful contributions were brought to HSCI2020 to be shown online at the conference website and or presented live. As always, a large varied number of subjects are addressed in different perspectives all with a common ground: to improve science education and scientific and technology literacy in our schools and communities.

The book herein aims to contribute to 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 17th International Conference on Hands-on Science held online, July 13 to 17, 2020.

Vila Verde, Portugal, July 3, 2020.

Manuel Filipe Pereira da Cunha Martins Costa
Editor in chief

FOREWORD

CONTENTS

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Antibio-Don´t! A Hands-on Approach to Antibiotic Resistance: the Use of Disk Diffusion Method and Bioinformatic Analysis of Proteins

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Abstract. Science education is essential to promote scientific culture and the effectiveness of “hands-on” approaches is undeniable, promoting meaningful learning. A hands-on, laboratory project is proposed to approach antibiotic resistance in bacteria, adapting a well-known protocol of transformation of Escherichia coli with pGLO plasmid. To test the ability to resist ampicillin, a Disk diffusion method is proposed. Expression of Green Fluorescent Protein (GFP) is used to introduce structure-function concepts and bioinformatics analysis with database use of protein 3D structure, mutations and impact in protein fluorescence.

Keywords. 3D Protein Structure, Antibiotic Resistance, Bioinformatics, Disk Diffusion Method, GFP, pGLO Transformation.

1. Introduction

Biology is an experimental science that also relies on the creativity of the subject, so is important to promote a hands-on approach contact with scientific knowledge. This allows students to construct their own knowledge, being aided by the teacher, according to inquiry principles. Keeping this idea in mind, promoting practical activities, lab activities or experimental work and fieldwork is crucial to students´ academic and personal development [1].

1.1. Microorganisms and antibiotic resistance

The study of microorganisms has been proved to be of great importance through the course of history, from drug development to interactions with other organisms, including humans [2]. Therefore, it is not surprising that the study of microorganisms is part of the scientific curriculum. Microorganisms can bring both best and worse sides from various subjects and bacteria are no exception. They can both improve and negatively affect food industry, and show promising evidence concerning anticancer activity [3]. Their capacity to produce antibiotic components is also widely known and studied [4].

Antibiotic resistance is not a new issue. To survive in a highly competitor environment, bacteria tend to develop abilities to gain advantage. Increasingly, episodes of antibiotic resistance and even cases of multi resistant bacteria are being reported, having a direct impact on humanity´s quality of life. Resistant bacteria may emerge upon exposure of bacterial populations to sublethal concentrations of antibiotics [5]. According to Eurobarometer [6], more than half of Europeans believe that antibiotics are a successful treatment for virus caused infections, such as colds, revealing a widespread misconception. In this way, with exaggerated antibiotic use, these compounds can escape into the environment, derived from human activities, such as farming and medical uses [7]. Antibiotics are used widely in agriculture and aquaculture and may result in exposure of the consumer to these drugs [8]. Therefore, it is extremely important to address the use of antibiotics, as well as the problems that are associated with their misuse.

1.2. Competence, transformation and gene regulation

A great way to understand how antibiotics work on microorganisms is through genetic engineering, and in particular, bacterial transformation. Genetic transformation is a widely used technique, where DNA from one organism is incorporated in another. These DNA molecules are inserted in plasmids, that are characterized by being small circular molecules, separated from chromosomal DNA, having capacity to replicate independently. Engineered plasmids are commonly used in the laboratory as vectors in molecular cloning. This gives the host the capacity to produce new proteins, encoded by new genes and providing different characteristics from the originals [9].

In order to save energy and increase their efficiency, prokaryotic organisms possess regulatory mechanisms that allow adaptation to specific environments by regulating the expression of specific genes. One possible way to show students how this process works, is through competence induction in *Escherichia coli* (*E. coli)*, followed by transformation with pGLO plasmid. This plasmid codes for ampicillin (antibiotic) resistance, conferred by β-lactamase, and for Green Fluorescent Protein (GFP) whose expression is regulated by a promoter of the arabinose operon. This means that its expression will only occur in the presence of this organic compound, allowing a visual, simple and effective identification [10].

1.3. Technological revolution and biological studies

Nowadays, due to the development of techniques such as Next-Generation Sequencing, it became possible to obtain large amounts of information in a shorter period. To be able to respond efficiently to these technological advances, bioinformatics emerges with enormous importance. Bioinformatics is a field of study where mathematics and computational power come together to process biological data, extracting valuable information and drawing conclusions. To make this possible, two categories of platforms were created: databases, that contain and organize information, and tools, such as sequence analysis and prediction of three-dimensional protein structures, that aid to analyse and make sense of this data [11].

1.4. Aim

In this work, a laboratory activity involving *E. coli* transformation was developed, followed by a bioinformatical analysis, aiming to provide high school students (or even students from first years of college degrees) a close contact with molecular biology, but also to introduce them to the field of bioinformatics, which is being proved increasingly helpful to produce new scientific knowledge.

2. Material and methods
2.1. Growth media

To prepare the Lysogeny Broth media (LB) DIFCO (25 $g.L^{-1}$) for bacterial growth, 5 g of this media were dissolved in 200 ml of distilled water, in three flasks. 3 g of Agar (15 $g.L^{-1}$) were added to each LB medium and sterilized in the microwave. Microwave can be used as an alternative to autoclave, since high schools are not typically equipped with such devices, and they have been proved to be a working alternative [12]. It is important to monitor the activity to prevent the sample from boiling and overflowing. Dissolution is complete when no suspended particles are observed. After cooling down, 200 μL of ampicillin was also added to two of these flasks, to a final concentration of 100 $\mu m.mL^{-1}$. Arabinose (600 mg) was added to one of these flasks to the final concentration of 3 $mg.mL^{-1}$. Media was plated, being the plates marked according to their composition.

2.2. *Escherichia coli* DH5α

E. coli is a widely used organism academically, but also in terms of educational practice, since it has a small genome, already sequenced, and is easily manipulated, reason why it is widely used to test new technologies. DH5α is a non-pathogenic strain that was used to perform this experiment since it is engineered to maximize transformation efficiency and it also lacks some endonucleases, which could digest the plasmids during the procedure [13]. It does not produce significant repressor protein lacI, which means there is no need to use lactose to activate expression under the control of lac promoter in high copy number plasmids.

2.3. pGLO plasmid

The pGLO plasmid used in this experiment (Bio-Rad's pGLO plasmid, Bio-Rad Laboratories #166-0003-EDU) is broadly used as a vector plasmid since it comprises several interesting genes, such as the GFP, isolated from a bioluminescent jellyfish, *Aequorea victoria*, which allows to detect visually the success of the transformation process, in the presence of arabinose, and the ampicillin resistance gene, allowing the host to thrive in media containing the antibiotic.

2.4. Competence induction

Prior to competence induction, a culture of *E. coli* DH5α was grown in LB medium, incubated overnight at 37°C, with vigorous agitation. Culture should then be cooled down between 5 and 10 minutes. It is important to keep cells at low temperatures and to be properly handled, since cells are highly sensitive throughout the hole procedure.

To induce competence in the *E. coli* DH5α strain, a the CaCl2 method was used. 10 ml of culture were centrifuged for 5 minutes, at 1500 rpm. Supernatant was discarded, cells were resuspended in 5 ml of $CaCl_2$ (100 mM, sterilized and previously cooled on ice) and were placed on ice for 20 min. Afterwards, centrifuging was repeated and supernatant discarded. Then, cells were resuspended in 1 ml of $CaCl_2$. Calcium chloride stabilizes membrane negative charges.

2.5. Transformation

To transform *E. coli* competent cells, two 1,5 mL sterile tubes were prepared and identified as +pGLO and -pGLO and placed on ice. Cells previously prepared should be smoothly shaken, to resuspend. 100 µL of the cell resuspension should be added to each tube. Plasmid DNA (5 uL) should be added to the +pGLO tube and not to -pGLO. Both tubes were placed on ice from 10 to 15 min.

To favour plasmid movement to cell interior, a heat-shock was induced, placing both tubes at 42^{o}C for 45 seconds. After this time, tubes were removed and placed on ice for 2 minutes. Afterwards, working next to a flame, 400 µL of LB media without antibiotic was added and incubated for 30 to 40 minutes, at 37^{o}C, allowing bacteria to recover from the heat-shock (recovery phase).

Finally, cells from +pGLO tube were plated to LB+Amp and to LB+Amp+Ara plates and -pGLO cells were added to LB and LB+Amp plates. Plates were incubated overnight at 37^{o}C, before checking for colonies. Finally, plates were placed on a UV transilluminator to check for transformed bacteria expressing (or not) fluorescence. A low budget alternative could be used by replacing the UV transilluminator by a homemade box with a UV or black light, and a UV blocking lid, to guarantee safe use.

2.6. Structural approach

To obtain three-dimension (3D) protein structure, a search in Protein Data Bank (PDB) [14] was performed. Structural analysis of the target proteins was performed using an academic version of PyMol [15]. Sequences for GFP (uv, APD28479.1), Cyan Fluorescent Protein (CFP, 5OX9) and Yellow Fluorescent Protein (YFP, improved, 1HUY) were retrieved from PDB and National Center for Biotechnology Information (NCBI) [16]. Multiple alignment was performed using BioEdit [17], being manually edited.

3. Results and discussion
3.1. Transformation

After every procedure was completed, the plates were observed and results were registered. As shown in Fig. 1 and Fig. 2, obtained results were in line with previous results [18].

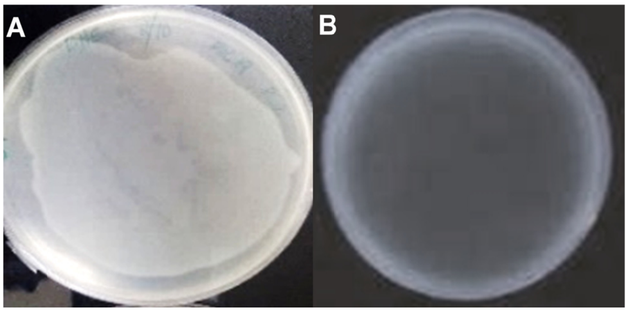

Figure 1. Plates with non-transformed bacteria (without pGLO plasmid) in LB medium (A) and in LB+Amp medium (B)

Concerning plates that did not contain pGLO plasmid, LB medium plate showed a lawn growth. This plate was used as a control for the quality of the culture, since it did not contain growth inhibitors. The plate that contained LB medium and ampicillin, in contrast, did not show any growth, since bacteria did not contain the antibiotic resistance gene.

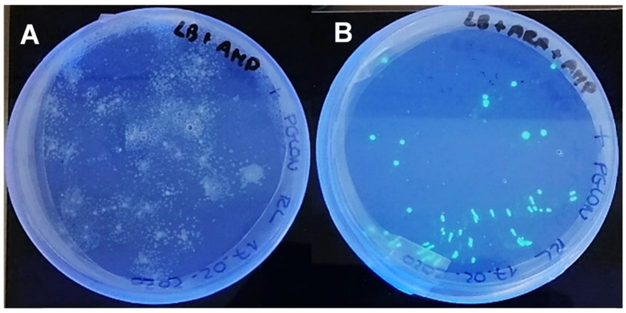

Figure 2. Plates with bacteria transformed with pGLO plasmid in LB+Amp medium (A) and in LB+Amp+Ara medium (B)

The pGLO recombinant cells contained genes that coded the ampicillin resistance gene. Considering this, plates with LB medium supplemented with ampicillin showed bacterial growth in colonies. In some cases, satellite colonies were observed. This result could be related to a longer incubation, as it was reported in previous studies [19]. This is related to the fact that resistant bacteria release β-lactamase to media, which is associated with ampicillin decreased efficiency, due to the hydrolysis of ampicillin, which allows non-resistant cells to grow [20]. The appearance of small colonies could be also explained by the quantity or concentration of ampicillin used or even to adding ampicillin to a hot medium, decreasing its efficiency. To avoid these formations, plates should not be maintained on the incubator for too long. When placed on a medium containing LB, ampicillin and arabinose, plates showed white colonies. When placed in the UV transilluminator, cells containing pGLO plasmid only showed fluorescence in medium containing arabinose, since that sugar is needed in order to express GFP.

Even though this process is considered efficient in school environment, only a very small percentage of these bacteria can successfully complete the procedure of competence induction and transformation, which explains the reduced number of colonies formed.

3.1.1. Disk diffusion method

Sometimes students find it difficult to relate the results obtained in different media. In this case, a good alternative to this experience is the use of disk diffusion method [21]. To be able to perform this experiment, media should be prepared exactly as described before with one small difference: they should not contain ampicillin. An ampicillin disk should be added later, after spreading bacteria, at the centre of the plate. The remaining procedure should occur as described before.

Expected results should go in line with the previously described in this work, with the exception that is possible to observe different results, in the same plate, as shown in Fig. 3.

Concerning plates containing cells with no plasmid, the plate without ampicillin disk (Fig. 3A) functions as a bacterial culture control. Since the LB medium does not contain antibiotic, it is expected that bacteria show lawn growth. On the other hand, the plate that contains LB medium and an antibiotic disk (Fig. 3B), an inhibitory halo should appear, since these cells do not contain the ampicillin resistance gene.

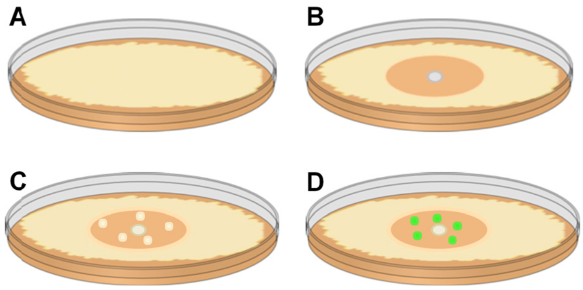

Figure 3. (A) non-transformed bacteria, LB medium, (B) non-transformed bacteria, LB medium with ampicillin disk, (C) transformed bacteria, LB + ampicillin disk, (D) transformed bacteria, LB + arabinose + ampicillin disk

In terms of plates containing bacteria transformed with pGLO plasmid, plates with LB+Amp disk and plates with LB+Ara+Amp disk are expected to show the same result at the naked eye (Fig. 3C): an inhibitory halo, containing a small number of white colonies, surrounded by bacteria biofilm growth, containing both transformed and non-transformed bacteria. This is expected to happen since the surrounding area won't be exposed to ampicillin, therefore, both transformed and non-transformed bacteria are able to grow. When exposed to UV light, transformed bacteria placed in LB+Ara+Amp disk plate are expected to express fluorescence within the inhibitory halo, since the presence of arabinose allows GFP to be expressed (Fig. 3D). In this case, it is possible that no fluorescence is shown in the lawn region, due to both the low efficiency of the transformation method and to possible high bacteria density.

3.2. Bioinformatics

Some biologic concepts are hard to understand since they are theoretical, requiring a great abstraction capacity. This could be particularly difficult at some ages. On the other hand, the young are constantly exposed to new technologies, which means most of them contact daily with several devices. Combining these two worlds, bioinformatics can bring a whole new approach in school context. It has been reported that the use of new technologies in the classroom is related more significant learning [22]. Bioinformatics is also a good approach to use, since it requires material that is present in most schools and can promote both autonomy and teamwork.

Here it is suggested an approach in two steps (1) seek protein sequences of GFP (uv), CFP and YFP (improved) and (2) retrieve these protein structures. GFPuv is an optimized GFP, that is obtained by replacing Phe99Ser, Met153Thr and Val163Ala, resulting in higher expression in bacteria [23].

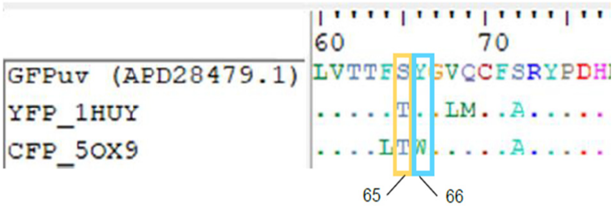

Figure 4. Protein sequence alignment of different fluorescent proteins. Differences in the chromophore region are highlightened (in yellow, residue 65 and in cyan residue 66)

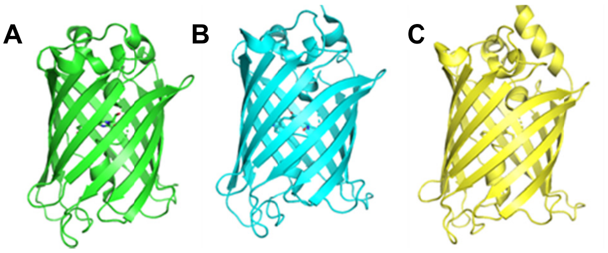

Figure 5. Protein structures of GFP (A), CFP (B) and YFP (C)

To promote the ability to search for information in different locations, the protein sequences were taken from two databases: NCBI and PDB sites. After retrieving sequences, they were aligned in BioEdit, where it was possible to compare differences between each fluorescent protein, as shown in Fig. 4. Students should be able to detect aminoacidic differences and relate them with available information retrieved from literature [24]. Depending of the target classes for this approach, information about differences between these proteins should be provided, to help focus the target of analysis, or students should be led to seek the information. With this work, it is possible to approach different types of mutations, namely through the distinction between synonymous and non-synonymous mutations. To do so, the original DNA sequences can be retrieved from the same databases, the different codons analysed, as well as their translations to the same or to different amino acids.

The second part of this analysis is related with protein structures. GFP 3K1K, CFP 5OX9 and YFP 1HUY structures were retrieved from PDB. First, using PyMol software, students can handle each protein structure and explore different functions, including amino acid display, protein folding or even mutagenesis, depending on their background. In this case, a simple approach is suggested, starting by retrieving, opening and observing three protein structures (GFP, CFP and YFP), as it is shown in Fig. 5.

After this introduction, students should be directed to overlap proteins, comparing differences between GFP and remaining proteins (Fig. 6).

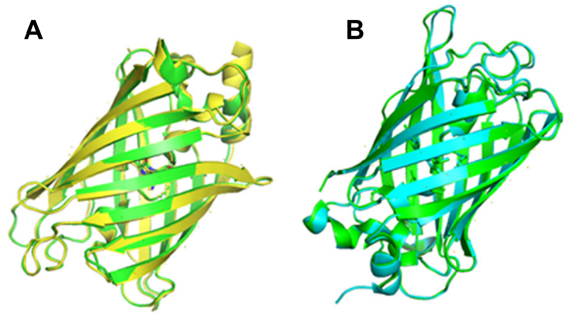

Figure 6. Overlapping of GFP and YFP (A) and overlapping of GFP and CFP (B)

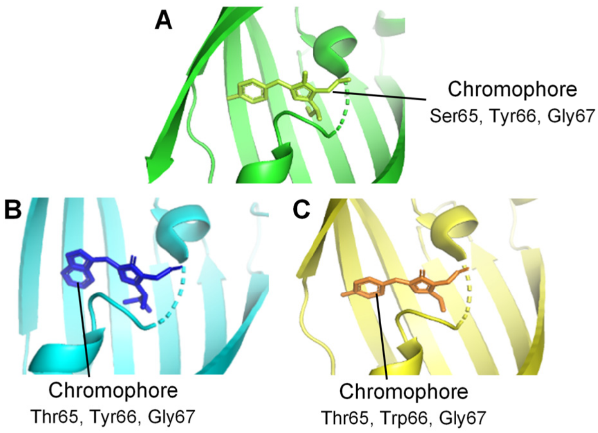

Figure 7. Highlight of the chromophore zone, constituted by residues 65-67. (A) GFP, (B) CFP, and (C) YFP

When comparing structures, students should be able to detect some differences in the chromophore region. In GFP, the chromophore is formed by Ser65, Tyr66 and Gly67, but when it comes to the other fluorescent proteins, amino acids change (Fig. 7). CFP contains Thr65, Tyr66 and Gly67 and YFP has Thr65, Trp66 and Gly67. These changes are in accordance with previous reports and are related to the different colours shown by these proteins [24].

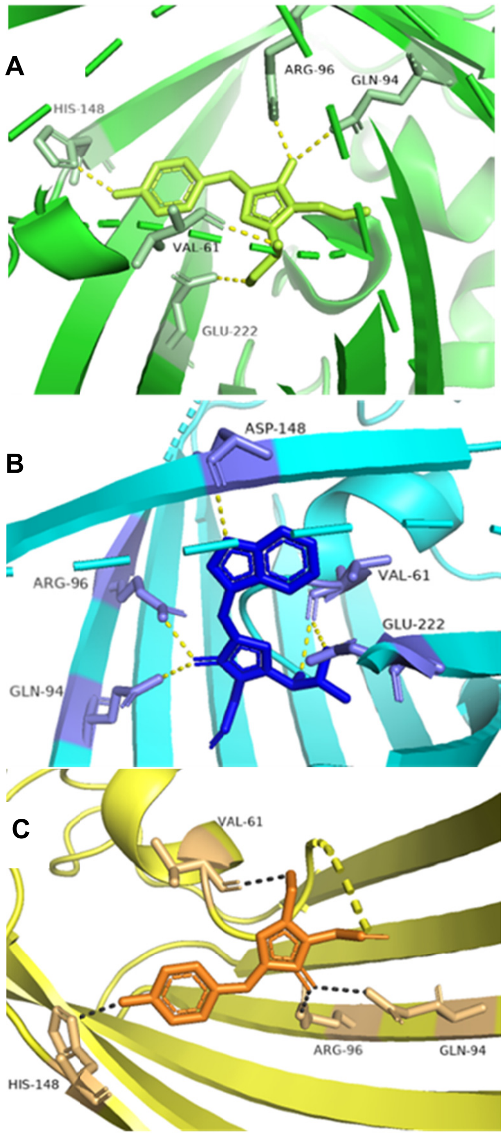

Figure 8. Close up on polar contacts of each fluorescent protein chromophore. (A) GFP, (B) CFP, and (C) YFP

A final approach is suggested, by using a slightly more advanced tool, which studies polar connections between chromophore and some aminoacidic residues. In some cases, these contacts are common to two, or even three of the studied proteins (Fig. 8).

Polar contacts established between each chromophore and amino acids matches in all three structures for residues 61, 94 and 96. Considering residue 148, it is possible to detect differences between GFP and CFP (Fig. 9). This can be explored by showing how different amino acids have different structures. Finally, contrarily to GFP and CFP, in YFP there is no contact between the chromophore and Glu222. This is a great opportunity to mention that different aminoacidic sequences result in different 3D protein structures. Using this tool, students can combine several scientific areas, such as biology, chemistry and physics.

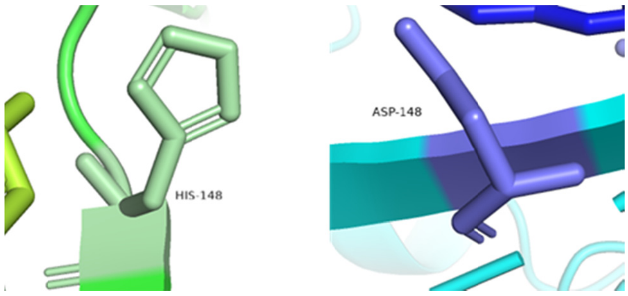

Figure 9. Residue 148 is different in (A) GFP (His148) and (B) CFP (Asp148)

4. Conclusion

It Is possible to promote interesting activities for students, even with low budget, by using cheaper alternatives or by establishing collaborations between schools and universities or science centres. We live on a technological era and it is in our power to take advantage of the benefits that these resources bring.

Using transformed *E. coli* strains allows students to visually understand the effects of antibiotics and tighten the bridge between “school knowledge” and “day-to-day application” of the theoretical knowledge, contributing to population´s scientific literacy and increasing the percentage of informed individuals. A hands-on approach allows a direct, personal contact between student and life sciences, which allows a meaningful learning experience.

Disk diffusion method is a good alternative to allow students to understand differences between transformed and non-transformed bacteria, but also the difference between presence or absence of antibiotic, in bacterial growth. The analysis using bioinformatics might be a great asset to introduce in schools, since it does not require very specific equipment and can catch the attention of students.

This experiment allows to introduce matters of great importance, such as antibiotic use and resistance as a starting point for many other matters. It also provides a glimpse of the potential use of bioinformatics not only for academic research, but also for application in medicine, biotechnology and many others.

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Informal Learning of Science and Technology from an "Inductive Signatures" Research Project

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Abstract. The research project "Inductive Signatures" intends the design of a prototype for detection and registration of vehicle inductive signatures. In this paper, we explain different activities performed with two objectives: 1) explain fundamental concepts of electromagnetism and 2) disseminate results of this research project. The materials, designed to bring ideas to the society in general, have been used for the exhibition that took place in the Cultural Intervention Space of University of A Coruña (A Normal).

Keywords. Electromagnetism, Exhibitions, Research Project.

1. Introduction

"Inductive Signatures" is a research project of University of A Coruña (UDC) which intends the design of a prototype for detection and registration of vehicle inductive signatures. These signatures will allow to determine important parameters for traffic control as, for instance, the vehicle type, the road occupancy, the vehicle speed, etc. For this purpose, we have developed both hardware and software [1, 2]. The physical layer of our prototype is based on the well-known phenomenon of the electromagnetic induction.

The most common way to publish and disseminate the results of research projects is through articles published in journals or in conference proceedings. However, the authors consider that new alternatives must be explored in order to translate knowledge of science and technology closer and more efficiently to society in general. For this reason, we have developed materials and different activities related to this "Inductive Signatures" project.

We have elaborated some material for the informal learning of electromagnetism (physical basis, history and applications) and for making more accessible to all types of public the different elements that are part of our prototype. This material has been used in the exhibition that took place in one of the showrooms of A Normal, the Cultural Intervention Space of UDC, from December 18th, 2019 to January 31st, 2020 [3]. During this exhibition we have also held a workshop for children from 6 to 12 years. The results obtained from a survey show high satisfaction of all participants i.e., maximum scores in all items.

This paper is organized as follows. Section 2 presents the explanations devoted to fundaments on electromagnetism. Section 3 shows the research project on vehicle detection and registration. Finally, a discussion and conclusions are included in Section 4.

2. Exhibition on electromagnetism

This section about the exhibition is oriented to disseminate the fundaments of electromagnetic induction needed to understand our research project.

Figure 1. Poster to explain prodigious breakthroughs on electromagnetism

Figure 1 shows the poster (in Galician) which presents some of the prodigious breakthroughs performed in less than 100 years by leading scientists, as follows,

- 1785: Charles-Augustine Coulomb mathematically describes the electrostatic force of attraction and repulsion of electric charges, which is known as Coulomb's law.
- 1820: Hans Christian Oersted empirically discovers the relationship between electricity and magnetism. His experiment shows that an electric current produces a magnetic field.

- 1826: André-Marie Ampère formulates the so-called Ampère's law, which allows magnetic fields to be calculated from electric currents. It also contributes to the development of the galvanometer.
- 1831: Michael Faraday detects induced currents for the first time and transforms magnetism into electricity, performing the Oersted experiment in reverse. Fourteen years later he discovers the magneto-optical effect, known as the Faraday effect.
- 1835: Johann Carl Friedrich Gauss contributes in a fundamental way to electromagnetism with the formulation of what are known as Gauss's laws for electricity and magnetism and from which two of Maxwell's four equations are derived. Gauss's law for electricity can be used to derive Coulomb's law, and vice versa.
- 1873: James Clerk Maxwell publishes his electromagnetic theory, which for the first time brings together electricity, magnetism and light as elements of the same phenomenon, known as *electromagnetic phenomenon*. Maxwell's four equations rewrite Gauss's laws and Faraday's law and also correct Ampère's law.

Prodigious inventions arise from this formulation of the electromagnetic theory, such as the electric lamp (by Edison) or the alternating current generator (by Tesla), and also leads Einstein to formulate his theory of relativity. Moreover, in the middle of the twentieth century the modern quantum electromagnetic theory storms in [4].

We have designed also several experiments to understand main concepts of magnetism and electromagnetism. Figure 2 shows three activities, which are,

- Experiment to see the magnetic field lines of magnets using two transparent plates with small magnetic bars. The exhibition visitants can view the effect of magnetic and non-magnetic objects with these bars.
- Experiment of magnetic induction using a kit made up of a coil of 1100 turns, a rectangular magnet, and a galvanometer. Introducing the magnet into the coil generates an induced current that is measured in the galvanometer. When removing the magnet another current is generated but of opposite sign. In addition, a non-magnetic bar does not induce current.
- Experiment of employing electromagnetic induction to turn-on a lamp. A coil is affected by a variable magnetic field when the visitor moves a handle. This generates an electric current that lights a light bulb.

Figure 2. Experiments on electromagnetism

3. Exhibition on vehicle detection

Traffic monitoring is one of the most important aspects of Intelligent Transportation Systems (ITS), essentially those applications whose aim is to count the number of vehicles on a roadway or to know their speed, occupancy, or structural characteristics like density and type.

Since their introduction in the 1960s, the active sensors known as Inductive Loop Detectors (ILDs) are the more commonly used sensors in traffic management systems. This type of sensor has the advantages of being a highly developed technology; of simple operation; of being unaffected by environmental conditions, and of low installation cost.

During the last years, the authors of this paper have worked on the development of hardware and software for vehicle identification from ILDs. In [1], we propose a multiplex system for the Simple Detection of Inductive Vehicle Signatures (SiDIVS) that does not require the use of complex and expensive analogue processing circuits or of analogue signal acquisition methods. In [2], we propose a novel method for vehicle classification based on only one signature acquired from a single-loop sensor, in contrast to standard methods using two loops.

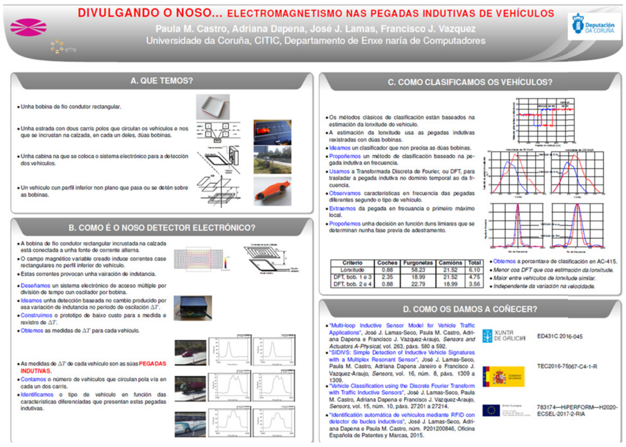

Figure 3. Poster to explain the main ideas of the research project

For the exhibition, we have designed some material to disseminate the research project to general public. Figure 3 shows the poster with the following descriptions:

- System elements: 1) a coil of rectangular conductive wire; 2) a road with two lanes through which vehicles travel and with two coils embedded under each lane; 3) an electronic system for detection placed on the cabin, and 4) a vehicle with a non-plane lower profile that passes or stops over the coils.
- How is our electronic detector? The coil of rectangular wire embedded in the driveway is connected to an Alternative Current (AC) source. The created variable magnetic field induces currents almost rectangular in the lower profile of the vehicle. These currents cause a variation in inductance and in the period of the signal which is detected by our system.
- How do we identify the vehicles? Classical classification methods are based on vehicle length estimation. Length estimation uses inductive signatures recorded with two coils. We devised a classifier that does not need both coils based on the inductive signature in frequency.

In Figure 4, we can see a photo of the showcase with the elements of our prototype: a 3D model of both the road and the car and the scheme of the electronic device. The visitants can interact with this material to observe the signature acquired by our prototype when different cars (in 3D models) pass on the road (in 3D model). The signatures of each coil are shown in a small display.

Figure 4. Showcase with element of the research project

Finally, we have also designed a mobile game oriented to simulate different car profiles. At the same time that the user designs the profile of a car, van or truck, our mobile application shows the signature that theoretically would generate when going through the coils. Figure 5 shows a photo of the tablet where the game is available, and the corresponding explanatory sheet.

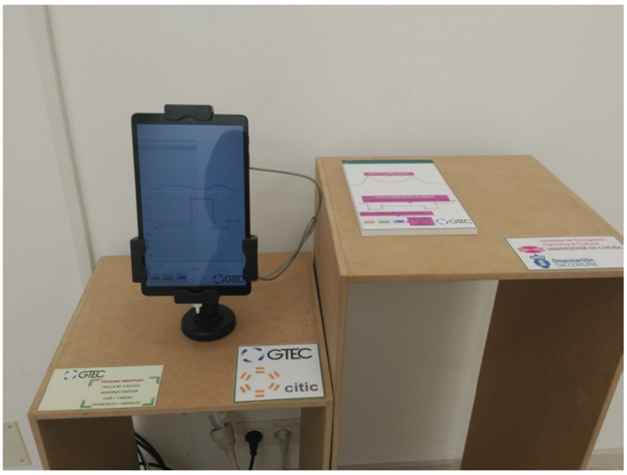

Figure 5. Mobile application of the research project

4. Discussion and conclusion

The dissemination of research projects for general public is an important challenge for researchers used to publishing results only in journals and research conferences. It requires to determine the more important aspects of the project and the relationship with concepts close to potential exhibition visitors. In particular, in our exhibition we focus our attention on the fundamentals of electromagnetism and on the connection with ILD detectors.

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We think that through the combination of all simple explanations, showcases, and experiments we have been able to explain the fundamental concepts, avoiding technicalities.

In 2020, we have also participated with this project in the “Open Day” event organized by the Faculty of Computer Science of our university, oriented to potential new undergraduate students and also this material is being currently used for school visitors to the Centre for Information and Communications Technology Research (CITIC) of University of A Coruña.

Acknowledgements

We thank to the entities that have helped us to develop this exhibition: Diputación de A Coruña; CITIC Research Center and Campus Innova (agreement I+D+i 2019-2020 between Consellería de Educación, Universidade e Formación Profesional and Universidade da Coruña).

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The Effect of Science and Technology Fair Projects Based on Learning Experiences in Inquiry on Students' Attitude to Science and Technology

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Abstract. Inquiry is an approach in which motivated learners participate in their learning and build their own scientific knowledge. Students' learning outcomes in the inquiry process can be presented as a learning experiences in a science fair projects. In the present study, which was conducted in 2019 - 2020 academic year in the Qarchak city in Tehran province, the female students of Erfan school in grades 7 to 9, first participated in the learning process based on inquiry and then presented their learning experiences in a scientific exhibition. An attitude scale based on science, technology, engineering and mathematics (STEM) was used to assess students' attitudes toward science and technology and students completed the attitude scale before and after visiting the exhibition. They were also asked three open-ended questions for reviewing students' attitudes towards science and technology. The results of the study show that the exhibition of students' learning experiences can lead to a significant difference in students' attitudes towards science and technology and make them interested in science and career future in this regard.

Keywords. Attitude, Inquiry, Learning experiences, Science education, STEM.

1. Introduction

Today, the use of inquiry in science education as an appropriate approach to fostering thinking has been accepted by science education researchers. Paying attention to learning experiences in inquiry can create a good environment for teaching and creating attitudes to science in learners [1-2]. Learning experiences are activities that learners do in order to achieve educational goals. The student has a more active role in learning experiences. Experiences and learning activities give students a great opportunity to solve problems. Learning experiences should also give the student the opportunity to review and study the content related to the intended purpose.

Learning experiences should be chosen in such a way that the student is satisfied. If learning experiences and activities are not satisfactory for the learners, the desired learning will not occur in them. Students' desired response to learning experiences occurs when these activities are consistent with students' abilities. In other words, learning experiences and activities should be commensurate with the student's current growth, knowledge, aptitude and ability. Therefore, if the learning experience is such that the student is unable to do so, it is difficult or impossible to achieve educational goals. So, in order to choose learning experiences that are appropriate to the students' abilities, the teacher must have sufficient information about the current knowledge, aptitude, backgrounds and cognitive structures of the learners. Meanwhile, the teacher can provide conditions that motivate him or her to engage in the learning process. During the learning process, the teacher also controls the students' learning experiences in order to put them in the right direction. To do this better and more effectively, the inquiry approach can be used.

A variety of experiences and activities can be used based on inquiry to achieve educational goals. Students' learning experiences can be presented in a science fair projects [3-4] and visited by other students, who can get acquainted with other experiences and encourage them in their own learning process. In the present study, the inquiry based learning experiences of students were presented in science fair projects and the effect of this fair on students' attitudes towards science and technology was studied.

2. Methodology

In this study, female students in the seventh to ninth grades from Erfan and Hadis Mehr schools in the Qarchak city at Tehran province in academic year 2019-2020 were given projects on concepts related to mathematics, science and technology (Figures 1- 6). To delegate projects to students, the talents,

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interests, and materials available for doing the activities were considered. Emphasis was also placed on innovation and creativity in carrying out projects. After ten days, the students reported their ideas in the presence of the teacher, some of which they had established individually and some by forming two-person groups. After reviewing the plans by the teacher and providing guidance if it was necessary, the students were notified to make and prepare their plans for two weeks. The students started to build their structures and the plan within the given time.

Plans made by students were reviewed again in the presence of the teacher to be corrected if necessary. For this purpose, the teacher used appropriate questions for students' thinking. With the questions asked by the teacher, the students modified and completed their plan. After completing the work, the report was presented by the students and a brochure of the work was prepared.

Along with completing the learning experience, the teacher provided necessary guidance to the students so that they could master the concepts related to their learning experiences. This process leads students to have sufficient mastery of the concepts associated with their learning experiences.

Figure 1. Some science projects (mathematics) presented by students

The final learning experiences were then displayed in an exhibition at the female Erfan school based on the topic and the relationship between the concepts and the students were able to visit it and listen to the explanations of the person providing the learning experience at each station. They had a discussion about learning experience with each other.

Figure 2. A number of technology projects provided by students

Figure 3. Some science projects (physics) presented by students

For investigating the effect of science fair projects on students' attitude to science and technology, the STEM attitude scale in the form of a five-point Likert scale with six factors

(Mathematics, Technology, Engineering, Science, Science, Mathematics, Engineering, Technology and Career) for secondary school students was used [5]. Before visiting the exhibition and after visiting, the students completed the STEM Attitude scale. The Cronbach Alpha (α) internal consistency reliability value of the STEM attitude scale was found to be 0.773 in this syudy. Also, after visiting the exhibition, the visitors answered three open-ended questions about their attitude towards science and technology.

Figure 4. Some science projects (chemistry) presented by students

Figure 5. Some science projects (geology) presented by students

3. Results and discussion

The projects presented in the exhibition were about 120 learning experiences (Fig. 7) in the fields of chemistry, physics, biology, geology, mathematics and technology in six sections, some of which are listed below:

- **Physics**: pressure concept, Jack and hydraulic lift (based on Pascal principle), making machines with special wheels to display friction force, Newton' s cradle, making pulleys, levers and gears for the concept of machines, pendulum and more.
- **Chemistry**: Fruit and charcoal batteries, chemical change experiments, Light production with pencil, optical sensor, Making mock-up of the distillation process, detecting starch in a variety of materials and more.

Figure 6. Some science projects (biology) presented by students

- **Biology**: Eye illustration mockup, heart illustration mockup, respiratory illustration mockup, diaphragm and lungs illustration mockup, the structure of the urinary tract, the hand and muscle illustration mock-up, plant cells and more.

- **Geology**: Astrolabe, earth's crust, the process of waterfall formation, volcanic formation, Earth illustration mock-up and more.
- **Mathematics**: Sudoku puzzle, Rubik, spaghetti structures, Mobius tape, geometric volumes, number axis, scales, abacus and more.
- **Technology**: Telescope, water and air pump (based on the concept of pressure), turbines, fans, washing machine, vacuum cleaner, Galileo thermometer, mixer, microwave oven, popcorn machine for the concept of heat transfer, wind meter and more.

The study of presented projects shows that in most of them, there is a connection between various science topics and steps have been taken to create technology for human comfort and well-being. In their learning experiences, students could feel the connection between science and technology through mathematics and engineering.

Figure 7. Science and technology fair projects based on learning experiences in inquiry

Analyzing the results of the STEM attitude scale shows that there is a significant difference between the attitude of students before and after visiting the exhibition in the attitude towards science and technology, and this shows the effectiveness of exhibiting students' learning experiences in creating a positive attitude towards science and technology.

Analyzing the open-ended questions of the visitors' answers shows the interest of students towards science and technology, some of which are mentioned here.

Question 1: What caught your attention at the science fair projects?

In response to this question, most of the participants pointed out that in the exhibition, they noticed creativity, innovation and enthusiasm of students to explaining their hasnds on activities, and they realized that they can come up with ideas with simple and affordable tools. Therefore, as a result of this visit, some participants were motivated to build similar structures so that they could later apply the science to everyday life. Some students also said that in this learning environment, they were able to gain a deeper understanding of previously learned concepts. Visitors also mentioned learning experiences that were interesting to them.

Question 2: What decision do you make after visiting the exhibition in the field of science and technology?

The participants expressed their emphasis on strengthening their attitudes and motivations as the use of science in daily life. Visitors also expressed their enthusiasm to strive for science and technology. In this regard, the following can be mentioned:

- In the future, I will have a job in technology.
- In the future, I will create a job for myself in the field of technology.
- I became very interested in science and I would like to choose a field related to science and technology.
- I try to work better and more in the fields of science and technology than before.
- Let's use science more in our lives
- I decided to come up with new ideas in science and technology.
- What inventions can be made with simple things.
- Science is very interesting.
- To create more interesting ideas in the fields of science and mathematics by thinking and reasoning.
- I decided to participate in future learning experiences exhibition.

- I decided to do more research on technology related to science.
- Science and technology are very important.
- I decided to do more science experiments.
- I decided to think about what I had learned so that I could create new and better ways for others to learn science more easily.

Question 3: Visitors were asked to comment on science and mathematics.

In response to this question, the visitors of the exhibition pointed out the importance of science and mathematics in daily life and stated some of the following:

- Science and math are very important in our lives.
- Science and math are very good and practical.
  Science and mathematics are very useful in life.
- We can use science a lot in our daily lives, and I'm really interested in science and math.
- Science and math are enjoyable.
- I love math and science, and I want to study science. Of course, I also like math, but I have trouble understanding some of its examples.
- I am interested in science and I want to study in this field.
- Science and mathematics are related together and have many applications in life.
- I am interested and would like to learn science and mathematics professionally.
- Sometimes they can be sweet and interesting.
- Two lessons you need to understand, not memorize.
- These two lessons are practical and useful in society. They provide us comfort and well-being.
- Science, math, and technology complement each other.
- I am interested in science and my future job will be in this field.
- Science and mathematics are interrelated, and both are essential in achieving a technology.
- It was interesting to see the connection between these two lessons.

4. Conclusion

It is very enjoyable for each person to acquire knowledge during the active learning process, and this occurs during the inquiry based learning process, which can be presented as a learning experiences. Providing an exhibition to present experiences can have a significant impact on the attitudes of all learners to science and technology, even those who did not participate in the presentation of learning experiences.

it should be noted that the designing of science fair and how the students participate in it to present their learning experiences will affect the effectiveness of exhibition. It is also necessary to provide appropriate conditions for students to be involved in the inquiry based learning process in science in order to achieve the learning experience appropriately and its connection with technology.

Therefore, the role of the teacher in guiding learning activities in order to achieve the desired effectiveness in learning is important. On the other hand, the educational management of schools can help to achieve the desired results by providing appropriate conditions to support of this process and the establishing a science exhibition.

5. Acknowledgements

The authors would like to acknowledge the support of faculty of science of Shahid Rajaee Teacher Training University, head of the Qarchak city education department (Dr. Bakhtiari) and Director of female Erfan School in the Qarchak city (Ms. Hajari).

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Candasat I: from a Secondary School to the Edge of Space

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Abstract. In this paper we describe the first space mission carried out at the IES de Candás; it consisted basically in designing testing, launching, recovering and analysing collected data of a payload flying to the stratosphere driven by a helium-filled high altitude balloon.

The main purpose of this experience was to demonstrate that it is feasible and worthwhile to develop and fly a low-cost scientific payload on a balloon-borne platform.

The activities lasted for several months and, after some cancellations and delays due to meteorological and legal issues, the balloon reached the stratosphere, obtaining data of position, temperature, pressure, humidity and wind as well as some pictures and videos.

By participating in this project, students developed 21st century learning skills like creativity, innovation, communication and collaboration, critical thinking and problem solving, as well as life and career skills like productivity, perseverance, leadership and responsibility.

Keywords. Space, Education, Robotics, Arduino, STEM.

1. Introduction

The near space is the region of Earth's atmosphere located between 20 to 100 km of altitude, including the stratosphere, mesosphere, and the lower thermosphere. During the last recent years, there was an emerging interest in flying balloons to the edge of near space, due to recreational and educational purposes and facilitated by the cost reduction for most of the electronic and mechanical components.

The view and environmental conditions in this part of the atmosphere are rather similar to outer space, that's why these balloons are said to reach to near-space. The participation of secondary school students in the entire near-space mission, including the design, construction, testing, launching, tracking the balloon trajectory using GPS systems, and data analysis after recovering, makes this high-altitude ballooning an attractive small-scale version of real spaceflight programs that is suitable to implement in secondary schools [1].

2. Objectives and motivation

The main purpose of this experience, from the scientific point of view, is to approach the climate crisis and environmental sustainability, one of the issues that most concerns our society. We want students to reflect on the human impact on climate change and play an active role in the global response to the climate change.

Figure 1. The balloon, payload and parachute at the moment of launching

We also propose to focus on the topic of space and space missions [2] and how their exploration allows us to have a better understanding of our planet [3].

In this sense, the objective is to study the atmosphere, composition, properties and dynamic phenomena by launching a stratospheric device [4], driven by a helium balloon and equipped with electronic systems to measure physical parameters and a SD card for data recording and further analysis.

From the pedagogical point of view [5], our students were encouraged to demonstrate that it is possible to launch a high altitude balloon in an educational environment, which means, with no high level of scientific previous knowledge and reduced budget.

3. Motivation and preliminary work

From the pedagogical perspective, our students were encouraged to demonstrate that it is possible to launch a high altitude balloon in an educational environment, and they were able to look for information about similar experiments [6], design electronic systems and mechanical elements, as well as they could design, elaborate and integrate the different systems; moreover, they could conduct some hands-on activities to test the performance in different extreme space-like conditions. The most challenging concern was to be able to localize and recover the payload after landing to analyse the collected data, images and videos.

Launching a device to the near space is an exciting and stimulating activity for students and also for teachers, parents and other members of the educational community [7].

Figure 2. The earth photographed from near the maximum altitude of 25000 meters

In general, for projects involving high altitude balloons (HAB) the following components are needed:

- A latex balloon, there are a wide range of weights and sizes, which should be select depending on the ability to be inflated with helium, the weight of the payload and the expected altitude to be reached. Common use for HAB may weight 200–2000 g.

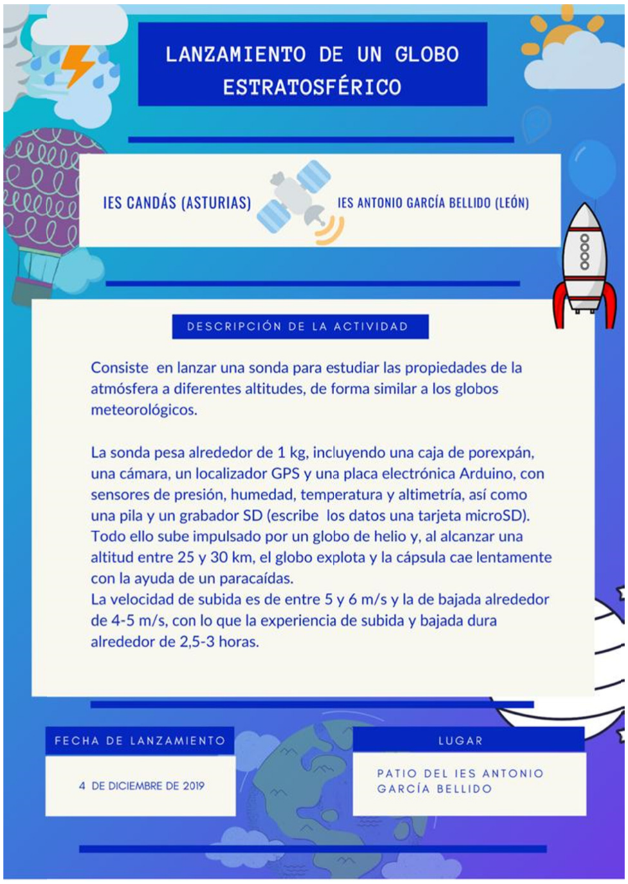

Figure 3. Poster announcing the launching at IES García Bellido

- A payload, including the container and all the necessary electronic circuits and devices for conducting the experiment and retrieving the collected data.
- A parachute, used for diminishing the descent rate after and avoid undesirable and unrecoverable damages for the on-board equipment during landing.
- A ground station used for communication during the flight and after landing for successful recovery of the payload.

In a first step, students conducted an organized search for information about similar projects carried out by different institutions all over the world, including research and academic institutions, meteorological agencies, schools and amateur clubs.

They were able to look for information about similar experiments, design electronic systems and mechanical elements, as well as they could design, elaborate and integrate the different systems; moreover, they could conduct some hands-on activities to test the performance in different extreme space-like conditions.

The students worked in groups on the design of the capsule, the electronic instrumentation and the assembly and launch systems, as well as the preliminary tests with the aim of minimizing possible eventualities and unforeseen events. The probe was equipped with an electronic system, based on Arduino technology, for taking data of inner and outer temperature, pressure, humidity, etc. and its recording on an SD card. A GoPro camera was incorporate to take images and videos during the journey, as well as two systems with GPS and an APRS device for surveying the path during the flight and, specially, for its location and recovering after landing. All this devices were conveniently fastened and protected in a polystyrene container.

4. Design

In this first space mission, our expectations were limited to the launching of the balloon and successful recovering of the payload, without aspirations to complicated scientific measurements or other kind of experimental tests in space-like conditions.

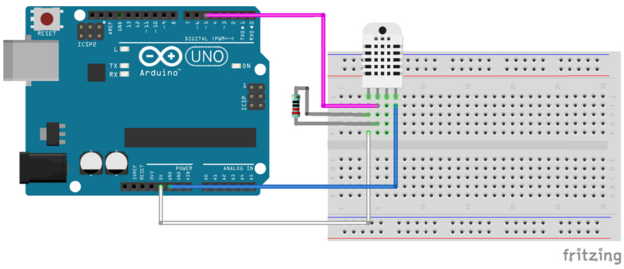

Figure 4. Circuit for temperature and humidity measurements

The electronic system was designed based in an Arduino platform, with the following devices:

- DHT11, is a low cost temperature and humidity sensor, widely used in different applications, it was placed outside the container in order to determine the temperature and humidity of the atmosphere at different altitudes.
- Bmp180, is a low cost pressure and temperature sensor; it was situated inside the container in order to measure the pressure and the temperature compared with the environment, in order to check the properly thermal insulation provided by the container walls.
- Micro SD card module, that allows the communication between the Arduino and the memory card in order to write the information provided by the sensors on removable devices for future data analysis.

Students designed the circuits separately and implemented for testing. Fritzing software was used for design the electronics and Arduino Integrated Development Environment (IDE) was used to code the programs for retrieving data from sensors and write them on a micro SD card.

Two sport cameras were used to take pictures and videos, one of them was placed directed to ground and other was placed on one side of the container box.

A smartphone was used as a way to track via GPS and transmit the position of the payload during the experiment.

Figure 5. Assembling the battery, heater and electronic systems in the payload box before launching

An additional satellite GPS tracker was used: the SPOT Trace, which offers advanced tracking by using satellite technology for communication with a ground station managed

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by the manufacturer and retrieved to users via web in near real-time; it can communicate anytime from some of the most remote locations around the world where mobile phone stations signal is not available.

Figure 6. Packed payload ready for launching

A third GPS locator was implemented, in order to avoid failures or breakdowns which would compromise the recovering of the payload and, consequently, the success of the mission. It consisted in an APRS-based system which used the network of the radio amateur operators, who were “listening” the position of our mission from more than 500 km far and eagerly reporting their findings.

As a power supply a special power bank was used, that provides electrical energy for the electronics and, at the same time, thermal energy. This device is used as a heater that keeps the temperature inside the container at values within the range of operational temperatures for the electronics.

A polystyrene foam 40 mm thick box was used to enclose all the devices as well as protect them against shocks, impact and sudden movements. At the same time, the polystyrene walls acted as an excellent thermal insulator, in order to keep working the electronic systems, when the surrounding temperature decreases at values around -60 ºC.

Everything was well packed and attached with plastic adhesive tape and cords. It has been specially regarded the European Commission Implementing Regulation number 923/2012, which states that ropes or other devices used for suspension of the payload must requires an impact force of 230 N or more to separate the suspended payload from the balloon.

5. Experimental tests

The expedition to the stratosphere is trip exposed to extreme conditions and any unexpected issue can result in a disaster for the near space mission. In order to avoid any trouble in the performance of the electronic and mechanical systems, different experiments and tests have been carried out before launching.

The electronic equipment was checked in normal conditions as well as at low temperatures. For this purpose, the first temperature test was made in a home freezer; a second one was achieved in an industrial ice cream freezer, which reaches temperatures low to -24 ºC. The third and decisive experiment was performed in a cryogenic chamber which reaches values around -60 ºC, by using liquid nitrogen.

Figure 7. Entering to an ice cream factory to carry out the temperature tests

The ascent and descent rates are two parameters that can be adjusted to control the maximum altitude, the time of flight and the horizontal shift. The test for the first one involves high costs, due to the helium required and the lost or damage of the balloon.

Figure 8. Students and teachers at the entrance of Materials Research Centre to conduct thermal test in a cryogenic chamber

Nevertheless, the descent rate could be estimated experimentally by throwing the parachute with a load with equivalent weight from a high point, with the help of a 50 meters measuring tape to determine the position. The release was recorded in a video and the descent rate was calculated from position vs. time diagrams, since time was obtained from the video frame timing data.

Figure 9. Free fall tests in order to determine experimentally the descent rate

Students proved that the air resistance provokes the stabilization of the descent rate in a few meters from the release point.

Additional training were carried out to ensure the correct inflation and fastening of the balloon and to avoid delays due to unexpected issues.

6. Simulation and predictions

Taking into account the limited experimental capability to make tests, the use of simulation software is a helpful and essential tool in this field of science.

A prerequisite of the effectiveness of many types of balloon near space missions is an accurate path forecasting capability. In particular, sample return missions, or flights carrying expensive instruments or whose recovery is essential, rely on the software used for simulation.

In a first step, specific online software was used to calculate the relationship between the amount of helium inside de balloon, the ascent rate and the maximum altitude, depending on the balloon size and the weight of the on-board equipment.

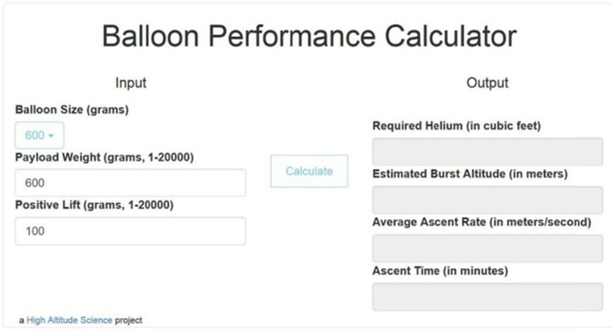

Figure 10. An HAB's lift and burst calculator [8]

Furthermore, the more critical aspect is the prediction of the landing point, which let us, together with the weather conditions, to take the decision for launching the initially scheduled date.

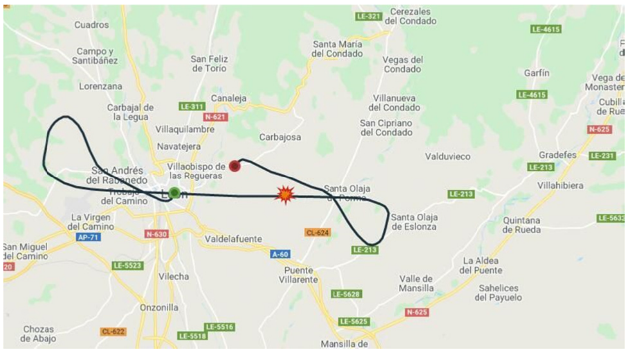

Figure 11. Trajectory followed by the device, as predicted [9]

The landing point obviously depends on the trajectory, and this trajectory (in horizontal and vertical components) depends mainly on the wind speed and directions at different altitudes. The wind characteristics can be obtained from observations and numeric models carried out and published by meteorological agencies. On the other hand, the trajectory can be also artificially and slightly adjusted by tuning the ascend rate, which depends directly on the amount of helium used to fill the balloon at the launching station.

7. Legal permissions

The launching of this kind of balloons are subjected to legal regulations in Spain; moreover, the launching point was included in the air servitude zone of the military airport of León, and this last issue made the application for legal permissions more complicated; approval terms were longer as well, due to the different procedures used in civil and military offices.

(D1656/19 NOTAMN
Q)LECM/QWLLW/IV/M /W /000/821/4235N00526W001
A)LECM B)1905220800 C)1905241100
D)080C-1100
E)RADIOSOUNDING. ASCENT OF FREE METEOROLOGICAL LIGHT BALLOONS ON
423526N 0052533W
LEON
BALLOONS FEATURES
TYPE: SPHERICAL
COLOUR: BEIGE
DIAMETER: FROM 2M TO 4M
WEIGHT: APROX. 2000GR INCLUDING SOUNDING
ASCENSIONAL SPEED: APROX. 4M/S
FALLING SPEED: APROX. 4M/S
MAXIMUM ALTITUDE: APROX. 25000M AGL
MAXIMUM DEVIATION: APROX. 50KM
F)SFC G)25000M AGL)

Figure 12. NOTAM

Applications for authorizations should be made at least three weeks before launching, in this period of time, information about meteorological conditions are not available in order to confirm definitely the launching.

A notice to airmen (NOTAM) was broadcasted by ENAIRE, the institution in charge of the air navigation management in Spain and Western Sahara; it consist in a notice to alert aircraft pilots of potential hazards along a flight route or at a location that could affect the safety of the flight. NOTAMs are common unclassified notices or advisories broadcasted by telecommunication ways, containing concerns about the establishment, conditions or change in any aeronautical facility, service, procedure or hazard, the correct knowledge of which is essential to personnel related with flights.

During the arrangements for launching, it was compulsory to establish direct and bidirectional communication in real time with the León TWR (air traffic control tower), to abort the activity in case of emergency and communicate their conclusion, it was also necessary to obtain the ATC (air traffic control) authorization, with a half hour advance, before takeoff. Moreover, it was legally obligatory to have detailed and updated meteorological information, in particular, information on the wind on the surface and at altitude.

8. Launching and recovering

The orography and physical terrain conditions around the IES de Candás are not appropriate for recovering the payload after landing: the sea is located on one side and on the other side there is an area with high mountains and with hardly walking paths; for this reason, we decided to search for another launching point.

Figure 13. Preparations for launching, filling the balloon with helium

Figure 14. Preparing for launching

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The launch took place in the playground of the IES Antonio García Bellido, in León, located in the north of the central plateau of the Iberian Peninsula. This region is a flat area, surrounded by cereal fields, other arable crops and also some smooth forests.

The inaccuracy of the `prediction for the fall point is significant and can reach several kilometers, nevertheless, the accessibility of the predicted landing area, is an important aspect to take into account to take the decision for launching.

Figure 15. Tying off the ballon

After several cancellations and delays, mainly provoked by unsuitable weather conditions and legal restrictions of the air space, the balloon was launched on December 4, almost seven months later than the initially scheduled date.

Figure 16. Less than one second after takeoff, view from the on board camera

About more than an hour after launching, the balloon reached its maximum altitude (around 25000 m), with an external temperature of around -60 ºC, and an approximate diameter of 8.5 meters, the balloon exploded and right away a parachute was deployed to facilitate the return, achieving a descent rate of around 5 m/s, somewhat higher than initially calculated. Initially it headed west and, at an altitude of around 14,000 meters, veer east due to different laminar air currents in different layers of the atmosphere. It remained flying over the León sky for approximately 2 hours, until it landed in a peaceful place near the Torío river

Figure 17. Image taken from the on board camera

The payload was easily located in a grass field by a group of students, guided by their smartphones sharing the location with the smartphone on board. The other positioning systems worked also correctly.

A group of 30 students travelled by coach to León; further the necessary equipment for the launch, the coach was loaded with mountain bikes, in order to recover the payload if it fell in a remote area or with difficult access for another type of vehicles, which finally did not happen.

9. Data analysis

Later, the students from both schools prepared a report analysing both the data obtaining by the electronic measurement system as well as the information and evidences observed in the images and videos taken by the on board camera and the final trajectory followed by GPS.

The main scientific outcomes from this experiment [10] are the following:

- Temperature of the atmosphere decreases significantly with the altitude, although some data at higher altitudes were lost due to the limited range of the measurement low cost sensor.

- The heating system operated properly, as deduced from the inner temperature which remained always in positive Celsius degrees.

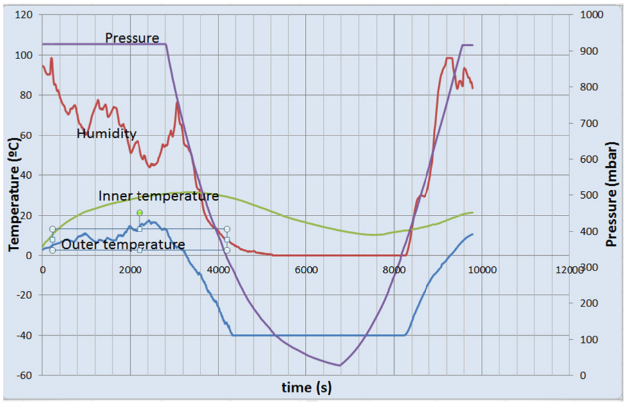

Figure 17. Time variations of the pressure, inner and outer temperatures, and humidity

- Humidity decreases with altitude, no significant amounts of water vapour is found at high altitudes.

Figure 18. Opening and checking the payload after landing

- Pressure variations are the key to determine the launching, exploding and landing points, since the measurements started to be registered in the moment of plugging the electronics, almost one hour before taking off.
- The curvature of the earth could be observed in the images taken from space, although some camera lens optical distortion was provoked.
- The observed black sky in the pictures is observed as a consequence of the very low concentration of air molecules above the reached altitude and, therefore, the absence of Rayleigh dispersion.
- The wind speed and directions can change depending on the altitude. In this particular experiment, the payload followed a path analogous to a vertical circle.

More findings can be obtained from a deeper analysis of images and numerical data collected by the electronic sensors and positioning systems.

10. Conclusions

The above mentioned activities contributed decisively to engage students, teachers, parents and external institutions and individuals on STEM education.

Our goal is to provide our students with the best possible insight in the field of natural science, while they are thrilled about knowledge, discovering and eager to develop long-term activities.

Figure 19. Students and teachers pleased after successful recovering of the payload

Discover a whole new world with fascinating learning scenarios and breathtaking moments all around the STEM related subjects is possible with the aid of the weather balloon and a lot of enthusiasm.

Several disciplines have been cooperating collaboratively and working together to accomplish the realization of this project.

- -Computer science: with a data logger, students are able to code with Arduino and measure and record many different parameters, like temperature, pressure, altitude or the position. Later they can evaluate the data, make diagrams and presentations.
- Mathematics: is an essential part of this space mission and indispensable for its success. The major parts will be to calculate geometrical quantities, the right amount of helium, statistical calculations, etc.
- Physics and engineering are the most directly involved fields, including the electronics design and assembly, materials properties, forces, energy conversions, properties of gases, etc.
- Physical education, students develop skills in open-field orientations and parts assembling by using different types of rope knots.

The field of space exploration at experimental level still remains inaccessible for pre-university education. In the last decade some projects raised in this area and this is our first step which should be continued.

11. Acknowledgements

The preparation of the project was a very challenging work, both from a technical, logistical and administrative point of view. This activity would not have been possible without the collaboration of different individuals and institutions who, understanding the benefit of this activity for students and its contribution to improving the quality of education, were involved in the different stages in a fully altruistic way. The URE (Union of Radio Amateurs of Spain) contributed with the APRS tracking technology, through its international network of stations and signal repeaters and the collaboration of the community of radio amateurs, the payload was heard directly by stations more than 500 km away and reported their position via web.

The Carburos Metálicos company understood the educational value of the project and provided the helium bottle free of charge to get the balloon going. The ITMA (Technological Institute of Materials of Asturias) opened access to its facilities in Avilés for thermal tests in its cryogenic chambers, with the aim of verifying the operation of the equipment in extreme conditions at high altitude, while these tests lasted, they offered a guided tour of the centre for students and parents. The Poeta Antón School provided its facilities, due to the height of the building, for parachute tests, in order to determine the descent rate. The Helio Brothers ice-cream shop made possible to carry out the first operational tests of the different systems at low temperatures.

Figure 20. Institutions that contributed and assisted the IES de Candás in the Candasat I near space mission

The ENAIRE Airspace Operational Coordination Department advised on legal aspects and provided the necessary permissions and was in charge of issuing the Notam (notification to airmen) to report the event to the aircrafts flying through that area of airspace during the ascend and descend. A real time two-way communication was established from the two hours prior to launch, with the control tower of La Virgen del Camino and the Air Traffic Control Squadron of the military airport of León, providing access to its restricted airspace. The Signal Theory department of the Gijón Polytechnic School of Engineering provided guidance on the topic of communications; even a teacher went to School and gave a talk to students about communications with mobile devices.

The colleagues in charge of Marumasat project [11] in Galicia and Galasat [12] in Andalucia helped and encouraged us at all times, sharing their experience and knowledge.

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Hard-to-Transport Experiments

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Abstract. We would like to take advantage of this year's online conference and demonstrate several experiments with which we cannot travel due to the size of the devices or their dangerous nature. The experiments will concern Newton's laws, the impulse of force and change of momentum. We will also show some experiments from acoustics.

Keywords. Mechanics, Acoustics, Physics Experiments.

1. Introduction

Physics concerning forces and their effects is one of the foundations of mechanics. It might seem that everything is very simple – it is enough to know Newton's laws of motion, which contain all the necessary information. Unfortunately, it is not so easy. Our everyday experiences seem to tell us something different than the mentioned laws of movement. It is therefore necessary to pay increased attention to forces and their effects during teaching [1-3]. It is useful to have a stock of suitable experiments with which we can supplement the teaching. Several such experiments are described and discussed in the following paper. We also included two more experiments from acoustics.

This paper is a free continuation of our previous HSCI contributions [4-7].

2. Plucking out the tablecloth and the carpet

This experiment is often a part of many magic shows. The first variant, when we pull the tablecloth out from under the pot with a flower with a sharp movement, is not very surprising (Fig. 1). The pot needs to be heavy enough and have the centre of gravity low so that it does not tip over. With a sharp twitch, the tablecloth exerts a force on the pot for a very short time, which is not enough to set it in motion.

Figure 1. Plucking out the tablecloth

The experiment can be demonstrated in another, more interesting variant. Instead of a tablecloth, we use a carpet and put bobsled on it in which one demonstrator sits (Fig. 2). The other plucks the carpet out from under the bobsled. The experiment needs to be trained, it takes some practice. The demonstrator in the bobsled must sit with her back to the plucker. Otherwise, she may fall backwards and hit her head.

Figure 2. Plucking out the carpet

3. Several ways how to break the wooden bar

In next experiments, we will break wooden bars. Suitable are wooden (spruce or pine) bars with a cross-section of 5 mm x 20 mm, 5 mm x 25 mm or similar. Such bars can be bought in various hobby markets. Their length is about 2 m and for our experiments we cut them into

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three parts - a suitable length is 60 cm to 70 cm. For breaking the bars it is suitable to use a large knife, resp. machete.

3.1. Breaking the bar on fingers

We would like to point out that this experiment needs to be practiced properly and you must be careful during it. You will perform the experiment with an assistant who is holding the bar on outstretched forefingers of outstretched hands (Fig. 3). Break the bar with a sharp slash of the knife. The breaking must be really swift. Practice it, for example, first by supporting the bar with two backrests of a chair. Only after you get the necessary training, proceed to breaking the bar on fingers. The result is surprising for the experimenter and his assistant - the assistant feels almost nothing. If you are hesitant and the slash is not sharp enough, the assistant may feel it quite intensely.

Figure 3. Breaking the bar on fingers

What is the explanation and what physical knowledge can we demonstrate by the experiment? In order for the bar to break, it must be subjected to a force equal to its ultimate strength. If the impact is intense enough, the force exerted by the knife on the bar in contact with it will increase very rapidly to the ultimate strength value and it will burst. The harder the blow, the faster the bar will break. A relatively large force acts on the outstretched fingers of the assistant during the time the knife is in contact with the cracking bar, but for a very short time. The effects of this force on the fingers are therefore "harmless". If you chop into the bar with insufficient force, it would exert less force on the fingers, but for a longer time, and the assistant would feel it much more strongly than with a sharp cut.

3.2. Breaking the bar on glasses

You can follow up on the previous experiment with another "action" variant. This time, support the bar with two wine glasses. It is advisable to place the glasses on the edges of two tables, between which there is a sufficiently large gap (so that you do not hit the table and damage it when breaking the bar) (Fig. 4). The experiment will turn out well again if you hit the bar very sharply. The explanation is the same as before - when a large force is applied to the glasses, but for a very short time, the effects of the force are not significant. In this very short time, there will be no overturning or breaking of the glasses.

Figure 4. Cutting the bar on glasses

3.3. Breaking the flying bar

You can continue the sequence of bar chopping experiments by trying to break it by throwing it up and breaking it with a knife during its flight. To begin with, you may say that you are looking for something even more fragile to support the ends of the bar than fingers or a glass, and you will think that you would not have to support the bar with anything at all. That is, you break it during its air flight (Fig. 5).

This variant of the experiment requires some practice. The slash must be very strong again and you have to practice the method of throwing.

You can use this experiment to demonstrate important physical knowledge - to show the physical content of the term mass (specifically inertial mass). It is worth recalling the notation of Newton's 2nd law in the form $\vec{F} = m\vec{a}$ and in the discussion to come to that the mass expresses "the reluctance of the body to change speed" (or to change its state of movement).

Figure 5. Breaking the flying bar is easier after loading its ends with plasticine

The mass of the bar is small, and therefore its reluctance to change speed is also small and the bar will be willing to accelerate after the impact of the knife. After all, acceleration is "prevented" and therefore the knife has the opportunity to apply a force equal to "ultimate strength" of the bar in the case of a very sharp slash. The bar breaks very quickly and the knife has a very short time to speed it up. The result is that you break the bar without it significantly "flying off" in the direction of the slash (both parts of the bar fall a little in front of you).

Now you can think with students how to facilitate the breaking of the bar. Students could find that it would help to increase the "reluctance of the bar to change speed", i.e. to increase its mass. You can increase the mass of the bar, for example, by injecting two lumps of plasticine at its ends. This will create a dumbbell that will weigh much more than the bar itself. After throwing it into the air, it is enough to break the bar less sharply. The loaded bar will accelerate much less when the knife strikes. The force exerted by the knife on the bar increases faster after impact, and after reaching the ultimate strength the bar breaks.

4. Change of momentum and impulse of force

An important consequence of Newton's 2nd law is also the relationship between the acting force and the change of momentum, i.e. the introduction of the notion of impulse of force. You can show students that this is a simple consequence of Newton's 2nd law. We get to the relationship by a sequence of mathematical modifications of the notation of this law:

$$\vec{F} = m\vec{a} = m\frac{\Delta\vec{v}}{\Delta t} = \frac{\Delta(m\vec{v})}{\Delta t} = \frac{\Delta\vec{p}}{\Delta t}.$$

From here we can easily obtain the known relationship between the impulse of force and the change of momentum:

$$\vec{F}\Delta t = \Delta\vec{p}.$$

The required change of momentum can be achieved, for example, by applying a large force for a short time, or, conversely, a small force for a long time. To demonstrate this relation, we can show the following experiments.

4.1 Stopping an air gun pellet

You need a cloth baby diaper to this experiment. We recommend to try everything beforehand, and again we encourage great caution when experimenting. If you have a brave enough assistant and you trust your shooting skills, ask the assistant to hold the diaper folded several times and shoot from a distance of about 2 m at the lower edge of the diaper (Fig. 6a,b). The diaper stops the flying pellet. You will find it either inside a folded diaper or it will fall to the ground under a diaper. You can demonstrate the experiment in a safer, albeit less action-like form by attaching the diaper to a cord stretched between two stands. Instead of diapers, another piece of fabric can probably be used - but everything needs to be tested properly in advance.

Figure 6a. Stopping the fired pellet

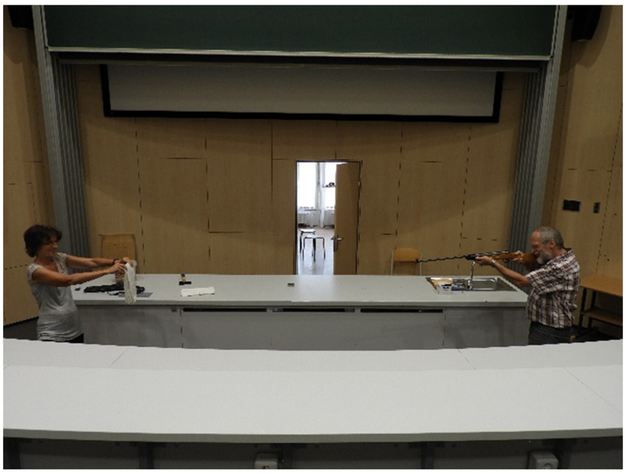

Figure 6b. Stopping the fired pellet

The free-hanging diaper bends for a relatively long time after being hit by the pellet and exerts a force against the flying pellet. The force is not very great, but due to the fact that it acts for a relatively long time, the result of its action is a change in the momentum of the pellet to zero. Note: In experiments of this type, the magnitude of the force is variable. Therefore, we should speak correctly about the average magnitude of the force multiplied by the respective time.

4.2. Nutcracker

We can also use the above mentioned relationship between the impulse of force and the change of momentum to explain the following experiment. The assistant lies down on the table and you put a heavy metal plate on her belly (we use 8 kg). Then hit the plate with a hammer. The assistant can barely feel it. The experiment can be enriched by cracking nuts on the plate (Fig. 7).

The explanation is that the hammer blow - a relatively large force, acts for a short time. Due to the large mass and thus the great reluctance to change its speed, the plate hardly moves.

Figure 7. Nutcracker

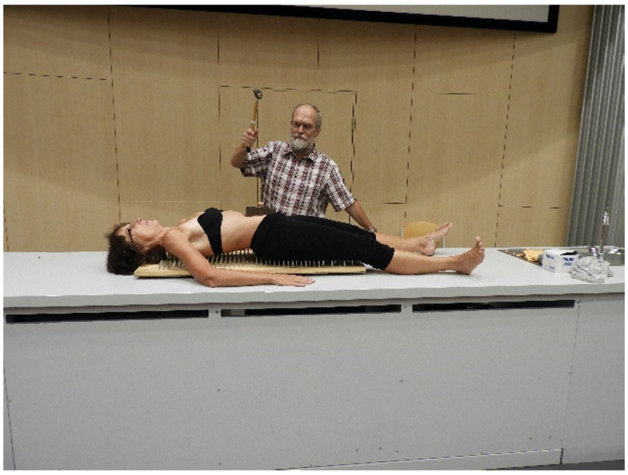

Figure 8. Fakir bed

5. Fakir bed

An impressive experiment how to demonstrate the decomposition of force is the fakir bed. We use a wooden board with 950 nails (with sharp ends). With an assistant of mass of 60 kg lying on, let’s say 200 nails, each nail would react with a force of 3 N.

Nut - preferably coconut - can be cracked on the fakir's belly to increase the effect (Fig. 8). (Be careful, drain the milk from it first).

6. Acoustics

Finally, we will describe two more experiments from acoustic.

6.1. Crowing cup, mooing bucket

Pierce the bottom of a yogurt cup and stretch a string through it. Hold the cup in your hand, take a wet cloth into your fingers, press the string with it and move it down. Then do the same with a larger cup, a bucket and a big bucket. (Fig. 9) Interesting sounds will be heard.

Figure 9. Crowing cup, mooing bucket

6.2. Savart wheel (siren)

The Savart wheel (sometimes called Savart siren) is an acoustical device incorrectly named after the French physicists Félix Savart. (Originally it was developed by Robert Hooke in 17th century.) The main part of this siren is a spinning toothed wheel. If we hold some elastic card to the edge of a spinning toothed wheel a sound is created (Fig. 10). With a little courage we can speak about tone. The pitch of the tone varies with the speed of the wheel. Using this experiment, we can demonstrate how pitch of the tone relates to frequency. (Like Robert Hooke in the Royal Society in 1681.)

Figure 10. Savart wheel (sirene)

7. Conclusion remarks

These few experiments in mechanics, together with considerations and suggested discussions around them, can help in teaching those parts of mechanics that relate to Newton's laws of motion and their consequences.

As we have indicated, these parts of physics are associated with various misconceptions. These ideas are often deeply ingrained in students' minds and affect their physical thinking even after the relevant parts have been properly explained to them in physics classes. Correct understanding of Newton's laws (and

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not only them) is much more difficult than it might seem at first glance. So there is no choice but to return to them on various occasions, discuss with students different situations and hope that we may be able to correct their (physical) view of the world in the right direction.

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Physics and Math Integration Using Digital Tools

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Abstract. In this work we present an experience report of a project of integrated activities in physics and mathematics using softwares of motion analysis and computational modelling. The project involves the study of the vertical and horizontal components of objects moving in 2D or free fall. The activities were performed by first-year high school students from a public school in Brazil, where high school is integratead with technical education.

Keywords. Computational Modeling, Information and Communication Technology, Integration between Physics and Maths, Kinematics.

1. Introduction

As stated by John Allen Paulos in his book *Innumeracy: Mathematical Illiteracy and Its Consequences*, the term innumeracy can be defined by “an inability to deal comfortably with the fundamental notions of number and chance” [1]. Although innumeracy is not often mentioned or discussed, it is a reality teacher face in classrooms in a variety of ways [2].

The Common National Curricular Basis [3], hereby referred as BNCC, is a document provided by Brazilian Ministry of Education concerning public policies for education and the development of curriculum proposals at elementary and high school levels. The BNCC states that mathematics literacy is the competence and hability of reason, represent, communicate and argue in a mathematic way. It is the hability to use concepts, procedures, facts and mathematical tools to solve problems in a variety of situations.

In everyday situations physics and maths teachers face typical mistakes commited by students, them all evidencing students' misinterpretation of mathematical proprieties, such as:

$$\frac{1+2\sqrt{3}}{2} = 1+\sqrt{3} \quad \text{or} \quad \frac{10}{0,5} = 5 \qquad (1)$$

Students also struggle to identify the relation between equations when the letters that represent the same quantities are changed. The combining concepts seen in physics class, such as velocity and acceleration, as well as linear or quadratic functions seen in math classes, are a challenge when teaching kinematics for first-year high school students. All those concepts are distant from students' reality, as pointed by some studies [4-5]. For instance, some students interpret and treat in distinct ways equations like:

$$y = ax + b \quad \text{and} \quad x = x_o + vt \qquad (2)$$

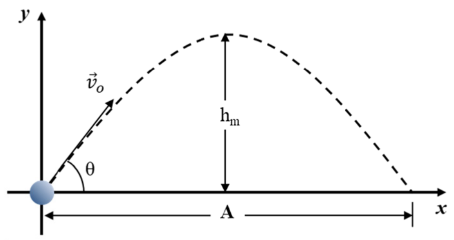
Mistakes and difficulties of this nature hinder the performance of our students. Although it may seem such problems are only present in the context of school exercises, the difficulty of performing simple operations and establishing satisfactory relationships between quantities can be seen in real situations [6].

If on one hand there are difficulties intrinsic to students' background knowledge and understanding of complex contents, on the other hand there are difficulties inherent to the school curriculums. In the case of schools with technical courses integrated with high school, for instance, physics and mathematics classes are few, while the program is extensive, covering all the typical contents of the first grade. Whereas in both, physics and mathematics classes, some quantities are related by linear or quadratic functions, this subject is first seen in physics, to only later be discussed in math classes. Thus, students have not yet properly developed language and skills in algebraic manipulation of relationships, which will be the focus in mathematics classes, but must already apply them in physics classes.

In the context of our institution, specifically, an additional issue was present: the great number of exams and tests, due to the integrated high school and technical courses, proved to be rather stressful to students, impairing their academic results and psychological health [7-8]. Therefore, activities carried out jointly by more than one discipline could contribute to not only integrate skills and improve students' comprehension of contents and its relations, but also extenuate the number of assessments and student stress levels.

The pictures seen in Fig. 1 and Fig. 2 are two examples of exercises from a physics book and a math book, respectively. In essence they are similar in the method of calculation and the results.

A ball is thrown in the air from the ground with a speed of 50 m/s and angle θ (sin θ = 0.6; cos θ = 0.8), as seen in the picture:



Considering g = 10 m/s^2 and neglecting the air resistance, determine:

a) the speed of the ball in its maximum height;
b) the time needed to reach its maximum height;
c) the maximum height;
d) the maximum reach A.

Figure 1. Example of an exercise from a physics textbook [9]. Translated by the authors

A ball is thrown in the air. Suppose that its height after the launch is given by the equation: $h = -t^2 + 4t + 6$.
Determine:

a) the time the ball reaches its maximum height;
b) its maximum height;
c) the time, after being launched, the ball touches the ground.

Figure 2. Example of an exercise from a math textbook [10]. Translated by the authors

The teaching of mathematics in high school level, according to BNCC [3] discourses as follows:

> "The BNCC of mathematics and its technologies proposes a consolidation, expansion and deepening of the basic knowledge developed during the elementary school years. Hence, it proposes to address, interrelatedly, the knowledge acquired in the previous stage, in order to allow students to build an integrated view of mathematics, still within the perspective of its application to reality […]. Therefore, in order to develop skills that involve reasoning, it is necessary students can, in interaction with colleagues and teachers, investigate, explain and justify the solved problems, with emphasis on mathematical argumentation processes […]. The competences directly associated with representing presuppose the elaboration of records to evoke a mathematical object […]. After solving the mathematical problems, students need to present and justify its results, interpret colleagues results and interact with them. In this context, the communication skill gains relevance. […] In relation to the argumentative competence, its development also presupposes the formulation and testing of conjectures, with the presentation of explanations in addition to the previously mentioned aspects related to the competences of reasoning and representing."

Add to this the considerations of Professor Elon Lages Lima [11]:

> "Finding meaningful applications for the subject being exposed are a challenge and should be a constant concern of the teacher […] The lack of applications for the themes studied in class is the most striking flaw in the teaching of mathematics in all school grades. It cannot be remedied without the concept being reinforced. […] Problems of life are not accompanied by formulas! […] The dedicated teacher should try to organize his course in order to obtain the balance between the three fundamental components: concept, manipulation, and applications. In doing so, he will have taken a large step towards success in the mission of educating."

Concerned with the situation of our students and with the above quotations in mind, we proposed the project we will soon explain in details. We believe that an interdisciplinary proposal combined with technological tools can provide a favorable environment for the development of skills:

> "It is through engineering design that students are able to see the applicability of abstract and somewhat intangible concepts. In addition, students are able to make connections across disciplines and provide improved solutions to specific problems."[6]

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The above mentioned favorable environment also fosters experimentation, manipulation of objects, register logs of activities devoloped by students, as well as interaction between classmates and between students and the teacher.

2. The project

The project was carried out with first-year students of our high school integrated with technical education courses. The students had free access to computer labs and free time at school to use them. Most of the students also had their own notebooks or a computer at home.

The topics chosen to be explored in the project were kinematics and linear and quadratic functions. These are topics students see in the last year of elementary school, superficially, but in which most of them have doubts and misconceptions when studying physics and maths in high school.

The proposal implied in the use of the softwares Tracker, which is "a free video analysis and modeling tool built on the Open Source Physics (OSP) Java framework" and is "designed to be used in physics education." [11], and Geogebra, which is a "dynamic mathematics software […] that brings together geometry, algebra, spreadsheets, graphing, statistics and calculus in one easy-to-use package". [12] In the project we used Geogebra Classic 5.

2.1. Preparation

Before the development of the activities, students explored and tested the softwares, knowing its functionalities and procedures.

All the activities were performed in extra class time. The teachers were available to clarify their doubts, to guide, and supervise. The development was divided in four steps:

- Scene Definition: The students, or the teachers, defined the scene to be studied and raised questions regarding its availability or obtaining in a digital format compatible with Tracker. Here some questions could be raised and some conjectures noted. For example: does the shooting angle influence the results? Is the frame rate per second the same in any recording and during the length of the recording? What kind of scene (reproduced, everyday or game experiment) will be chosen?

In our project we performed, in separated years, three different approaches. In the first year the students recorded a video of an experiment we planned. It was a ball thrown horizontally from a ramp, shown in Fig. 3. It was the same video for all the students. In the second year, the students selected a scene from a game of their preference in which something had a horizontal and/or vertical motion, Fig. 4. For the third year, the students recorded, with their mobiles, an everyday situation involving a free fall or a two dimensional motion, Fig. 5.

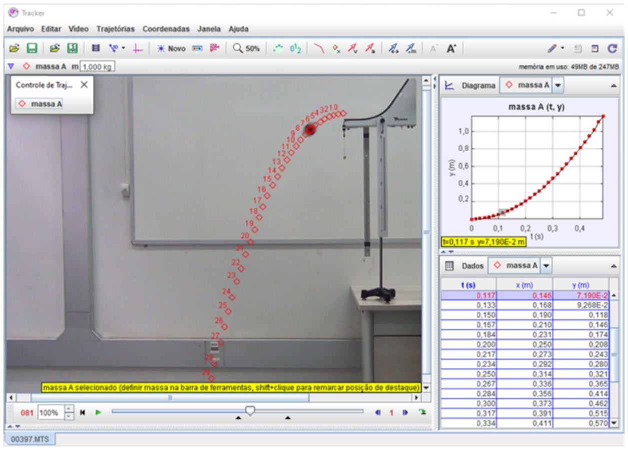

Figure 3. Print of the software Tracker screen of ball thrown horizontally

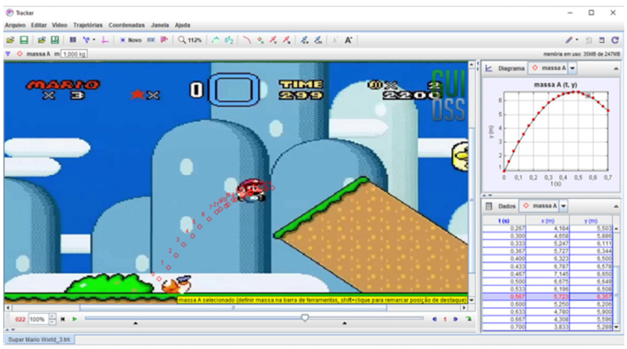

Figure 4. Analysis of a parabolic motion from a scene of a game

- Video analysis: The students performed, a study of the horizontal and vertical components of the moving object using the software Tracker, that allows to display the graphs of the horizontal and/or vertical components of the

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position in relation to time, a spreadsheet with the values in the selected positions of the trajectory and the parameters of the functions that interpolate the obtained values.

- Discussion of mathematical models: We discussed the mathematical models that represented the movement under analysis. From the data in the spreadsheet, the students found the function parameters that approximated the given function in each case and compared with the values obtained using Tracker. After that, the students represented those functions in Geogebra using both the parameters obtained via Tracker and those determined by them. They also created an animation in Geogebra that represented the recorded scene.
- Conclusion: The students wrote a report, an article, about the topic and their results. In this case, we have found it useful to provide a text template to be followed, which contained the screens representing each step. One can take advantage of this work to deal with the writing and reading of scientific articles. It is also important for the teacher to comment on the work done and discuss with students any misconceptions that have arisen. This project can also be developed in conjunction with language teachers, so that the results can be presented in the form of a technical report, scientific article, or other model that is most appropriate.

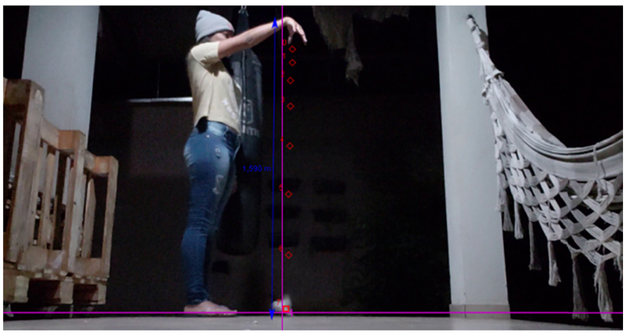

Figure 5. Analysis of an object in freefall

It is worth to be noted that when working with game scenes, the teacher must be careful as not all games follow our laws of physics, or use the same constants values, with their developers sometimes choosing other models. Still, this is interesting because it can raise a discussion about the real world *versus* the virtual world. In the case of technical courses in the field of computer sciences, such discussion is more natural for students, but it serves all students and courses in the contemporary world.

2.2. Objectives

This project was planned to provide the student with a greater understanding of the concepts of linear and quadratic functions studied in mathematics, from an interdisciplinary proposal, showing their applications in physics learning. To do so, the students conducted a study of the independence of the horizontal and vertical components in the movement of a projectile launched horizontally. In addition they measured the value of local gravity by studying the vertical component of the projectile movement.

It also introduced the students to the video analysis tool Tracker, which can be used later for other tasks or projects, even for other subjects.

2.3. Analysis

The work, as developed with high school students from different levels and background knowledges, is very rich in terms of possible discussions and questions to be placed, as to foster students understanding and comprehension of the topics studied.

Tracker settings generate curves such as, $y = At^2 + Bt + C$. An interesting starting point is to discuss with students the physical meaning of constants A, B, and C, and establish a comparison with the equations seen in kinematics.

From the Tracker analysis and curve fit it was possible to obtain the value of the acceleration of local gravity, in the case of the videos made by the students. This has been shown to be very important for students and generates a good deal of discussion because the measurement results normally differ from the known value, $9{,}8\ m/s^2$.

When a game scene was used, the value of gravity acceleration could be completely different. For instance, in games from the

Super Mario Bros series we have found values around $50\, m/s^2$. Results like this also raised the question of why that amount was chosen for the game. In addition, this result was discussed again when the gravitation content was introduced to students, leading to questions about the type of planet on which the game takes place.

From the extraction of some points it was possible to deduce mathematically the equations of the curves, compare the calculated parameters with those provided by Tracker, and even simulate the observed movements in GeoGebra.

When discussing the mathematical models, students were asked to choose data in the spreadsheet and obtain their respective mathematical expressions. This made students analyze the best data to be selected and how the software obtains data for the models. It raised a discussion that provided oportunity to talk about linear, quadratic, least squares regression and data statistics. Although not part of students' curriculum, these topics are useful for their technical school subjects and professional formation. This kind of discussion generally does not occur in a traditional approach with textbook exercises.

Other discussions raised were regarding the value of the initial speed, maximum height reached (when applicable), or the maximum distance reached by the object or character.

The equations studied in kinematics predict that the graph of the horizontal component of velocity *versus* time is a horizontal line, indicating that the velocity is constant. However, the results of the analysis showed a different behavior. This difference is due to the presence of air resistance that is ignored in the kinematics as a way of simplifying the calculations. Air resistance can have a big impact when the surface area of the object is very large compared to its mass, for example in the case of a cap left to fall under the influence of gravity. Still, it was interesting to find a point of comparison between the acceleration of air resistance and the acceleration of local gravity.

In the case of free fall, once the movement was linear, students also expected a linear graph for the vertical motion. They did not realize, as it was an accelerated motion, the graph would be a parable. This discussion evidenced the relevance of the use of softwares and experimental activities to help students understand complex and intangible concepts in maths and physics.

3. Conclusions

It was observed that this work allowed students to develop both practical skills in relation to its execution, as well as skills related to the mathematical and physical concepts of the problems. The teacher instruction also proved to be essential, helping students explore the problems and conjectures that arised, avoiding the perpetuation of misconceptions and providing a well constructed knowledge on the topics discussed. Some aspects observed by our students were the difference between the graph of the motion and the mathematical model that describes the movement under certain hypothesis, like absence of friction, etc.

Also, in the cases when the graphics were not straight lines but could be closely approximated by them, the students had to debate the ideas and choose the arguments to be used. It was observed that the students started to question what is happening and tried to explain such phenomena, sometimes with mistaken ideas, but that produced a rich debate. Compared to a traditional list of exercises, in which students only hope to reach the correct number, a positive change in the attitude of students in the search for understanding the phenomena was noticed.

The development of this project allowed the students to explore conjectures, something natural in mathematics and physics but unusual in performing traditional exercises. The search for the answer to such conjectures provided a rich learning environment, and the results of the simulations encouraged students do question and reshape their previous knowledges and misconceptions.

During the work, students were more involved with the discussion of the physical understanding of the phenomenon on video, than in the realization of conventional exercices lists that ended up being seen only as "bureaucratic" tasks to find the correct answers. With the non-integrated teaching of mathematics and physics, obstacles emerge,

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making it harder for students to interpret and understand the concepts and the language used by both areas. Our preliminary results suggest a good efficiency in the use of computational resources such as Tracker and GeoGebra in integrated mathematics and physics classes, however more research is needed to measure qualitative results.

When working with game scenes, care must be taken as not all games follow the natural laws of physics, with their developers sometimes choosing other physical models. This is interesting, as it provides chance to discuss the real world and the virtual world engines.

Although these are activities that require more preparation and monitoring time, our perception is that the development of such activities favors greater learning on the part of students.

4. Acknowledgements

We acknowledge the institutional and financial support given by CEFET-MG.

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Epoxy Jewelry as STEM Project

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Abstract. In this paper the results of hand-made epoxy jewelry both for children with special needs and common children are given. The easiest and the most popular examples of jewelry are given. The fundamental lows of epoxy curing and their explanation for children are analyzed. The examples of epoxy jewelry with different fillers both traditional like glitter or dry flowers and shells and unusual like coffee grounds, plastic wastes, metal wastes are described. The connection with base school disciplines while realizing such STEM project is shown.

Keywords. Children with Special Needs, Curing, Initiator, Epoxy Jewelry, Fillers, Wastes.

1. Introduction

Any STEM project must meet the following criteria:

- materials and equipment must be cheap, compact and not heavy in weight;
- materials and equipment must be safe both for children and environment ;
- project results should be achievable in short time, from 1 hour to 5 days;
- STEM project should deepen the knowledge gained through the school curriculum or explain some theoretical material using hand-on science classes;
- it should be interesting for boys and girls.

If we have as participants of STEM project children with special needs, than two new criteria are appeared:

- easy for making and understanding sequencing looking for children's physical and mental condition;
- shown children with special needs ways of their future ability to make business using ideas of given STEM project.

Not all STEM project can be successfully realized in groups, where common and children with special needs are together [1].

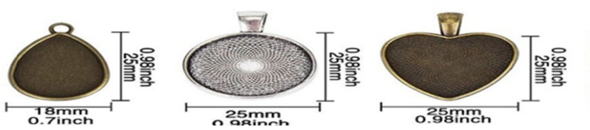
2. Materials for polymer jewelry

Among all different polymer materials for jewelry we have choose this one:

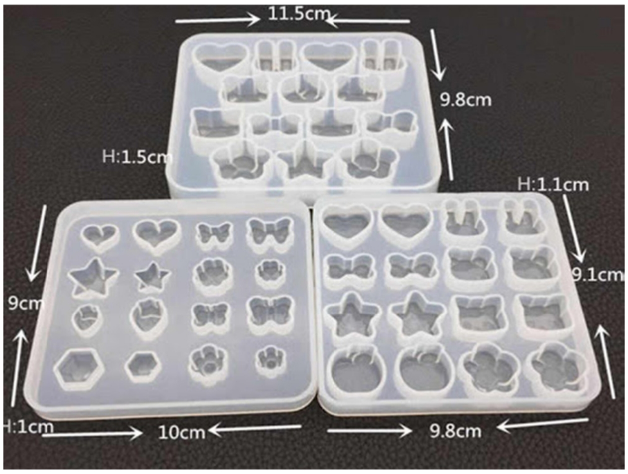
- modified polyacrylamide (MPAM), that crosslinked by ultraviolet rays in 5-15 minutes (time depend on jewelry thickness);
- epoxy resin (ER), that crosslinked without heating in 24 hours (using curing agent);
- hydroxyethyl methacrylate with photo initiator hydroxycyclohexyl phenyl keton –well known material for nail art (HEM).

Table 1. Characteristics chosen polymer materials (PM): Price $/kg, Substance Hazard Class, Special Equipment Needed (Price $), Color Palette

PM	P	SHC	SEN	CP
MPAM	65	3	Y, 15	RGBY
ER	25	3	N	Transparent
HEM	100	3	Y, 10	>20



a)



b)

Figure 1. Illustration of molds and frames for jewelry

Their price and other characteristics are given in Table 1. 1 kg of any polymer material is enough for making more than 100 examples of jewelry. As fillers and additional materials for

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rings, bracelets, earrings, pendants, brooches you can use different materials, even diamonds. But we offer to use cheap or free materials:

- wastes materials – broken glasses, old buttons, colorful plastic and metal wastes, coffee grounds;
- floral materials – fresh and dried flowers and grass, branches, cones, coffee beans, tea;
- natural materials – stones, colorful sand, shells and other materials for hand-made.

Using of waste materials is the way for sustainable development of any country [2]. For jewelry's better appearance you can buy reusable silicone molds (Fig. 1a) and metal frame (Fig. 1b).

3. Processes, which demonstrated during this STEM project

In Ukraine children in secondary schools have different disciplines like biology, chemistry, physic that are not in one integral course but are being studied separate. Sometimes, depend on school program, topic from chemistry, which was studied in 8 classes, repeated in 10 classes during studying physic. That is why STEM project, that can combine several school discipline are important.

Polymer ER, MPAM, HEM curing process illustrate following theoretical knowledge for children:

1) from physic - transition from liquid to solid without changing temperature (heating or cooling) or pressure changing
2) from chemistry - polymerization and polycondensation reaction;
3) from ecology – environmental friendly technology of making jewelry, when nothing is emitted to atmosphere and no fusel fuel is burning for heating;
4) from biology – light is essential not only for living organism (if you use HEM and MPAM) from physic – sunlight consist not only from visible light but also of ultraviolet light (if the weather is sunny you can make jewelry from MPAM without special lamp, open air)

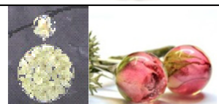
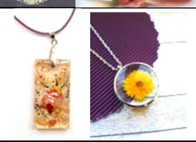
4. Children with special educational needs in the given STEM project

Working together under some STEM project is useful both for common children and children with special educational needs. For three last years authors have hold more than 15 events like STEM projects, where common children and children with special educational needs were together. Some of them have been taken 2 hours, other – 2 weeks.

It was noted that the children with special educational needs are very happy about the opportunity to receive financial rewards for the manufactured material object. The money received from the sale of the making by their hand object becomes the incentive that forces them to continue classes on the STEM topic at home.

Fashion trends of five last years have shown an increase in popularity handmade decorations. Two last years in Eastern Europe one of the fashion trend is jewelry from epoxy resin with flowers. Their price is different (Table 2). As we see, selling such jewelry is real business.

Table 2. Price of epoxy resin Jewelry: Sample and Price

J	S	$
rings		5<P<45
bracelets		30<P<75
earrings		10<P<80
pendants		7<P< 50

5. Results and conclusions

The cheapest material, that doesn't need any additional equipment (ultraviolet lamp), is ER. But for curing you should mix epoxy resin with curing agent in clear proportion. For some children with special needs it can be difficult. Taking in the mind this problem, we decide to create jewelry, based on MPAM and HEM but also show them how to make jewelry based on ER.

This STEM project was realized in Kharkov, Ukraine (winter 2020) during project “Vacations with Polytech”. Among participants there were 6 children with special educational needs.

First we explained children how MPAM comes solid in special ultraviolet lamp (Fig. 2).

Figure 2. Ultraviolet lamp or so calling 3D ultraviolet own

We have made standard figure – sea horse (Fig. 3a). Mould for it was included to set with 3D ultraviolet own (Fig. 3b). We also show the possibility to mix two MPAM colors (red and yellow) and get new color (orange) in one object (Fig. 3a).

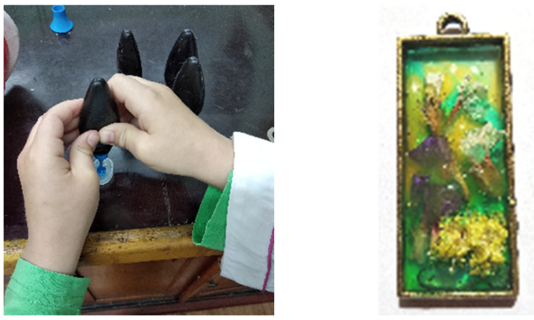
Our second step was making pendants in silicon mould (Fig. 4a) and in metal frame (Fig. 4b). As fillers children have proposed dried flowers (result at Fig. 5). Many children did their own herbarium during summer holidays. So, this material was free for us.

From ER we have made necklace beads (Fig. 6) with butterfly and flowers. If you add special pigments, you can receive colorful ER, not only transparent.

From HEM we made ring (Fig. 7). It consist of 6 layers of gel polish, including colorful layers and transparent layers of base and top coat. Also we use flowers and got original, extraordinary form of ring.

a) b)

Figure 3. sea horse from MPAM



a) b)

Figure 4. Making pendants from MPAM

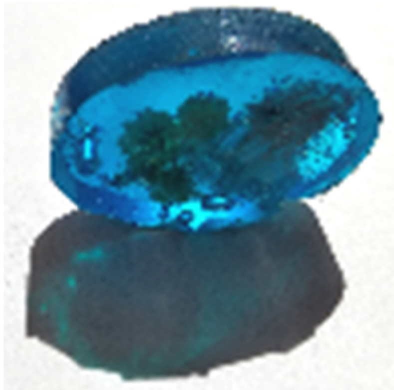


Figure 5. Blue pendant with flowers from MPAM

Figure 6. Necklace beads from ER

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Figure 7. Ring from HEM

This STEM project was interesting for children. Teachers, who were with them, take into account this idea for their future project.

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The Stereotyped Images of Scientists and Science Made by Children are Slowly Changing over the Past Few Decades

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Abstract. The last Spanish survey showed a low social interest in science. This lack of interest affects Europe students and the whole society.

As science teachers we are interested in understanding how children feel science, any science. Allowing children to use their imagination and creative originality for drawing some images of science and scientists is one opportunity for help them to increase their interest about science.

The objective of this work is, using children drawings, to analyze and understand how science is perceived by primary school students and to compare results with the same approach performed and analyzed ten years ago.

Keywords. Creativity and Imagination, Drawing Scientists, Gender Equality, Primary School, Students and Teachers.

1. Introduction

The last Spanish survey about Perception of Science in Society conducted in 2018 by the Science and Technology Spanish Foundation "*Fundación Española para la Ciencia y la Tecnología, FECYT*" [1] showed a few interest in science.

Survey answers were analyzed and let us to understand why our society must increase science knowledge. Some hot points are:

a) Science and technology arouse similar interest (16.3%) to topics such as food and consumption (18.9%), travel/tourism (18.5%) and retirement funds (16.1%). However they were a considerably less interesting subjects than medicine and health (37.9%), work and employment (31.9%), education (28.8%), sports (24.4%) even politics (22.7%)
b) Spontaneously declared interest in science and technology continues to be greater among men (18.9%) than among women (13.9%).
c) Interest in these topics decreases as the age of citizenship increases, thus the greatest interest in science and technology is recorded among people aged 15 to 24 (22.7%) and the lowest among people over 64 years (6.7%).
d) The increase in the perception of obtaining good information on science and technology topics is greater among younger people (15 to 24 years old). However, younger and older people who have a lower educational level have considered that they receive less information on science and technology.

While, children are not been represented in this survey. As science teachers we have been interested in understanding how children feel towards science.

2. What about teaching science to children?

In the early twentieth century, appeared a curriculum known as "nature study". It was an approach to introduce science to elementary education with the help of institutions such as zoos, botanical gardens and museums. The objective was to encourage the direct knowledge of nature as a society benefit.

In the XXI century there are many activities to introduce children to experimentation and science. They learn experiments, in a fun way, which illustrate science concepts of chemistry, physics, biology, geology, mathematics or robotics. Two of these activities are "Nanorobots" and "YoMo Fair"

2.1. Nanorobots and Nanoscience

Nanoinventum [2] is a project based on Science, Technology, Engineering, Arts and Maths (STEAM), aiming to introduce science in

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primary school. The main objective is to create a model for a nanorobot, imitating nature, based on the knowledge of different scientific topics, such as nanotechnology, matter, atoms and molecules. The project uses strategies like co-creation and design thinking, Fig. 1 shows two creations.

Figure 1. Examples of Nanorobots drawings made by children

Young students explain their drawings "Our nanobot will resolve and cure the heart attack. A quantity of nanobots will enter injected through the Superior Vena Cava (SVC). With a special sensor, they will detect the blood clot and will enter it. When the nanobots enter it, they will warm up and then the blood clot will melt so that the blood can normally continue to circulating."

2.2. YoMo Fair

YoMo Barcelona 2019 [3] offered engaging hands-on interactive activities designed for children, teenagers and adults.

Students can discover science, chemistry and biology, from monitoring radiation to exploring Nanoscience or to unlocking our own DNA. Participants can also witness how architects and designers apply creativity. In addition, they can explore how technologists and programmers, in the information age, use advancements from the digital revolution to transform our world. Finally, students can find out how physicists, geologists and even astronomers are using the fundamental principles of the universe in their studies.

Children can discover scientists around the world who are tackling diverse obstacles such as the challenges of human health, climate change and food quality. They can observe from virtual Reality to Artificial Intelligence, advanced manufacturing in 3D. Finally, the advancements in science and technology allow us to talk, entertain and inform in ways we could never imagined.

3. How do children describe science and scientist?

Children imagination and creativity are essential in their personal and scientist progress. Creativity is an innate quality that everyone possesses and it is the freest form of self-expression. As Einstein once said, “To stimulate creativity, one must develop the childlike inclination for play.” Ask any child how many uses there are for a paper clip, and you’re get a quantity of imaginative ideas.

Imagination is the ability to form a picture in our mind of something that we have not seen or experienced. Every child is born with a great imagination. At times, parents and adults support children's imaginations and take pleasure in their creative thoughts and acts. Every so often, we suppress (consciously or not) children's imaginations, probably we are worried about children understand reality and imagination.

The youngest kids imagination is an usually entertainment. for them. As example, Zoe, a kindergarten girl close to six years old, was explaining to her family an invented story. In the middle of her tale, she enthusiastically told them, "… then we drank pink milk that came from a pink cow next to a pink unicorn, do you know?…" or else, when children are playing with invisible (for adults) friends and things. However, most children older than three years old know that pink cows don't really exist but they enjoy to imagine and think creatively in other reality.

The best satisfaction for the majority of kids becomes perceptible when they are able to express themselves openly and without judgment.

Allowing children to use their imagination is very helpful for them and creatively drawing science and scientists is one opportunity for their expression.

3.1. Draw a scientist

It has been indicated that the stereotypical scientist remains a dominant image in most children's mind [4].

To investigate it, in 2002 the Draw-A-Scientist Test [5] was used by the authors with Catalan primary and secondary school students. Then students' images and feelings about science and technology were analyzed [6-8].

Since 2012, we have been carrying out with school children the "Draw a scientist" supported by the Official College of Catalan Chemists [9] and the University of Barcelona [10-11]. In this project science and scientists' drawings were collected again from Catalan primary school students (8-12 years old) and science workshops [12-13]. The analysis of drawings were used to compare them with our previous works [6-7]. In addition, boys and girls drawings were evaluated along the last years and they show some changes.

4. Results and discussion

This project was conducted in Catalonia with students from Barcelona and surrounding areas. Finally, 844 primary school students (8-12 years old) drew images about science and scientists. Table 1 shows its analysis.

Table 1. Results

	Boys	Girls
Total drawings	426	418
No human image	138	122
Human images	288	296
Man image	218	50
Woman image	40	226
Unknown	30	20

Table1 shows the 69.19% of primary school students who drew human image, balanced in gender, 45.55% female images, 45.89% male images, and 8.56% human spectrum but with an unknown gender (Fig. 2).

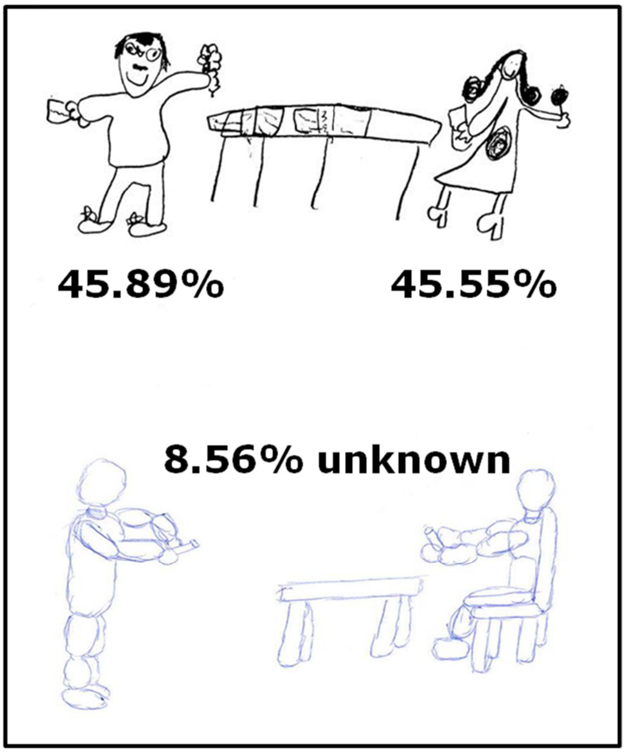

Figure 2. Representation of human images

Results presented in Table 1 and Fig.2 are concordant with our previous ones. The pictures drawn by these students were similar to these found in our previous research, in 2008 more than 67% primary school students drew the human image (43.45% female image, 43.78 % male image and 11.44% was unknown gender).

In addition, drawings without human references (32.55% in 2008 vs 31% in this work), usually show, in both cases, a laboratory bench, some animals, plants and scientific instruments, particularly glass and plastic. Laboratory glassware was illustrated in the majority of the drawings depicting a research laboratory environment. Figure 3 shows some examples.

Glass and plastic equipment drawings were not a surprise for the authors because older students (11-12 years old, in the last years of primary education) have occasionally worked in a chemistry/physics and biology laboratory. They had seen many chemical reactions, substances changing its colour, form and state (solid, liquid and gaseous). Usually these material, glass test tubes, bottles, balloons, Erlenmeyer, etc. were used in their experiments.

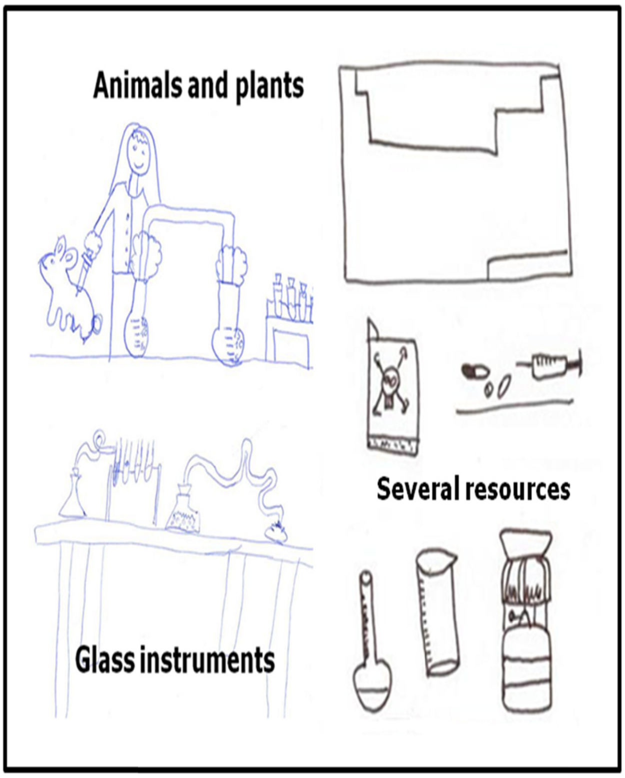

Figure 3. Many laboratory tools

When the drawings were examined while keeping in mind the gender of the student we observed few differences between both groups, boys and girls (Table I). In addition, these images and concepts were similar to those found by other researchers [14-15]

In Table 1 it can observe that in primary school education, the 75.69% (77.05% in 2008) of the boys who drew a human representation did a male scientist. In the same way, the 76.35% (72.99% in 2008) of the girls who drew a human image did a female scientist. This analysis clearly shows that the gender of the figure depicted was unbiased, it only was based on the gender of the student itself. It was not affected by adult discrimination and intolerance.

The most reasonable and easy explanation is that the children in primary school are still unaware of the significant role that gender plays in our society. There is no reason why a doctor, administrator, engineer or scientist have to be the father rather than the mother, the brother rather than the sister, the boy rather than the girl, luckily the kids do not think so. At the time of making drawings most of these children were imagining themselves in that environment and also conducting those experiments, they were "the scientists" (Fig. 4).

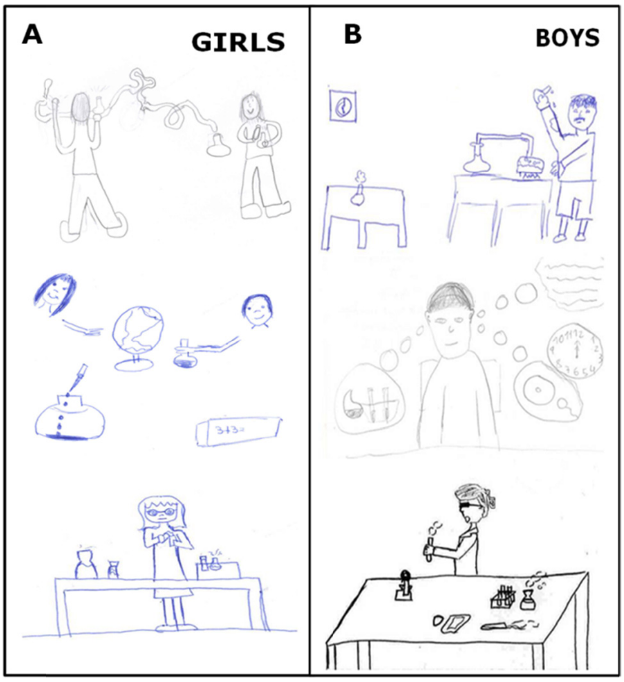

Figure 4. You can observe some human images drew in their classroom by primary school students A) girls and B) boys

Schreiner [16] think the drawings are an identity symbol for both boys and girls.

The authors proposed [17] to do a number of measures focussed on young students and directed to girls to achieve gender equality. In fact, the role that gender plays in our society (which harms girls and decreases their interest in science or STEAM studies) arises in secondary education.

Furthermore, in every science fields, gender equality could increase if scientists, men and women together, find time to disseminate their findings to society and more important, they have to disseminate their knowledge in an understandable approach to primary and secondary school students. In Spain the media must play an important role in this "science diffusion."

Finally, Matthews and Davies [18] had proposed that teachers, scientists, journalists and science communicators, all together, must

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change children's images of scientists and science perception.

5. Conclusions

Comparing the results from 2018, the first analyzed drawings on science and scientists images by the authors, to the most recent ones we do not find great differences but it is important to emphasize:

The drawings collected offer a vision of the perception that children have of scientists and we can conclude that, over the years, the image of primary school students towards the science and the scientist is slowly changing.

In the last study, more human images were drew representing scientists than the previous one. This result lead us to think that both boys and girls were seen themselves in the scientist profession.

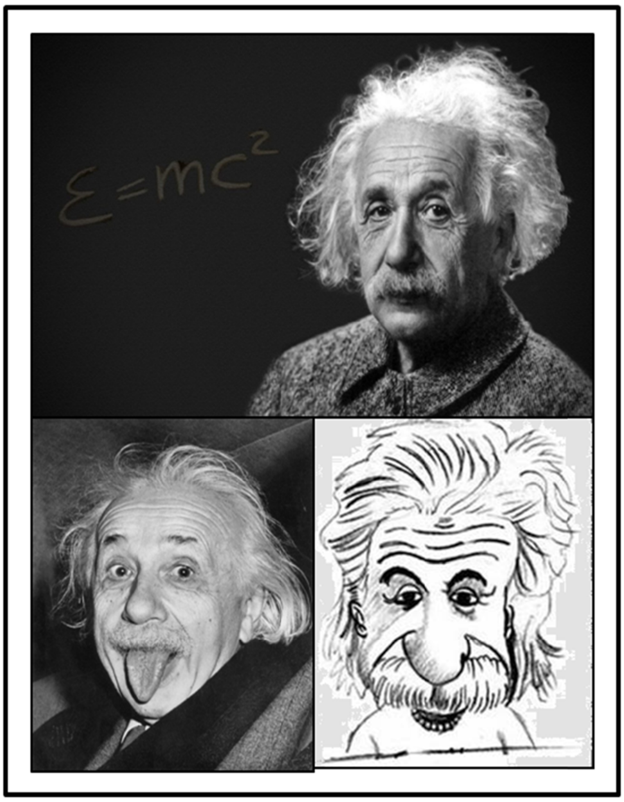

Figure 5. Three different Albert Einstein's images which illustrate how we can change the scientist stereotype. Einstein's pictures are from [19, 20] and Einstein's comic was drew by Josep Fernández, "Jepi"

In addition, the female presence in drawings was also increased. Perhaps this is a reflection of a deep change in our society in general.

The authors want to trust in it.

The usual stereotypes about science and scientists coexist in the drawings with other images that are much closer to what the scientific activity really represents in schools and laboratories. The image of an elderly man, dishevelled, with an evil or fanatical face and hair completely untidy, is slowly decreasing in the last drawings.

You can examine in Figure 4 the presence of "normal and young scientists working and thinking in a laboratory environment" in some drawings did by both boys and girls from primary school.

For changing the stereotype of the old and crazy scientist we can show to primary school students the serious image of Albert Einstein and his most important principle ($\Delta E = \Delta m * c2$, it explain a relationship between mass and energy), then the amusing Einstein's image showing his tongue and, finally, the Einstein's image using cartoons and comic strips. Fig. 5 shows these three images together.

In addition, if we give the opportunity for young university scientists to visit primary and secondary schools, talking to students, explain and developing demonstrations and experiments in the middle of their classroom and, alternatively in school laboratories, we will contribute to change these images of bad science (Chemistry, atomic bomb and climate) and crazy scientists.

In this context, young university scientists with their stories about science and research will appear in primary and secondary students imagination.

Science diversity in gender is becoming more and more real, and society perception of this fact is also adjusting to reality. This is very motivating, our society could feel closer to science if everybody can see themselves or his / her neighbour, male or female, doing any science.

Probably, this small improvement has been built by little changes in teaching science at elementary level with increasing the experimental part and the presence of women scientists who collaborate in bringing science to schools.

The final objective is fight against the lack of interest in science in our young students and our society.

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Let's Play with the SDGs Toward a Sustainable Future: 2030 Is Coming!

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Abstract. The paper reports a case study concerning an activity developed to inspire debate and reflections about our sustainable future among the youth within the frame of the SDGs of the UN 2030 Agenda. The contribute contains a detailed description of the workshop and the designing process, highlighting contents, methods, and approaches. Moreover, the activity has been successfully carried out in two festivals and the evaluation outcomes are reported too, thus providing interesting arguments fostering the debate on youth education and engagement on the SDGs. The activity is an attempt to change how we communicate and educate on sustainability since informal education for sustainable development needs further implementation to be broadened and transformative.

Keywords. SDGs, Education for Sustainable Development, Youth, Future

1. Introduction

In September 2015 the UN General Assembly launched the 2030 Agenda for sustainable development [1]. Worldwide attempts in communication actions on this transformative document and the 17 SDGs (Sustainable Development Goals) also involve Science Centers and Science Museums, particularly after the Tokyo Protocol "On the role of Science Centre and Science Museum worldwide in support of the United Nations Sustainable Development Goals" [2]. MUSE-Science Museum of Trento is a cultural institution engaged in science and sustainability education and communication by the mission but has recently oriented its activity around the UN 2030 Agenda introducing specific actions on SDGs [3-4]. In 2017 the museum launched the postdoc project "TASK - Toward A Sustainable Know-how", entirely focused on SDGs' communication and education [5-7], and became member of ASviS (Italian Alliance for Sustainable Development), participating in the working group on SDG4 and education for sustainable development. Among the activities of the project TASK, the author developed the workshop "Destination 2030" as an educational activity on the SDGs for the youth. It has been proposed during two festivals where more than 700 people partook in the workshop, giving the opportunity for collecting data for evaluation and research purposes. Therefore, the results provide useful elements in supporting the discussion on such informal educational actions: how do participants approach the future? How do they feel engaged with the SDGs? Can informal education provoke change in the youth? Which aspects of the activity design are more effective?

These days science and sustainability education have to be transformative, the main goal should be to provoke reflections, dialogue, and debates, to raise awareness and to promote active participation and action for the change. It is crucial to speak about sustainability without catastrophism or alarmism, keeping the focus on the future and change. A renewed idea of sustainability should be presented, despite the historical vocation of natural science museum we do not speak about the environment only, we assert on the four dimensions of the concept of sustainability and the need to reinterpret the meaning of this word [8-9]. The case study presented here is an example of educational activity on Sustainable Development Goals.

2. "Destination 2030 – Let's change our world through SDGs"

The workshop, designed to inspire thoughts and discussion on the future in the youth within the framework of the UN 2030 Agenda, is based on two pillars: 1) the integrated nature of the 2030 Agenda and the interconnections among the SDGs [10-11]; 2) the System Thinking approach to describe, understand and maybe even rule our complex world in a sustainable perspective [12-13]. System Thinking is a new and useful conceptual tool used to discern processes and learn how to deal with the ambitious challenges of the future. System Thinking allows us to understand the whole picture, while seeking relations and dependencies inside it, in order to explain its complexity [14]. After the 2030 Agenda, this results as the foundation to understand sustainability, in fact, the SDGs present society, economics, environment, and institutions as part of one intertwined crisis, challenging one of them means to challenge the whole system.

The aim is to let young students talk about these relevant topics in three different ways: collective discussion with a facilitator, small groups, peer-to-peer collective reflection. Since we want them to discuss causes and effects in the context of their real-life, in order to raise awareness and prompt action and participation, discussing in a structured manner help in-depth reflections. As suggested by Heras and Tàbara [15] this can support participants' engagement with sustainable development. The different steps try to link present actions to future consequences and generate a context for the articulation of own thoughts so that the understanding of subjects will be deeper [16].

2.1. Activity design

The workshop is designed for youth from 11 years old. It is planned for groups ranging from a minimum of 10 up to a maximum of 25 participants, one or two scientific explainers facilitate the workshop. The activity is structured in 5 steps with an overall duration of 90 minutes (Fig. 1):

1 - Launch (15')

The facilitator opens a discussion about the future, starting from the question: "How old will you be in 2030?" and then asking the participants how they see themselves at that age considering physical changes, expectations, and dreams, but also transformations of the society and lifestyle. Then, they also investigate the general feelings of the audience: are they excited by the upcoming future, or maybe worried about it? The facilitator then proceeds to upset the setting, since those are serious topics and the participants are invited for a stupid game: let's move on!

2 - We are a complex system (15')

This multiple-steps game is designed to approach complex systems funnily and engagingly. First participants should dispose themselves according to their height. In this step, the position of each person depends on the stature of two others (these are invariable parameters). Each person can easily find its position; the final disposition is a simple line. Then, each person must choose two others as references (undisclosed), everyone spread randomly in the room and when the facilitator says "Go!" everyone has to place in between its references. In this step, the position of each person depends on the position of two others, but they are not fixed since they are moving following other people. In the end, the facilitator stops the group and lets people scatter in the room for a second round except for three people, which are fixed in their position (this will make some changes in the dynamics of the group) - adapted from "Systems Scramble" Copyright 2016 by Arizona State University, published under a Creative Commons Attribution-Noncommercial-ShareAlike license. Participants discover what is a complex system and how it works, a system emerges from the interactions among its components in a non-linear way and, consequently, it is not the simple sum of its elements. The facilitator must underline that they had simulated a system (referring to the role of models in science) and provoke them into thinking about real systems they are involved in. A collective conversation can be initiated using food, social relations, commerce, travels, and other everyday life examples and experiences.

3 - Teamwork on SDGs (30')

Due to the complexity of the real world, we must think in a systemic perspective to solve complex problems and reach the global goal of a sustainable future. In this context, the facilitator introduces the UN Agenda and the 17 SDGs to be achieved within 2030. In this large and ambitious frame, participants are divided into three groups, each of whom receives a die and rolling it will select randomly the SDG on which they will work. This allows speaking about the influence of chance in complex systems.

Each team is provided with a board, a marker and the text of the Agenda for that specific SDG. They have to draw a causal loop diagram using basic tools of the Systems Thinking: arrows to identify cause-effect relations, plus and minus symbols to categorize the positive and negative influences ('+' is used if causes and effects increase or decrease in the same way; '-' is used if the cause's increase leads to the effect's decrease and vice versa). Eventually, they can identify feedback loops (reinforcing or balancing) and add some delay effects, once the diagram has been sketched out. Theoretically, the work is open-ended so participants must be stopped after a while to keep the time.

4 - SDGs interaction (15')

Figure 1. Pictures showing the main steps

A final discussion gives voice to each group to report what they talked about and to show the resulting diagram to the others. Participants are distributed around a round floor-board where the three SDG boxes have been placed. After each presentation, the facilitator sums up the main connections that have emerged by the causal loop diagrams linking the specific SDG with some of the others (usually every map allows to identify several interactions among different SDGs, in some cases, they are reinforcing while in others tradeoffs could appear).

In the end, a unique net of multiple connections among almost the whole SGDs results from the work of the participants. This represents the concept of sustainability and the interdependence existing in the purpose of the UN Agenda. Some time is left for comments and questions.

5 - Let's touch the future (15')

Closing the activity, after reflections and teamwork on the future and how to act in such a complex and changing world, the facilitator asks the participant to use their smartphones and draw a connection through time by sending an e-mail into the future. Using FutureMe [17] each participant can write themselves a message they will receive one year later, so when they will be one year older and closer to our destination, the year 2030.

They can write a task they intend to achieve or a personal purpose to change their lifestyle (e.g. reduce plastic, use a bike, refill water bottle…) and the content of this message remains secret.

Phase 1 opens the workshop and provides a platform for critical reflection in which the public can articulate their expertise, desires, and expectations [18]. Phase 2 introduces participants to complex systems and phase 3 requires to apply the System Thinking approach. These activate creativity and personal knowledge to deal with complex problems in a personal way making global complexity visible on the local scale and with personal relevance [18]. In phases 3 and 4 interpersonal communication between friends, family or strangers (both in small groups and in collective sharing) impacts how relations between causes and consequences are understood [20]. Finally, personal actions should be understood as part of a complex system and this will intervene towards a desirable future [21] so that indifference and resignation are turned into responsibility opening up for collective and inspired action (phase 5).

Attention has been paid to the setting and materials. Three dice in cartoon boxes (30x30x30 cm) are used for each group to select the SDG they will work on (phase 3). The trick to rolling the "big" dice sounds funny but also gives the relevant message that chance has a role in what will happen in the future. Then each group receives the box of the selected SDG, as a support, and a transparent plexiglass board to assemble a table. They can write with a removable marker, which allows noting down and continuously re-build the map (causal loop diagram): every idea is good, there are no right and wrong connections and new ideas arise while working. The groups also get the original text of the Agenda (extract of the specific SDG), that is fundamental to see what each goal means - even if they had to apply the goal in their everyday life. They also receive a short story, a case study, in which strong and unexpected connections are pointed out - this can be inspiring. For the final discussion on the interaction among the SDGs, we use a floor-board that becomes the static center of the conclusion of the activity. Ideally, it is placed in the middle of the SDGs' wheel (floor adhesive) and the SDGs' boxes in the middle.

The most important aspect remains the role of facilitators. They should have a deep knowledge of the UN Agenda and the key elements of System Thinking, but, most importantly, they should be able to guide the discussion, listen to the outcomes, ideas, and doubts from the participants. Facilitators do not know the “right” answer or solution; they should make the participants at ease and help them find the best way to identify specific connections or discover new unexpected implications they had not considered before, in a comfortable environment free of judgment.

The activity design follows the educational criteria related to “Global Competence” as for the OECD PISA Assessment [22].

3. Evaluation and research

The workshop has been proposed in two festivals during the school year 2018/2019 - the Genoa Science Festival for schools and the general public (Genoa, 25/10-04/11/2018), and the SDGs Week for schools only (MUSE-Science Museum of Trento, 19-22/02/2019). Thus allowing carrying out evaluation and research on two different samples of participants and with different methods, the main aim is to assess the impact of the activity and investigate students’ attitudes and thoughts about the future.

3.1. Data collection

At the Genoa Science Festival, the activity reached about 570 people (mainly students of 11-19 years old, but also the general public until 40 years old). A reflection wall was used for summative evaluation, such a tool allowed to gain feedback from participants in a playful way, which is suitable for a festival context with many participants, and to involve other visitors who are not taking part in the activity. The reflection wall also allowed them to strengthen the need to being part of the collective change and inspire other participants (leading to the idea that we all are “traveling” toward our common “destination”, namely 2030).

In Trento, during the SDGs Week, 10 classes (230 students and 19 teachers) took part in the workshop. Pre-activity and post-activity surveys were arranged and we asked students to fill in the former during the previous week and the latter right after the conclusion of the workshop. A survey for teachers had also been arranged and handed them at the end of the activity.

3.2. Results and discussion

During the Genoa Science Festival, 156 sticky notes were collected through the reflection wall, they mainly contain text, few have drawings. Most of them had #hashtag and @mentions. Based on the content, they can be classified into four meaningful categories (66%) while circumstantial messages like “thanks”, “hello” (34%) are all considered as not relevant (Fig. 2-A). The four categories emerged from the comments are the following:

- Enthusiasm (21,79%). Considering the festival atmosphere, it is not surprising that many participants give enthusiastic feedback. However, this is not a fun science activity designed to entertain, on the contrary, it deals with serious issues and a bit of hard content unknown to the audience (System Thinking): interesting two sticky notes report “Strangely fun” and “Lovely but also complicated”. These declare participants’ feeling, maybe a mixture of good vibes and awareness.

- Educational value (19,87%). Since many participants were school classes, it is worth that many comments explicitly refer to the educational value of the activity. This was the main aim of the design, together with a fun way to engage. Participants (students, maybe teachers, but also general audience) found the workshop informative, useful, interesting and reflective. A definitely representative sentence must be quoted: “A simple way to learn about topics that are not so simple”.
- Taking action (12,82%). As a matter of fact, call to action is the natural outcome expected from the activity; people can move by themselves from awareness to activism, and decide to state and share their position on a sticky note. The content of many messages is extraordinarily relevant and must be quoted: “Future is in our hands”, “We are the future!”, “Let’s stop climate change!”, “I want to be UN staff”, “Now it’s my turn”, “Change is beautiful”.
- Connections (11,55%). Close to the educational value of the activity, those messages indicate that participants understood the complex nature of our world, and they were fascinated by the existence of connections. It is interesting to find how the specific content of System Thinking struck the participants so that someone even decided to sketch their idea (Fig. 2-B).

Thanks to pre and post-activity surveys, a more punctual investigation was possible during the SDGs Week. We analyzed 230 post-activity surveys from students (12-19 years old; middle and high school from the provinces of Treviso, Vicenza, Verona, Brescia, and Roma) and 19 questionnaires from teachers. Only 139 students’ pre-activity surveys were collected.

We asked students two questions related to their attitude and thought about the future:

A) Five-point Linkert scale (not at all – a lot) for the following items:

- Future is far away, I don’t care about it
- Future does not depend on my choices
- Change is fast and unavoidable
- Change is hard to perceive, apparently nothing changes around me

B) Selected feeling (more than one choice):

Worries; Interest; Boredom; Challenge; Indifference; Hope.

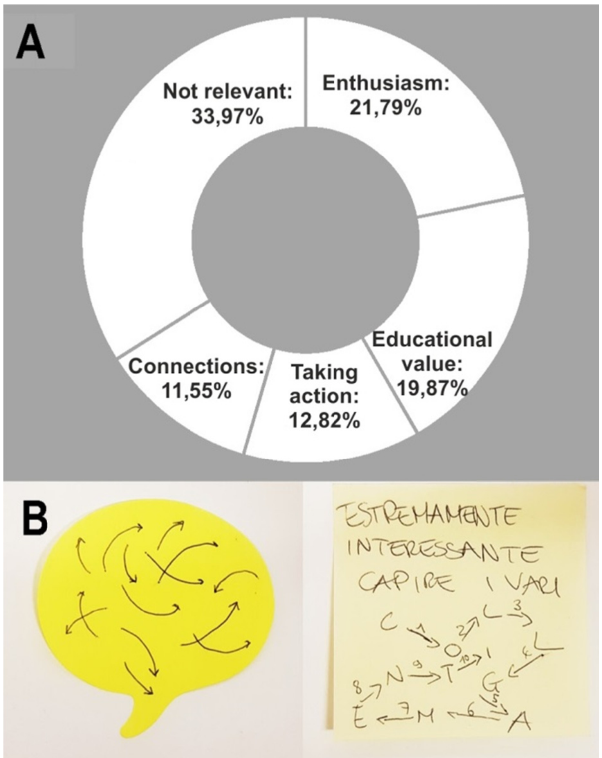

Figure 2. A. Sticky notes collected from the reflection wall have been classified according to the content as described in the text – pie chart shows the different percentage; B. Graphic sticky notes concerning the idea of “connections”, the text translation is “Extremely interesting to understand diverse c-o-n-n-e-c-t-i-o-s”

From the comparison of results (Fig. 3) students move from a medium disagreement on irresponsive attitude toward the future to a new position where they express the need to take care of the future and that it depends on their choices. There is also an increasing percentage of students that disagree with the idea that change is unavoidable, meant as a significant shift from the common thought of an other-directed future. Concerning their perception of change, it shows they already have a clear perception of changes around them, but after the workshop, some moved from agreement to a doubtful or disagreed position, especially on the item of fast and unavoidable change, they consider a much relevant impact of their choices in shaping the future and generate the change.

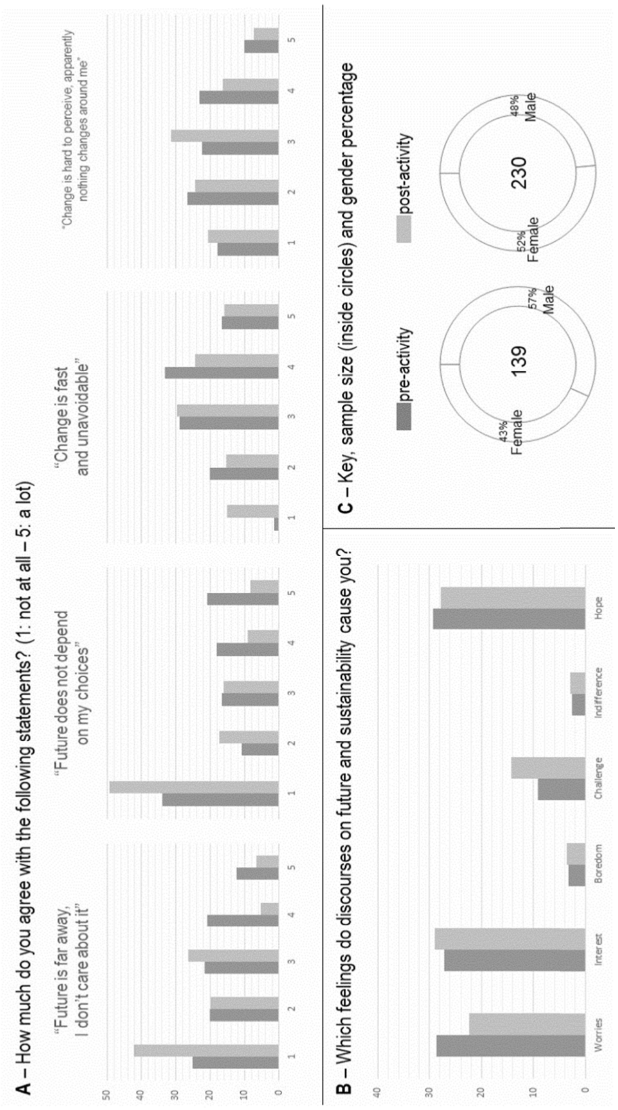

Figure 3. Results of two questions related to students' attitudes and thoughts about the future, before and after the workshop, gained through surveys during the SDGs Week for research purpose

Among the proposed feelings (Fig. 3-B), many students chose the opposite terms of "worries" and "hope", pessimism and optimism are both common among the youth, and interesting, after the activity, a significant reduction appears for "worries". Students are also interested in discourses on future and sustainability, and the workshop feeds such attitude. The sense of empowerment, linked to the idea of "challenge", is not common, but it increases after the activity: the global goals, the global effort, and the systemic approach may have led to the new idea of sustainability as a challenge for humanity.

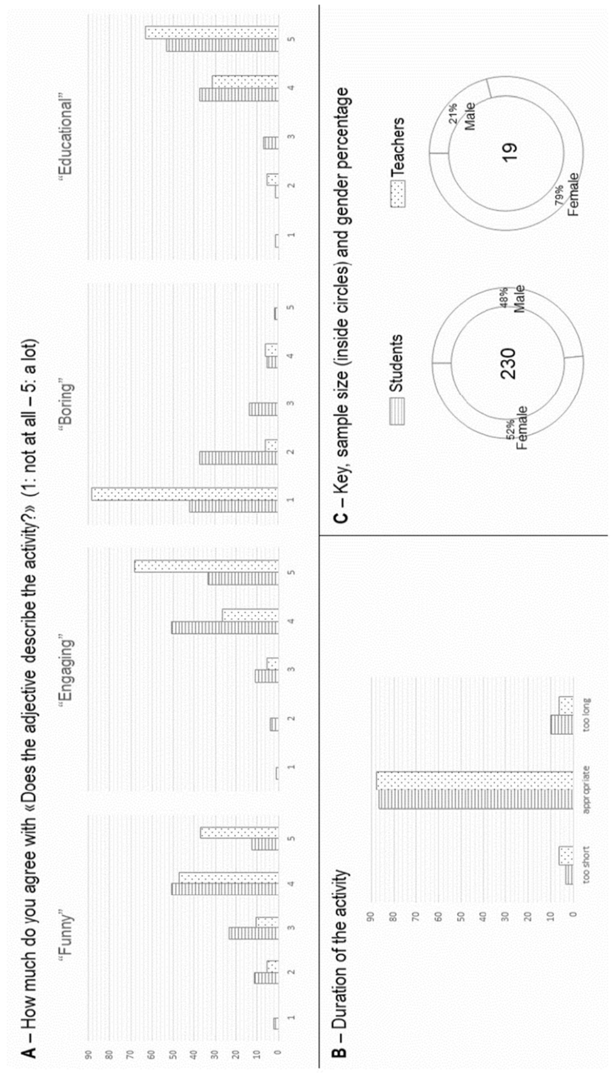

Figure 4. Results of two questions on students' and teachers' feedback after the workshop, gained through surveys during the SDGs Week for evaluation purpose

Since the educational purpose of the workshop, the post-activity survey investigates also how much the students feel familiar with some key concepts: sustainability, complex systems, and System Thinking. 90% of the students know about sustainability (that is integrated into school programs), while 56% has already heard about complex systems, which is a new topic for the 43% of the students. Finally, the System Thinking approach is unknown for most of them, only 31% answered positively on this item.

Concerning the evaluation, we asked students and teachers to use four adjectives to describe the activity and to evaluate the duration:

A) Five-point Linkert scale (not at all – a lot) for the following items:

Funny; Engaging; Boring; Educational

B) Duration of the activity (one choice only): Too short; Appropriate; Too long

As shown in Fig. 4-A, the workshop resulted quite funny, definitely engaging and not boring, with a marked difference in the perception between students (who experienced the activity and are less enthusiastic) and teachers (who only observed their students, giving an overstated feedback). Surprisingly, students and teachers agree on the educational value of the activity, marked as high. They also agree on the appropriate duration of the workshop (Fig. 4-B).

Finally, we asked teachers about their satisfaction (95% agree) and whether the activity supply sparks for further work at school (100% agree), this latter point is extremely relevant, because the activity is expected to bring new interest in some participants that will learn more about the topics in a traditional context [23].

4. Conclusions

The activity represents a concrete example of the commitment of MUSE-Science Museum in developing actions toward the implementation of the SDGs, with particular reference to SDG4 Quality education, but also in a more integrated framework enhancing the meaning of the whole UN 2030 Agenda, boosting a new mindset for youth and provoking action for a better future. The workshop is the first educational activity in our museum to teach the SDGs developed for youth and has been run in the first edition of the SDGs Week in Trento, and in the Genoa Science Festival.

Audience engagement with the SDGs and learning outcomes result positive, particularly in combining with the System Thinking to get evidence for the interdependency of the goals. Among the several scenarios emerged during the activity, participants linked SDG4 (Quality education) with SDG1 (No poverty), SDG3 (Good health and well-being), SDG8 (Decent work and economic growth), SDG9 (Industry, innovation and infrastructure), and SDG10 (Reduce inequalities) – thus they identify SDG4 as a key goal with multiple positive interactions. Less predictable are some connections between war (SDG16) and pollution (SDG13), via weapon industry; or bees increase (SDG15) thanks to bike mobility (SDG11), because of extended cycle-lanes and green areas in the cities. These examples offer a glimpse of the outcome the participants gained: the interlinkages within the SDGs, that represent the educational core of the activity, is not explained as in a lecture but spontaneously emerges during the teamwork, discussing in small groups the personal experience in a new perspective, using the tools of System Thinking to discover unexpected connections. It is only in the end that the facilitator discloses how the maps of each group design a unique net among the different SDGs so that everyone can catch the meaning of sustainability. In fact, a renewed idea of sustainability arises from the UN 2030 Agenda, environmental issues are intertwined with social challenges and economical drivers, within a frame of institutional powers. The education for sustainable development should go beyond the usual environmental education, thus keeping the focus on the systemic vision of the world: SDGs' integration constitutes an efficient tool to foster this idea, particularly at school, where different disciplines are far from a comprehensive and transdisciplinary vision.

Participants' feedback on the learning outcome of the activity is clear, either from the sticky notes collected from the Genoa Science Festival and the specific question in the survey during the SDGs Week, where both students and teachers firmly recognize the educational value of the activity. The experience allowed exploring a bit of how participants approach the future and comparing their attitude before and after partaking in the workshop, it results that the activity reaches the aim of provoking students on a major awareness and responsibility, possibly linked with taking action. "Think global, act local" was written on a sticky note collected at the Genoa Science Festival, it seems that participants understood the global implication of the ambitious program by the UN Agenda, but also the role everyone has, committing themselves toward a sustainable future. Moreover, as stated by Salazar [24], the future is not a stable object, there are multiple futures and to become real they require to be acted upon [19]. The emotional aspect is crucial too, our findings are in agreement with Myers et al. [25] considering emotions associated with a frame: frustration should be avoided when discussing sustainable development while the proposed frame, which links overwhelming problems of the 2030 Agenda to everyday life and concerns results more engaging in a cognitive, affective and behavioral dimension [26].

Concerning the activity design, it appears that participants had fun, learned and displayed desire of being involved – from the need of information to action-taking; this emerges both from the specific questions in the questionnaire and from the reflection wall. The workshop has an informal and engaging style, useful to deal with hard topics positively and playfully. The results support an overall positive impact of the workshop but also highlight advice for further adjustment, namely the need to pair the activity with a social media campaign (e.g. most of the sticky notes had #hashtag and @mentions). This was an unintended outcome not considered while planning the activity, but the idea of people being connected through social networks fits with the main concept of the activity and represents a good direction for improvements.

The role of facilitators is determinant because the workshop is intended on the concept of "communication *about* sustainability" according to Newig et al. [27], which refers to a horizontal communication flow, from many providers to many receivers. This represents the main challenge. The facilitators are decisive to inspire and keep a comfortable setting for open discussion, especially when dealing with elements from the private sphere without making someone feel guilty. Their fault is clearly the main weakness. They should be inspirers, neutral observers of the discussion and not leaders pointing to a determined direction; they should also be able to listen to any detail and making the connections visible and strong.

If the activity succeeds in stimulating the audience, then such an informal education format can provoke change in the youth: attitude, thought, and maybe action. Even if it is hard to measure the true impact, and it was far from the purpose of the evaluation carried out in this case study, the overall positive and enthusiastic feedback, with the awareness concerning the global challenge of the sustainable development, the need for urgent action (2030 is not far away), and the complexity of our world. For these reasons, new projects on SDGs education are welcomed. After this experience, we found that the topic meets the public interest and the global visibility of the UN 2030 Agenda makes teachers and students curious and sensitive. The high number of participants who register for partaking the activity in the SDGs Week and curious attracted by the workshop in the Genoa Science Festival (this was the only one highlighting the SDGs), indicate such a trend. The workshop can be adopted in schools and analog contexts. For example, it will be part of the museum's school programs for the school year 2019/2020 and has been proposed in the program of the Sustainability Fest, which took place on April 2019 at the Free University of Bozen (IT) – university students main target audience.

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Science Teachers' Questioning Themselves

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Abstract. There are questions that arise in scientific meetings and start very interesting discussions. Usually, different answers to the same question can appear, all of them are valid, Why? These answers depend on the teachers' personal circumstances who are defending them, their living and teaching experiences and their scientific background.

Two questions are shown in this article: Who was the first scientist? and is it necessary to apply the "Scientific Method" to become a science teacher? Answers are enlightening teachers' different points of view, from the first artisans to Archimedes to the first question and Yes or No to the second.

Keywords. First Scientist, Science Teachers, Scientific Discussion and Scientific Method.

1. Introduction

Many scientific questions arise in scientific meetings, they are interesting and also stimulate exciting discussions. Some different answers to the same question can appear but all of them could be valid according our approaching to them.

These different answers depend on the personal circumstances of who are defending them, their living and teaching experiences, their scientific background and the classroom level where he or she teaches science.

Two questions are shown in this article: Who was the first scientist? and Should the scientific method necessary perform to become a science teacher? Both questions are connected.

Questions started last year, the International Year of Periodic Table (IYPT) [1] in a conference on the Periodic Table of elements held at the Official College of Chemists of Catalonia (COQC) [2] in the presence of chemistry and science teachers at high school and university.

Once the conference was over, some questions were proposed, nothing relevant for this work. However, at the end someone asked "Who discovered the first chemical elements, such as gold, silver, copper, tin, lead, iron, and mercury, the metals of antiquity." The speaker answered without problems but, immediately, a new question was asked "were they the first scientists?" and a real and deep discussion began about the first artisans, Pythagoras, Chinese science and the scientific method.

After a brilliant discussion there were three well-differentiated positions about who was the first scientist: a) the first artisans, b) a Mesopotamian women and c) Archimedes.

On the other hand, in the seventh Conference on the teaching of chemistry in Catalonia 7esJEQC in 2018 [3], with the participation and contribution of chemistry and science teachers from all educational levels, a special session was focused on analyzing the relationship between the scientific method and the science teaching. It was raising the question "Should teachers always apply the scientific method? You can imagine the answers, only two, yes or no. The answers are enlightening the different teachers' points of view.

In front of these differences, it is important to remember the phrase attributed to Einstein “An idea can be a great scientific and technological advance and the opposite idea too”. We could apply this premise in those discussions.

Our work will introduce and discuss two special questions with many acceptable answers. This is an important reality for science teachers to make an approach to science discussion between themselves and, probably, they can describe it in their science classroom.

2. The first scientist

First of all, what is science? Science is all about facts and discoveries, with some of the remarkable breakthroughs which are in fact coming from everyday occurrences and experiences.

The origin of science is linked to the getting and utilize of large amount of materials such as stones, bones, wood, fire, metals and services linked to the development of the first cities and the agriculture.

Measurements, quantities, and weight were appeared in these processes and they originated the "first sciences", mathematics, arithmetic, geometry and astronomy, which were born even before writing appears, 2700 years before our era [4].

2.1. The artisans

When mankind discovered fire started to cook meat. Then these ancient men and women realized that the clay surrounding the bonfire was hardened by the heat, and increased their resistance to water. Later on, they became aware that they could managed to produce their first water and liquids containers, all of them made by clay, the pottery.

Priests and artisans together tried to understand the nature, ones by submission to fear and the gods, while the artisans worked their method trial - error.

The first artisans, related to "soft" science worked with their hands, they were goldsmiths, builders, blacksmiths, and a further significant range of other workers. In Fig. 1 you can observe a representation.

The Bronze Age is the ancient civilization defined by its bronze production, either by smelting its own copper alloyed with tin and other metals, or by trading for bronze from production areas elsewhere. Bronze itself is harder and more durable than other metals available at that time, allowing Bronze Age civilizations to augment their technological advantage.

Tin's low melting point of 231.9 °C and copper's relatively moderate melting point of 1,085 °C placed them within the capabilities of the Neolithic pottery kilns, which date back to 6000 BC and were able to produce temperatures greater than 900 °C.

In spite of iron is very abundant on Earth, its high melting point of 1,538 °C placed it out of reach of common use until the end of the second millennium BC.

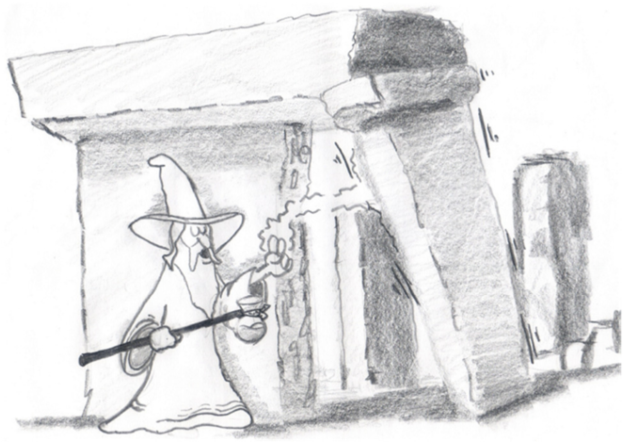

Figure 1. Represents a blacksmith under a "taula" meaning "table" in Catalan. They were built by the Talaiotic culture. Drawing by Josep Fernández, "Jepi"

The clay furnace allowed studying the nature of matter. With this kind of clay they started to produce a lot recipients where they kept different substances, between them food, and for this reason the ancient men and women discovered the fermentation.

Actually it is believed that in the year 4000 BC the first kiln was made in Egypt. A lot of Egyptian clay recipients are found in the excavations throughout Egypt by the pharaohs. A lot of these recipients have incrustation of metals and prove Egyptians were the leaders of this issue, this science. In addition, the mummification [5], the death body is preserved by dehydration and it is protected by chemicals against pests, such as insects, could be another fact that supported the idea that those artisans were the first chemists, the first scientists.

Some science historians consider chemistry as a science, which studies the properties and behavior of matter and its reactions, only since the time of Antoine-Laurent Lavoisier (1743 - 1794). However, other historians believe that those first artisans who more than 3,000 or 4,000 years ago worked with fire to obtain copper or make alloys such as bronze or brass, although they were not chemists, they accidentally made chemistry, made science. For some people who discussed about it, the first scientists were those artisans.

2.2. Astronomy

Astronomy is to knowing the position and motion of heavenly bodies: sun, moon, stars and planets. On the other hand, there are no predicted eclipse records before the first millennium BC, Fig. 2 shows an eclipse representation. Furthermore, did you know that astronomy is already appearing on Sumerian cuneiform tablets?

2.2.1. Mesopotamia

Sumerians were the first to leave a written record in cuneiform writing and today museums have a legion of clay-baked cuneiform tablets.

These baked tablets were marking the passage of daily life around the fertile plains between the Tigris and Euphrates Rivers, the Mesopotamian area.

Figure 2. A Sumerian representation of Solar eclipses [6] from the British Museum

In addition, some of them indicate the Sun and Moon positions at that time, and occasionally, planets and stars position in the Heavens are showed.

Babylonian first motivation for doing astronomical studies was to obtain a calendar, but quickly became a study for obtaining a religious step between the Earth and the Heavens. Sumerian astronomy was adopted by their northern neighbours, the Babylonians, around 2500 BC, and as a result it has come down to our day.

2.2.2. Enheduanna

The monarch of Sargonic period appointed his eldest daughter, Enheduanna [7-8], high priestess of the Moon goddess (Nanna), a position of considerable prestige. Definitely, the priests and priestesses accomplished a fundamental position in the Mesopotamian civilizations.

It is known that she was a learned, diversely talented woman of power. She employed her creative talents in the written word, her poetry was the first written form of a religious belief system. Fig. 3 shows a bas-relief with Enheduanna portait. She was the editor of the Sumerian Temple Hymns and experts on Sumerian culture have her poems.

Figure 3. Ancient bas-relief portrait depicting Enheduanna (third from right) Obtained under the Creative Commons Domain

Enheduanna managed the great temple of Ur, this was an important Sumerian city-state in ancient Mesopotamia. In addition, she controlled the extensive agricultural enterprise surrounding the temple as well those activities scheduled around the liturgical year. She also directed important activities such as trade, agriculture and handicrafts. It is because of this role that she can be regarded as an Astronomer, one of the activities falling under her authority.

Confusing astrology with astronomy is a generalized mistake. The astronomy has always to be the first and then the astrology was appeared, this is a pseudoscience that try to find divine information about human affairs and terrestrial events by studying the movements and relative positions of celestial objects (astronomy studies). In the time of the ascendance of Ur there were cuneiform tablets with astronomic data in use but not astrologic data.

She was using measurement to 'track the path of the Moon' and she was regulating agriculture on the basis of some logical hypothesis of her astronomical ability. For some people who argued about it, this amazing story located in Babylonia indicates the first scientist was Enheduanna.

2.3. Archimedes

The honour of First Scientist went to Archimedes [9], who after observing the increase in the depth of water in his bath yelled "Eureka! Eureka! (I have found it! I have found it!)," and ran naked through the streets to his workshop to test his hypothesis that the volume of water displaced and the apparent weight of the object suspended in water would distinguish a solid gold object from a less dense material. Fig. 4 shows an Archimedes' drawing.

Figure 4. Archimedes' drawing, it was drew by Josep Fernández, "Jepi"

It was time to check out the crown. To find out the crown's volume, Archimedes immersed the crown in a bucket filled with water to the brim, and measured the volume of the spilled water. Then he took a bar of pure gold of the same mass and compared the volume of spilled water to determine if crown is indeed made of pure gold. Surprise, surprise, the numbers were different! The crown displaced more water than the piece of gold. Therefore, the crown's density was less than pure gold. So, indeed the king had been cheated by the goldsmith.

Archimedes went on to make a number of important contributions in science as the Archimedes Principle and mathematics, he determined an accurate estimation of the value of Pi, among others.

An essential criterion for "scientist" could be to offering an explanation for observed phenomena, which goes beyond simply recording the observations. And Archimedes meets this criterion, for some people who discussed about it, he was the first scientist.

3. Should teachers always apply the scientific method?

What exactly the "scientific method" is? [10]. Scientific method refers to ways to investigate phenomena, get new knowledge, correct mistakes, and analysis theories. The process of the scientific method involves making hypothesis, deriving predictions from them as logical consequences, and then carrying out experiments or empirical observations based on those predictions.

When 7esJEQC participants were asked for their opinion about scientific method and teaching science, it can probably find two types of answers: Obviously yes, and obviously no, both answers are possible.

YES, there is no science teaching and learning it without scientific method

NO, teaching science is possible without scientific method.

The answer depends on the opinion of teachers, their imagination, predilection and possible application to students in their science classroom, teaching science to primary school children is not the same as going to college.

Nevertheless, the 'scientific method' could be something more/different than only a strict procedure [11]. Fig. 5 shows a scientific method scheme.

On the other hand, there is a first step in any scientific activity (teaching, learning and experimenting) which is "the observation". Both antagonist teacher's groups agree with this observation.

Some details from the two answers are presented about the same observation: people see that if the glass drops on the ground, it will be broken.

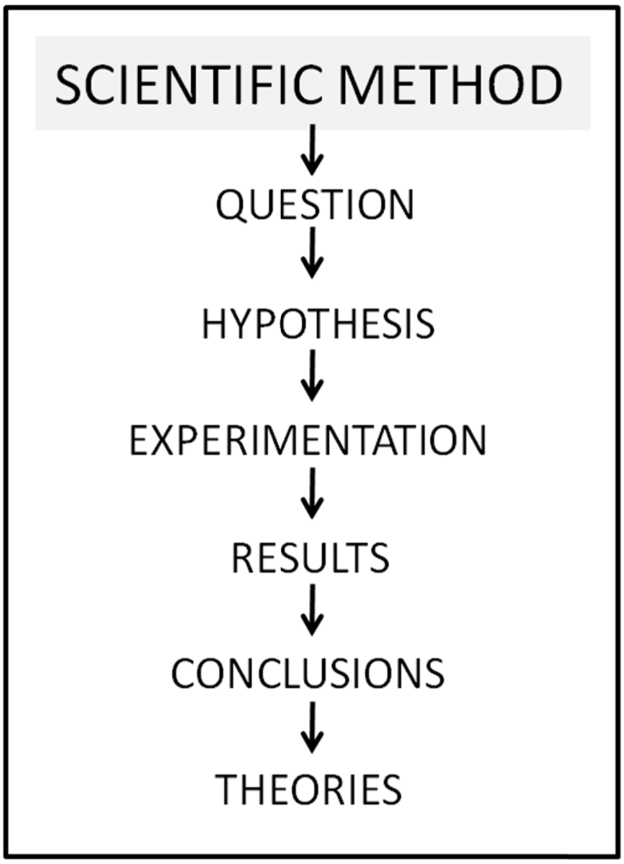

Figure 5. Scientific method scheme made by the authors

3.1. Yes

Teachers who deny in principle that any kind of science can be done and learn without the scientific method support.

STEAM (Science, Technology, Engineering, Art and Mathematics) are crucial keystones in today's society. For these teachers, it seems that the STEAM approach is apparently the most complicated thing to teaching and learning without the scientific method support.

Group "yes" teachers explanation requires that we have previous scientific knowledge. For example in the previous question, glass is broken because the structure of glass is formed by strong silicate bonds, but it has an amorphous structure that allows to break it, and instead the plastic glasses are made of polymers, very long molecules and tangled together that give them a less fragile but softer structures.

The science of everyday phenomena is not as easy as it sounds, science teachers need the scientific method to explain them.

3.2. No

The contents of the nature are: elephant, frog, sea, milk, granite, river, detergents, nutrition, planets, Mars, and more and more. It can summarize in objects, species, systems, substances, products and... Here it is there is all chemistry, biology, geology, physics, maths and...

After this introduction, teachers from the group "no" want to remember that young children ask for all explanations from the world around them in a mixture of indiscriminate curiosity and their why? why? why? which never end.

Children see that if the glass drops on the ground, it will be broken. At this moment, teachers can explain the foundation of formal logic, "push a glass (cause)" generates "glass is broken (effect)". They are not teaching science, the final science, but they will be laying the essential base to learn it. The same situation occurs when teachers make "Wow experiments" [12] is science classroom, without the scientific method support.

Finally, the answer to basic questions, as always, will depend on who is asking it and where it is done. The elephant has fangs, ears, legs. But it also has liver, stomach, veins and arteries. And each organ is formed by cells.

Mayonnaise is made by oil, egg yolk, salt. And, in turn, the egg yolk is made by fat, of water, of proteins. And fat is made by molecules that are made by atoms such as hydrogen, oxygen, carbon,... Let's stop! This does not belong to this study, thanks.

4. Conclusions

The authors have expressly refused to take part in the discussions because they agree with the initial statements, all the answers may be valid depending on the context. Say yes or no is irrelevant.

Primary school science teachers must teach science to children while science taught in college will have a different approach. Both descriptions are correct.

Science teachers must keep in mind that different answers about one science question or problem could be valid and they have to explain it to their students and discuss it into classroom.

5. Acknowledgements

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Building a Visually Rich Learning Environment to Bridge the Communication Divide in Deaf Education

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Abstract. Visually rich learning environment could potentially serve as an effective approach to organizing education for deaf students, because persons who are deaf are primarily visual learners. By the end of 2016, over 700 deaf students study at 72 universities and 41 vocational schools in Ukraine, but only 62 of 113 provided the assistance of a sign language translator, which is a traditional method of supporting the education of deaf students. Instruments of information technology are being increasingly used to support communication with deaf students, both in the classroom and during extracurricular events. Examples include numerous voice typing applications and adding subtitles to educational videos.

Keywords. Deaf Education, Communication Divide, Voice Typing, Speech Recognition, Video Materials, Subtitle, Accuracy, Error Correction.

1. Introduction

The implementation of new effective tools and strategies in deaf education is a vital issue in Ukraine where the population with hearing impairment reaches 42 thousand. They can receive secondary and vocational education at many special schools in all regions of Ukraine. A few institutions of higher education have introduced associate or higher degree programs for deaf students, though these students were enrolled in special groups and did not have any instructional activities together with other students.

According to the data provided by Dr. Natalia Adamyuk (Institute of Special Education, Kyiv) [1], Kyiv Vocational School of Light Industry and Kherson Medical School pioneered the vocational education for the deaf in 1958 and 1978 correspondingly. Initially, higher education has become available at 8 universities where special groups were established. At present, increasingly high school graduates are electing whenever possible to go to institutions of higher or vocational education on general terms within the framework of inclusive educational model. The number of universities and vocational schools where deaf students can study individually or in small groups and get associate, bachelor or higher degrees is constantly growing. By the end of 2016, over 700 deaf students study at 72 universities and 41 vocational schools. This will be the appropriate place to mention that only 62 of them offer the assistance of sign language interpreters to deaf students. In addition, the staffing of special high schools does not include the position of a sign language interpreter, and very few teachers, 17 in 11 schools, have sign language interpreter certificates.

The Law on Inclusive Education in Ukraine which was carried out into effect on October 13, 2018, determines the educational terms and conditions for students with special needs and expands educational opportunities for deaf students. But nevertheless a communication divide between them and their classmates and teachers remains. Besides, deaf students are rarely involved in extracurricular activities along with fellow students, such as, for instance, science clubs and conferences, summer camps and the like. It is an additional challenge which deaf students have in or outside the classroom, and they would get through it if they are provided with assistive tools to facilitate efficient communication.

No universal method of deaf education exists. Most students who are deaf are primarily visual learners. That is why communication and instruction with this student population can be enhanced through building a visually rich learning environment using information technology tools and hands-on teaching methods.

2. Information technology tools

Instruments of information technology are being increasingly used to support communication with deaf students, both in the classroom and during extracurricular events. Examples include numerous voice typing

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applications and adding subtitles to educational videos.

2.1. Voice typing applications

From a user perspective, speech recognition accuracy is one of the most important features of a voice input tool. The accuracy of speech visualization was explored using a fragment of educational material on laboratory diagnostics with a size of 592 symbols. For comparison, the two types of applications of different technology implementation were selected: 1 - Speech Texter, Voice Dictation and the voice input function from the iPhone keyboard (iOS), which can be used without the Internet access; 2- Google Translate web-based service, available via the Internet.

Speech recognition accuracy was assessed by calculating a metric, which can be called *User Error Correction Factor* E:

$$E = (S + I + D) / N,$$

where S, I, D - numbers of substitutions, insertions, deletions, respectively, required to correct speech recognition errors; N - the number of characters in the text. This metric is similar to UCER [2], but it is based on the analysis of wrong recognition of characters, not words, that may be important to a user when choosing a tool.

Figures 1 - 4 show examples of voice typing with different software tools, with fragments of wrong recognition being marked.

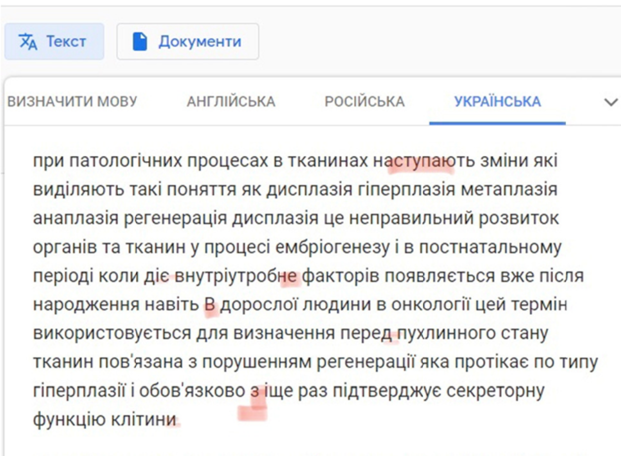

Figure 1. The result of voice typing using Google Translate with false recognition parts being marked

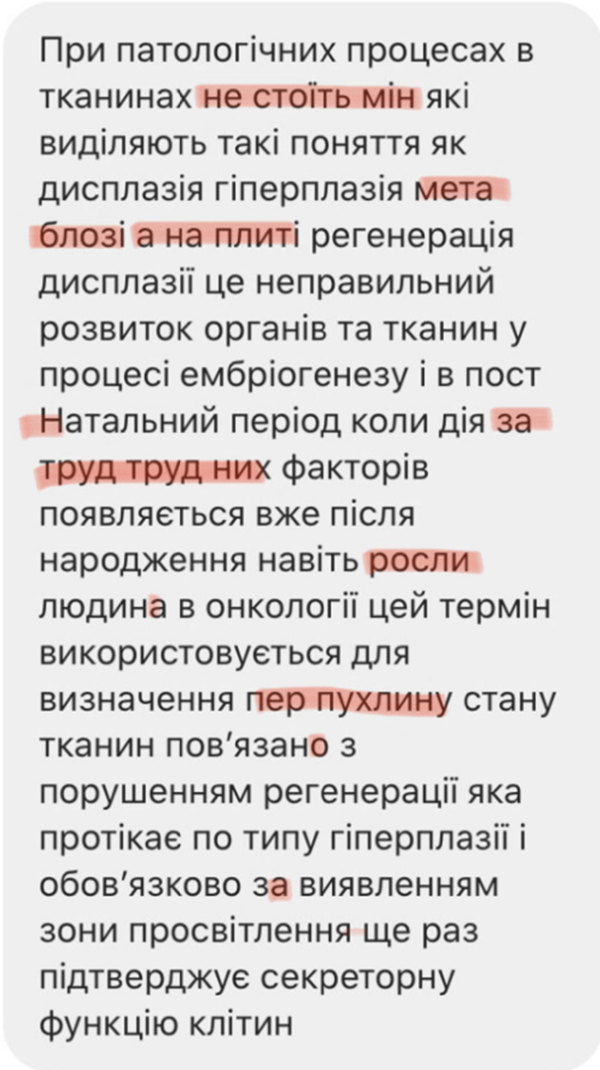

Figure 2. The result of voice typing using the voice input function from the iPhone keyboard (iOS) with false recognition parts being marked

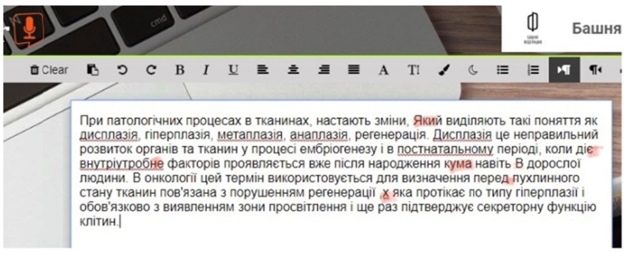

Figure 3. The result of voice typing using Speech Texter with false recognition parts being marked

Table 1 contains average numbers of substitutions, insertions and deletions made to correct the test text, and the values of metric E (%). Fig. 5 shows the total of substitutions, insertions, and deletions made to correct the test text.

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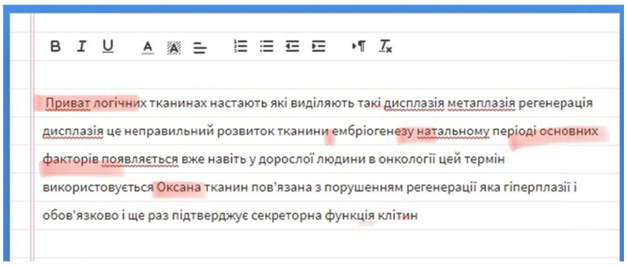

Figure 4. The result of voice typing using Voice Dictation with false recognition parts being marked

Table 1. Average number of substitutions S, insertions I and deletions D made to correct the test text, and *User Error Correction Factor* E

Application	S	I	D	E %
Google Translate	6	1	3	1.68
IPhone (iOS)	55	3	1	9.97
Speech Texter	7	1	6	2.36
Voice Dictation	5	113	11	21.80

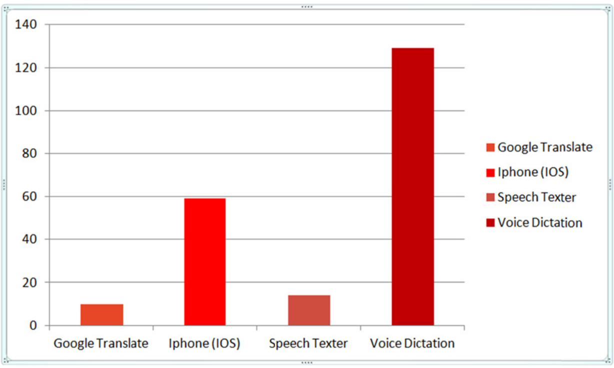

Figure 5. Sum of average amounts of substitutions, insertions, and deletions made to correct the test text dictated by experiment participants

The above data does not take into account punctuation marks that can be inserted using voice commands, because when communicating punctuation marks can be ignored.

2.2. Adding subtitles to educational videos

The advantages of subtitles include:

- Accessibility of material for deaf or hearing-impaired persons,
- Better understanding for people with attention deficit,
- Video can be viewed in the mute mode in offices, transport and libraries, etc.,
- Better user interaction ensure improved viewing results,
- Better understanding when strong accent, loud background noise,
- Easier to translate into other languages,
- Improved literacy.

Creating subtitles is shown on an example of the "Maggot Therapy" video, in which the demonstration is accompanied by comments in English.

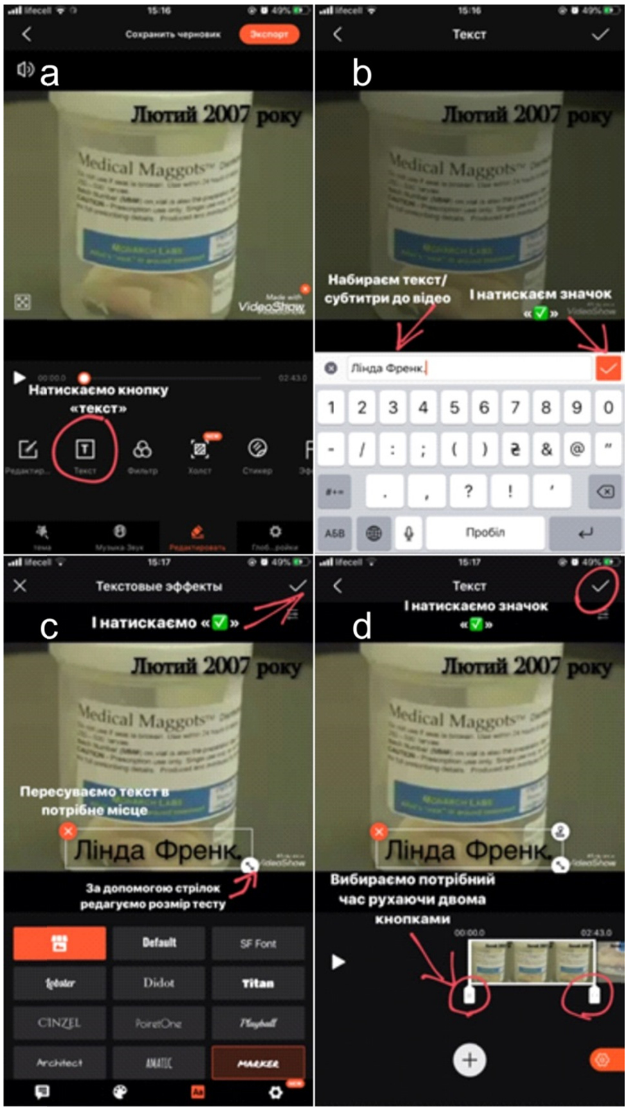

Figure 6. VideoShow video editing application, several steps

In this case, the first step in the subtitle development is translating into Ukrainian. An effort to use the feature of automatic translation prior to adding subtitles on the YouTube platform was not successful, although the text of subtitles is formed correctly in the original language. Therefore, the translation into Ukrainian and timing of the text were done "manually".

VideoShow video editing application was used to create subtitles. The procedure consists of 15 steps:

1-Open the application,

2- Select "Video Editing",

3- Select video file,

4- Select "Text (or Subtitle)" mode (Fig. 6a),

5- Start adding subtitle by pressing (+),

6- Type text (Fig. 6b),

7- Add text effects,

8- Choose text color,

9- Select "Font" mode,

10- Choose font,

11- Put text on a desired location (Fig. 6c),

12- Define a time of subtitle display (Fig. 6d),

Next, steps 4-12 need to be repeated to form all the subtitles of the video, taking into account the subtitle timing, i.e. moments of the start and duration of playback on the screen.

When adding subtitles have been finished, the final stage of saving the result can be done:

13- Export of the video file,

14- Save video.

15- Progress of export (Fig. 7).

When the export is completed, the video along with the subtitles will be saved in the gallery of a mobile device.

3. Conclusions

The convenience of voice input tools is not limited to visual representation of speech. They reduce the fatigue that is inevitable when working with the keyboard for a long time, and reduce the time to type long texts. They can also be used by teachers to contact with deaf students during classes, especially for individual explanations and in extracurricular activities. The results show that up to 80% of the text is displayed correctly. The lowest input error rate is provided by Google Translate service (1.68%) and Speech Texter application (2.36%). However, while choosing a tool the availability of Internet access should be taken into account. In general, voice input is a useful supplement to the assistance of a sign language interpreter which is the traditional form of learning support for deaf students.

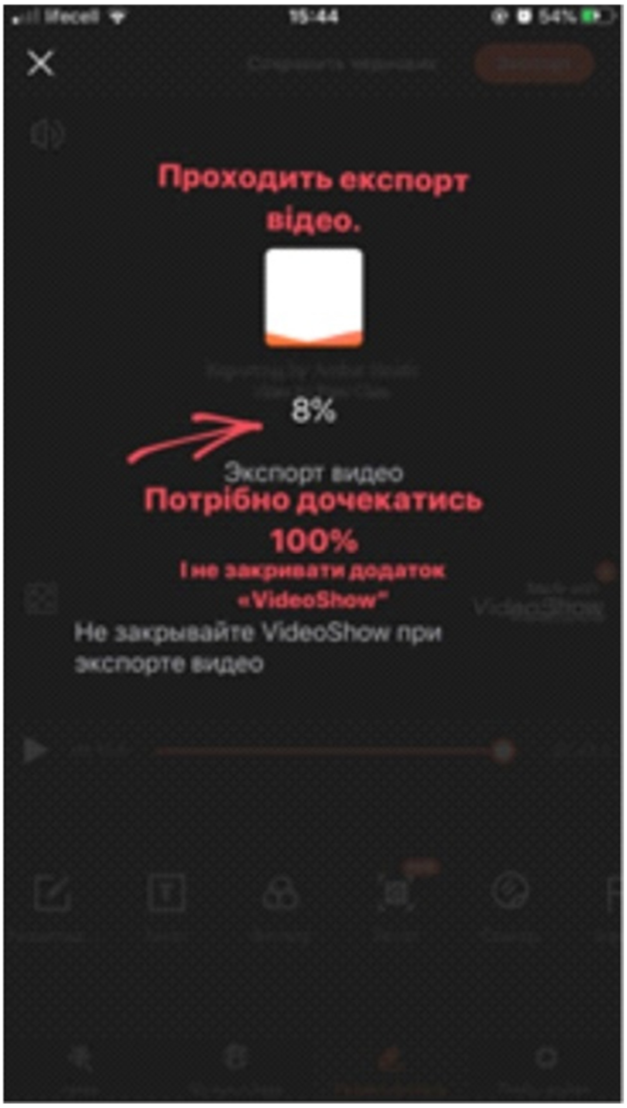

Figure 7. Progress of export

It should also be pointed out that that the use of subtitles is reasonable not only while working with deaf students, as they provide a number of additional benefits: for example, improving language skills in learning new languages; clear understanding of any technical terminology, full names and titles; maintaining concentration for a longer time; reducing the likelihood of fatigue. Creating subtitles with VideoShow may seem like a time-consuming process compared to YouTube automatic mode, but VideoShow allows editing the content of subtitles, that is often necessary when developing educational videos.

Thus, information technology tools in combination with traditional methods of organizing the educational process ensure a more complete implementation of the inclusive education model for deaf students.

7. Acknowledgements

Yana Prysyazhna and Anastasia Vlasenko, 3rd year students, are grateful for conducting the experiment with voice typing applications and documenting the development of subtitles.

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Creating of STEM – Equipment: MagLev Train

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Abstract. Ukraine is rapidly developing in the direction of technical innovation, which is what encourages the growing need for a large number of highly qualified specialists in the field of innovation, which will be the key to successful economic development and competitiveness of our country in the near future. A rapidly developing area of education is the STEM learning system, through which children develop logical thinking and technical skills, learn to solve problems, become innovators, inventors.

The main task and current stage of sustainable development of STEM - education in Ukraine is the development of key devices for demonstration, promotion and study of basic physical laws at the modern technical and research level. One of the most important areas of physics, magnetism, is quite difficult to understand and requires visual demonstrations.

The article proposes a technical implementation of a train on a magnetic suspension for a simple demonstration of magnetic forces.

The developed model of the MagLev train is a fairly simple demonstration that students will be able to work with on their own, which allows them to easily explain and demonstrate the basic laws of magnetism and technical aspects.

Keywords. Magnetism, Physics, Innovative Development of Education, Magnetic Forces Innovators, Inventors, STEM – Education MagLev Train.

1. History of Maglev

The fundamental ideas underlying MagLev technology can be traced back to the early 20th century. It took a lot of work to lay the foundation for these trains, including the development of electric motors and research in the field of magnetism. Several scientists, namely Robert Goddard and Emile Bachelet, even dared to offer a vehicle that will float on magnets [1]. In 1934, German Hermann Kemper received a patent for the first concept of a magnetic, levitating train [1]. Only in the 1960s did this idea really begin to emerge. At this time, Germany and Japan began to explore the potential of MagLev. In the 70s and 80s, both countries made great strides in the development of these trains. Germany built and tested a number of prototypes of MagLev systems and named the TransRapid project (Fig. 1a). Trains reached speeds of more than 250 mph (402 km/h) on the test track [2]. Japan also tested two series of its own developments, called the ML-500, and then the MLU. Their trains were capable of reaching 300 mph (483 km/h) [2].

a)

b)

Figure 1. MagLev train on testing center in Germany near Bremen (a) and Shanghai Maglev leaving the Pudong International Airport with the Shanghai Transit Map (b)

Japan continued to develop its MagLev technology in the 90s and beyond. They tested a new series called MLX, which accelerated to 350 mph (563 km/h) in 2003 [1]. To date, no commercial lines have been established in the country, but they are still conducting research.

In Germany, the TransRapid commercial line connecting Berlin and Hamburg was laid in 1992, but in 2000 the government closed the project [2]. However, not everything was lost, as the Chinese paid attention to this and instructed the Germans to build the TransRapid train in Shanghai.

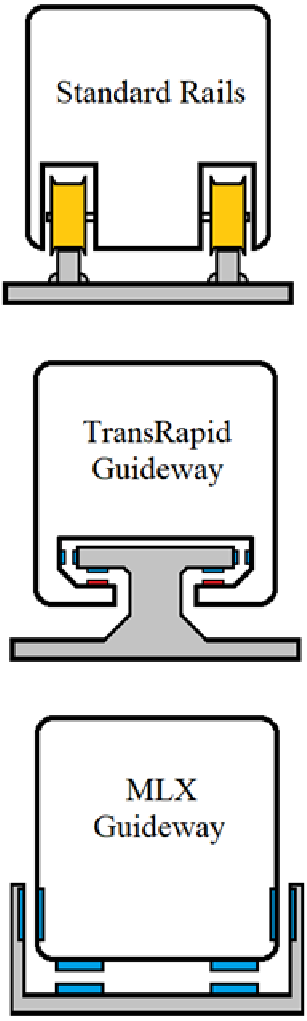


Figure 2. Comparison of Wheel-Rail versus Guideways

The Shanghai MagLev (Fig. 1b) resulting from this project is currently the only MagLev-style high-speed train in commercial use. It carries passengers to a distance of 19 miles (30 km) in 8 minutes, developing a top speed of more than 250 miles per hour (431 km/h) [3]. Thus, China quickly became the only player in the global MagLev market.

2. How Does it Work?

Maglev trains have no wheels or rails. As shown in Figure 2, they have guides, and they float along these guides without even touching them. There are three important and necessary forces for achieving MagLev functionality: levitation, movement, and direction (Fig. 3).

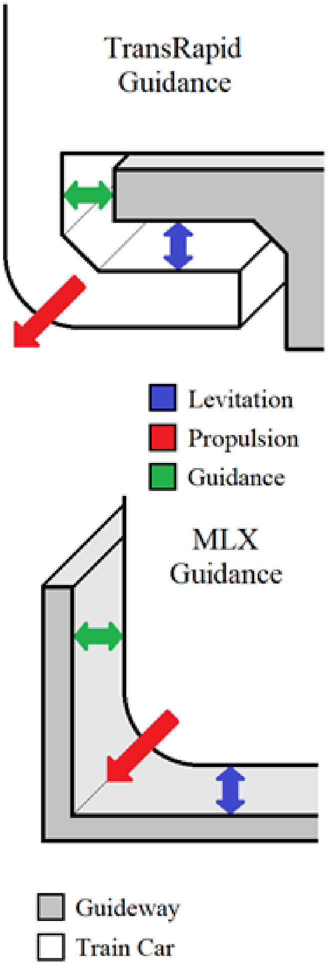


Figure 3. Levitation, propulsion, and guidance in MagLev

2.1. Levitation

Levitation is the ability of a train to stay suspended over a rail. There are two important types of levitation technology.

Electromagnetic Suspension (EMS) uses the attractive force of electromagnets located on the rail and in the train to achieve levitation (Fig. 4a). The advantages of this method are that it is easier to implement than electrodynamic suspension, and that it supports levitation at zero speed. The disadvantages are that the system is inherently unstable. At high speeds, it becomes difficult to maintain the correct distance between the train and the guide. If this distance cannot be maintained, the train will not be able to levitate and stop. To take this into account, EMS requires sophisticated feedback control systems to ensure that the train is always stable.

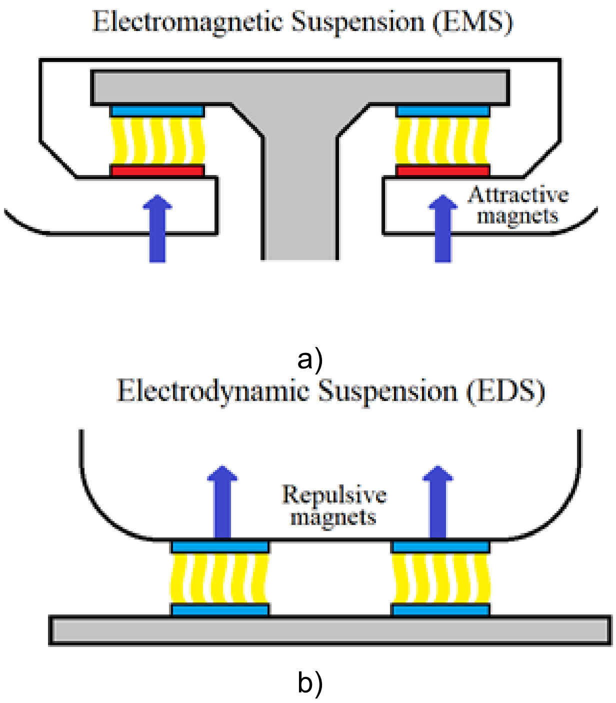


Figure 4. Electromagnetic suspension (uses attractive magnetic forces) (a) and electrodynamic suspension (uses repulsive magnetic forces) (b)

Electrodynamic Suspension (EDS) uses the repulsive force of the (superconducting) magnets located on the rail and on the train to achieve levitation (Fig. 4b). The magnets move past each other while the train is moving and generate a repulsive force. The advantages of this method are that it is incredibly stable at high speeds. Maintaining the correct distance between the train and the guide is not a problem. The disadvantages are that it is necessary to gain enough speed so that the train can even levitate. In addition, this system is much more complicated and more expensive to implement.

2.2. Propulsion

Propulsion is the force that propels the train forward. MagLev uses an electric linear motor for traction. A conventional electric rotary motor uses magnetism to create torque and axis rotation. It has a fixed element - a stator, which surrounds a rotating element - a rotor. A stator is used to generate a rotating magnetic field. This field causes a rotational force on the rotor, which makes it rotate. A linear motor is simply an expanded version of a conventional motor (Fig. 5). The stator lies in the plane, and the rotor lies above it. Instead of a rotating magnetic field, the stator generates a field that moves along its length. Similarly, instead of a rotational force, the rotor experiences a linear force that pulls it along the stator. Thus, the electric linear motor directly produces movement in a straight line. However, this motor can only exert force when the rotor is above the stator. As soon as the rotor reaches the end, it stops.

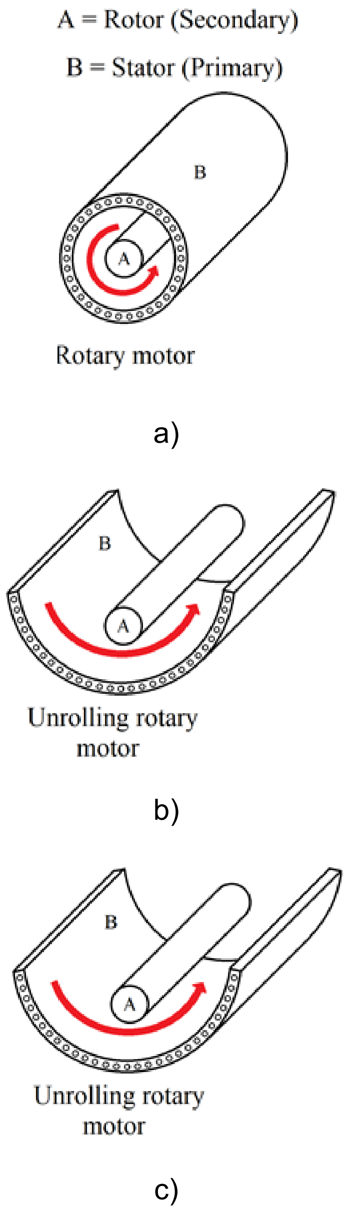


Figure 5. Rotary motor versus linear motor

When describing a linear motor, the standard is to use the term "primary" instead of "stator" and "secondary" instead of "rotor". On MagLev trains, secondary is attached to the bottom of the wagons, while primary is in the rail. Thus, the magnetic field is directed along the guide, and it pulls the train. The entire MagLev track can be considered part of the train engine. The system that has been described to date is the Linear Induction Motor (LIM). It is called that because the magnetic field in primary induces a magnetic field in secondary. It is the interaction between the initial field and the induced field that creates traction.

However, in this configuration, the secondary device is always slightly behind the moving field in the primary. This lag is a source of energy and speed loss. In Linear Synchronous Motor (LSM), lag is eliminated by attaching permanent magnets to the secondary device. Since the secondary device now creates its own stationary magnetic field, it moves along the primary element synchronously with the moving field - hence the name of this version of the engine [4]. Because LSMs are faster and more efficient, they are the preferred engine on MagLev high-speed trains [5].

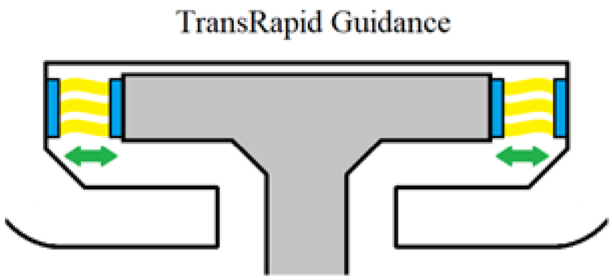
2.3. Guidance

Guidance is what keeps the train in the center of the rail. For high-speed MagLev, repulsive magnetic forces are used for this (Fig. 6). In TransRapid, on a train located on either side of the rail, two electromagnetic rails are installed.

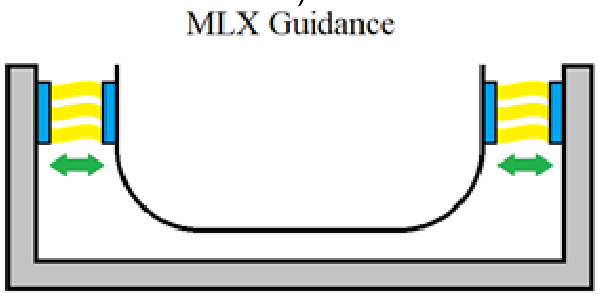
In MLX guidance, it is associated with a levitation system. Levitation rails on both sides of the train are connected to each other. Thanks to this connection, when the train moves closer to one side, a force arises that pushes it back to the center. Thus, MLX simultaneously levitates and guides [5].

2.4. Benefits of Maglev

The most obvious appeal of MagLev trains is that they can travel faster than traditional rail trains. The only commercial MagLev expressway, Shanghai MagLev, is currently the fastest train available. It travels at 50 mph (80 km/h) faster than the fastest high-speed Rail Train. And this is only the main advantage. The lack of friction between the train and the rail eliminates many of the limitations that traditional trains have. It follows that in the future MagLev will only be faster.



a)



b)

Figure 6. Guidance system of TransRapid and MLX (both use repulsive magnets)

3. How to do it?

No matter how complicated the design of modern MagLev Trains is, their work is based on the basic laws of physics, in particular magnetism. And an understanding of these fundamentals is necessary for the future engineer from his school years. Within the framework of a number of STEM-events held at the National Technical University “Kharkiv Polytechnic Institute” (Kharkiv, Ukraine) [6- 8], one of the projects was the development of such a MagLev train.

Based on several introductory classes, an independent analysis by the project participants of the available information and the principles of maximum simplification of the design, we came to the following design (Fig. 7), which we propose to use in the future.

Regarding the three necessary forces discussed earlier and necessary for the functioning of MagLev, they are implemented as follows.

Levitation in our project is provided by permanent magnets, which makes MagLev non-volatile. Primary magnets are located along the entire line, thereby providing the necessary repulsive force throughout the route. Secondary magnets are located directly on the moving part - the train.

Guidance is provided according to a simplified scheme through the use of vertical guide axes moving along a horizontal groove along the entire route. The main objective of the implementation is to reduce the coefficient of friction of the guide, which is ensured either by using a material with a low coefficient of friction, or by using rolling elements.

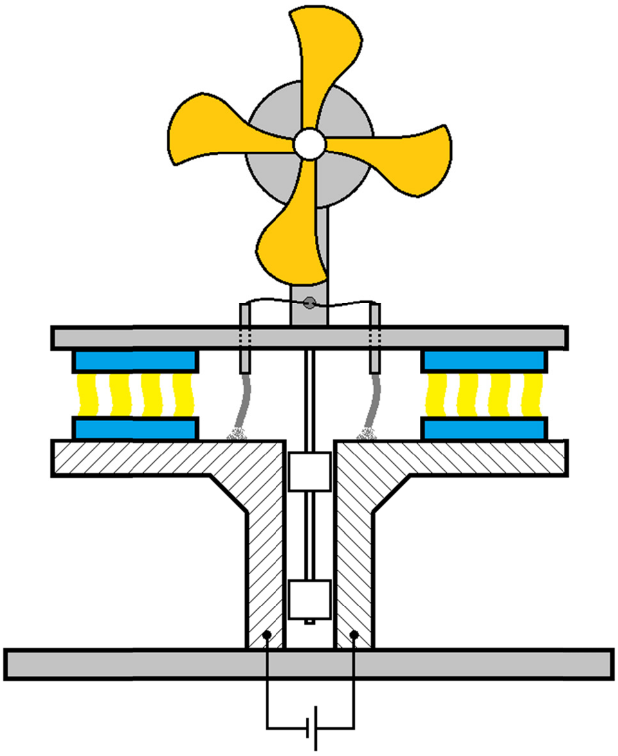


Figure 7. Our simple MagLev system

The train comes into motion due to the rotation of the propeller on the moving part. However, the use of classic AA batteries on the moving part was unacceptable based on their mass, which exceeded the permissible load. It was decided to power the propeller through the feed rails. The basis of the route design was made on the basis of aluminum corners, which were both a strong structural material and electrical conductive sliding contacts. A voltage was applied to the corners from the battery, which was removed by the sliding contacts of the train (Fig. 7) along the entire route.

Using the proposed solutions, a working MagLev train layout was created, examples of which are shown in Figure 8.

Figure 8. Example of simple MagLev train for school

4. Conclusions

Thus, the work offers an easy-to-understand, mastery and implementation example of a MagLev train, which makes it quite simple to explain and demonstrate the basic laws of magnetism, the transfer of electrical energy and the interaction of various forces.

A fairly simple design allows you to implement this project in a short time with a minimum of material and equipment costs.

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Light Activated Surface Cleaning

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Abstract. The growing concern about environmental pollution and its side effects on human health has attracted the attention of the scientific and industrial communities. The development of functional tissues capable of reducing or eliminating organic compounds and/or pathogenic microorganisms can be a step forward in improving human and environmental well-being. This class of materials includes anti-odor, self-cleaning, UV protection, hydrophobicity and antibacterial fabrics.

The project consists in impregnating cotton and polyester with titanium dioxide (TiO2) and their use as functional fabrics for the degradation and model pollutants (dyes, caffeine). The characterization of the functional fabrics is followed by electron microscopy, contact angle determination and solid UV-vis spectroscopy. The efficiency of the materials is assessed by UV-vis spectroscopy.

Keywords. PBL, Surface Cleaning, Functional Fabrics, Photocatalysis.

1. Introduction

The development of functional tissues capable of reducing or eliminating organic compounds and / or pathogenic microorganisms is an enormous progress for human and environmental well-being. This class of materials includes fabrics with anti-odor, self-cleaning, UV protection, hydrophobicity and antibacterial characteristics [1]. Self-cleaning of light-activated surfaces is widely used in the textile industry [2]. The self-cleaning behavior refers to the ability of a solid surface to remove its contaminations under natural conditions, presenting two fundamental properties of hydrophilicity and photocatalytic activity [3]. Thus, photocatalysis is applied to favor the degradation of contaminating compounds on surfaces of different materials. This mechanism is due to the activation of a catalyst of the optical semiconductor type, by the action of light. Titanium dioxide (TiO_2) is the most used semiconductor in photocatalysis studies, due to the good knowledge of its physical and chemical characteristics, being, therefore, selected for the work developed. TiO_2 has high chemical stability in aqueous solution over the entire range of pH values, photostability, low cost and non-toxicity [4]. The use of TiO_2 coatings in the functionalization of surfaces is very promising, since they have high resistance to organic contaminants and their hydrophobic feature is quickly recovered after their surface has been contaminated, which gives them excellent self-cleaning capabilities. In addition, TiO_2, when exposed to UV radiation, changes from hydrophobic to hydrophilic.

The Figure 1 shows the TiO_2 photoexcitation mechanism. Semiconductor materials have a valence band (VB - valence band) completely filled with electrodes and an empty conduction band (CB - conduction band). A selection between these two energy bands called an optical gap (band gap).

In the presence of light (excitation source) with energy higher than the hiatus energy of the material, an electron (e − CB) is excited, passing from the valence band to the conduction band, generating a positive electron hole (h + VB) in the valence band (Fig. 1). The photoexcited electron can recombine with the electron hole and reduce the efficiency of the process. Charge carriers, which do not undergo recombination, migrate to the surface, where photoexcited electrons can reduce atmospheric oxygen and form radicals. The hole in the valence band can also oxidize the adsorbed surface, generating water or HO- and produces OH. These reactive oxygen species are responsible for converting organic pollutants into CO_2 and water, resulting in surface cleaning. A major limitation in the development of self-cleaning materials using TiO_2 is its semiconductor bandwidth, limiting its absorption to the UV region of sunlight, which comprises only 3-5% of the solar spectrum. Due to this gap, the usefulness of pure TiO_2 is restricted in the manufacture of self-cleaning materials for outdoor application, using low cost light sources, called light emitting diodes (LEDs).

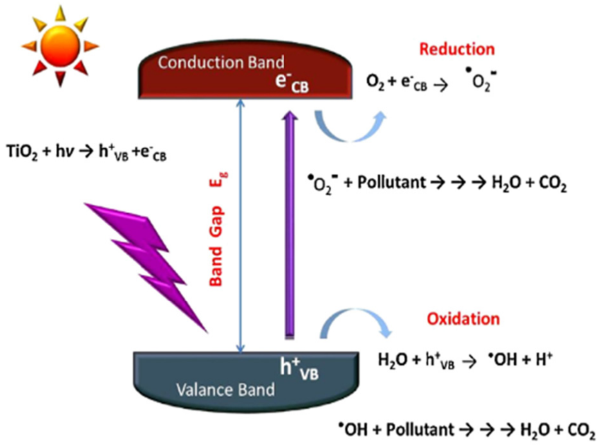

Figure 1. Schematic illustration of several processes that occur after photoexcitation of pure TiO_2 with UV light [4]

1.1. Objective

This work aims to apply photocatalysis for the degradation of organic pollutants, using a model molecule (Rhodamine B - RhB), using TiO_2 as a catalyst. The present project is based on the use of TiO_2-based photocatalysts and their impregnation on cotton and polyester substrates, aiming to show the effect of TiO_2 on the cleaning of pollutants in artificial fibers such as polyester and in natural fibers such as cotton, through modifications of textile surfaces induced by UV radiation.

2. Materials and methods

2.1. Materials

As a model molecule, Rhodamine B (RhB, ≥95%), purchased from Sigma-Aldrich, was used. The catalyst used was TiO_2 Evonik P25, which is a reference material in photocatalytic applications. Cotton and polyester substrates were available in the laboratory. Some of these substrates were subjected to an acid treatment with 1% (v / v) nitric acid (1% HNO_3), in order to study the effect of this treatment on the adhesion of the catalyst on the surface.

2.2. Catalyses Features

The optical absorption of cotton and polyester fabrics coated with TiO2 was obtained by diffuse UV-Vis reflectance spectroscopy (DRUV-Vis), using the JASCO V-560 spectrophotometer.

The morphology of the coated tissues was analyzed by scanning electron microscopy (SEM) using the FEI Quanta 400 FEG ESEM / EDAX Genesis X4M (15 keV) equipment.

2.3. Experimental Procedures

The self-cleaning efficiency of tissues coated with TiO_2 was evaluated through the photocatalytic treatment of the substrate in aqueous solutions containing RhB (0.005 mM). The textile substrates were subjected to a washing with ionic detergent for 1h and a treatment with nitric acid 1% by vol. (1h), to facilitate the adhesion of the catalyst on the substrate surface. Then, the tissues were immersed in TiO_2 suspensions of concentration 0.2 g / L, 0.5 g / L and 0.7 g / L at 40ºC for 3 hours, in order to impregnate the catalyst in the substrates. Finally, the tissues were washed to remove loose particles.

For the photocatalytic experiment, a borosilicate reactor equipped with a glass water recirculation jacket (to maintain a constant temperature) was used, which was filled with 100 mL of the contaminating solution (Fig. 2). Then, each prepared coated fabric (5.0 cm x 5.0 cm) was placed inside the reactor and the contaminating solution was continuously saturated with air.

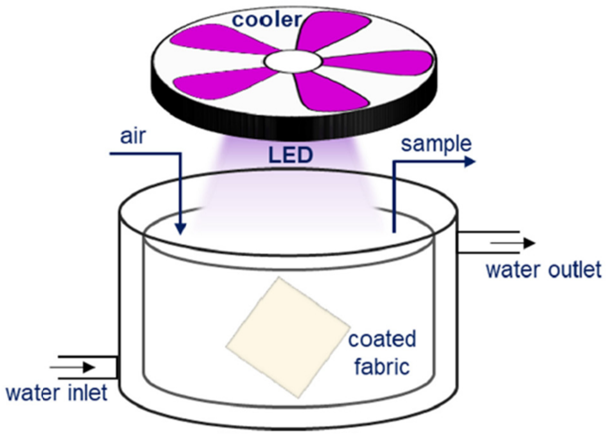

Figure 2. Configuration used in photocatalytic experiments [1]

Before the experiments, reactions were carried out in the dark to establish the adsorption-desorption balance between the coated cotton fabrics and the contaminant for 30 min. The photocatalytic efficiency of the coated fabrics was evaluated for 210 min using a light emitting diode (LED) with a maximum wavelength at 417 nm. The LED intensity (115 W) was measured at 9 cm from the contaminating solution using a UV-Vis spectrum-radiometer device (USB2000 +, OceanOptics, USA). The RhB concentration was monitored by UV-Vis spectrophotometry using the Jasco V-560 spectrophotometer.

3. Results and discussion

3.1. Characterization of substrates by UV-Vis spectrophotometry

OT and ZEA could be studied under positive and The DRUV-Vis characterization of tissues coated or not with TiO_2 were evaluated before the photocatalytic experiments, and the results were compared (Fig. 3 and 4). These analyzes were carried out in different points of the fabrics to prove the homogeneity of the coating.

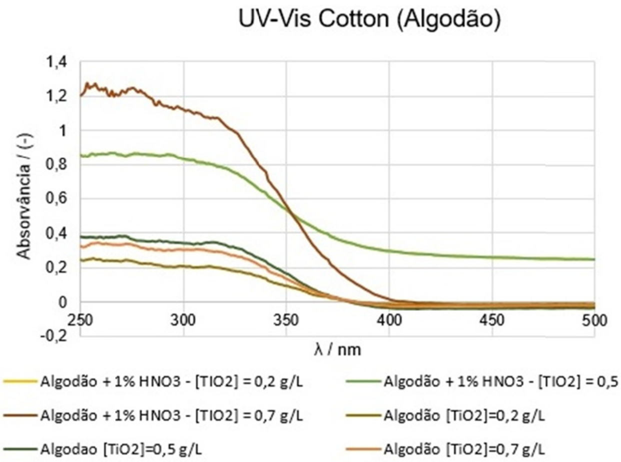

Figure 3. DRUV-Vis characterization of cotton substrates

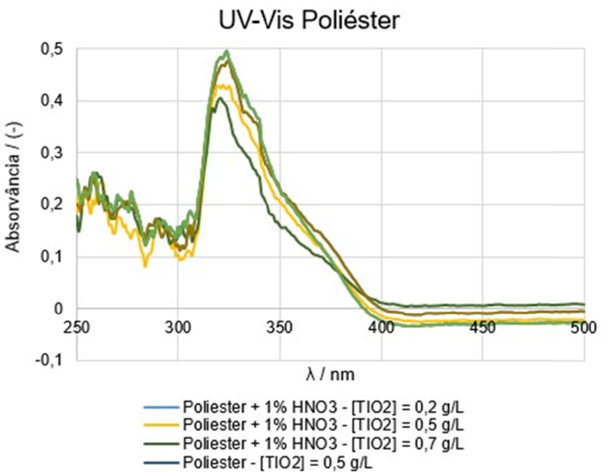

Figure 4. DRUV-Vis characterization of polyester substrates

It was possible to verify that the introduction of acid treatment and the use of TiO_2 suspensions with higher concentrations in the impregnation step resulted in greater absorbance, which indicates the existence of a greater amount of material deposited on the fabric.

3.2. Morphological characterization of substrates

The morphology of the coated tissues was investigated by Scanning Electron Microscopy (SEM). For comparison purposes, a SEM image of the control fabric (uncoated fabric) is also shown (Fig. 5 and 6). After treatment with HNO_3, the introduction and defects on the surface of the cotton fibers are observed. SEM images also reveal a homogeneous distribution of TiO_2 in tissues.

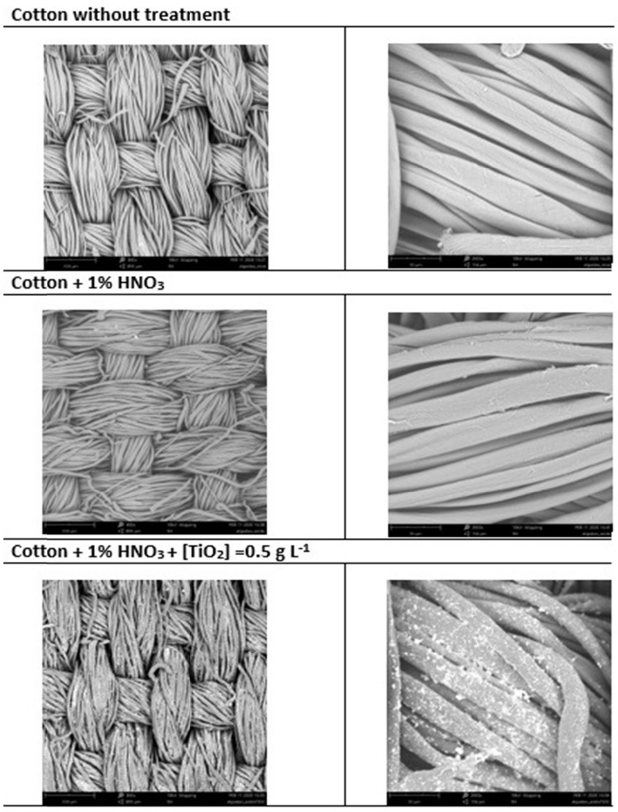

Figure 5. SEM characterization of cotton substrates

3.3. Photocatalytic self-cleaning of coated fabrics

In order to evaluate the self-cleaning photocatalytic properties of TiO_2-coated fabrics, each substrate will be placed in contact with aqueous RhB solutions (model used as organic contaminant). At this time, only the cotton substrate impregnated with 0.5 g / L TiO_2 was evaluated, the results being shown in Fig. 7. In this experiment, there was a decrease in rhodamine concentration over time, revealing that the impregnation of the treated substrates is effective in the degradation of this dye, which is a promising result for the possible application of these surfaces in the degradation of organic compounds.

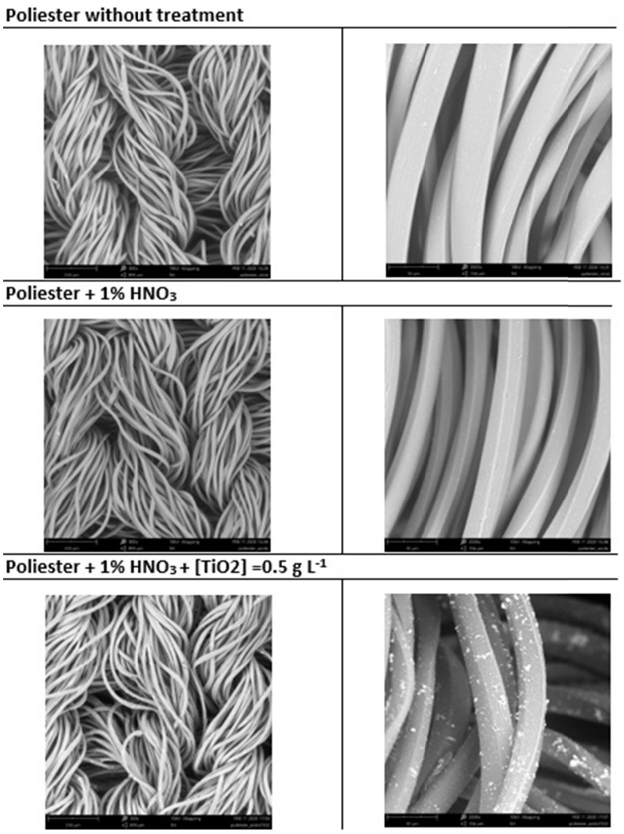

Figure 6. SEM characterization of polyester substrates

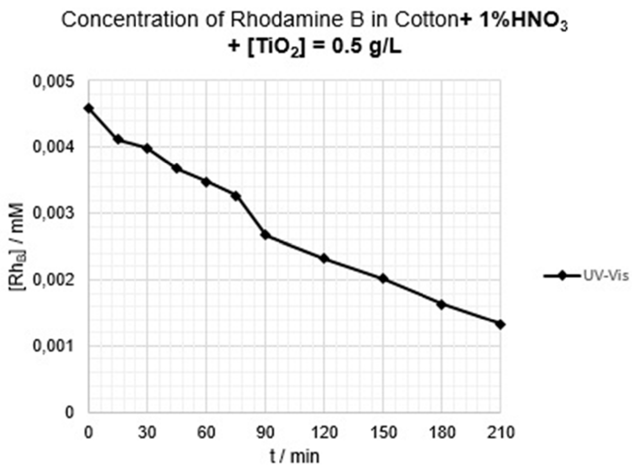

Figure 7. Photocatalytic degradation of RhB using acid-treated cotton coated with $[TiO_2]$=0.5 g / L

4. Concluding remarks

The coating of the tissues with TiO_2 was carried out successfully. The photocatalytic self-cleaning ability was verified, using RhB as target contaminants under visible light radiation.

5. Future work

In the future, degradation reactions should be carried out on cotton and polyester substrates, without catalyst and with different concentrations of it, in order to verify the effect of the concentration of catalyst on the removal of Rhodamine in the fabrics. It is still possible to compare the behavior of the two tissues in the degradation of pollutants. In addition, it is suggested the study of new catalysts, preferably without metallic elements effective in the photocatalytic degradation of pollutants and the adaptation of the experiment to other types of pollutants, for example other dyes and caffeine.

6. Acknowledgements

To our supervisors: Professor Cláudia Silva and Engineer Isabel Barbosa. For their availability, kindness and patience. For everything they taught us. For marking our school path in a special way. For hosting us at LSRE-LCM, an excellent research group at the Faculty of engineering of the University of Porto (FEUP). To FEUP, Department of Chemical Engineering and LSRE-LCM. For providing the essential technical resources to carry out this work.

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Using Folklore and Sayings as a Basis for Observing Our Environment

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Abstract. Observing and understanding nature is a fundamental part of growing up and childhood development, that should be nurtured from as early as possible. The author suggests simple ways of exploring elementary science ideas based on folklore and local sayings, which can be investigated through observation and recording. The truth behind many of these sayings can be explained simply at primary school age. Theoretical understanding can be imposed at a later stage, usually in secondary school when children are considerably older and have more understanding of the science involved. Using safaris to generate observation and recording skills which can then form the basis for further simple analysis and discussion are also suggested. Finally a point is made that observing and understanding nature is an essential part of Environmental Awareness which should be part of every citizen's knowledge.

Keywords. Environmental Awareness, Importance of Science Experiences, Natural Environment, Observing, Recording Skills.

1. Introduction

The importance of introducing science to young children cannot be underestimated. Science experiences at an early age stage stay with us for a lifetime [1], and memorable experiences colour our feelings about science for ever [2]. Developing the essential skills necessary for science stands us in good stead for whatever we may aspire to as we mature. Enjoying science in primary school enables us to develop our problem solving skills through observation, recording, and analysing in later life [3] and currently offers an understanding to the issues facing our planet. Recent research carried out by the Institute of Education at UCL for the (English) Wildlife Trust [4] found that children feel more confident after spending time participating in outdoor activities. This article suggests that children would benefit from spending at least one hour everyday participating in outdoor activities.

Our world is a place of never ending surprises and more so for young children. Our role as teachers should be to encourage their development through experiences and observation when they are very small to watching and recording their observations as they mature into primary school age [5].

2. Practical Observing projects

Much of my working experience has been to develop observation and recording skills with children aged from five up to students aged 18 or more. I believe that currently our education system in England particularly is far too formal at age five. We should be looking at extending the Early Years programmes of getting children to appreciate and understand some of the wonderful things that go on round about us. In Britain, we are particularly lucky to have seasonal weather which we can name as spring, summer, autumn and winter. Each season has very distinctive characteristics in nature – in plant growth, bird and animal life and weather all of which work together to produce these different features.

The word nature suggests a 'power' that encompasses all natural phenomena [5] and I prefer to use the word environment instead. However, children of all ages are interested in various aspects of their surroundings from the earliest age – interacting with animals, investigating water and soil and going on to explore woods and parks or other local environments. Observing environments is a skill applicable to all and gradually as young people develop they become more adept at recording their observations, then understanding and interpreting them. Observing is the first stage of enquiry and a basic scientific skill.

I have used a number of ways to integrate science observation with other subject areas at this level (age 3 up to 11); one is by using some of the many folklore and old wives tales to investigate our environment, and the second is through the idea of a 'safari' which children find exciting.

3. British Folklore

In Britain we have many tales, rhymes and stories that have been handed down through

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the generations. Traditionally people observed and understood how nature affected their everyday lives. Farmers and sailors in particular had good reason to become intuitive about observations and the outcomes these would bring. Today these ideas can be investigated from an early age and in more depth as children grow in understanding and ability.

Weather in particular is something difficult to understand theoretically but easy to observe. Practice at observing actual weather and outcomes means that it is possible to forecast what might happen next. Sailors had excellent observation and prediction skills – I hesitate to call this forecasting, but in essence that is what it was. The sailors watched the sky and noted the different clouds, horizons and wind directions. Children can do the same! Sunsets are very useful and generally very correct in predicting the following days weather.' Red sky at night is the shepherd's delight, but red sky in the morning is the shepherd's warning' is one of the best known of English traditional weather rhymes.

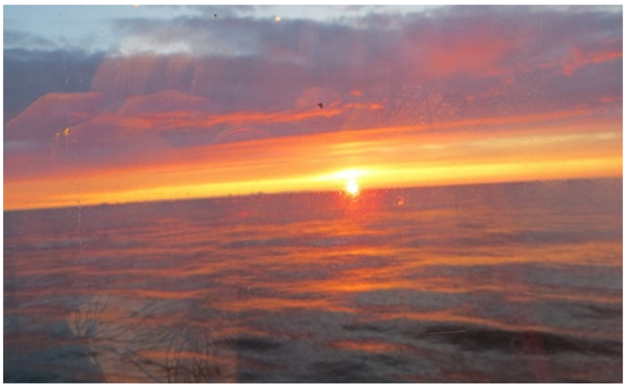

Figure 1. Red sunset

Other colours at sunset can be very predictive too. Yellow tinged skies in the evening sunset predict windy conditions to come.

Simply recording sunset colours and then following up on their predictions is an easy way to start learning observing, recording and predicting skills. Understanding the reasons why red sunsets are forecasters of fine weather is much more difficult and probably best left to much later. Although a simple explanation would be that at sunrise and sunset, the Sun is low in the sky, which means that the sunlight we see has travelled through a much thicker amount of atmosphere. The shorter wavelength blue light is scattered further, as the sunlight passes over a greater distance, and we see the longer wavelength yellow and red light. This effect can be demonstrated in the classroom by passing light through prisms where white light is broken into its component parts and colour varies according to the thickness of the prism.

Figure 2. Windy sunset

Figure 3. Broody (yellow) sunset

Red sunrises are supposedly indicative of bad weather – the rhyme says 'shepherd's warning', but this needs testing out: recording sunrises in the winter months when sunrise is about 0730 (just before school) is a good way to get children observing!

Clouds were frequently observed by sailors to be predictors of oncoming winds or storms. 'Mare's tails and mackerel scales make tall ships take in their sails'.

The saying 'Mackerel sky, less than 24 hours dry' has some truth too.

Figure 4. Red sunrise

Figure 5. Mares Tails cirrus clouds

Figure 6. Mackerel sky

Both these sayings understand the cloud types associated with oncoming depressional weather, and children can record when they see the clouds and what happens to the weather to assess the truth of the statements.

By plotting changing cloud types from very high (cirrus) with gradually lower clouds appearing, a warm or cold front can be observed approaching by older pupils and this can be linked to observations taken from a barometer which will show falling pressure.

Watching the horizon at sea, and also over water 'if the Lakes are clear there's rain on the way' is a saying I grew up with as a child. Clearly defined horizons are indication of cold frontal air, and suggest that rain, in particular heavy showers, may be on the way.

Figure 7. Clear Horizon

However, others will say if you can see the horizon its not raining, if you can't it is!

Fine settled weather associated with high pressure results in a blurring of the horizon and so not being able to see the horizon is a positive sign for your holiday.

Halos often form around the sun and moon. These are circles of light, sometimes slightly coloured and predict rain on the way, with the moisture in the atmosphere causing the halo/rainbow effect. Halos around the moon are particularly effective and sometimes look like circular rainbows.

But the idea that rainbows have buried gold where they reach the ground is unfortunately not true and difficult to find evidence for as rainbow ends move quickly before one can get to them to dig.

Understanding how rainbows form can be demonstrated using a hose pipe spraying water on a sunny day. Facing into the spray and the sun, children will see a magical 'rainbow', and will learn where to look for one when it is

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raining and the sun is shining by facing into the sun.

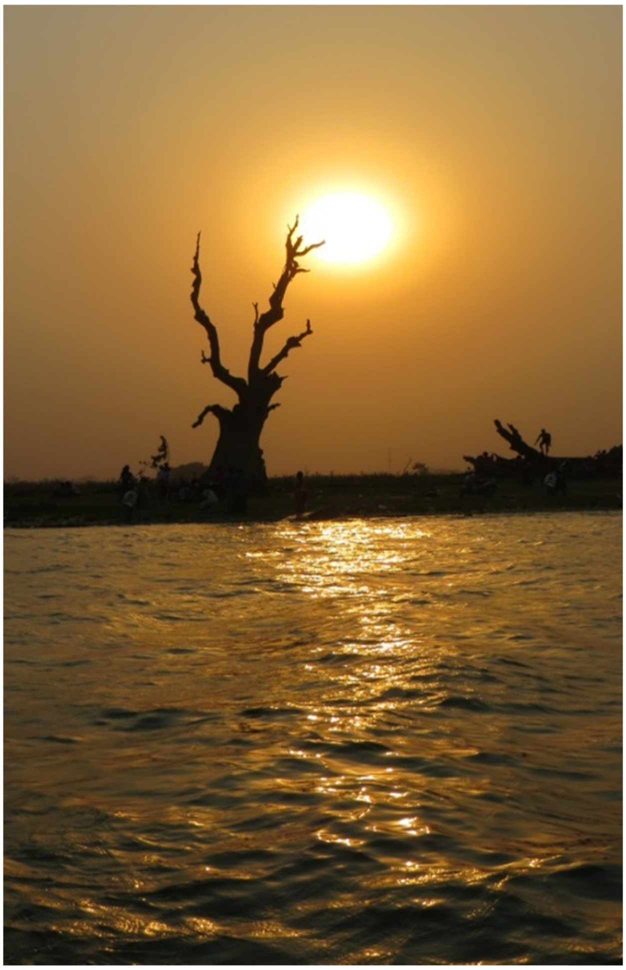

Figure 8. Sun Halo

Older children can gather and record simple weather data then make their own forecasts – perhaps to the class at first but as they become more accurate, to their school, many schools have their own programmes running in their reception areas on view to all!

Figure 9. Rainbow

And another saying that can be investigated by children is that 'rain on St Swithins Day (15 July) will bring 40 days of rain! Unfortunately St Swithin's Day falls at the end of the summer term and the forty days are within the summer holidays, so this project would have to be designated a 'special project' by most British schools if teachers wanted children to collect data!

4. Observing Plants and Animals

Plants and animals have long been used by farmers to predict forth coming weather events, though not always with success. There are many sayings, known as 'old wive's tales' which children can investigate. It is said that a good crop of berries on bushes and shrubs indicates a cold winter to come. However, this is not often true, and if a weather diary is kept, it will be seen that the previous spring had weather conducive to flower forming and the setting of berries, rather than anything else! Observing the first new leaves and buds opening in spring can be compared with previous years, if you have records, but there are also many recordings from a hundred years or so ago that can be accessed nowadays.

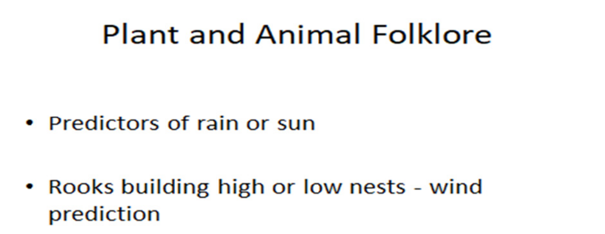

Figure 10. Animal and Plant Folklore

'Ne'er cast a clout 'til May be out' can be taken to have two meanings, both of which can be studied. The first suggests that one doesn't take off one's winter clothes and exchange them for lighter summer garments until the end of the month of May, as it won't be warm enough. The second suggests that the May, the flower of the hawthorn bush, is the indicator of warmth to come. There are many other tales: 'Oak (budding) before ash – forecasts a splash, ash before oak, suggests a soak', predicts more heavy rain. Looking for black coloured ash buds on stems and leaves beginning to open on oak trees, will get children looking for specific trees in spring.

Rooks nesting high in the trees suggests a fine, windfree summer. Whereas it is said that if the nests are built lower in the trees, it is a sure sign of wind to come. It has not yet been

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proven that this is correct, but there seems to be some truth in the saying.

Scarlet pimpernel flowers open if it is going to be sunny, pine cones close if rain is on the way.

We humans too are often able to forecast what weather is coming. Many say that their joints begin to ache before cold weather. I sneeze before the onset of frontal weather – this is due to the spores in the atmosphere – but it would be interesting to investigate whether other people have similar experiences with coming weather. Children can ask their families if they notice weather causing aches and pains

Apart from using traditional folklore to investigate nature there are many ways that children can explore and observe what is going on around them, not seemingly seen as being 'science'. The first signs of new growth – these can be hazel catkins in January – identifying the male and female flowers, then looking in the autumn to see if nuts have formed, bulbs starting to flower, grass starting to grow – it is interesting to keep records of when your family had to mow the lawn and how often over the winter, as grass only grows if the average temperature is above 8C. In many parts of Britain average winter temperatures are below grass growing levels, so cattle have to be fed on hay or brought inside to feed. Another project could be to see where your local cattle spend the winter!

All investigations use the skills children develop by asking their favourite question 'Why?' surely we should put this to good use, and encourage their observation and hence a little more understanding of the environment around them. This can then develop into a life-long understanding of their locality and the ability to look at science positively for the rest of their lives.

5. Safaris

Safaris are another simple way of enthusing children to go and look around them. The word safari means expedition or hunt and inevitably requires clipboards and pencils. Young children will need an adult to record what they find and sometimes where. The class needs to decide what they are going to hunt and how they are going to record it. It may be a bug hunt, a tree hunt, a geological hunt for different materials, a windy place hunt, there are numerous possibilities. All however need a similar format. There needs to be a set area in which to 'hunt' and a given time. A format for recording needs to identified – sometimes it is just the number of similar items found, eg 10 woodlice, 3 worms but can also include location – under flower pot, on grass etc.

The day of the safari children can dress in appropriate safari outfits and it is interesting to see what is deemed appropriate wear. Nearly always children wear hats, always have a clip board, sometimes wellington boots! I have found that any safari causes great excitement and the word in itself can lead to more discussion and research.

Safaris

- A safari is an expedition
- Identify purpose
- Plan
- Observe
- Record
- Discuss

Figure 11. Safaris outline

Urban areas are not bereft of the wonders and safaris around the school playground can demonstrate this. How does a plant manage to push its way up through a tarmac path, or a crack in a pavement? What strength is needed to achieve this? Look at tree roots pushing up paving stones. How do some plants manage to grow on heaps of broken building stones and rubble? Why do plants or what creatures live on walls – so many investigations here! Where do puddles form and why do some take longer than others to dry out. – I could go on for ever. Plotting the information gained on a specific safari can spark many questions and more investigations. Each child can explore as much or as little as they can and returning to these ideas at a later stage in the year can show a child's thinking progression and development. It is also necessary to ensure there is time to use the data collected. Generally it is best to 'pool' the data on a large board or on a computer so that everyone can see what has been found. The data can be converted into bar or line graphs as appropriate.

Another safari that is very different is a ‘noise’ safari. The children go outside and sit quietly with their eyes closed and just listen. They need an adult with each small group to record what the children hear and it is often surprising at how many different sounds can be recorded. Birds singing, the wind blowing, scuffling along the ground - all sorts of sounds which you cannot see, but which are very much part of the environment that we rarely identify with as we are too busy. Older children find this quite difficult but also are surprised at how many different sounds they do hear which they wouldn’t normally notice.

6. Environmental Awareness

There are numerous questions to be asked and hence plenty of opportunity for children to discover what goes on in their worlds, local to them. Every child needs to understand their own surroundings and how soils, rocks, weather plants and habitats work together. A better understanding of our own local earth science will encourage appreciation of the importance of local changes on a world scale. This is the initial phase of understanding Environmental Awareness.

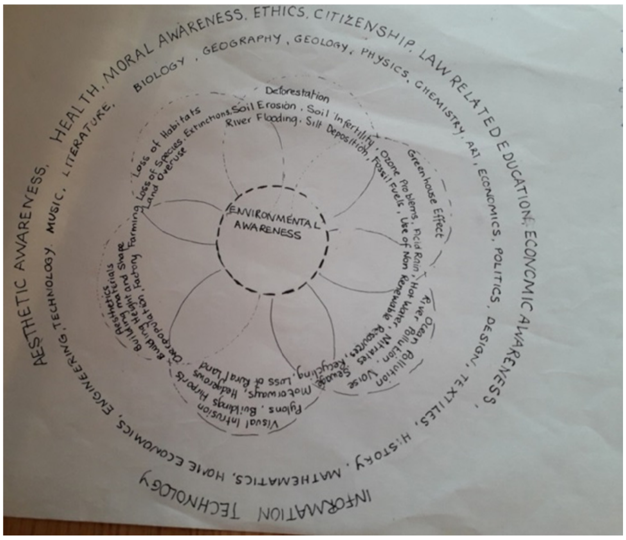

Figure 12. Environmental Awareness Flower

7. Conclusion

Every child needs to understand their own surroundings and how soils, rocks, weather plants and habitats work together. Surely a better understanding of our own earth science would encourage appreciation of the importance of local changes on a world scale. Now is the time to ensure the next generation have this knowledge and understanding.

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Seafuel: Seaweed Used as Biofertilizer

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Abstract. Acknowledging the negative effects that non-organic fertilizers have on all the ecosystems [1], our team decided to create an alternative for this method, so we can contribute to the decrease of both water and soil pollution.

To do that, knowing that Portugal has a long coastline with a lot of unique advantages, we've decided to use one of these many advantages: seaweed [2,4]. Since ancient times, the Portuguese, especially the ones that live in the coast, have been using seaweed to fertilize their soil by means of traditional methods.

Our experience is a study about the effects of different types of seaweed when applied using different methods on a bean growth project [3,5]. This approach to sustainable fertilization has the capacity to improving the bioeconomy.

To test this, we measured different parameters: the size and matter of the leaves, roots and beans. We also aim to do biological analysis of the plant in order to compare and discuss the results of the study. In fact, we can take from this experience that there are differences when it comes to the growth of the plants between the soils that had seaweed and the ones that don't.

Keywords. Bioeconomy, Fertilizer, Growth, Seaweed, Sustainability.

1. Introduction

The use of different inorganic fertilizers, pesticides and insecticides is important for the agricultural economy, but harmful to the environment and damages/destroys the soil. This type of chemical, over time, makes the land unsuitable for agricultural production and compromises ecosystems [11]. The production of a natural algae-based fertilizer is an environmentally sustainable alternative [6] and would replace commercial fertilizers, as it would prevent eutrophication and pollution of soils and the environment due to the high amount of nitrates and phosphates that chemical fertilizers contain in their composition, and which contribute largely to soil contamination [7].

Algae are a good alternative to commercial fertilizers because they contain essential nutrients, promote accelerated seed growth and increase crop yields. Furthermore, they are biodegradable and are neither polluting nor toxic to living beings [5]. This alternative is a combination of nitrogen, phosphorus and postasium, contains alginate and monosaccharides. As seen in the Skelton experiment, (1969) the use of a liquid algae-based fertilizer on cereal seeds and vegetables caused a significant increase in the germination capacity of the plant.

Sustainable organic fertilisers come from natural resources, such as algae, and thus represent viable alternatives for crop fertilisation due to their high content of organic matter, micro and macro elements, vitamins, fatty acids and growth hormones [4].

In order to identify the potential of various types of algae as a biological fertilizer, we created a bean crop [3]. Seaweed extracts are an alternative of organic fertilizers that contain high amounts of nutrients and promote rapid seed development and germination [10].

After the planting of bean crops (with algae, in solid state), and in partnership with ISEP (Instituto Superior de Engenharia do Porto), we subjected a liquid fertilizer, based on these, to numerous tests and analyses, which allowed us to infer plausible conclusions regarding the possible chemical and organic contributions that could be made to the crops.

Thus, the objective of our study is to test if the application of different types of algae (red, green and brown) on the soil of the beans will present significant differences from the control group, where we will grow beans without any additives.

2. Materials and Methodology

2.1. How was the algae preparation process performed?

Samples of brown algae (Fucus vesiculosus; Sargassum; Saccorhiza; Laminaria), green (Ulva lactuca) and red (Gracilaria verrucosa; Palmaria Palmata; Gelidium corneum) were used in this investigation, collected from the

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Portuguese coast (like our ancestors), in the region of Vila Nova de Gaia and Porto (Madalena beach and Carneiro beach, respectively). The algae were collected and put to dry (Fig. 1) so that the salt present would stay on the surface and thus facilitate its washing, which was done twice, with cold running water, in order to remove sand particles and other types of impure waste (Fig. 1).

After drying, they were cut into small pieces in a shredder and properly separated into different deposits: one for each type of algae (Fig. 3).

Figure 1. Algae washing

Figure 2. Algae drying

Figure 3. Shredded algae

2.2. How was the algae preparation process performed?

Once the algae preparation process was completed, different bean crops (black beans - Phaseolus vulgaris) were created, using a customised method [5] - using algae in small pieces, in a pre-prepared bottle with 200 grams of gravel and 1300 grams of soil: three crops with red algae, three crops with green algae [8-9], three crops with brown algae and three control group crops, giving a total of 12 crops. The crops were placed in demijohns with the same amount of soil and gravel, were periodically watered with the same amount of water and were exposed to the same amount of light in order to reduce the variables.

Thus, our research consisted of 12 cultures of three beans in each bottle, in which, in those intended for testing with algae, 20 grams of algae of each type were deposited, mixed evenly in the soil.

In the bottles 1, 2 and 3, (Fig. 4) a total of nine beans, the Control Group took place, without any algae additive or fertilizer, just a layer of gravel and soil.

In the bottles 4, 5 and 6, (Fig. 5) there are crops with the same pre-preparation, but with 20 grams of green algae, the (Group A)

In the bottles 7, 8 and 9 (Fig. 6) the cultures were mixed with 20 grams of red algae (Group B)

Finally, in the bottles 10, 11 and 12, (Fig. 7) 20 grams of brown algae were used (Group C)

Figure 4. Bottles 1-3

Figure 5. Bottles 4-6

Figure 6. Bottles 7-9

This whole structure of bean crops was planted on January 22, after a rigorous study of literature from other experiences of seaweed use in agriculture, for two months. During the experience, we followed each crop closely, watering the beans with 100, 200 or 300 mL whenever necessary, always the same in all, depending on the absorption of the previous irrigation.

Figure 7. Bottles 10-12

2.3. How was the experience followed?

In the two/three months in which the bean growers developed, several common and individual aspects were recorded in writing and photographed in the crops, our main focus being to measure the growth of the beans over time, allowing us to elaborate a graphic synthesis.

In fact, from the first day of planting we measured the beans, initially using a 50 cm ruler, but about a month later the beans began to grow exponentially, forcing us to use a tape measure. Together with this measure, we also had to adopt the use of something that would make a stake/support for the plants, since they were climbing plants, using a fishing line that was attached to the roof, vertically to each one of the demijohns, so that they could grow without the risk of leaving.

The measurements were made weekly and, together with Instituto Superior de Engenharia do Porto, at the end of the experiment, when the beans have reached their maximum growth, we will proceed with the organic and biochemical study of the different plants, so that we can draw more substantiated conclusions.

2.4. Preliminary characterization of seaweed extracts

The seaweed extracts were prepared with 20 g of seaweed in 100 mL of water. The mixture was boiling for one hour and then filtered before analysis. The extracts were

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analysed together with a commercial fertiliser (Profertil) and the results compared.

2.5. Determination of total phenol content (TPC)

One of the most commonly used methods for the spectrophotometric quantification of phenolic compounds (one of the families of antioxidant compounds) is the Folin-Ciocalteu method. This method uses the Folin-Ciocalteu reagent (a mixture of phosphomolibdic and phosphotungstic acids) which by means of an oxidation-reduction reaction, which occurs in basic medium, is reduced and the phenols in the sample are oxidized (Equations 1 and 2). The coloration developed is proportional to the content of phenolic compounds and is measured by absorbance at 765 nm.

$$Na_2WO_4/Na_2MoO_4 \rightarrow (\text{phenol - }MoW_{11}O_4)\text{-}4 \quad (1)$$

$$Mo(VI)\ (\text{yellow}) + e^- \rightarrow Mo(V)\ (\text{blue}) \quad (2)$$

2.6. Experimental procedure

1. Prepare 25 mL of a standard solution of gallic acid (AG) ≈ 200 mg/L in ultrapure water (Fig. 3). This solution should be protected from light. Gallic acid (Fig. 8) is used in this test as a representative of the family of phenolic compounds.

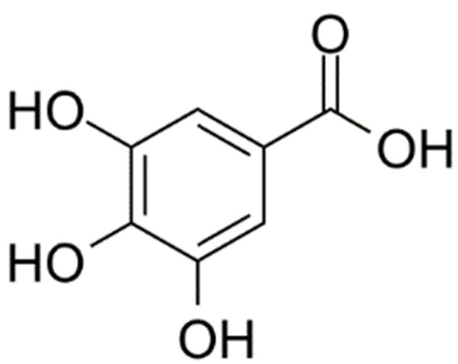

Figure 8. Gallic acid

2. From GA standard solution prepare 200 μL of each of the diluted standard solutions (Table 1).
3. Prepare Folin reagent solutions (diluted 1:1 in deionized water) and Na_2CO_3 at 75 g/L (10 mL).

mAG= 5.7 mg (adjust concentrations in the table from actual AG concentration)

4. In microplate (and in triplicate) add in this order:
   - 25 μL sample/standard/water deionised;
   - 75 μL deionized water;
   - 25 μL diluted Folin reagent;
   - Rest 6 min under the light;
   - 100 μL of Na_2CO_3 solution;
   - Shake;
   - Keep in the dark for 1 hour;
   - Read the absorbance at 765 nm and calculate the equation of the line (Table 2).

Table 1. Preparation of solutions for the calibration curve

St.	AG (μL)	Water (μL)	Conc. (μg/mL)
P1	10	190	10
P2	25	175	25
P3	50	150	50
P4	100	100	100
P5	150	50	150
P6	200	0	200

Table 2. AG concentration and mean of the absorbance values for the calibration curve

Conc AG (mg/L)	Media Abs.
0,00	0,0459
11,4	0,116
28,5	0,289
57,0	0,501
114	0,940
171	1,36
228	1,69

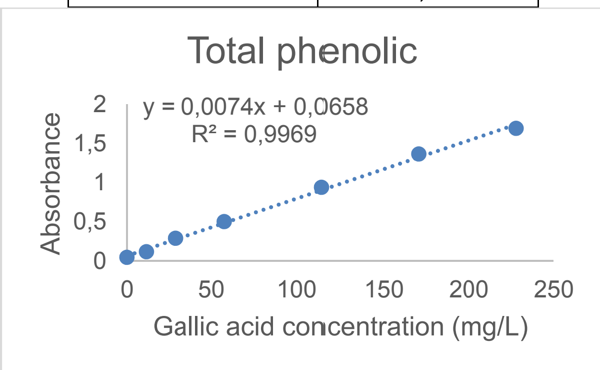

Figure 9. Calibration curve for the determination of total phenolics

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2.7. Determination of florotanin content

The content of florotanins in the samples will be determined by the 2,4-dimethoxybenzaldehyde method (DMBA, Fig. 10), referred to in the literature as a simple method for the estimation of the content of total florotanins. The standard used will be floroglucinol.

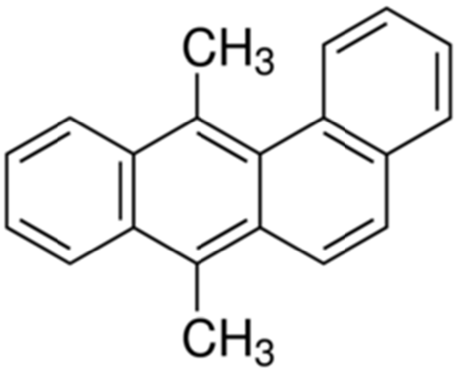

Figure 10. Structure of 2,4-dimethoxybenzaldehyde

Experimental procedure:

1. Prepare 25 mL of a standard solution of floroglucinol (FG) concentration (≈) 100 mg/L in ultrapure water (Table 3). This solution should be protected from light. In this test floroglucinol is used as representative of the florotanin family;
2. From the FG standard solution prepare 200 μL of each of the diluted standard solutions;
3. mFG= 3.0 mg (adjust concentrations in the table from the actual FG concentration).

Table 3. Preparation of solutions for the calibration curve

St.	AG (μL)	Water (μL)	Conc. (μg/mL)
P1	10	190	5,0
P2	25	175	12,5
P3	50	150	25,0
P4	75	125	37,5
P5	100	100	50,0
P6	125	75	62,5

4. In microplate (and in triplicate) add in this order:

- 30 μL sample/standard/water deionised;
- 150 μL of working solution;
- In the blank wells of the samples place 30 μL of sample and 150 μL of acetic acid instead of the working solution;
- Shake;
- Keep in the dark for 1 hour inside the hotel;
- Read the absorbance at 494 nm and calculate the equation of the line (Table 4).

Table 4. AG concentration and mean of the absorbance values for the calibration curve

Conc AG (mg/L)	Media Abs.
0,00	0,0458
6,00	0,125
15,0	0,476
30,0	0,832
45,0	1,17
60,0	1,56
75,0	1,89

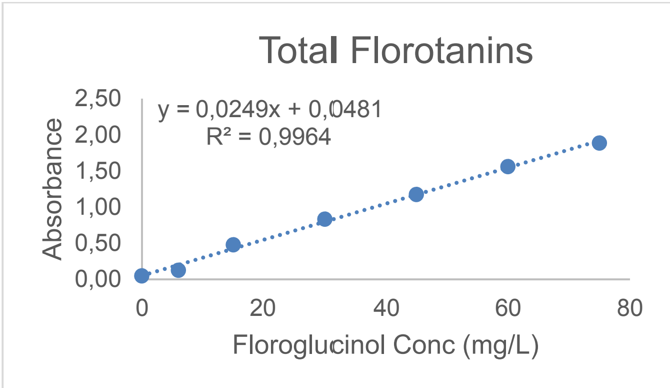

Figure 11. Calibration curve for the determination of total phenolics

3. Results

The following Graphs (Figs. 12-17) represent the growth of the beans over the initial 50 days of the experiment.

3.1. Control Group

Three black beans were planted on each crop. As with the other crops, it was found that the plants grew strongly about a week after they were grown. By the 20th day, all crops had grown at about the same rate. All the crops reached very reasonable and similar values in terms of height of the beans. From the 20th day on, there was a slight difference between the 3 crops: while crop 1 decreased its speed of development, crop 2 significantly increased its rates of development and growth. Crop 3, on the other hand, remained more or less stable, evolving at the same rate and without great oscillations. Until the end of the growing period, there was a very slight increase and a very low evolution of the bean plant on the part of crop 1. And a very sharp and evident growth, in the last week recorded, of crops 2 and 3, which allowed the bean plants, after 50 days of experience, to show very high values of growth of the species.

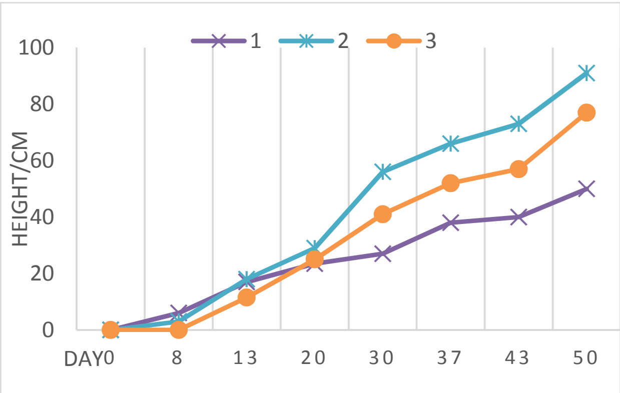

Figure 12. Measurement of the stalk height of the plants of the Control Group over time

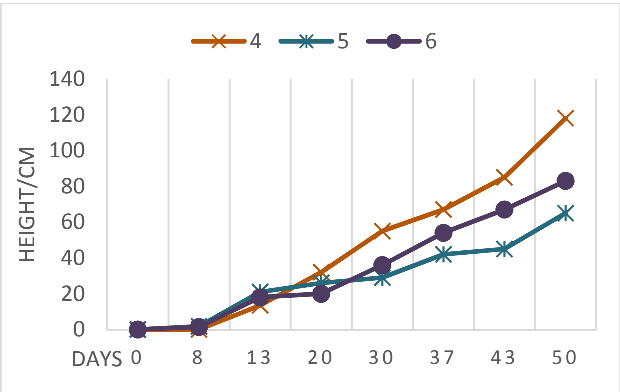

Figure 13. Measurement of the stalk height of the plants of the Group A over time

3.2. Group A

Three black beans were planted on each crop. It was found that the plants grew sharply about a week after they were grown. The beans, until then, grew and developed in a similar way and at the same rate. From the second week onwards, crop 4 progressed and developed on a larger scale than the rest. After the first month of planting the beans, the growth of crop 4 overcame the growth of crops 5 and 6, which grew at more or less the same rate. From the 30th, while crop 4 continued to develop at an accelerated level, and quite expressively, crop 6 also gained momentum. After 1 month and a half, since the beginning of the project, the 3 cultures started to grow significantly and gradually, especially culture 4, which, in the last week analyzed, reached quite positive growth levels. All this can be seen in graph 2. Another evidence in these crops was the accentuated leaf growth, the strong green colour of the leaves and the appearance of numerous branches on the stem, which made its perimeter larger compared to the other crops.

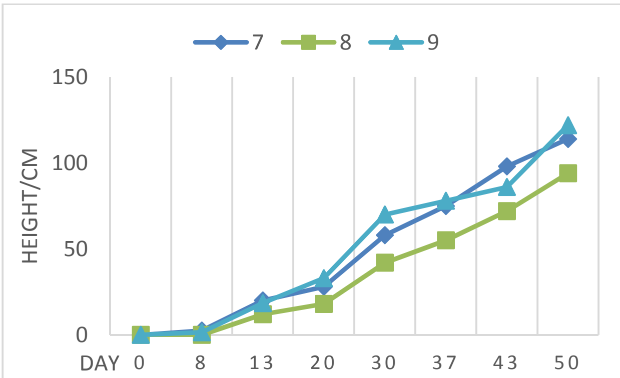

Figure 14. Measurement of the stalk height of the plants of the Group B over time

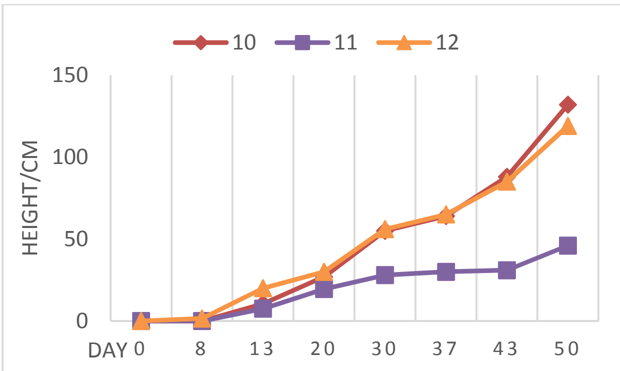

Figure 15. Measurement of the stalk height of the plants of the Group C over time

3.3. Group B

Three black beans were planted on each crop. Contrary to what happened in crops where algae of other species (green or brown) were inserted, it was found that the growth of the beans, where red algae were inserted, was much more homogeneous and regular, and the beans of the same crop developed at a level that was practically identical and proportional. It was found that the plants grew at a pronounced rate, approximately one week after they were grown. Until then, the beans grew and developed at a similar rate. Although crop 8 was less developed, compared to crops 7 and 9, the beans grew at the same rate, and from the 20th day they grew faster, especially crop 9. After the first month of planting the beans, there was already a significant difference in height and development, between crop 8 and the others, but it was still growing at a good rate. From the 37th, the difference between crop 7 and 9 decreased, almost completely disappearing. Until the end of the growth period, crop 8 was growing steadily and invariably, and the remaining 2 crops, although with some ups and downs, reached quite reasonable and identical growth and development values after 50 days of study.

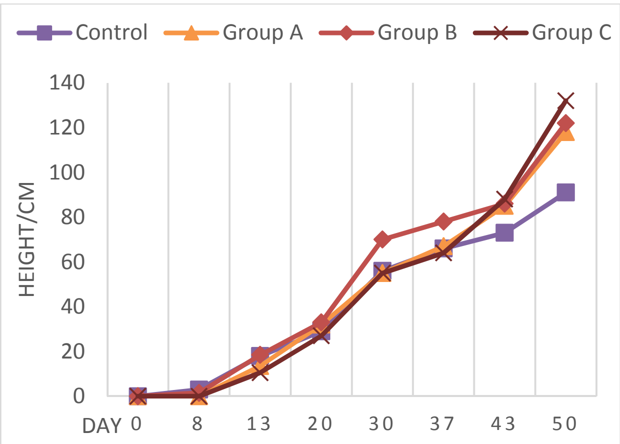

Figure 16. Height measurements of the largest plant in each group over time

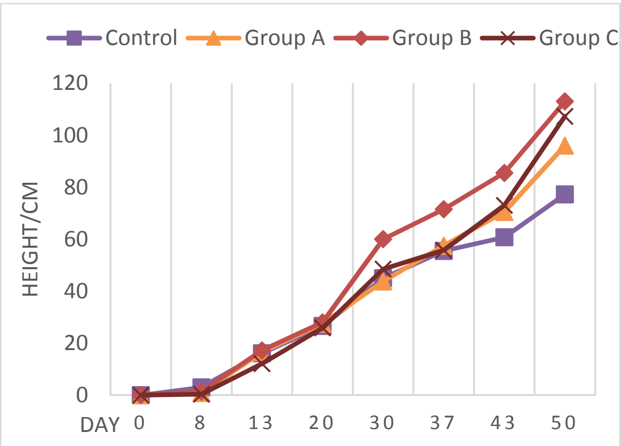

Figure 17. Average height measurements of the three bottles of each group over time

3.4. Group C

Three black beans were planted on each crop. As with the other crops, it was found that the plants grew strongly about a week after they were grown. One of the crops planted, crop 11, was found not to have grown as well as the others, it grew in a conditioned way, and perhaps because it did not adapt to the conditions imposed, it did not grow as expected, reaching the end of the study period, only 46 cm high. The remaining 2 cultures, cultures 10 and 12, developed in a similar and uniform way, until approximately the 37th day. The great particularity of these cultures occurred, from this period on. Cultures 10 and 12 started to grow, evidently and quite significantly, evolving more than any other culture, in any period. Until the end of the project, this enormous and relevant evolution was proved, which allowed them to reach very high values at the end of the analysis period. Another factor evidenced in these cultures was the formation of fungi, which, consequently, led to the appearance of insects.

3.5. Preliminary analysis of seaweed extracts

Table 5 shows the results obtained.

Table 4. a) total phenolic ± SD (in mgAG/L), b) total florotanin ± SD (in mgFG/L) content and c) % florotanins in relation to total phenolic content in the Brown, Green and Red seaweed extracts analysed and comparison with the commercial extract (Profertil)

	a	b	c
B	107 ± 9,3	2,94 ± 2,75	2,75
G	90,4 ± 7,0	n.a.	n.a.
R	107 ± 6,8	n.a.	n.a.
P	13568 ± 1147	297 ± 28,5	2,19

The phenolic values are lower in the case of green algae and about 100 times lower than in the case of commercial extract. No florotanins have been detected in green and red algae, as florotanins only exist in brown algae. The brown algae extract has a similar florotanin ratio to the commercial extract.

The commercial extract has been boiling for 4 hours and Profertil dry extract has 20 % Ascophylum nodosum algae. In foliar fertilization it is recommended to apply in concentrations below 1,2 L Profertil/100 L water. If it is placed in the soil the amount of Profertil should be increased by 25% (about 1,5 L Profertil/100 L of water).

Considering the results obtained, about 1 L of Profertil's solution can be prepared to be placed in the vessels by diluting 15 mL of extract in water. The extracts obtained from the algae can be placed directly in the pots without dilution.

To prepare an extract with 20 % algae in dry weight, a larger quantity of extract can be prepared and dried and then diluted in water to the desired concentration.

These results also indicate to us that the algae used in these experiments are rich in antioxidants that allow good plant growth.

At a later stage the algae used will be characterized in relation to their macro and micronutrients with impact on plant growth and development. Beans obtained from these experiments will also be analyzed to see if their nutritional value is affected using natural fertilizers.

4. Discussion

Through the study of (Figs. 12-18) we were able to validate the hypothesis imposed at the beginning of the report, in which we believed that the use of algae in agriculture, in this case by using them directly on the land, would favour crops and provide more growth, using resources that would once have been wasted.

The comparison between the different types of algae implemented in the crops and the evolution observed in the bean growers of the control group, showed the significant effect on the growth and yield of the bean growers subject to algae implantation in their crops.

Our research, supported by previous research with the same bean (Phaseolus vulgaris) [2], allows us not only to say that the use of algae in agriculture is an environmentally sustainable alternative and within everyone's reach (mainly in Portugal, due to our extensive coastline), but also to say that it also provides an optimized and faster growth as with chemical fertilizers.

At present, the use of natural products made from algae as an alternative to the use of inorganic fertilizers has gained relevance and importance. Recent studies show that algae based fertilisers can compete with other types of fertiliser, and in return are more cost-effective.

Bearing in mind the current situation of our world (COVID19), our work is unfinished and some of the studies that we aimed to do (eg: measurement of organic matter and the nutrients present in the soil of each group) weren't completed. In spit of this, we plan to finish these studies as soon as possible because we think this is a promising work that can have a remarkable impact on the planet.

5. Acknowledgements

We would like to thank Dr Cristina Santos from ISEP for all the information and resources that were kindly handed to us, and for the supervision.

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Bioinformatics, a Befitting Tool for *e*-Learning: Potential and Constrains according Teachers' Perceptions

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Abstract. Bioinformatics tools are suitable didactic instruments to combine updated knowledge with spotlight teaching strategies, e.g., *e*-learning. This study depicts the status of computational resources at schools pinpointed by teachers. Frequently, computers are obsolete, with outdated software, not connected to internet, their number is limited and often placed in areas not primarily aimed for teaching (schools' libraries and/or classrooms for professional/technical programs). These are key limitations preventing the implementation of digital-based activities in classrooms. This reality calls for the need to provide schools with updated informatics resources and fast internet connection to scaffold top-notch learning.

Keywords. Bioinformatics, *e*-Learning, Informatics at School, Teacher Professional Development.

1. Introduction

Computational resources and biological research are strongly connected [1-3]. Nowadays, every biology laboratory has computers with robust internet access to perform bioinformatics analysis [4-5]. In this regard and trying to adequate modern teaching practices to the new developments in biological research, several initiatives have been implemented to integrate bioinformatics-based approaches as an educational strategy [6-9]. In this scope, a portfolio of bioinformatics activities is available for the educational community to approach scientific issues such as antibiotic resistance, genetics, food preservation or evolution [10-13].

Recognizing the key role of teachers in this process, research institutions, universities, policy makers and teachers training programs, need to focus their interventions in helping teachers to implement bioinformatics in their classes [14-17].

Several studies were carried out to diagnose teachers' perceptions about bioinformatics integration in middle and high school curricula [17-20]. Teachers revealed to be interested in bioinformatics and recognized the importance of its incorporation in the curricula. However, from these studies was not clear the impact of the availability of computational resources at schools, namely computers and internet access. This study is a diagnostic of in-service teachers' perceptions about the accessibility of computational resources at schools to promote digital-based teaching and learning approaches in general, and to implement bioinformatics activities in particular.

1.1 Study Context

In a previous study, we diagnose teachers' perceptions about bioinformatics and identify the constrains for bioinformatics integration in middle and high schools [20]. In fact, Martins *et al.* [20] showed that teachers were interested in bioinformatics as a scientific area and as a didactic resource. Teachers revealed to be acquainted with bioinformatics definition, well-aware that computer and consistent internet access is required for data mining of biological datasets to retrieve meaningful information. Alongside with teachers' need of further training to boost their confidence to carry out bioinformatics-based interventions [20], it is urgent to revise middle and high school curricula to fuel an effective integration of bioinformatics in teaching practices, which is in line with other studies [6-7,16-19].

When in-service teachers were asked about the informatics readiness of their schools to promote bioinformatics-based approaches in their teaching practices, the majority admitted that their schools have the necessary conditions to implement bioinformatics-based approaches. Despite this, participants pointed out as one of the main constrains the poor internet connection and lack of computers [20].

The importance of clarifying these testimonials was reinforced particularly taking into account the recent need to rapidly implement *e*-learning strategies as a

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consequence of the compulsory containment due to COVID-19 pandemic [21-23]. To fully investigate the reason why teachers acknowledge that although schools have the resources (i.e. computers and internet) these are unsuitable to implement bioinformatics activities, we carried out an inquire to 37 Biology teachers who attended a bioinformatics workshop for science teachers [24].

To tackle this, two research questions were raised:

- How well are Portuguese middle and high schools prepared to implement bioinformatics in the classroom?
- Is the informatics equipment available at schools, updated and accessible for all teachers and at any time, *i.e.*, do schools have the equipment available to teachers and ready to be used in the classroom?

2. Methods
2.1. Participants

This research focus on a group of teachers who attended a training workshop in bioinformatics "*From DNA to Genes and to Comparative Genomics: Bioinformatics in the Classroom*". This four-hours workshop occurred in Lisboa in the context of an annual international meeting for teachers [24]. This group consisted of 37 Biology teachers from 28 schools (26 public and 2 private) from 8 different regions, mainly urban areas, being 78.40% of the participants teaching at schools in Lisboa and Setúbal which are built-up areas with a high population density.

Eight of the 37 teachers hold a MSc degree. One teacher holds a PhD degree. Participants have an average of 25.44 ± 7.75 years of teaching experience. At the moment of the workshop, 12 teachers taught at middle school level (students between 12-15 years old), 12 taught at high school level (students between 16-18 years old) and 12 taught both middle and high school levels. One participant did not fill in this information.

2.2. Materials
2.2.1. The Workshop

The workshop "*From DNA to Genes and to Comparative Genomics: Bioinformatics in the Classroom*" was designed and implemented for the first time in 2018 under the scope of the V International meeting for teachers of Casa das Ciências [25]. This workshop is aimed to explore with teachers the potential of bioinformatics as a didactic resource. Following specifically designed guidelines [11], teachers are guided to explore four bioinformatics tools in order to data mining a DNA sequence focusing on identifying genes and determine the putative functions of their products. Additionally, using bioinformatics resources of comparative genomics, the presence of certain genes in different taxonomic groups is also analysed in order to infer evolutionary relationships. This holistic approach contributes to understand basic notions of genomics, genes, genomes and proteins and, adding to this, introduces genomics-related key concepts such as Open Reading Frame (ORF), Basic Local Alignment Tool (BLAST) or synteny [26].

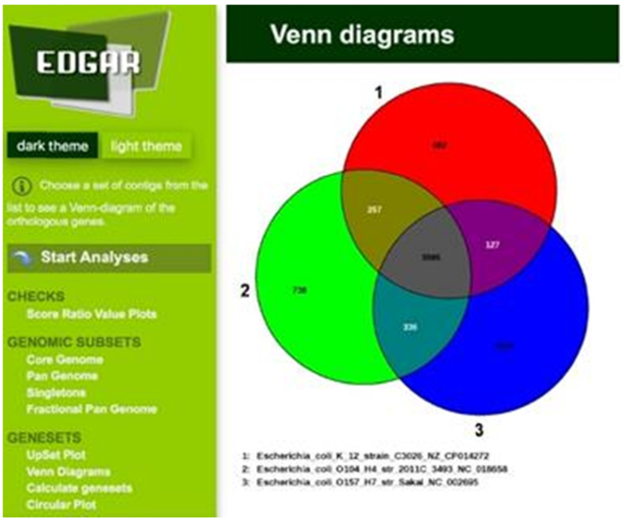


Figure 1. Genome comparison between three strains of *Escherichia coli* using a Venn Diagram to identify the core genome, pan genome and accessory genome

In 2019, a reedition of the workshop was considered and performed during the VI International meeting for teachers of Casa das Ciências [24]. The workshop was updated to include further resources. Efficient Database framework for comparative Genome Analyses using BLAST score Ratios (EDGAR) platform was added in the workflow of the workshop to run genome comparisons [27].

The activity was intended to identify, among up to five bacterial strains, the set of homologous and specific genes of each strain using the Venn Diagram functionality of EDGAR (Fig. 1). Based on the results obtained, notions of core genome, pan genome and accessory genome are discussed. Circular Plots and the Nucleotide Identity Average matrix (ANI) (Fig. 2) are analysed from a comparative genomics perspective. EDGAR functionality for the creation of phylogenetic trees is also explored.

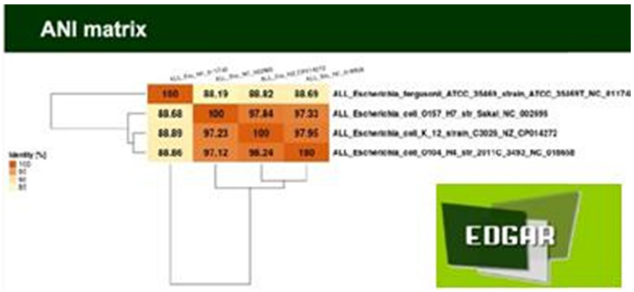


Figure 2. Genome comparison between a set of three strains of *Escherichia coli* and one strain of *Escherichia fergusonii* using an ANI matrix to identify genomes that belong to the same bacteria species (>95% according to [28])

All the exercises proposed in the workshop privileged simple, intuitive and user-friendly tools. Adding to this, the graphic interface of the outputs obtained at EDGAR are appealing and empower analytical skills of data interpretation through graphs and/or tables.

2.2.2. The Questionnaire

The questionnaire (Fig. 3), developed in our previous study [20], was clustered in two dimensions: teachers perceived knowledge on bioinformatics (Q1, Q2, Q3, Q4, Q5, Q6, Q7, Q9, Q12, Q13, Q14, Q15, Q16) and in-service teachers' perceptions about the computational and internet resources available at their schools to implement bioinformatics-based activities (Q8, Q10, Q11).

These two dimensions aimed to know if the participants are acquainted with the definition and scope of bioinformatics, and to collect data on their perceptions of school readiness to implement bioinformatics as a didactic tool.

The questionnaire also included an initial section for demographic characterization of the group and three additional items to assess teachers' opinions about the questionnaire itself.

Teachers' perceived knowledge on bioinformatics	**Q1:** What is *Bioinformatics* for you? **Q2:** Bioinformatics-based activities are more suitable to be framed: **(a)** in the Biology curricula; **(b)** in the Information and Communication Technology (ICT) curricula; or **(c)** in both Biology and ICT curricula. **Q3:** Rate your interest on Bioinformatics: 1 (*Not interested at all*) - 5 (*Very interested*) **Q4:** Rate your perception of knowledge on bioinformatics: **Q4.1:** Before the workshop: 1 (*Insufficient*) - 5 (*High*); **Q4.2:** After the workshop: 1 (*Insufficient*) - 5 (*High*) Rate the importance … 1 (*Not important at all*) - 5 (*Very important*): **Q5:** … of bioinformatics for research and scientific advances; **Q6:** … of integrating bioinformatics activities in elementary education; **Q7:** … of integrating bioinformatics activities in secondary education. **Q9:** Have you explored bioinformatics tools by yourself in order to implement bioinformatics-based activities in your classes? *Yes* __ *No* __ **Q9.1:** If so, did you implement the explored resources in the classroom? *Yes* __ *No* __ **Q9.1.1:** If not, please indicate the main reasons why you do not implement the resources in the classroom. **Q12:** Please rate your agreement with the following sentences; 1 (*I totally disagree*) – 5 (*I totally agree*): **Q12.1:** My academic background gave me the tools to teach using bioinformatics tools; **Q12.2:** My professional training gives me the tools to teach using bioinformatics tools; **Q12.3:** Planning bioinformatics-based activities takes more time and resources than other practical activities; **Q12.4:** Implementing bioinformatics-based activities in the classroom is more time-consuming than other activities; **Q12.5:** The opportunities to attend training courses on bioinformatics for teachers are still scarce. **Q13:** Indicate the main reasons that motivated you to attend this workshop. **Q14:** List the main difficulties that you found while performing the activities proposed in this workshop. **Q15:** Please make suggestion(s) for improvements that you consider important concerning the activities of the workshop you attended. **Q16:** Would you be interested in attending more training courses/workshops promoted by research groups which use bioinformatics tools in their lab routines? *Yes* __ *No* __
Computational and internet resources at schools	**Q8:** Do you frequently use computers/tablets to explore online resources in practical classes? *Yes* __ *No* __ **Q8.1:** If so, please indicate how frequently in a school year do you use computers/tablets to explore online resources in practical classes: 1 (*Never*) – 5 (*Very often*) **Q8.2:** If not, please indicate the main reason(s) why you do not frequently use computers/tablets to explore online resources in practical classes. **Q10:** List the main constrains that can arise when implementing bioinformatics-based activities in the classroom. **Q11:** Do you think that your school/institution has the needed conditions (computers and internet access) to explore bioinformatics in the classroom? *Yes* __ *No* __

Figure 3. Questionnaire used in the study

2.3. Data Collection

Teachers voluntarily enrolled in the workshop which included a theoretical part and a practice component during which teachers co-worked in teams of two or three participants.

After the workshop all the participants were informed about the main aim of this study and, with their consent, the questionnaire (Fig. 3) was applied.

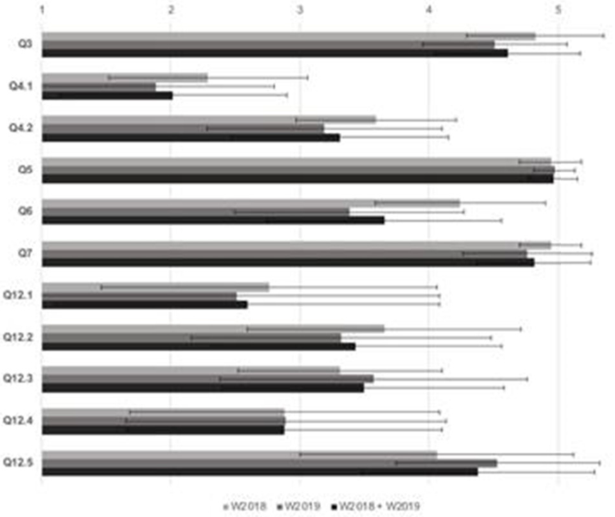
2.4. Data Analyses

Descriptive and inferential statistical analysis were performed for quantitative data [29]. For qualitative data, a thematic content analysis of the participants' responses to open-ended questions was carried out [30-31].

3. Results and Discussion

3.1. Teachers' perceived knowledge on bioinformatics

The participant teachers of this study revealed to be aware of the main scope of bioinformatics field (Q1). The majority (54.29%) of the participants defined bioinformatics according to the etymology of the word, which is a one-dimensional definition referring to the application of information technology to biology. However, data analysis and data storage were also mentioned. In this regard, it can be considered that participants knew what bioinformatics is, recognized its importance for scientific research (Q5) and revealed to be highly interested in this scientific topic (Q3) (Fig. 4).



**Statistically significant differences between groups.*
***Statistically significant differences before and after the workshop*

Figure 4. Answers given by participants according to a Likert Scale (Range 1 to 5). Bars represent the mean value and the error bars refer to the standard deviation

Participants (51.35%) agreed that bioinformatics can be framed in Biology classes and understand its potential as a teaching and learning topic (Q2). Interestingly, teachers added that bioinformatics could also be explored both in Biology classes and Information and Communications Technology (ICT) classes. The reasoning is that bioinformatics can be framed in the Biology curricula, but it can also be used to promote interdisciplinary based pedagogies. These approaches are strongly encouraged according to up-to-date science teaching standards, such as the Next Generation Science Standards [32], especially in the Science, Technology, Engineering and Mathematics (STEM) field [33-36]. This result reveals that participants of the study were aware of the adequacy of bioinformatics for Biology classes, but also went further and showed to understand the follow-up potentialities of this integration for other curricular areas. It is important to emphasize that participants were science teachers and consequently do not teach Information and Communications Technology (ICT) classes.

There was a general agreement among participants that bioinformatics-based activities are adequate for high school level (Q7) (Fig. 4). However, teachers inquired in this study, showed concerns about the importance of integrating bioinformatics-approaches in middle school level (Q6) (Fig. 4). This result is lower and statistically significant ($p<0.01$) when compared to the results obtained among the teachers who participated in the workshop edition of 2018 that more confidently agree on the importance of integrating bioinformatics in middle school [20]. This difference can be due to the exercises explored in workshop edition of 2019 that broaden the range of platforms explored when compared with the first edition of the workshop. This could have contributed to teachers better understand how they integrate bioinformatics in high school classes and, at the same time, feel that all bioinformatics tools are too complex for middle school level. When designing a new workshop other platforms can be explored such as Pathogen Modeling Program (PMP) [37] or Combined Database for Predictive Microbiology – ComBase [38-39] that showed to be compatible with middle school level to explore, for example, food preservation techniques [12,40].

Not surprising, and consolidating the data obtained in the first study [20], the majority (70.27%) of participants admitted that they have never explored bioinformatics tools by themselves (Q9) and most of them (72.73%) revealed to have actually implemented the bioinformatics tools in their classes (Q9.1). Teachers confirmed the perception that bioinformatics-based strategies are more time consuming and requires more resources than other type of practical classes (Q12.3) (Fig. 4).

Furthermore, they feel that their academic background and professional training is not sufficient for them to confidently explore bioinformatics tools within a didactic context (Q9.1.1; Q12.1; Q12.2) (Fig. 4).

Concerning the perceived background of teachers on bioinformatics, there is a statistically significant difference between teachers' answers ($p<0.01$) before and after the workshop (Q4.1; Q4.2) (Fig. 4). Teachers clearly agree that the workshop contributed to deeper their background on bioinformatics. In fact, workshop participants admitted that their background on bioinformatics improved after the workshop, boosting their confidence to explore bioinformatics in the classroom. Interestingly, the reason that motivated around half (48.65%) of the teachers to participate in the workshop (Q13) was to gain further training, corroborating the previous study [20].

These results were also obtained in the assessment of other training interventions on bioinformatics for teachers and corroborate the need of teachers update on this field (Q12.5.; Q16) [6-7,16,18-20] (Fig. 4).

Regarding the workshop itself (Q14, Q15), most of the participants did not mention any improvements on the bioinformatics-based activities explored at the session. The ones who did, claimed for a longer workshop (more than 4 hours) or a 25 hours training course to broaden their perspectives on the potential of bioinformatics-based tools adapted to different school levels. Adding to this, informally teachers express their will to access scientific counselling to implement bioinformatics in their classes all over the school year.

3.2. Teachers' perceptions about the computational and internet resources available at schools to implement bioinformatics-based activities

According to the first dimension of questions, regarding teachers' perceived knowledge on bioinformatics, it is legitim to assume that participants were aware of the main aim of bioinformatics, of its potential as an educational resource, and that teachers were interested and motivated to learn more about this scientific field.

These participants were also conscious of what is needed in order to implement bioinformatics in their classes. Accordingly, they are able to have a critical and a helpful perception about the possibilities and the constrains to integrate bioinformatics in their different school realities.

The second dimension of questions aimed to diagnose in-service teachers' perceptions about the computational and internet resources available at their schools for bioinformatics-based activities.

More than 90% of the participants admitted using computers/tablets to explore digital resources in their classes (Q8) which indicates that teachers are used to take advantage of technologies in their classes (Q8.1).

When asked specifically about the readiness of their institutions to develop bioinformatics activities, the majority (62.16%) of the participants assumed that the school/institutions where they were teaching did not have the necessary conditions to integrate bioinformatics-based strategies (Q11). Although this data may apparently contradict what teachers mentioned in the first edition of the workshop [20], the evidence gathered in the current study suggests that teachers understood that the existence of computers and internet does not ensure by itself the possibility to carry out bioinformatics exercises.

Other constrains pointed out by teachers impairing the implementation of bioinformatics activities in the classroom (Q10) are related with: logistic constrains (75%); training needs (8.33%); literacy (perceived knowledge and skills) (13.89%); and student's performance (2.78%).

Regarding the logistics constrains, teachers mainly mentioned that computers at school are obsolete, not easy to access and internet connection is often poor (Fig. 5). Around 10% of teachers reported informatics-based resources understood as computers and internet limitations.

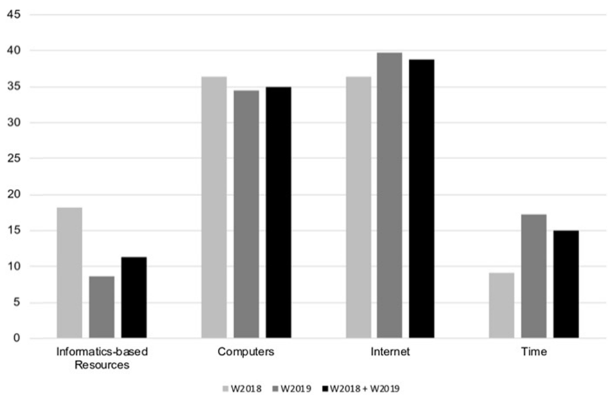


Figure 5. Main logistics constrains to implement bioinformatics in the classroom from an in-service teacher perspective (Q10)

Participant teachers who referred not to use technological equipment in their classrooms (Q8.2) mentioned reasons such as: "*Lack of computers and time-consuming administrative procedures to get access to a classroom equipped with computers*"; "*Difficulties to* *access the internet*" and "*Lack of computers in the schools and so teachers have to ask students to bring their personal computers*". These statements suggest that school computers are not really available for teaching, being frequently allocated to no teaching activities (school libraries and/or classrooms for professional/technical programs).

Furthermore, it is important to highlight that these results are likely biased since the inquired teachers serve in central schools located in large urban areas, in which is expected that informatics resources (i.e. computers and internet connection) are more likely accessible comparatively with non-urban schools. This suggests an inequity between urban and non-urban schools regarding the integration of bioinformatics in learning activities.

A possibility to overcome the lack of computers at school or to avoid using obsolete computers is inviting students to use their own. However, between 2009 and 2012, the percentage of students who reported having a least one computer or more at home in Portugal is lower than OECD average [41]. This reality become recently obvious with the *e*-learning strategies implemented due to COVID-19 pandemic [42-43].

Computers are now a key tool for teaching and learning and more than ever their role as a didactic instrument, that can connect students and teachers, is highlighted [44-46]. In this regard, governments should develop programs and create funding opportunities in order to make possible for each student to have a computer at home.

Alternatively, personal smartphones may be used to perform simple and accessible tasks that do not require a computer as for instance to introduce Phyton to answer biological questions [47], or explore biodiversity using deep-learning platforms such as the iNaturalist® [48-49].

Regarding limitations related with internet access, teachers stated: "*It is present at school, but it is not working in an efficient way*". In fact, among the schools sampled, although internet connection is available, its efficiency can only provide basic tasks, such as email or to access digital resources for teachers, thus not suitable for bioinformatics analysis. In public schools, the internet network is provided by the ministry of education and it has a limited access (both concerning speed and number of computers connected with). This means that even if the students bring their personal computers, a request for access a robust wireless connection has to be made to execute bioinformatics exercises. In this context, improving internet access to both teachers and students within the schools needs to be urgently considered by educational stakeholders.

Finally, it is worthy mention that technical support is important to ensure that informatics equipment is set to operate normally. Although this aspect was not mentioned by teachers, it was inferred from informal discussions at the workshop "*From DNA to Genes and to Comparative Genomics: Bioinformatics in the Classroom*" (2019). Furthermore, interdisciplinarity and collaboration between Biology teachers and ICT teachers during the activities could help to address problems related with computers and internet connection.

4. Conclusion

Generally, teachers acknowledged that their schools are equipped with computers and internet connection [20]. This may suggest that resources would be available to integrate bioinformatics in teaching practices. However, in the present study teachers admitted that often computers are obsolete with outdated software, poor internet connection and inaccessible for teaching.

Focusing on these considerations the active use of educational web-based resources, in which bioinformatics can have a key role, calls for a digital reform of schools as encouraged by Next Generation Science Standards (NGSS) [32].

5. Acknowledgements

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STEM Activity: Saving Home

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Abstract. The aim of this research is to determine how the thermal insulation subject at the 7th grade of Science course can be applied according to STEM learning approach. The Energy Saving Home STEM event, developed by the researchers, was implemented in the 7 / B class of 27 students in the Ova Küme Evleri secondary school of Salihli district. The research was designed in the form of action research. Opinions of students and researchers were taken regarding the application. Content analysis was used in the analysis of the qualitative data obtained in the research. As a result of the research, it was found that it is possible to organize STEM learning activities, students cooperated without getting bored during the application, used their problem-solving skills and gained the attainment of thermal insulation.

Keywords. Problem Solving, STEM, Thermal İnsulation.

1. Introduction

STEM education provides multi-dimensional learning by bringing together different disciplines and providing a link between them [1]. STEM education, which is a multidisciplinary approach that aims to educate students with a holistic perspective on science, technology, engineering and mathematics, requires that these disciplines are used independently and together in the solution of daily life problems [2]. STEM education approach in primary education can increase students' interests, achievements and motivations especially with issues involving real world problems [3]. One of the real-world problems is the thermal insulation of the houses to reduce the use of fossil fuels. When conducting thermal insulation, it should be known what insulating materials that heat preservation will be best. Before starting the activity, students in the class were divided into groups of 5. In the distribution of professions such as engineers, architects and entrepreneurs, the group tried to choose the people who can perform the profession they have determined by making the most appropriate decision. In this study, the Energy Saving Home STEM activity prepared for the students to work in collaboration and find solutions to the thermal insulation which is a real-world problem will be presented.

2. STEM Activity, Energy Saving Home

2.1. Attainments

- Science Course: From the heat-temperature relationship experiences, students infer that the most prominent effect of heat on substances is warming-cooling.
- Maths: By modelling different rectangular prisms with given volume measures, students infer that the volume is the multiplication of floor area and height.
- Engineering: For the design idea s/he developed for the solution of the problem, students conclude how well s/he can meet the criteria and constraints of the problem.
- Technology: Students conclude that it should be the tools to be used in the design will give the best thermal insulation.

2.2. Problem

People on earth live in homes to shelter. People use either fossil fuels or electrical energy to heat their homes on cold days. Making more use of solar energy will save these energy sources. The energy sources we use will eventually be exhausted. We must save energy in order to leave enough energy sources for future generations. For this reason, can you design a house that can protect the heat of our houses, which are the areas we live in, for a long time?

2.3. Aim of the Activity

The purpose of this event is to design and build a house model using solar heating techniques to maintain its heat as long as possible.

2.4. Information on Thermal Insulation

In some cases, we want to protect the heat and in some cases to be protected from its harmful effects. For example, while we try to maintain the ambient temperature in winter, we try to prevent the ambient heat in summer. In such cases, we use heat insulating materials with very little heat transfer. The purpose of thermal insulation is to prevent heat exchange. In other words, we try to prevent the ambient heat from coming out or entering the heat from outside. Thermal insulation is provided by covering the areas where the indoor and outdoor environments directly contact with heat insulating materials. For example, the exterior surfaces of the buildings are covered with heat insulating materials for thermal insulation in buildings. Any process that is done to protect the heat of the materials by preventing heat exchange is called thermal insulation. Thermal insulating materials used for thermal insulation are called insulation materials. Insulation materials are made of heat insulating materials that do not conduct heat well. Wood, plastic, glass wool, rock wool, plastic foam, tar, bakelite, air gap are used as an insulating material. The best example of the use of air gap is the air between the double glasses.

2.5. Design

According to the question "How can I provide the best heat preservation at home?" students designed the house where the thermal insulation will be the best. While designing, students clearly thought how to reach their intentions by turning their ideas into the drawing; for example, to put the window of the house towards the south. The students proposed different ideas about their problems as they could produce. With the design drawing, the starting point of the solution started. I noted that the materials may not work as they expected, that engineers may often have to make a few changes to their original designs to be successful. Each team member drew at least one design idea. (The groups were given design drawing paper).

2.6. Tools

Foam, thin transparent plastic, thin rubber, black background cardboard, adhesive, abeslang, utility knife, scissors, silicone gun.

2.7. Product Development

Students, in their applications, created their prototypes, taking into account the volume of the house, its positioning, the direction of windows and doors, and which materials for insulation should be used in which parts of the house. They marked and cut a rectangular base 15 x 10 in size from the foams. They formed the doors and claws on the foams in any shape and size they wanted (Fig. 1). They designed the house in the optimal volume for heat preservation. At this stage, they completed their mathematics attainment. They applied the volume formula when creating the house model with the rectangular prism.

Figure 1. Measuring insulation material (foam) according to the wall size of the house

Figure 2. Measuring insulation material (wood) according to the floor size of the house

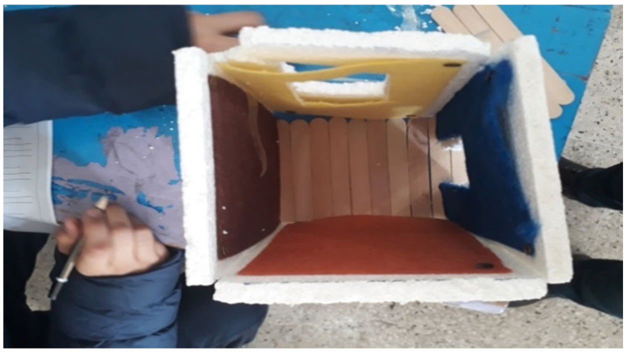

Figure 3. Top view of the house

The material to be used for thermal insulation varies according to according to the region. For example, glass wool on the roofs, wood (Fig. 2) on the floors, plastic foam on the walls, double-glazed systems are used on the windows. For this reason, wood and rubber and foam materials were used on the floor, ceiling and walls of the house.

Abeslang rods were brought side by side and glued to the base with silicone (Fig. 2). Its dimensions were measured in accordance with the base dimensions.

They cut rubber in the same size of the foams. With the help of adhesive, they adhered rubbers to the inner surface and ceiling of the foams. They combined the rectangular foam edges into a rectangular prism with the help of a fastener. They taped across the cellophane to prevent the edges of the prism from getting air (Fig. 3).

They covered the walls, ceiling and floor of the house with suitable insulation materials and created the house prototype (Fig. 4). Finally, they covered the exterior with colored cardboards to make the house visually beautiful (Fig. 5).

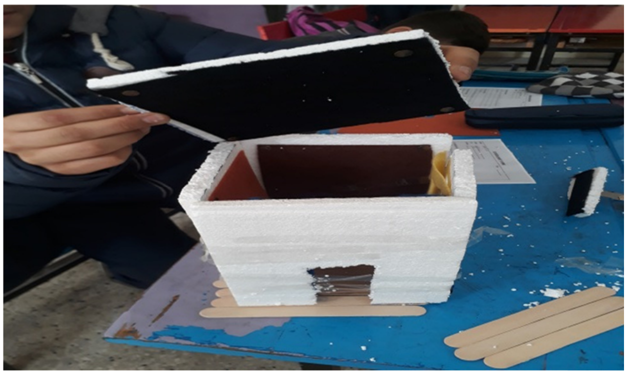

Figure 4. Insulated house

Figure 5. Evin dış cephesi yapımı

2.8. Testing

The regions where the heat loss is highest in the houses are roof, windows, doors and walls. In order to prevent losses here, these sections should be heat insulated. At the same time, the direction of the house designed is also important to provide heat conservation. Windows and doors should be designed to see the sun. Students tested their home models according to this feature of heat preservation. The stages of this testing process are given below.

Figure 6. Wind receiving house

Figure 7. Degree after wind breeze

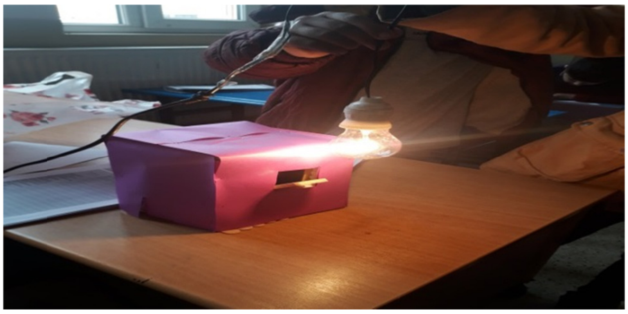

Figure 8. House receiving sunlight

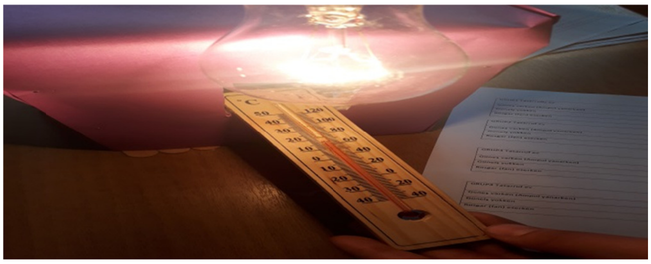

Figure 9. Degree of the House receiving sunlight

In the first stage, they simulated the wind breeze (Fig. 6) and recorded the temperature with the wind breeze (dryer). This part of the test will show how well your model house retains heat.

The temperature of the house with its window and door in the direction where the wind blows was measured as 8 degrees (Fig. 7).

In the second stage, they placed a thermometer in their prototype houses and illuminated their houses with a large bulb (representing the sun) at an angle of 45 degrees for 8 minutes (Fig. 8). During this time, they recorded the temperature inside the house to see how warm the house was.

The door and window of the house facing the sun were seen to benefit more from solar energy and the temperature of the house was measured as 14 degrees.

3. Findings
3.1. Student Opinions

After the activity, opinions regarding the application were collected from the students. These data were analyzed by content analysis method. Themes were created in line with the answers received from the questions. When students give more than one answer to a question, these answers are added to the relevant themes. Students' opinions about the activity are given in the table.

According to Table 1, students found the STEM activity beneficial because they understood thermal insulation, were able to design, find solutions to real problems, develop manual skills and are referred to thinking. They stated that collaboration, problem solving, prototyping, designing and communicating with team members are positive features. Some students stated that they had difficulty in creating prototypes, raising time, working with team members and design drawings. Nearly all of the class found the STEM activity positive and stated that they wanted it to be applied in other lessons.

3.2. Researcher Opinions

According to the opinion of the researcher, the Energy Saving Home STEM activity implemented can be applied in the form of STEM activity, the activity is completed in the desired time and features, students complete their studies in cooperation without getting bored in the lesson.

Table 1. Student Opinions on STEM Activity

Questions	Opinions	N
Do you think the activity you have applied has benefits for you? In what areas?	In collaboration	12
	Respect different ideas	5
	To be able to design	19
	Finding solutions to real problems	14
	How can I insulate	21
	The development of my dexterity	9
	in thinking	7
What were your favorite aspects in the activities you applied?	Design	12
	Finding a solution to the problem	15
	Collaborate	23
	Prototyping	17
	Communications	7
What was difficulty in this event? Why is that?	In drawing	3
	In prototyping	4
	In raising time	2
	Working with the group	5
Would you like to reapply such activities on other lessons or topics?	Yes	25
	No	2

4. Results

Most of the teachers practice heat-insulated home activities in their classrooms. This event is not a new event. The specificity of the Energy Saving Home STEM activity in this study is to determine in which parts of the house the insulating materials are used to create the thermal insulation and to decide the direction of the house in order to provide the best heat protection.

According to the opinions of students and researchers in this activity,

- The students worked in groups taking responsibility. It was observed that they collaborate with teamwork and in this way, they also use their communication skills.
- To solve the problem, students were prompted to think and team members envisaged different ideas. While trying to find the best idea, they respected each other's ideas.
- Hand skills are improved when designing and making a house model.
- It was observed that some students had difficulties in design drawing and model

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building. It has been determined that some students experience time problems compared to other team members.

- Researchers stated that there was no problem in implementing STEM activity and stated that it served for the purpose of the activity.

According to the result of the research, STEM activity served for the purpose of the Science course.

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Production of Magnetic Chitosan Nanoparticles

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Abstract. Chitosan is a natural biopolymer, cationic, biodegradable, non-toxic and, therefore, biocompatible. The Magnetic Nanoparticles currently have extensive applications, namely in nanomedicine, bioengineering, magnetic drug delivery systems (MDDSs), biosensors and in improving the quality of medical diagnostic images such as Nuclear Magnetic Resonance imaging (NMR). The importance of biomaterials for the sustainability of the planet is currently a given and inevitable fact and that's also the main theme of this project. Thus, in this project chitosan was synthesized from the chitin of the shrimp shell, and later were developed ferromagnetic particles of chitosan. The functionality of the chitosan nanoparticles was tested in a simple experiment, in which the MNP adsorption capacity for the methylene blue dye was evaluated.

Keywords. Adsorption, Biomaterials, Fourier-Transform Infrared Spectroscopy, Sustainability.

1. Introduction

Chitosan is obtained from the chitin present in the shells of most crustaceans. It is a cationic biopolymer, biodegradable, with low toxicity and, therefore, biocompatible. These characteristics and the fact that it is a natural material, of low cost and abundant, made it chosen as one of the main materials for our project.

This product is obtained from the deacetylation of chitin and the subsequent presence of the amine groups makes it highly reactive and, consequently, there is a better adhesion with other materials. It can be used in several areas namely in the pharmaceutical and biomedical sciences. In addition, the shells of crustaceans are waste that are neglected by the industry and their integration in experiences like this ends up highlighting the importance of biomaterials, associated with the concept of sustainability.

Magnetic nanoparticles currently have extensive applications, namely in the nanomedicine, bioengineering, magnetic drug delivery systems (MDDSs), biosensors and improving the quality of medical diagnostic images, such as nuclear magnetic resonance (NMR).

In this project, we synthesize chitosan from the chitin of the shrimp shell for the development of magnetic chitosan coated nanoparticles. From these nanoparticles, it is possible to use them in several ways: it can be possible to test its adsorption properties using Ultraviolet-Visible spectroscopy (UV-VIS) and to characterize the chitosan by Fourier-transform Infrared Spectroscopy (FTIR).

One of the characteristics of these chitosan nanoparticles is their ability to adsorption for various anionic or cationic dyes. So, possibly, they could be used for cleaning waters contaminated by these dyes, such as removing from methylene blue from pharmaceutical wastewater effectively.

In this project, we focused on cleaning water dyes due to the timeless importance that this resource represents.

2. Methodology

Initially, the shrimp shells were washed to remove protein residues and other types of impurities, dried in an oven at 80ºC overnight and crushed until small particles were obtained. 15 grams of that powder resulting from the shrimp shells were weighed and 250 mL of the 2% sodium hydroxide solution was added. This mixture was heated to a temperature of 60-70ºC, with constant stirring and for 1 hour. Subsequently, filtration and washing with deionized water was performed until the pH of the washing water was neutral, that is with pH=7.

Finally, drying took place in the oven at 80ºC overnight. The purpose of this step is to denature and remove proteins present in the exoskeleton.

In a next step, the shrimp shell was transferred to a beaker and 250 mL of 7% HCl solution was added, leaving under constant stirring until the gas (CO_2) release ceased. To verify that the reaction was complete, 10 mL of 7% HCl was added. If no gas is released, filter the chitin and wash the filtrate until the washing water comes out with neutral pH. Drying of the material.

As the calcium carbonate present in the shrimp's exoskeleton was removed, chitin was deacetylated to obtain chitosan. Thus, 100 mL of 50% NaOH solution was added to 2 g of the obtained chitin (heat to 100ºC, under reflux and stir for 5 hours). If there is no reflux equipment, it will be necessary to top up the water volume constantly so that the reaction does not dry out. After completing the reaction, the chitosan was filtered and washed with water and then with ethanol. Drying of the product.

To purify the chitosan, the product was dissolved in a 0.5 mol.dm^{-3} acetic acid solution, allowing to stir for 1 day. Subsequently, insoluble compounds were filtered, discarding them. The NH_4OH solution was added until complete chitosan precipitation, the product was filtered, washed with distilled water until the pH of the washing water was around 7.0, and then washed with ethanol. Drying of the obtained chitosan.

Dissolving 2 g of chitosan in 100 mL of 2% glacial acetic acid solution in a 150 mL beaker made it possible to prepare a chitosan solution.

An important stage of this project was the production of nanoparticles. For this purpose, proceeded: the preparation of 20 mL of a 0.5 mol.dm^{-3} aqueous hydrochloric acid solution; preparing 100 mL of a 1.5 mol.dm^{-3} aqueous sodium hydroxide solution; solubilizing 2.1624 g (8 mmol) of iron (III) chloride hexahydrate in 5 mL of 0.5 mol.dm^{-3} HCl aqueous solution; mixing the two iron salt solutions mentioned above; adding the resulting solution to the aqueous NaOH solution under vigorous stirring for 30 minutes; magnetic separation of the resulting black precipitate and washing twice with 50 mL of deionized water; finally, the dispersion of the precipitate in a stabilizing medium (tetramethylammonium hydroxide solution).

In the next stage, the chitosan ferromagnetic nanoparticles were prepared. For this, 1 g of magnetite nanoparticles were weighed and suspended in 50 mL of deionized water.

Under vigorous stirring, the magnetic nanoparticle solution was added over the acetic chitosan solution. Thereafter it was stirred for 30 minutes. A magnet was placed under the beaker and waited until complete decanting of the compost (around 5 minutes). The supernatant solution was removed with a pipette until approximately 50 mL volume remained and 25 mL of 5.0 mol.dm^{-3} NaOH solution was added slowly.

With a magnet placed under the beaker, the supernatant solution was discarded and the magnetic nanoparticles coated with chitosan thus obtained were washed. It was washed first with deionized water and then with acetone.

Finally, a diluted methylene blue solution (0.2 mg.dm^{-3}) was prepared (solution A0). Then, different mass values of the chitosan nanoparticles were weighed in 3 beakers (0.1 (A1); 0.2 (A2) and 0.3 (A3) grams). Subsequently, each of the masses was added to three methylene blue solutions of equal volume. Samples of each of these beakers and a sample of methylene blue solution were collected in cuvettes in order to test the adsorption properties of the nanoparticles through UV-VIS spectrophotometry at 665 nm. Chitosan was characterized by FTIR.

3. Results

The magnetic chitosan nanoparticles production didn´t led to the exact expected result. Due to the agglomeration of some of these nanoparticles, their dimension become bigger than desired, what make the interaction between nanoparticles and the magnet much more difficult.

In order to solve this issue, an additional filtration process was needed to isolate the smallest nanoparticles. This nanoparticles were suspended in the solution that was previously decanted and due to their smallest dimension, their interaction with the magnet was better (Fig. 1 and 2).

In the final phase of this project, four different samples have been produced: the A0 sample which contained only a solution of Methylene Blue and the A1, A2 and A3 samples that besides containing the same amount of solution of Methylene Blue, also included, respectively, 100, 200 and 300 mg of magnetic chitosan nanoparticles (Table 1).

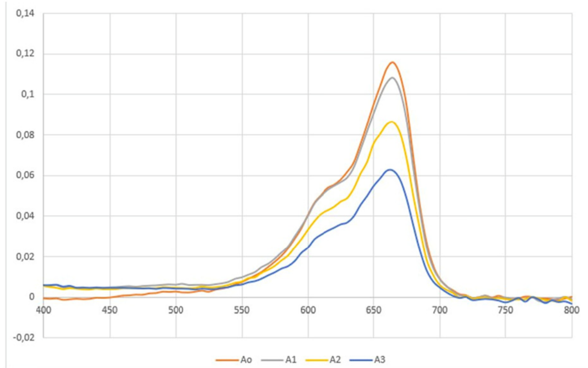
Figure 1. Interaction between nanoparticles and magnet

Figure 2. Interaction between nanoparticles and magnet

Table 1. Experience data table

	mass (Adsorbent) mg	[Adsorbent] g/L	[AM] mg/L	Abs UA
A0	0,0	0,0000	0,2000	0,115714
A1	100,8	1,2600	0,1867	0,107997
A2	200,9	2,5113	0,1491	0,086265
A3	301,5	3,7688	0,1079	0,062429

The Graph 1, obtained by using spectroscopy technique, show us the absorption values of these samples in the UV-VIS radiation. The maximum absorption value is obtained for each sample when the wavelength of the rays is 665 nm, as we can see in the Graph 1. The final results are in line with the expectation as the biggest is the quantity of magnetic chitosan nanoparticles the lowest are the absorption values.



Graph 1. Adsorption spectrum of solutions A0, A1, A2 and A3

Based on the formula (1), using absorption values and molar absorptivity coefficient we were able to calculate the concentration of the solutions and, with formula (2), the absorption values of the samples.

In the second equation (2), q_e represents the adsorption value (mg AM/ g Adsorbent) that we pretend to achieve, C_0 is the concentration of AM (mg/L) in the sample A0, C_e is the concentration of AM (mg/L) in the sample which we are trying to calculate the value of adsorption, m is mass of nanoparticles (mg) and V volume of solution (mL).

$$C = \frac{Abs}{\varepsilon} \tag{1}$$

$$q_e = \left(\frac{C_0 - C_e}{m}\right) V \tag{2}$$

In equation (3) it's possible to calculate the value ε (molar attenuation coefficient) of the AM solution.

$$\varepsilon = \frac{Abs(A_0)}{C_0} \tag{3}$$

The values of Table 2, let us conclude that the biggest the nanoparticles concentration in the solution is, the biggest will be the adsorption values.

It is also very important to mention that the pH also has influence on the adsorption values. In our case we decided to not adjust the pH as it was already very close to 6, value already validated by other studies as the one presenting better absorption by magnetic chitosan nanoparticles.

Table 2. Adsorption obtained values

Sample	Adsorption
A1	0,01056
A2	0,02027
A3	0,02444

4. Conclusions

Through the analysis of absorption spectrum, we could conclude that sample A0, without nanoparticles, has a better absorption at 665 nm than samples A1, A2 and A3. This is related to the fact that nanoparticles absorb the Methylene Blue and, therefore, having a lower absorption. Analyzing the results allow as to conclude that increasing the amount of nanoparticles in the solutions, the absorption values also increase and the concentration of Methylene Blue will drop significantly. This cannot be solely explained by the addition of a solute and consequent reduction of concentration.

Based on adsorption values and the drop of the concentration, we can conclude that these nanoparticles have an efficient adsorption of Methylene Blue, what make them appropriate for remove, for example, pharmaceutical waste from water. Last but not least, we would like to mention that the effects from the pH of the solutions on nanoparticles adsorption or the effect of contact time and initial concentration of Methylene Blue, could have been studied to give more consistency to our project, however due to the actual pandemic situation we decided to perform only FTIR tests.

5. Acknowledgements

We would like to thank *"Departamento de Química e Bioquímica da Faculdade de Ciências da Universidade do Porto"* for their support allowing that part of the experiences were performed in their premises and, Professor Carlos Rocha Gomes, by his support on consulting along the project.

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Nanoinventum: Approaching Nanotechnologies and Science to Primary School

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Abstract. Nanoinventum is a scientific co-creation project, based on disciplines in Science, Technology, Engineering, Arts and Mathematics – STE(A)M – aiming to introduce nanotechnology in primary school. The main objective is to create a model for a nanorobot, based on the knowledge of different scientific topics, such as nanotechnology, matter, atoms and molecules, adapted to the curriculum. The project uses strategies like co-creation, design thinking and concept maps. The project's pedagogical approach works with different areas of the curriculum through didactic demo activities that attract the interest of school pupils and enhance their competences through reasoning, deduction, play and key roles.

Keywords. Nanoinventum, Primary School, Nanotechnology, Nanomaterials, Mind Map.

1. Introduction

While being children, we used to wonder about the falling of leaves or snow, didn't we? As a matter of fact, while wondering about the mechanisms behind nature, children naturally behave in a scientific fashion. The question is, when and how science becomes something we are not interested in anymore? Why do we lose our scientific vocation? Science is a two-sided coin; one of them tells us about the certitude (equations, known facts) and the other, widely more unknown, tells us about vocations, feelings, emotions, dimensions of human life which are usually misrepresented in our classrooms but much closer to the classical scientific spirit that sprouts from the cry of joy "Eureka!" and that nurtures our creative dimension, passionate to apprehend the truth and embedded in the challenging experience of discovering our surroundings. Science, then, becomes a game that tries to understand life by means of experimental activities that children understand as something close and familiar.

The teaching and spreading of new technologies is not an easy task [1] and Nanoscience and Nanotechnology (N&N) are, by no means, no exception; N&N deals with highly complex phenomena, seasoned with a dense and very specific terminology, usually in English. It is mandatory to promote activities that, far from losing conceptual rigorousness, let students and teachers to develop the skills to be able to remain critical in face of the future usages of N&N in daily life. One of the main particularities of teaching N&N is the challenge that sprouts from multidisciplinary (physics, biology, chemistry, engineering,...), as it nourishes from concepts that break the (imaginary) limits between disciplines.

Figure 1. Science as a vocation

Nowadays, youngsters living in developed countries are losing interest in scientific careers [2]. In Spain, scientific vocations are in full retreat; this fact leads as to a main crossroad when it comes to consider the regeneration of scientific critical mass. Willing to deal with this fact, "La Caixa" foundation (and FECYT) engaged a study to evaluate the impact of scientific divulgation initiatives in the promotion of scientific-technological vocations [3]. One of the main conclusions is that these kinds of actions positively affect the number of youngsters interested in pursuing scientific and technological careers. Experts agree with the fact that promoting scientific vocations at all educational levels is an urgent and utterly important enterprise, and that the role of educators in this challenge is paramount. Last PISA report [4] evaluated mathematical, scientific and reading skills. All the Spanish regions participated in the study. In science, Spain (483) scored 6 points below the OCDE average (489) and 10 below the 2015 report.

Undoubtedly, and in order to improve these results, projects oriented to boost the number of scientific vocations and to improve the mean scientific level of population must be engaged. These projects, as is the case of NANOINVENTUM [5], must engage students itself both in the co-creation of materials and contents and in the development of teamwork skills, so as to set the basis of the I+D philosophy sprouting from multidisciplinary.

The main goal of NANOINVENTUM is to introduce the N&N language and tools to the participants, as well as to set up workshops and ready-to-use learning contents for primary school environments. In order to do so, we plan to contact with the different agents implied in N&N communication and dissemination. Knowledge in the fields of of science and technology is paramount to tackle the enormous global challenges we will all face as society in years to come. According to the paper “Movilidad virtual, el reto del aprendizaje de la educación superior en Europa 2020” [6], more than 40% of workplaces will require advanced educational skills. The study claims that scientific divulgation initiatives increase the number of youngsters interested in pursuing scientific or technological careers.

2. The project: Nanotechnology and primary school

Nanoinventum is a scientific co-creation project, based on disciplines in Science, Technology, Engineering, Arts and Mathematics – STE(A)M – aiming to introduce nanotechnology in primary school. The main objective is to create a model for a nanorobot, based on the knowledge of different scientific topics, such as nanotechnology, matter, atoms and molecules, adapted to the curriculum. The project uses strategies like co-creation, design thinking and concept maps.

The project seeks on one hand to involve students in the co-creation of research materials, thus getting to know a new technology for the future, and on the other hand, working together as a team, assimilating work in research and development that is increasingly based on multidisciplinary, which favours interaction with other team members and audiences. The project’s pedagogical approach works with different areas of the curriculum through didactic demo activities that attract the interest of school pupils and enhance their competences through reasoning, deduction, play and key roles.

The project deals with a series of successive activities that are based on a didactic progression map and educational resources, with the aim of obtaining an artefact based on a NANOROBOT that is able to develop an application for the future. Participants must submit a drawing or a model made with recycled materials with brief explanations of their proposals.

Figure 2. Nano robots creations

The first edition of the NANOINVENTUM project was developed and deployed in springtime 2017, in the frame of the Festival Nacional de Nanodivulgación, 10alamenos9 [7]. All along the 2018/19 school term, the project was applied in 5 schools in the area of Barcelona (220 students). 3 schools engaged the first edition of the project (6 primary school groups, 130 students): during this period of time, and by using the NANOINVENTUM webpage [5], 36 different ideas/applications aroused. All of them were published in the NANOINVENTUM webpage and shared in social networks.

2018/19 edition was devised to have a more ambitious scope: the calendar widened so as to better suit the needs of 5 schools that produced 52 different ideas/applications/proposals, periodically published in the NANOINVENTUM webpage and social networks. Then, specialists in scientific divulgation, didactics, development of activities and research in N&N implemented the projects in the classrooms. The project ended with a Scientific Fair in the frame of the Festival Nacional de Nanodivulgación, 10alamenos9, 2019 edition. During the 2019/20 school term, the project was reedited. During November 2019, a training course was implemented and in February 2020 a meeting with teachers took place so as to provide them with the Nano kit NANOEXPLORA [8] and to initiate the classroom work. Results are summarized in [9] and [10].

NANOINVENTUM's main goal is to incorporate science and technology in primary schools. In practical terms, we intend that students to create a model of a nanorobot by using the skills and knowledges acquired during the development of the NANOINVENTUM project. We truly want kids to be familiar with science, to enjoy it, to wake up their love for it with the ultimate goal of feeding their interest for science and to improve their scientific knowledge.

NANOINVENTUM offers a didactic proposal in consecutive steps. First of all, specific training is provided to teachers, which are furnished with didactic and experimental tools (most of them highly innovative) to deal with N&N concepts in the classroom. The consecution of the training process and application in real educative environments results in the generation of didactic charts, written in a collaborative basis between teachers and students, with specific proposals that aim to generate N&N challenges. Final products will be ultimately shown in a scientific fair that will simulate a scientific meeting.

2.1. Phases of the project

The project is divided in a series of consecutive steps:

2.1.1. Training of the teachers

Teachers will participate in a formative session, where the key points of the project will be thoroughly discussed. Theoretical and practical contents will be provided, so as to be straightforwardly implemented in the classroom. This sessions will be held in collaboration with the Centre de Recursos i Innovació Pedagògica de la Generalitat de Catalunya (CESIRE). So as to correctly deploy the activities, didactic charts will be created in the shape of progression maps [11] in order to provide teachers with suitable tools to explain N&N concepts. These charts will include the basic notions to understand the atom, the molecule, the properties of matter, the influence of shape and size, etc.

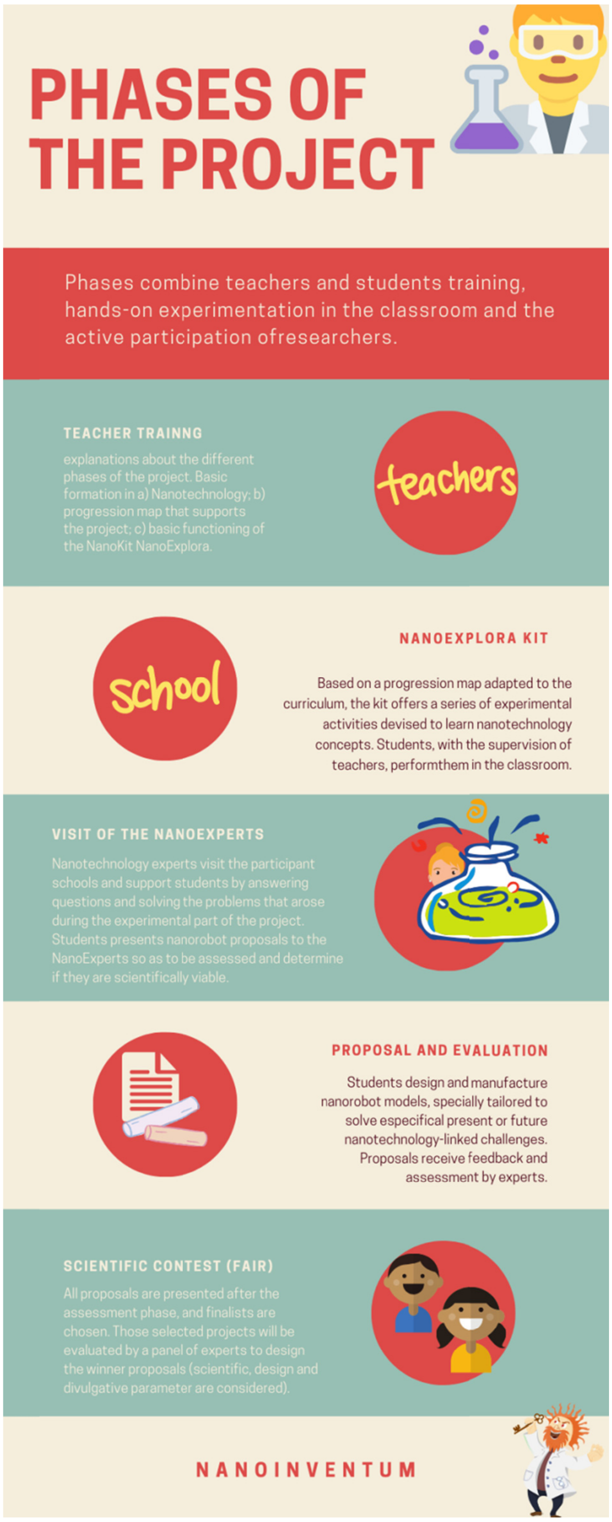

Figure 3. NanoInventum phases

2.1.2. Training of students

The final goal is for the students to create a N&N-based project. To do so, a didactic toolbox called NANOEXPLORA will be used. The toolbox holds the materials to perform 8 different experiments that exemplify the key points of the present project: What is nanotechnology, what is a nanorobot, what are nanomaterials, atoms and molecules and so on. The webpage of the project will be used as a backup and support platform where divulgative materials will be published.

2.1.3. Visit of a so-called NanoExperta (and redaction of the nanorobot charts and documentation)

During 4 days, a range of activities about N&N will be performed and models of the final projects will be manufactured by the students. A divulgator and expert about N&N will accompany the students in a fascinating journey across the Nano world, showing them a selected variety of real projects to exemplify the interdisciplinary and disrupting extent of this discipline. The third phase will be completed with a co-creation workshop that will bring birth to the projects designed by the students.

Multidisciplinary teams of 4 students will be created and each member of the team will hold a specific function (an image of the chart that teams will work on is included). The roles are as follows:

- Team leader (preferably a girl): it coordinates the team and presents the results to the audience. She describes the problem and its main characteristics and exposes the solution proposed by the team.
- Production manager: the production manager designs the model and picks up the correct materials to bring the project to life.
- Research manager: the research manager describes and analyses the problem to be solved and chooses the correct scientific tools to do so.
- Communication manager: the communication manager is in charge of the redaction of a document that summarizes the characteristics of the project itself. Publication of results and evaluation.

2.1.4. Publication of results and evaluation

Each team will present a final project to be assessed and evaluated by Nano experts. The finalists will record a video explaining their proposal. These videos will be published in our YouTube channel.

2.1.5. Presentation of results (Scientific Contest)

The project manager will present the results and the final models. The finalists will be selected, having in mind the following items: scientific proposal quality, innovation degree, communication and design.

NANOINVENTUM tackles the goal of changing the vision that primary school students have about science. After the whole process, they consider that science is something natural and challenging. The project succeeds in waking up interest about science and technology and STEAM disciplines (Science, Technology, Engineering, Art and Mathematics), improving their skills and chances of success in the academic and professional spheres and boosting their will to participate, to innovate and to create by means of artistic activities. The project highly underlines the key role of girls, historically underrepresented in these kinds of disciplines. A whole variety of didactic strategies are deployed, as could be team working, Design Thinking (an innovative methodology) and progression maps. The project deploys a series of consecutive activities based on a didactic chart that underlines the evolution of the project and on educative resources that point towards the manufacturing of a “Nano invention”, designed to fulfil a specific function in the future. The project holds to a set of main guidelines: Education, Divulgation, Ethics, Science and Arts.

Besides, the project aims for a set of secondary goals: a) the development of a logical and independent thinking in students that helps us to take rational decisions, to solve conflicts and to consolidate the necessary skills to tackle daily life situations; b) To Boost scientific vocations in young girls and to encourage them to actively participate in scientific activities; c) To train both students and teachers to high standards of scientific knowledge, while providing educators with tools and activities that promote a dynamic and attractive vision of science and technology as a suitable complement of academic curricula; d) To teach science by performing experiments based on scientific thinking, as a rightful and necessary complement of theoretical contents.

NANOINVENTUM encourages personal and team-based initiative, originality and creativity to respond to problems, develops the paramount “learning to learn” skill, putting into practice experimental experiences, observations and researches that let students to get closer to the world of science, mind storming together and team working, always with a multidisciplinary scope. Besides, NANOINVENTUM promotes:

The ability to think in a logical and independent way, to solve conflicts and to acquire the necessary resources to tackle daily life challenges.

- The processing of daily life knowledge so as to to give it a new significance.
- Opportunities to develop scientific vocations and to promote interests.
- The engagement of young girls in the path of science and technology.
- Team working. Two minds are more than the sum of their individual potentialities.
- Experimentation as a key component of knowledge.
- The fact that we must deal with real problems together and find solutions together. Doing so, and step by step, we learn to apply our creativity to real life, which becomes a key skill for the future.
- The demystification of the Pygmalion effect, where sciences are regarded as difficult but necessary for the development of professional careers.

From a didactic point of view, the project promotes the introduction of scientific-technological concepts by means of the so-called “progression maps”, that is, charts where concepts are introduced in a consecutive and progressive way and in a pre-established logical order. From a scholar point of view, the introduction of concepts will benefit from ludification, game and interpersonal interactions to facilitate the assimilation of concepts.

NANOINVENTUM promotes the interest for observation and generation of scientific questions and provides the necessary scaffolding to produce coherent answers based on well-known scientific facts. It uses materials, instruments and specific laboratory techniques, keeping in mind security and operational instructions. NANOINVENTUM is devised to be applied in the second part of primary school and adapts to legal curriculum

We firmly believe that this project, being oriented towards primary education students, may boost interest for science and may contribute to break gender stereotypes, leading to an increase in the number of feminine careers in college degrees where their presence is, even today, very sparse, as is the case of engineering, mathematics and physics. In this sense, an important part of the proposed contents devised to deal with ethical and social aspects of nanotechnology will focus on the urgent need to provide an egalitarian access to new technologies.

3. Progression Map

NANOINVENTUM is a scientific co-creation project that intends to introduce N&N in the primary school classrooms. By means of experimentation and progression maps a whole range of scientific concepts are introduced. After that, work teams are formed and roles are chosen. Then, with the help of provided materials, the students create a model based on nanotechnological concepts designed to solve a future problem. The singularity of the present project lies in the fact that all this knowledge will be introduced and presented to very young students, that is, in primary school, a special moment of life where scientific vocations begin to build up. Besides, NANOINVENTUM offers new tools so as to approach STEAM disciplines, like the toolbox with didactic experiences based on a progression map that sets a progressive and comprehensive way for students to apprehend the nanotechnological concepts. Finally, the experimental work is complemented by an artistic part that boosts creativity and breaks frontiers between disciplines, promoting a less intimidating regard on science.

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NANOINVENTUM is intimately bounded to the academic curriculum and expert assessment has been considered. The basic competences that students develop while progressing through NANOINVENTUM are:

a) To make questions about the environment and immediate surroundings, applying strategies of data research and data analysis so as to reach scientific answers;
b) To consider social issues while interpreting causes and consequences, proposing answers for the future;
c) To use materials in an efficient way by means of scientific and technological criteria so as to solve daily life issues;
d) To design simple machines and to use artefacts in a safe and efficient way;
e) To adopt good habits about the acquisition and use of goods and services by applying social and scientific knowledge and promoting a responsible consumption;
f) To generate interest in observation and in the generation of coherent scientific questions;
g) To design and put into practice experiments. To analyse and communicate results;
h) To use materials and specific laboratory techniques considering security aspects.

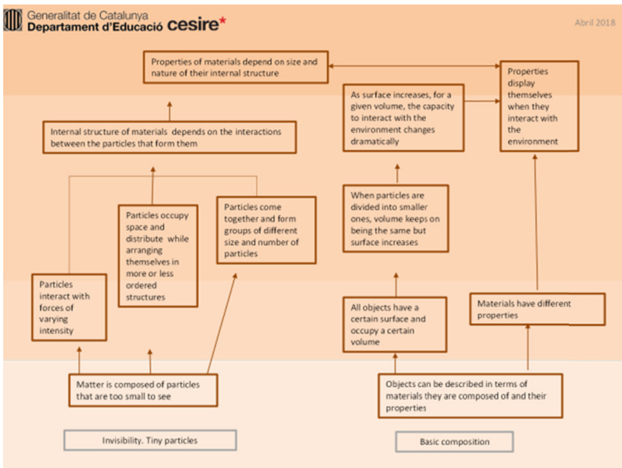

Figure 4. NanoInventum progression map

The didactic approach combines theory (training for teachers) and experimentation (hands-on work by the students using the Nano kit NanoExplora). This Nano kit is the first to be specifically designed for primary school and is intimately linked with the progression map that paves to way to a thoroughly learning of nanotechnology concepts.

3.1. What do we teach? How do we structure knowledge?

- An invisible world. The properties of materials can be explained according to their structure, that is, how are they formed and which is the ordering of their composing particles. These structures can only be seen by using nanotechnology-related instruments. In this activity, the main frame of what "nano" means is set.
- Smaller but more… We tackle with the difference in properties that arise from the variation of particles size. Having in mind that the amount of surface incredibly increases as particles get smaller and smaller, the different interaction of light and the predominance of certain forces in front of gravity can be explained. This second activity provides the tools to simulate these effects and to observe the different colours that nanoparticles have in water according to their size.
- Amazing possibilities. Nanotechnology opens the way to produce materials with incredible properties, so amazing applications open wide.
- It's time to take your decision. Nanomaterials are increasingly present in our daily life. They have advantages, but it is necessary to use them responsibly and to consider the pros and cons (usually in the shape of potential dangers for health). We still lack of long-term risk studies to assess their potential harmfulness, as well as suitable legislation to deal with their use and commercialization.

3.2. Progression maps steps

The progression map sets the steps in which the different concepts will be presented to the students:

- Phase 1: a) Structure of matter; b) Description of the objects in terms of materials.
- Phase 2: a1) How particles bind together; a2) Distribution of particles; b1) Surface and volume; b2) The properties.
- Phase 3: c1) Binding of particles and formation of compounds; c2) Specific surface.
- Phase 4: d1) Inner structure; d2) Relationship between specific surface, interaction and reactivity.
- Phase 5: e1) Properties of materials as a function of the structure; e2) Properties of materials as a function of the surface.

3.3. Applied methodology is based in 4 basic ideas:

- Experimentation in the classroom: the conditions to promote a certain phenomenon are set up, so testing can be done after following the sequence Observation / Hypothesis / Experience / Results / Interpretation / Conclusions.
- Progression map: didactic charts are developed by following the strategy of the progression map so as to help teachers to explain N&N concepts in a structured way by considering basic concepts as the atom, the properties of matter and so on. We firmly believe that this is a tool of great interest for primary schools to teach students how to read, think and learn. Progression maps are paramount when it comes to deeply comprehend how concepts are interlinked and how they fit in bigger knowledge structures. Progression maps organize in the shape of trees that grow and sprout from a central concept and expand and ramify to reach a variety of secondary concepts.
- Team dynamics and roles: a series of different roles are specified in order to promote the creation of new ideas and team working
- Design Thinking and creativity: thinking is oriented towards the resolution of real problems and searches for adapted solutions to deal with the real needs of students. Prototypes are generated and their pros and cons are assessed, conclusions are applied to produce better and more interesting prototypes.
- Team work and team mind storming are highly regarded by keeping a multidisciplinary approach.

4. Timing of the project

4.1. First activity

Organization, certification and enrolling of teachers in the Training Course for Primary School Teachers (third term of the school year). From July to October, the selection of the educational centres that will participate in the project will he held.

Training course for primary school teachers (November - January): 8 hours in total.

4.2. Second activity

Hands-on work in the schools: experimentation with the kits NANOEXPLORA (February - March). Kits and didactic charts will be sent to the educational centres so as to perform the practical part of the project. During the development of this phase (theory and practice imparted to students), team works will be arranged by the teachers. During the development of this phase, the teacher will collect questions and comments and will be assisted by an expert tutor (a researcher). At the same time, the organizers of the final contest will provide information about it and will detail the format and content of posters, presentations, as well as all the details about the final venue.

4.3. Third activity

Visit of the NanoExperta and redaction of the nanorobot charts (March - April). After the experimentation phase, the redaction of the proposals will be initiated and the nanotechnology experts visit the schools so as to solve questions, impart specific contents, share knowledge and become referents for the students in the field of nanotechnology. During this phase, the groups of 4 that will develop specific proposals will be set.

4.4. Fourth activity

Publication of results and evaluation by Nano experts (April - May). Team proposals, redacted according the knowledge acquired along the development of the project, will be published. The teams will try to solve a challenge (a present or future one) related with nanotechnology. Proposals will be assessed by experts. After that, teams will receive feedback and will be able to present an improved proposal, manufacture a prototype and record a video where they would explain their proposal.

4.5. Fifth activity

Presentation of results (Scientific Contest (Fair)). May. A scientific fair with all the prototypes manufactured by the teams will be presented. A panel of experts will assess the implemented improvements in terms of creativity, design and scientific proposal. The venue will include other ludic activities.

4.6. Other (parallel) activities

Creation of a virtual community online (September - February). This is a transversal activity that takes place during phase 1 and that points towards the establishment of a community where scientific and educational agents are implied so as to support the project. The main goal is to boost the exchange of knowledge and facilitate the improvement of the project and that of the applied didactic methods.

Evaluate the impact of the project (May - June).

5. Mechanisms of impact evaluation

The evaluation will be held by means of two different paths of actions: firstly, a formulary that is proposed to the students after the completion of the activity and secondly, the transference of some of the contents to other learning environments. According to the first path of action, the general perception of students according to the degree of subjective significance that have represented the tackled contents is assessed, as well as the formal aspects of the presented proposals. According to the second path of action, the ability to relate the contents of the activity with other areas of knowledge (for example, linguistics) is also assessed.

The quantitative evaluation of the project impact will be performed according to the following indicators: 1) Number of participants (researchers, teachers and students). 2) Number of educative centres enrolled in the project. 3) Distribution of the educative centres and the participants. 4) Level of acquired knowledge: students will be evaluated with a knowledge test before and after the project. 5) Degree of satisfaction of the participants by means of a formulary. 6) Number of visits to the webpage. 7) Number of received messages and assessment of their impact in the social networks (this is a key point to reach the virtual goals set up in the NANOINVENTUM documentation). As an example, two tweets of the final fair: 1) https://bit.ly/34dTV8b (encouraging participation, more than 4000 reactions), and 2) https://t.co/JzG7keeX3s (final venue preparation, 5000 reactions). Results and products after the consecution of the project will be as follows: 1) After the consecution of phases 1 and 2, a pool of 200 to 400 students and 15 to 25 participant teachers will have acquired remarkable knowledge in a field that it is not yet represented in the official curriculum. 2) A virtual community will be created where educative agents (students, teachers, educational centres for teachers, associations), scientific agents (CSIC centres, universities, scientific associations) and society itself will be encouraged to participate. 3) The number of students will double thanks to the number of teachers that will also participate in phase 1. It is believed that the activity as a whole will keep active after the execution of the project.

NANOINVENTUM will be supervised by CREA (Community of Researchers on Excellence for All (12), a community of multidisciplinary researchers that sprouted from the University of Barcelona. It is formed by more than 60 professors that cover a wide range of Social Science disciplines. CREA coordinated in the past several research projects funded by the European Commission. These researchers lead research I+D+i projects at a state level. It is worth to highlight projects as IMPACT-EV, funded in the frame of the 7th Programme of the EU, where research guidelines concerning research politics in the fields of scientific, social and political impact of research, both in the EU as a whole and in their individual members were set up.

6. Conclusions

There is a remarkable misunderstanding in Spanish society about the professional openings that sprout from scientific careers and about the different academic subjects that are interlinked with them, and this creates a deep fracture that is so perceived from early ages. The project points towards the creation of a prototype based on nanotechnology. To do so, recycled materials are used. The implementation of projects that are heavily focused on the environment, energy, health is of capital importance. NANOINVENTUM provides teachers and students with a set of tools to introduce research, science and new technologies in the classroom and to boost creativity and teamwork. It promotes the participation of students in proposals of scientific communication. Doing so, they move from passive information receptors to active subjects, a change of paradigm where curiosity becomes the core driving force. The study of N&N spans, not only the domains of science and technology, but also other regions of human knowledge. For example, Social sciences and Humanities are also implemented, by means of the introduction of philosophical, ethical and social concepts. It is a powerful tool to boost scientific vocations and to transform science into a close, quotidian and playful discipline.

After the consecution of the project, we will obtain the following products: a) Didactic guide for the training of teachers; b) Didactic guide and experimental kit adapted to students and curriculum; c) Guidelines for team working and creativity tools to promote ideas; d) Videos of the prototypes created by the students; f) Webpage of the project; g) Documentation of the project that can be exported to other communities and places; h) YouTube channel of the project; i) Creation of a virtual community via webpage and social networks and j) Evaluation and impact of the project.

Implementation of NANOINVENTUM becomes an important educative complement as far as the following items are considered: a) Vocational aspect, as it provides opportunities to discover and develop new skills; b) Social aspect, because of team working and its interlink with community; c) Personal aspect, as it lets the development of hobbies deeply adapted to the development stage of the participants.

We want to democratise knowledge, to make it accessible to all population, independently of their income level, and to show that scientific knowledge can contribute to social equality and integration. The importance of science in society is of common knowledge but we still fail in engaging students in the consecution of a suitable scientific level. Then, initiatives like NANOINVENTUM points towards the fact that it is important to introduce such disciplines at an earlier age. Nevertheless, there is a lack of compelling contents in the nowadays curriculum, especially in compulsory education levels, that promote and boost the taste for science, independently of gender and social background.

7. Acknowledgements

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Box Ecofriendly – Interaction between Melanin and LEDs

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Abstract. Sustainability is spoken about these days as having a great impact worldwide, mainly due to climate change. In this way, this research tries to recreate an idea of growing aromatic herbs and plants in a more efficient way, through light-emitting diodes and with a totally renewable energy source, through photosensitive organic molecules, such as melanin. Light-emitting diodes have great potential as a complementary lighting system to the sun or as a unique light source for the growth of aromatic herbs and plants. Their small size, long and useful life and, finally, the specificity of the wavelength make this light source ideal for use in lighting projects. Seven different colours as well as a control group were used for the research in order to investigate which colours are the best and how they influence the plants.

As the energy required to power the light-emitting diodes is relatively low, we thought of feeding the diodes with energy from a battery whose electrolyte would be melanin. Such a battery would have copper and zinc as electrodes. When acting as an electrolyte, the melanin would be responsible for the transport of electric current between the electrodes. Being a chemically very stable molecule, the melanin does not degrade, so it is possible to continue this cycle for an undetermined period of time. Such energy supplied by melanin would be used to sustain energetically the consumption required by the different light-emitting diodes, thus doing justice to the name of the project, ecofriendly box.

As more sustainable ideas were brain stormed during the research, it was decided to investigate natural fertilizers, and in the end it was coffee grounds and melanin diluted in water that were the two natural fertilizers chosen for the test.

Keywords. Coffee, Fertilizer, Growth, LEDs, Melanin, Plants, Sustainable Development.

1. Introduction

Melanin is a bio macromolecule with particularly interesting characteristics for our project. To create an environmentally friendly power supply that could bear the energy costs of a future prototype. The result of months of intense research, lead us to the idea of a possible generator that we would refine over time. Melanin therefore plays a central role in this.

Among the most varied physical and chemical characteristics of the aforementioned molecule, the one that sparked more interest was undoubtedly the conduction of electric energy in the presence of water [1]. Taking into account this physical and chemical property we have created an aqueous solution of melanin that occupies the position of electrolyte in a certain container where there are two other electrodes, one composed of copper and the other of zinc. Besides the fascinating property of conducting electric energy in the presence of water, melanin, a molecule so common in our body, presents a high durability that potentiates the creation of an electrolyte that can last for years, composed of sustainable materials and molecules such as water and melanin with which we are so familiar.

The light-emitting diode, LED, is a semiconductor diode that emits light by electroluminescence. It is usually a light source with a small area to which a lens is normally added to increase the light emitted. Light-emitting diodes have advantages over traditional forms of plant lighting. Their small size, durability, long life and the option to select specific wavelengths to get a response from the plant make LEDs the most suitable type of light in plant growth. These advantages put us in a revolutionary position in horticultural lighting. But this is not the only aspect that revolutionizes this study and plant growth [2].

Coffee is a substrate rich in organic matter and many nutrients, therefore, ideal for fertilizing the planting of various aromatic herbs and plants. On the other hand, melanin is a molecule that, besides being a good electric conductor, has mineral substances in abundance. Thus, this molecule can also be a good fertilizer for the aromatic herbs and plants of the study.

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1.1. The possibility of making the project energy sustainable

Our research aimed to be ecologically sustainable, thus resembling the project's goal of creating a prototype in which all the actions taken for the growth of plants were as efficient as possible, never failing to take into account the environmental cost and energy independence.

Having a well-defined objective, we thought about different options to get around the problems that were appearing. Now, the first observation was that we needed a power supply. We therefore thought about photovoltaic plates, but the high environmental cost induced in their production went against the morale of the project. The melanin molecule emerged then, among great prominence.

As we had already mentioned, this molecule has characteristics that fill all the boxes in our list of requirements. The fact that it is biodegradable [3] adjusted to our concern for environmental sustainability, on the other hand, its incredible durability, combined with the power of conduction of electricity in aqueous solution, made us dream about an incredibly durable electrolyte.

1.2. The power of LEDs in plant growth system

As mentioned in [4], the first time that the use of LEDs to grow plants was suggested was at the University of Wisconsin, where the first paper on the subject was developed [5], in which they reported that the growth of lettuces under red LEDs supplemented with blue fluorescent lamps was equivalent to cold white fluorescent lamps plus incandescent lamps. At the time of the study, blue LEDs were not yet widely available on the market, so they used blue fluorescent lamps to replace them. Tests carried out subsequently by this group showed that the cotyledons of lettuce seedlings under red LEDs (660 nm) became elongated, but this effect would be avoided by adding 15mmol.m-2.s-1 of blue light [6]. After this research, studies on the growth of plants using LED lights began to grow, comparing red LED light with other types of lights, concluding that there are small differences, a consequence of different lighting sources. Performing a comparison of the photosynthesis rates of strawberry leaves with red (660 nm) or blue (450 nm) LEDs showed higher quantum efficiency under the red ones [7]. More recent studies on this subject have shown that rice plants grown under a combination of red (660 nm) and blue (470 nm) LEDs kept the photosynthetic rates higher than the leaves of plants grown only under red LEDs [8]. The authors of this study granted this event to a higher nitrogen content in implemented blue light plants.

1.3. LEDs in agriculture

LEDs can play a variety of roles in vegetable lighting. They are suitable for research applications, for example in growth chambers, as a result of their unique capabilities and low radiant heat production [9]. LEDs are also used for production lighting in controlled environments and supplementary lighting in greenhouses, and these applications can control spectral quality.

1.4. Coffee sludge as a natural fertilizer

In the course of the project, more ideas to make the project sustainable emerged, and one of them was to use coffee as a natural fertilizer for the plants. Coffee is one of the most important agricultural products in world trade, being mostly produced in tropical climates and consumed mainly in Europe and the United States of America [10]. The coffee drink is usually produced from the mixture of several beans of different types of coffee, producing coffees with identical characteristics, but different flavors among them.

As mentioned in [11], coffee is one of the raw materials produced in larger quantities, so there are large quantities of coffee grounds that become waste days after days. Nowadays, the political pressure to reduce coffee grounds waste has been increasing and has brought new research and ideas for the reuse of this residual asset. Thus, it has been concluded that using coffee grounds as fertilizer in agriculture can be very beneficial for plants, since coffee grounds are rich in organic matter and macronutrients and micronutrients [12].

2. Methods

The questions that this investigation seeks to answer are the following:

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- Is it possible to sustain research energetically through the energy produced by organic molecules?
- What are the best light conditions for the growth of the plants under study?
- How to create a sustainable environment for the growth of aromatic herbs?
- Are coffee grounds and melanin good natural fertilizers for plants?

2.1. The characteristics of LEDs

The operation of a LED is based on the emission of light through a semiconductor diode. This type of lamp is usually a light source with a small area where a lens is applied to project the emitted light. Thus, the colour of the light emitted by the LED varies according to the type of semiconductor material used, so it could be infrared, visible or even ultraviolet.

The combination of red, green and blue LED's enables us to produce white colour light, which is how white light was used in our project. However, a white LED is now available.

Table 1. Characteristics of LED lights

Características	Lâmpadas LED's
Rendimento luminoso	60 a 130 lm/W
Fluxo luminoso	20 a 220 lm
Potência	1 a 5 W
Classe de eficiência energética	A
Índice de restituição cromática	65 a 90
Temperatura de cor	2700 K a 4000 K
Tempo de vida útil	50000 a 100000 horas
Tempo de arranque de re-arranque	instantâneo
Aparelhos auxiliares	ligação direta à rede

Over time this type of light was developed, and a second type of LED was created, the so-called OLED's (Organic Light Emitting Diode), which consists of emitters with organic compounds, carbon molecules, which emit light when receiving the electric charge.

The simplicity of LED technology allows great versatility. During the last years, it was concluded that it is possible to commercialize this technology with several types of configurations, allowing it to compete with the rest of the market. Not only for this reason we chose LED light to develop our project, but also because it has the best performance compared to the rest of the market. In Table 1 some characteristics of LED lights are presented.

2.2. LEDs and their efficiency compared to the market

To choose the best type of lamp for the project, we checked the characteristics of various types of lights, in order to know which was the most sustainable lamp, in other words, the one with a better performance and a longer life. In this way, Table 2 presents the comparative data between various types of lamps.

Table 2. Comparative data between various types of lamps

Família	Tipo de lâmpada	Rendimento luminoso (lm/W)	Vida útil (horas)
Lâmpadas de descarga de alta pressão	Vapor de mercúrio Vapor de sódio Iodetos metálicos Luz mista	30 a 60 66 a 130 60 a 96 20 a 30	10000 a 12000 12000 a 18000 3000 a 9000 3000 a 10000
Lâmpadas de descarga de baixa pressão	Fluorescente tubular Fluorescente compacta Vapor de sódio	58 a 104 40 a 70 100 a 200	7500 a 12000 8000 12000 a 16000
Lâmpadas de indução	-	92	100000
Lâmpadas de incandescência	Convencional Halogéneo	10 a 13 16 a 25	1000 2000 a 4000
Lâmpadas LED	-	60 a 130	50000 a 100000

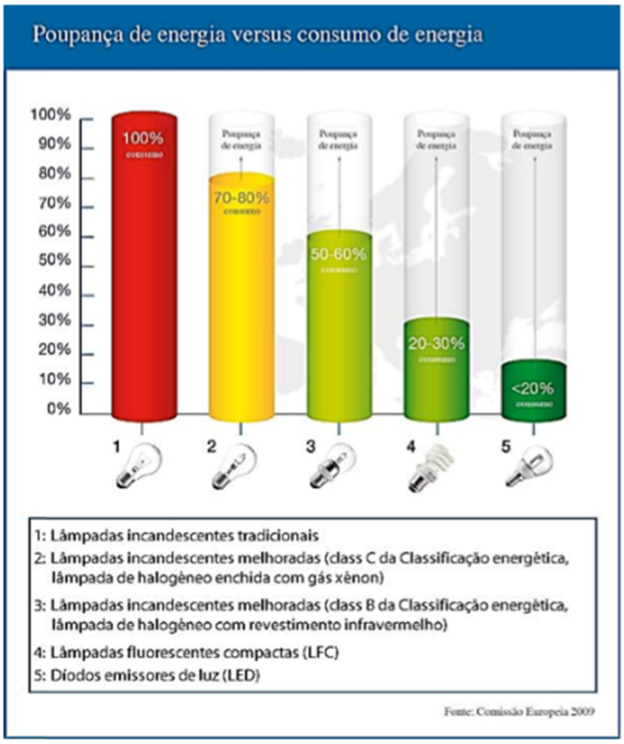

Figure 1. Energy savings versus energy consumption

Following the analysis of Tables 1 and 2, we were able to realize that LED lights are the ones that present a good luminous performance and a long useful life, benefiting for the choice in this project.

Still after this study, we continue the research, to have the best conclusions to present to future customers. In this way, energy savings versus consumption were compared in different types of lamps.

At the end of this study, we concluded that LEDs presented the greatest advantage in our work due to several aspects: higher performance over any other lamp on the market, no need for filters to emit a color and they have a very high life span and have very small dimensions.

2.3. The growth of parsley under the influence of LED lights in a sustainable environment

By combining the main objective of research with the recently discovered technology of melanin, we obtain a desired product from the very beginning of research. As we know, melanin is a molecule capable of conducting electricity in the presence of water. Melanin, being a molecule capable of causing hydrolysis of the water molecule, has an enormous potential in building future sustainable batteries. In order to carry out the above study in a sustainable way, we connected the circuit created by us to several micro LED's that lit a simple cardboard box with a parsley inside. With the power provided by the battery we were able to light some micro LED's, although right now these are still not enough for the healthy growth of the plant with the use of LED light only.

2.4. The growth of parsley under the influence of LED lights

As already mentioned in the introduction, different LED colours have different powers, being this one of the main factors for the change in plant growth. To carry out this experiment we used parsley as a support for our study. First, we started by sowing parsley seeds from the same lot on the same type of soil to maintain scientific accuracy. Then, after the aromatic herbs have grown under the same conditions (greenhouse conditions, plenty of sunlight and appropriate amount of water) we divide the parsley into the eight compartments, each one with its respective LED light (blue, green, red, yellow, magenta, cyan, white, control). The aromatic herbs were arranged inside the box, in which they were subject to different types of LED light, so that they all received the same amount of sunlight, and the LED light was the only independent variable that was different in each sample, as they all received the same amount of water, the same amount of sunlight and finally the same ventilation. Thus, the first part, the plantation, was completed. Then, at the most laborious stage of the research, we recorded the dependent variable, the growth of the plant. Over time, we took steps to make the research as scientific as possible, in other words, we used the same amount of water to all the samples at equal and regulated intervals of time. All these data were recorded in graphs for further analysis of the yield of each of the LED colours influencing plant growth. As the last step of the research, and to better accept the results obtained through the research, the leaves of the parsley were to undergo bio-resonance tests at the Abel Salazar Institute of Biomedical Sciences, a partnership established to help complete the study of plant variables. However, due to adverse conditions for us, the growth of the parslther hand, we also realised that the weather condition at the time of the study was not ideal and could be another source of the study disaster.

In this way, we changed the plant and started to plant lettuce but this time we also changed the place of germination. A lot due to the covid-19 pandemic that took us away from the place where we were doing the study, we had to adapt the study and once we already had the prototype done, we used it and planted at home the lettuce seeds in four pots, but always with the same colour to all. So, this study was to draw conclusions from what had already been discovered before. However, as we did not have any variables in study, we deepened the subject and decided to plant the lettuces under different soil conditions, that is, adding natural fertilizers, in order to show one more sustainable side in our project. This subject of fertilizers will be addressed more specifically in point 12 of the methods.

2.5. Introduction to the energy concept for research

Energy is an essential commodity these days. It drives sociability, economy, and especially industrial development. In the case of our research we decided to try to make it 100% sustainable. To do so, as described above, we use energy from a battery, which we have designed and built.

2.6. Physical and chemical characteristics of melanin as an electrolyte

As mentioned in the previous points, melanin is a macromolecule present in our body, more specifically, in our skin, eyes and hair. The melanin that is present in our body, which we all know by influencing the colour of our skin, does not vary from person to person just in quantity, this is because there are three types of melanin present in nature, eumelanin, pheomelanin and finally nuromelanin, which only differ from each other by the colour they cause. In short, in our body, the main role of this substance is the photoprotection. However, the presence of eumelanine (the type that beings belonging to the animal kingdom possess) in exposed and unexposed places of our body to sunlight suggests that this familiar biopigment can perform more functions than simply photoprotection.

Over time, therefore, more and more physical and chemical characteristics have been discovered, allowing us to better know this molecule, among them are the antioxidant activity, the oxidation-reduction activity, its biocompatibility, its affinity to the metallic bond, the photo conduction [13] and finally, the recently discovered hydro dependent conductivity.

After long reflections and research on the ability of melanin to become a good electrolyte, we came to a conclusion regarding the manufacturing process. Aware of the fact that melanin is a photoconducting molecule we immediately concluded that our energy source would have to be exposed to sunlight, so our image of a future prototype was beginning to take shape piece by piece.

Our conclusion was corroborated when we read that, as mentioned in [13], the oxidation activity reduction of melanin, central to the operation of the generator as will be explained later, is nothing less than a response to oxidation imposed by photochemical stress. When we knew that the oxidizing and reducing activity was essential for the operation of the energy cycle that resulted in the electrical conduction, we realized that the photochemical stress would be the real engine of our generator, and could even be compared with a photovoltaic plate. Furthermore, during the reduction oxidation process, in which the molecule oscillates between one state and another, since it is a reversible and natural system [14], it was observed that in solutions of oxidized melanin, the light absorption was up to 70%, thus improving the electric conduction properties of the electrolyte (when oxidized clear). In short, Figge [14] concluded that in solutions of oxidized melanin the absorption of light is up to three times greater than in the reduced one, thus discovering an important attribute in the electrical conductivity of this photosensitive molecule. That is, the fact of being exposed to the sun (photo chemical stress), presents extreme importance for the oxidation process (response to stress, caused by sun exposure).

2.7. Technical specifications and generator operation

As we had already revealed in the introduction, the generator is composed of five core parts, the sunlight, the melanin molecule, the water and finally the two electrodes.

Our power supply was assembled by steps with simple everyday objects that had no use at home. We began by arranging a firm wooden platform to serve as a reliable base. For the two electrodes we used copper wire and galvanized steel screw, the two poles were then applied to several cells (each cell with one electrode of each type), the cell consisted of a transparent and translucent plastic container (the fact that the cells were transparent corresponded to the needs of the solution requiring sunlight). We created with this method of assembly about 20 cells. For the connections between them we used copper conductor wire, this way we connected the cells two to two in series, having now only 10 cells, each one with double the potential difference they had initially. Later on, we connected all the cells in parallel, thus adding all the intensities formed. For the design of the electrolyte we used sepia ink as a source for the melanin molecule because it is more affordable than synthetic melanin, of the eumelanin type present mostly in the animal kingdom. We started by creating a concentrated solution of sepia ink. Later, after minutes of mixing, we filled the cells with the solution.

The innovative operation of this system can be explained by the ability of this bio-molecule to dissociate the molecule from the water with the help of sunlight, thus creating a significant difference in the concentration of hydrogen and oxygen in the electrolyte solution, since for each molecule of dissociated water one atom of oxygen and two of hydrogen are obtained, in addition to which two electrons are also released that play a central role in the contours of energy production. Given the existence of two poles, created by the two electrodes, the electrons tend to move from the negative pole to the positive pole, creating a directed movement of electrons (electric current phenomenon). By creating an electric current we also create a potential difference, and the intensity of this generator will be higher depending on the number of loads that cross a given section of the conductor in a given time interval, so the more loads, that is, the more electrons are in motion, and by logic, the more molecules are dissociated, the more intensity the generator will have [15-16].

2.8. Battery performance

As previously mentioned, when we created a prototype of a generator we knew that its operation was correct in theory, however in practice nothing was proven, so we did not know the intensity produced by the circuit, whether the resistance of the conductor wires was high or not, or whether the difference in potential fitted the type of LEDs we wanted to light.

In short, we discovered that our generator produced 1.3 volts and 0.3 milliamps, and when we measured the circuit with a multimeter, the voltage remained constant, but the amperage fluctuated a lot, which could have several explanations, such as the variation of sunlight incident in the circuit, or else the decrease in the concentration of eumelanine in the solution that was deposited at the bottom of the cell.

Due to the lack of amperage that we lacked, we decided to change the final consumer of this energy, so we started to recharge rechargeable batteries, since the voltage of these same batteries coincided with the voltage produced by the circuit, something that determined the correct charging of a battery. The recharged batteries would later be incorporated into a portable LED light system. In this way the generator would no longer power the circuit to become a continuous power source that was now charging batteries.

The charging time of a battery is the quotient between its capacity (mAh) and the capacity of the charger, which means when trying to charge a 200 mAh battery it would take 666 hours (28 days) to complete its charge.

The high charging time of a single battery made us go back and rethink the purpose of the energy produced. So we decided to use micro LED's, since they had the same consumption as the one produced by the generator.

2.9. Problems raised by the electrolyte

One of the most amazing characteristics of the melanin molecule is its longevity, that is, it has great chemical stability, often lasting thousands of years. A proof of this is the fact that melanin was found in remains of fossilized sepia ink. Therefore, one might think that the electrolyte would never stop conducting energy because it would never deteriorate. However, the low solubility of this molecule causes the solution to lose concentration over time, thus reducing the useful power of the circuit.

Over time, a sepia ink deposition is formed in the soil of the cells by the effect of gravity, which ends up proving to be our greatest enemy. It should be remembered that the decrease of melanin in this solution means that this molecule cannot perform its dual function, that of decoupling and conduction of electrons from pole to pole.

2.10. The choice of electrodes

For the choice of the electrodes we took into account several criteria, among them, its location in the electrochemical series and its market cost. As for the location in the electrochemical series we knew, by theory, that we would have to choose a strong reducing agent and a strong oxidizing agent. The reducing agent, in this case the anode in relation to the electrodes is responsible for causing the reduction of the electrolyte, oxidizing itself. On the other hand, the oxidizing agent, also known as cathode, is responsible for causing the electrolyte to oxidize, reducing itself and thus transporting the electrons to the rest of the circuit.

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However, the functioning of this device is not the most common, because in a normal battery there are two separate electrodes, each with its own electrolyte, connected by a salt bridge, in this case there is neither a salt bridge nor two electrolytes.

The operation of this battery, composed of an electrolyte resulting from the mixture of melanin and water, is different from the operation of a conventional battery such as Daniell's. First of all, in the electrolyte solution there are several substances that we do not know about, such as metallic ions and others that we know about, such as biomolecules. Thus, we are only sure that there is oxidation of the anode and reduction of the electrolyte, and later, oxidation of the electrolyte and reduction of the cathode. Thus, ions would have to be formed from the metal chosen for the anode, creating an ionic imbalance that would be counterbalanced by the movement of ions present in the electrolyte (whose exact chemical composition we do not know) in that direction. On the other hand, biomolecules such as melanin and its variants would have the role of conducting the electric current formed.

We also knew that the intensity of the electric current formed is explained by the difference in potential existing between the two electrodes chosen. Thus, we chose zinc and copper as electrodes, with zinc being the anode and copper the cathode. We chose these metals because of their abundance, their relatively cheap price compared to the efficiency they offered us and, finally, because we tried to resemble the work done by John Frederic Daniell at the time of his invention, the Daniell's pile, in this way we started to use the same electrodes and we tried to follow their success even if it was a completely different operation, however there are similarities between the pile in question and the one produced by us, since in both occurs the migration of ions from one direction to the other to promote the chemical balance. We can also mention that besides Daniell's pile, the one in Volta also presents similarities with the prototype created by us by having the same electrodes.

2.11. Composition of coffee grounds

Coffee is the powder resulting from drying, roasting and grinding the seeds of the coffee tree. Over time, coffee has gained great impact worldwide and, from many years to the present day, it is the most widely consumed beverage on a global level. Much due to its high levels of caffeine present in the seeds of the coffee tree that stimulate the human body, it is widely consumed, especially in Europe and the United States of America. But caffeine is not the only substance for which this powder is made. Coffee also contains other substances rich in minerals, which helps to enhance its use on the plantation. In Table 3 we can see the organic and mineral composition of the coffee grounds, a substance that results from the preparation of the coffee drink.

Table 3. Organic and mineral composition of coffee grounds [17]

Parâmetros	Concentração (%)
Matéria orgânica	90,46
Carbono/Nitrogénio (C/N)	22/1
Nitrogénio	2,30
Fósforo	0,15
Potássio	0,35
Cálcio	0,08
Magnésio	0,13
Alumínio	0,03
Ferro	0,01
Fonte: Mussato et al., 2011	

After analysing the data, we can conclude that the high amount of organic matter helps in the composting and formation of fertilizer, which is mainly composed of carbon molecules. On the other hand, the high number of nitrogen in plants, compared to the other chemical elements, also helps as a fertilizer, since it is the fourth most needed element by plants, after carbon, present in organic matter, and hydrogen and oxygen, present in water.

2.12. The use of coffee residues and melanin solution as material with potential agricultural application

The coffee grounds are an ideal substrate for planting in urban areas, since they are a residue that is selectively separated at the source and undergoes a "pre-pasteurization" in the coffee drawing process. Thus, this project tested the use of coffee grounds as fertilizer on the plants.

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At the beginning of the test, four pots were placed in a controlled place of temperature, humidity and light, so that all the plants had the same conditions. Of these three variables that I indicated, only one varied, the light. This one varied according to the studies we had already done before and which we will explain later. For the germination, the red light has been put, then the blue light to do a growth of the stem and, finally, the white light, since it is the mixture of all colours, therefore doing a generalized growth of the plants. All the pots were planted with lettuce seeds belonging to the same lot, but the substrate in each pot varied. In a first pot, only soil existed, calling it a control pot. Then the other pots all had more than one substrate, one pot with only coffee grounds and soil, another with soil and melanin and a last one with soil, coffee grounds and melanin.

2.13. Prototype and its development

The Box Ecofriendly project started in 2014 with other students, but with the same main objective of finding the best light conditions for the growth of herbs and plants. First of all, and with another team one year older ahead of the project, in 2014 an experiment called Light Bean was developed, which consisted in the study of the influence that the different colours of light, reproduced by filtering sunlight with cellophane filters, have on the growth of beans. For this experiment, two domestic greenhouses were used, divided in half. Of the four halves created, three were covered with red, green and blue cellophane paper. The remaining half was not covered at all, the control group being the only part of the greenhouses that absorbed all the sunscreen. In carrying out this experiment, we concluded that there are colours of the solar spectrum where the plants adapt better than to the solar spectrum in its entirety.

After the conclusion of the first experiment we decided to develop another one, but instead of using solar filters, we used light provided by various types of lamps. In this experiment, artificial light only served as a complement to sunlight and not as a substitute.

Later, the project gained other proportions and another experiment was developed. With a little help from partnerships, a cube was developed divided into eight divisions, all with the same properties and with a built-in ventilation system to eliminate variables and possible plant malformations due to lack of ventilation. Finally, in each compartment a LED ribbon with different colours was used, distributing the primary and secondary colours according to the RGB colour code (red, green and blue, respectively) and also the white light, leaving a compartment that served as a control space, that is, there was no LED ribbon. More concrete conclusions have already been drawn from this experience. As the project was more in-depth, the team that carried out the experiment was able to conclude that different colours have different functions throughout the life of the plant. In this way, the team corresponded the various stages of the plants to the colours that make their development more accelerated. As the last action of the experiential development in the last school year, the team established the following similarities between the colours and the different phases of growth: red - germination, blue - growth of the stem, white - growth and green - growth, but with successive death due to the lack of chlorophyll, since the colour is the same.

This school year, the current team joined the project, changing its name to Box Ecofriendly Project, since the idea arose to create a prototype with a commercial purpose, a prototype that would resemble a box and would be as sustainable as possible. This way the ideas came up and finally a final design consisting of an acrylic box with holes to provide air to the plants. At the top of the box, besides being present the lid for watering, would also be placed the multicolour 12 watts LED strip. Once the design was done, it was time to go into production. After some contacts with companies, we got partnerships to help us develop this idea. Finally, with the box completed, we proceeded to the tests, with the results present in point 3 of this article.

3. Results

To record the data collected on lettuces, three graphs were created with the three variables the plant covered. In this way, all the graphs have four lines, each one corresponding to each of the pots present in the study. Thus, the three main variables, growth, number of branches and leaf area of lettuces were recorded.

Figure 2. Height growth of plants over time

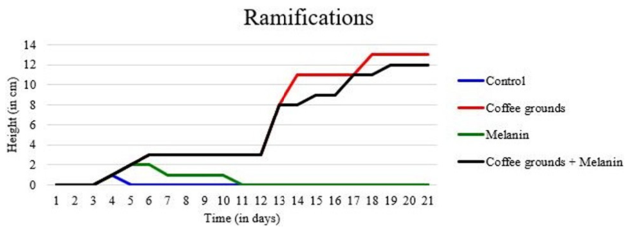

Figure 3. Number of plant branches over time

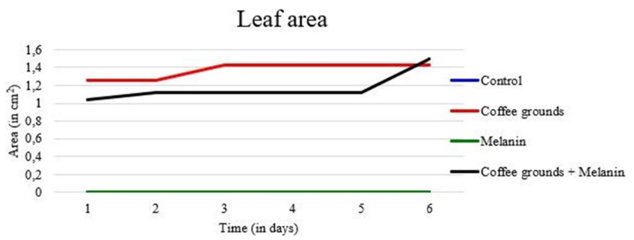

Figure 4. Leaf area of plants over time

To compare the variation in voltage and amperage over the days in the melanin circuit, the following graph was used:

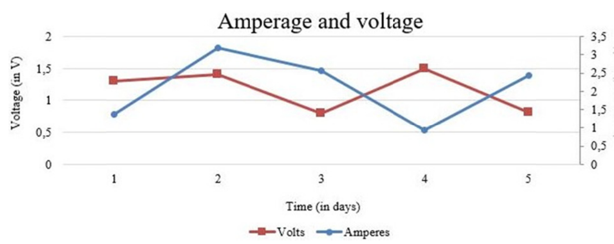

Figure 5. Relationship between potential difference and electrical current over time

4. Discussion

After reading and studying the articles referred to, we can conclude that the best light conditions for plant growth vary according to the stage of growth in which the plant is. The various LED lights have several effects on plant growth. Thus, we concluded that, at an early stage, different types of LEDs would be required from those used at a more advanced stage. Thus, throughout the project, the cultivation of parsley in different LED lights was carried out in order to draw more accurate conclusions about what type of LEDs should be placed in each phase of growth in order to obtain a higher yield from the growth of the plants.

As mentioned in point 2.4, due to the major climatic changes that were felt throughout the development of the plant and a possible suspicion of placing the plants under a high level of stress when transplanting was carried out, the experiment followed paths that were not expected. In March, with the prototype already carried out, however, affected by the COVID-19 pandemic, we started the second study, this one carried out at home and with the lettuce plant. With four pots inside the walls of the prototype, on March 27th the study had its beginning. Since then, the results started to be promising, since the germination took place just 3 days after planting and in the seed package it said that it would take 6 days to germinate. With the prototype with the proper light for germination, red light, it took half the time foreseen. As can be seen in graph 1, the plants immediately after the day of germination started to grow and therefore the light provided by the LED's was changed from red to blue after five days, since the blue light is the most suitable to accelerate the growth of the stem. After 5 days with the blue light, the stems were already high, and all plants already had several branches, except the control pot and the melanin variable pot, which both ended up dying. Therefore, the light was changed from blue to magenta. Once the stem was already high, it was necessary to strengthen it in order not to break and die. Finally, after 17 days of study, and as it was still developing at the time of the report, the light was changed from magenta to white, which was supposed, according to the previous readings, to be the last colour necessary for the growth of the plants. As can be seen in graph 2, it is possible to notice the high number of branches that plants have been gaining over time and will continue to have. Already in the graph 3, although it is with little information (the study is not yet finished), it can be seen that there is also a growth in the leaf area of the plant, this area is given by the product between the length and the width of the biggest leaf of the plant. In short, it was possible to draw the conclusion that we were already expecting it to happen, that is, the acceleration in the process of growth of the plants with the use of LED lights. On the other hand, we also drew conclusions about the fertilizer to be used for the lettuce plant. As you can see from the graphs, the coffee grounds showed to be the

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best fertilizer for the plants than the coffee grounds along with the melanin solution, which always remains a little lower in measurements. Perhaps, and looking at the data, we can conclude that the plant with the coffee grounds and melanin is currently with a higher growth rate than the pot with only coffee, which may help us to draw different conclusions from those drawn on the 18th of the investigation. Even so, as we are at an early stage of research, we will have to wait to obtain more concrete results.

As for the energy factor of the project, it was possible to create a sustainable environment for the growth of herbs and plants from organic molecules (water and melanin) and sunlight. Based on the electrochemical characteristics of the melanin molecule we created a model of a voltage source that was recharged with sunlight. While it worked with a battery it also worked as a battery, since the electrolyte was responsible for conducting electrons and also for dissociating the water molecule. So, we can say that yes, it is possible to create a sustainable source of energy from organic molecules. However, melanin has only proved to be capable of producing part of the energy needed for the prototype, however we can say that in a few years it will be possible to have batteries based on environmentally friendly molecules.

The integration of biodegradable elements such as these molecules into elements of the future and the present such as computers, cars, mobile phones or batteries that all have in common sets a sustainable and environmentally friendly pace or path. In fact, there is already promising research on the use of these same materials in devices as super capacitors [13].

Finally, we conclude that it is possible to accelerate the growth of plants with the use of LED's and natural fertilizers. In short, this electric current generator composed of melanin allowed us to demonstrate a concept and, as we predicted, to feed micro LEDs in order to light some of our samples.

5. Acknowledgements

We are grateful to Professor Jorge Machado of the Abel Salazar Institute of Biomedical Sciences at the University of Porto for the support he gave us in the supervision of the experiments and this article.

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STEM and Collaboration

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Abstract. STEM activities require working as a group. Developing the ability to collaborate within the group is one of the features of the STEM approach. With this feature in mind, the aim of this study is to obtain the opinions of the students for their collaboration as a group through the STEM activity called Let's Make a Telescope. It is an activity for 7th grade students. The implementation of the activity started by creating 5 groups of 4 in a class of 21. After the activity, each student in the groups was interviewed in accordance with the open-ended questions prepared by the researchers for cooperation. The data obtained after the interviews were analyzed by content analysis. According to the results of the analysis, it was concluded that the students used collaboration skills such as solidarity within the group, being open to ideas, forming team spirit, being respectful, developing friendship relations, creating common ideas, helping, communicating.

Keywords. Collaboration, Lens, Refraction of Light, STEM.

1. Introduction

With the change in what communities expect from individuals in the 21st century, it is aimed that the 21st century individual will be individuals who think critically, creatively, have strong communication skills and cooperate [1]. Cooperative learning is a course in which students work in teams, interact face to face and display a high level of positive dependence [2]. It is for students to help each other learn in small groups for a common purpose. In order for a group work to be cooperative learning, students in the group; both themselves and others are expected to maximize their learning. In other words; The feature that makes collaborative learning of group work is that students try to develop both themselves and their friends to the fullest of their capacities [3]. One of the approaches aimed at cooperative learning is STEM. STEM education is to provide students with experiences to collaborate to solve real life problems by providing them with interdisciplinary thinking skills, and to provide experiences that will prepare the ground for developing solutions for life [4]. In this study, Let's Make a Telescope STEM activity was applied. Through this activity, the opinions of the students about cooperation were taken.

2. STEM activity, Let's Make a Telescope

2.1. Objectives

Science goal: Distinguishes the properties of the lenses depending on the refraction of light.

Math goal: Calculates the circumference of the circle.

Engineering goal: Using a systematic process to determine how well they meet the criteria and constraints of the problem, he distinguishes his solutions positively and negatively.

Technology goal: He distinguishes the most suitable one from the technological tools for his design.

2.2. Problem

People thought the world stood at the center of the universe. Moreover, they thought that the sun, the moon and all the stars roamed around the earth in perfect circle orbits. Galileo observed the sky. Like everyone else, he thought that the Moon was like smooth polish. But as a result of his observations, he noticed that there were pits on the Moon. You will go back about 400 years ago and become Galileo. You will observe the Moon closely. You thought you needed a telescope to achieve this. How do you make the telescope you need using the most convenient and economical materials?

State the question as clearly and precisely as possible. Details are very important. The key question that arises from the question is: How can I make a telescope using the refraction feature of the light?

2.3. The purpose of the activity

This design aims for students to refine the light, adjust the angle of refraction and the focal points of the lenses in order to obtain the image clearly with a telescope design optimized to see distant celestial objects.

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2.4. Information acquisition / Research

Students were asked to actively seek information about the problem by the group. Computer or textbooks can be used as a research tool.

Students were directed to research through the following questions.

1. What information do you need to solve this problem?
2. How can you reach the best view of the telescope you will design?

They actively searched for the most relevant information about the question by the group. They researched the history of Telescope and the scientists in its development.

Figure 1. Uses of lenses

The researched ideas to create the most suitable telescope can be as follows: The lenses refract the light, and the mirrors reflect the light. For this reason, I should use a lens to break the light. I should be able to focus the lenses to create the clearest image of the telescope.

Refraction of light when changing from a transparent medium with different densities to another transparent medium is called refraction.

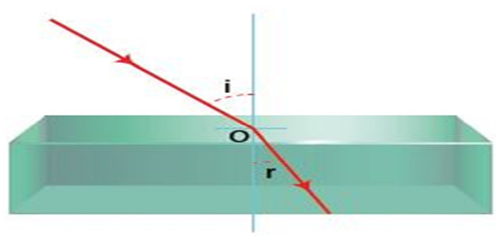

Figure 2. Refraction of light

The optical tools that we will observe the refraction of light best are lenses. Lenses are used in many optical instruments, from microscopes to glasses, from cameras to telescopes. Lenses are spherical tools with at least one side generally made of glass or hard plastic. Tools made of transparent materials with the ability to magnify and reduce the images of objects are called lenses. Lenses are divided into 2 according to their characteristics. These are thin-edged lenses and thick-edged lenses. Thick-edged lenses make the image flat and small. Thin-edged lenses enlarge the images of the objects. The projector, binoculars, flashlights and floodlight have thin-edged lenses. Telescopes also allow us to zoom in and see very far objects with the help of thin-edged lenses in their structures. The small lens is used as a magnifying glass to see the image more clearly.

2.5. Design

While designing, the students in the group thought about how to reach the solution by putting their ideas into the drawing. For example, what type of lens they will use to magnify the image in the telescope, how to bring two lenses back to back to clarify the image, from which substance the main body will be made. The group members proposed different ideas about their problems as they could produce. Each team member drew at least one design idea. (The groups were given design drawing paper).

2.6. Tools

2 cartons, 2 small lenses (focal length 1 inch, 25 mm), 1 large lens (focal length about 8 inches, 200 mm), silicone gun, scissors (Fig. 3). The lens was used in the telescope, since the light would have to be broken. Special attention was paid to ensure that the telescope was intact.

Figure 3. Tools

2.7. Product development

Cut one of the cardboards in the length of the small lenses. At this stage, the diameter of the lenses was calculated first. Thus, the mathematics goal was integrated (Fig. 4).

Figure 4. Circle circumference measurement. (Math integration)

Place the lenses on both ends of the cardboard. Wrap these lenses in a roll by sticking them with silicone (Fig. 5). Cut the second carton with a large lens diameter. Just wrap the lens with silicone on one end and wrap it in a roll. Put the small diameter cardboard into the large diameter cardboard. The large lens collects light and focuses it inside the tube. The small lens magnifies the image through the tube.

Figure 5. Sticking the lens to the cardboard

Figure 6. Sticking the rolls together

2.8. Testing

A test form is distributed to each group. The students were directed in accordance with the instructions below:

1. Look at the lens tip of your telescope.
2. Focus on a distant object by moving the inner cardboard in and out.
3. If you cannot see clearly, you will have to cut the cartons a little or realign both lenses.
4. Try looking at the moon in the evening with your telescope. Look at other objects in the night sky. Never look at the sun with this telescope!

Figure 7. Prototypes of the groups

There are two issues to be addressed to maximize the visibility and clarity of the telescope. The first is to choose a thin-edged lens, as the thin-edged lens has the ability to collect parallel incoming light at the focal point and magnify the image. The second is to adjust the focus by sequencing the two lenses in a suitable range repeatedly to ensure clarity. Thin-edge lenses feature the ability to collect parallel incoming light at the focal point and to magnify the image.

Students should:

In order to optimize the clarity, the first tests can be tried manually on an object without using pipes. Groups can take notes by measuring the distance they see clearly. They should then perform their trials by painting the inner surface of the pipe in black color or by covering it with a black background cardboard.

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3. Findings

3.1. Student opinions

Table 1. Students' views on the collaborative STEM activity

Question	Opinions	N
Let's do a telescope in the science class, you did the STEM activity. In this way, what are your feelings and thoughts about lecturing based on collaboration within the group?		
Positive thoughts and feelings	I started to deal with my friends that I hadn't agreed with before.	8
	I was never bored, it was fun.	17
	My confidence has increased.	12
	We learned by helping.	14
	We have communicated more with our friends.	16
	We learned by discussing as a group.	11
	It made me gain social skills.	6
	We finished the tasks in a short time.	9
	We respected each other's ideas.	10
Negative thoughts and feelings	We couldn't do the work on time.	6
	Some of my group friends caused problems and did not participate in the studies.	5
	I couldn't get along with my group friends.	2
	There was a lot of noise in the classroom.	4
	The failure of others also affected me.	1

After the event, interviews were made with students about cooperation within the group. The opinion of each student was noted by the researchers. The answers of the students were subjected to content analysis method and themes were created from these answers. The questions asked to the students and the answers received are given in the table below. When students give more than one answer to a question, these answers are added to the relevant themes.

4. Conclusion

We know that telescope making activities take place in most classrooms. In this study, this activity was not unique. The aim of this study was to learn the positive and negative thoughts and feelings of the study by the students in collaboration, which is one of the objectives of the STEM approach, through the Let's Make Telescope STEM activity.

As positive aspects of collaborating in STEM activity; They stated that the lesson was enjoyable, they were not bored, they communicated with the group members, their trust in them increased, they learned by helping and discussing, they respected each other's ideas, they completed the task in a short time. Few students stated the negative aspects of working in collaboration with group members; that the study does not end on time, some group members do not participate in the study, there is noise in the classroom, cannot agree with the group members, and group failure is affected by itself. According to the opinion of most students, we can conclude that working in cooperation with STEM activity has many positive aspects.

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Hands-on STEAM: Learning to Program in Elementary School Using Directed Elaboration

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Abstract. This article presents a practical example of the development of a STEAM project, carried out with elementary school students in Brazil. The goal was to promote interdisciplinary project-based learning, where the free software DuinoBlocks4Kids facilitated the teaching of programming. The interaction between teacher and student happened through the technique of Directed Elaboration in all stages of the work.

Keywords. Educational Robotics, STEAM, Visual Programming, Directed Elaboration, Primary Education.

1. Introduction

Since the middle of the last century, humanity has been developing increasingly complex systems such as the Internet, air traffic control, and artificial intelligence, which are reflections of a society that is undergoing rapid development. The transformation of traditional education into configurations that lead the student to think about this new interconnected world can benefit the students of this current generation by helping them to integrate into this socio-technical society in constant evolution [1].

According to Dewey [2], education is defined as the set of responses to the processes of reconstruction and reorganization of acquired experiences, which will influence future experiences. Any activity can be an experiment and possibility in education since the favorable conditions direct the students in his self-learning practice.

Dewey's approach is complemented by Seminério's studies [3], whose proposal of Directed Elaboration is the pedagogical intervention to improve the student's cognition based on questions that help him to reach the contents he needs. These questions occur through reflections induced by the adult during the dialogue, in an elaborated and discussed transmission, and not with the repetition of ready contents.

In line with the arguments above, the present work reports an experience that resulted in the process of construction of multidisciplinary ideas and knowledge, where students were protagonists of the self-learning. Throughout this process, concepts such as STEAM, Brainstorm, Computational Thinking, and Project-Based Learning were developed.

This article has nine sections: the introduction presented the tools used in this work; Section 2 describes the technique of Directed Elaboration as a means of teacher-student interaction; Section 3 contains precepts of the STEAM concept addressed in this project; the development of the Recycled Paper Machine Prototype, a project developed by the students during this proposal, is detailed in Section 4; Section 5 contains the teaching of programming through the free software DuinoBlocks4Kids. Section 6 presents the main results of this non-traditional learning process, followed by conclusions (Section 7), acknowledgments (Section 8), and references (Section 9).

2. Directed Elaboration

Directed Elaboration emerged as a response to the analysis of certain phenomena, observed by Seminério [3], approached by other authors who also researched the formation of human cognition. Among them, Colinvaux [4] proposes that the structure of knowledge supposes a mutual dependence between the real and the rational: if, on the one hand, there is pressure to understand reality, as science explains, on the other, there are intrinsic intelligence requirements of the cognitive subject.

Also, Piaget [5], an author widely studied by Seminério, suggested that Better Equilibrations between two fundamental processes, Assimilation and Accommodation, constitute cognitive development. The Assimilation process is the absorption of an external element, be it an object, situation, or any new content, by a conceptual or sensorimotor scheme existing in the subject. For the author, the interaction of the person with the environment since birth, more complicated as it matures, forms these schemes that make up the construction of knowledge [6]. The Accommodation process, on the other hand, is the need to consider the peculiarities of the newly assimilated new outer element, which causes the transformation of an existing scheme in the individual or the emergence of a new scheme, modifying his previous knowledge. According to Piaget [5], there is a cognitive disequilibrium when an individual is faced with a new experience. A disturbing state awakens the feeling of denial or exploration to understand the new knowledge in search of cognitive re-equilibrium. In Piaget's Theory of Cognitive Development [5], the Better Equilibration is when the recovery of cognitive equilibrium refers to a new state of equilibrium, different from the was before. In this case, there was the Accommodation process, which means that there was a change in prior knowledge [7].

For Seminério, the Better Equilibrations, cited by Piaget, promote the structuring of new languages from the existing ones. These languages mentioned by him do not refer to speech or writing, but languages that are at a level above these, which represent four fundamental competencies of human cognition found in the evidence of his research:

- (L1) Language 1 - It is the ability to structure perception into organized figures, as already identified in the Gestalt principles (imitation, continuation, closure, similarity, proximity, figure-ground, symmetry, and pregnancy), whose perception is understood as a totality and not as the sum of isolated elements, meaning that the whole has a much greater significance than the sum of the parts.
- (L2) Language 2 - It is the ability to assign meaning to the perceived shapes and not only store them as geometric shapes. L1 and L2 are lower hierarchy languages that include memorization learning, used in the traditional school, whose content is only retained, without cognitive leaps.
- (L3) Language 3 - It is the ability to assign successive meanings to facts, forming episodes or phrases, which make up the foundation of the capacity for imagination.
- (L4) Language 4 - It is the voluntary, reflective, and conscious control over everything that is perceived or thought. L3 and L4 are specifically human languages and form the basis for the construction of logical reasoning.

The purpose of applying Directed Elaboration is to reach L3 and L4, where teacher-student interaction cannot happen as a monologue in possession of the teacher, but with dialogue focused on what the adult can offer using questions that take turns with the answers obtained until they make sense to the student.

According to the technical procedures suggested by Seminério [3], during the application of the Directed Elaboration, the teacher starts the section by asking the students to answer a submitted question or to solve a proposed problem. The teacher, then, must verify that the students acted and interpreted the question/problem correctly and, based on their answers, proceed according to the alternatives presented in Figure 1.

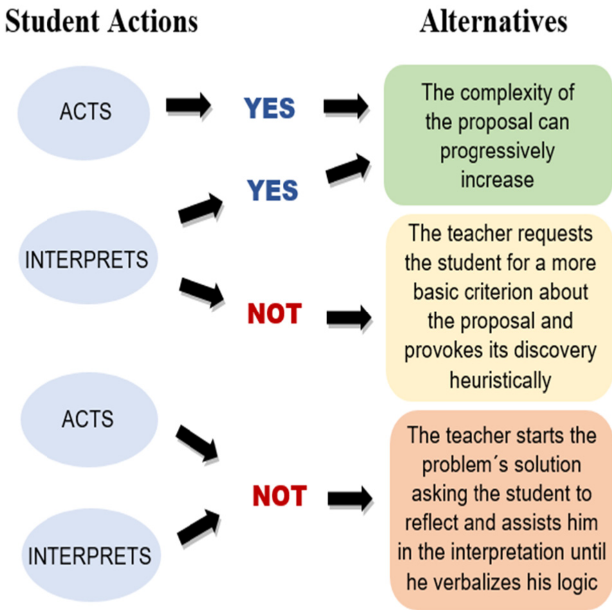

Figure 1. Application of Directed Elaboration [3]

3. STEAM Education

The term STEAM is an acronym formed with the initials of the words Science, Technology, Engineering, Arts, and Mathematics and means the interdisciplinary work of knowledge in these areas.

According to Boy [1], the discipline Arts was encompassed by the STEM concept of the exact areas (Science, Technology, Engineering, and Mathematics) because the current freely connected society requires the development of creativity to bring back the education that prepared humans for societal life. Due to consumerism provoked by the media, society has turned into spectators rather than contributors, and 21st century education needs to rescue people's ability to deal with unprecedented situations to know what to do in each case, and understand how to communicate the correct information to the correct people at the right moments [1]. This type of intellectual capacity can be developed with proposals worked in groups, in an interdisciplinary way, formulated on Project-Based Learning, whose approach focuses on the engagement of students in a cooperative and sustained investigation [9].

4. The Recycled Paper Machine Project

The project started when the theme of the Science Fair was presented to the class. About ten students were present at the Robotics Workshop, which takes place as an elective course from a Municipal School in the Interior of Rio de Janeiro, which attend students from the 6th to the 9th grade of Elementary School. At the time, the topic of bioeconomics was worked on through Directed Elaboration, whose questions raised were of the type: what is Bio? What is Economics? Thus, the dialogue extended until everyone had verbalized the understanding that the topic is the economy of natural resources.

After understanding the theme, were questioned types of natural resources needed to economize, and responses such as electricity, water, and petroleum were cited until class reached a consensus: save paper, which consequently saves the trees (due to needed cellulose) and consequently saves water for their manufacture.

It is essential to highlight that any of the natural resources that the class had chosen would become the object of study for the project because when the student acts as the protagonist of his learning, the content makes total sense to him, as defended by professionals who work with constructivist education. According to Becker [10], Constructivism is a theory capable of conceiving knowledge as something constructed by each one from their interaction with the environment. Constructivism´s theory explains the fact that students chose recycled paper as a solution for the Bioeconomy theme because to use and to discard paper is part of the school universe.

4.1. Inserting Robotics in the Project

As it is a class of regular students at the Robotics Workshop, they were challenged to insert robotics into the suggested idea of paper recycling. Given the unanimity that this insertion should happen with the creation of a robot or machine that recycles paper, the first step was to make resources available for students to learn, in practice, the entire process of paper recycling.

On the agreed day for the first attempt to recycle paper, some students had already watched videos that taught recycling techniques and took the shredded paper, already softened in water, even without being asked, which demonstrates the engagement obtained by constructivist choice. The first result was a thick mass that did not look like paper, and for this reason, new research was carried out on the process.

Figure 2. Practical Paper Recycling Process

Three other attempts were made, where students adjusted the steps of the process according to their new research (Figure 2). A thin and homogeneous paper was obtained and tested with several actions such as writing in pencil; erase with rubber; printing on an inkjet printer; fold to make envelopes and packages, as shown in Figure 3.

After understanding all the stages of the paper recycling process, students were invited to participate in a Brainstorm to idealize the robot or machine suggested by them. The Brainstorm consists of a meeting to explore ideas, where the group tries to find a solution to a given problem based on the various ideas presented [11]. On occasion, the students sat around a large table equipped with pencils, pens, adhesive tapes, scissors, and cardboard boxes. The moment was treated, by the participants, with surprise and fun due to its basic rules of applicability not so prevalent in the traditional classroom: criticism ban, encouragement of "out of the box" ideas, and combining and improving them.

Figure 3. Fourth Attempt Result

Brainstorm started with several sketches and ended with the creation of the cardboard prototype shown in Figure 4.

Directed Elaboration was used so that students did not forget to add all the stages of the recycling process already learned in the machine's idealization. It was also necessary to signal the devices needed for the autonomous operation of the project. The questions designed for students to achieve these answers were: what should be the first action of the machine? How will it be triggered? What is necessary to make this movement happen automatically? Is cardboard a material resistant enough for the final presentation of the project?

All these questions elaborated and directed, as the activities unfold, help the student to arrive at the answers for himself. Also, through the manipulation of resources and the attempts and changes that occur in the collective dynamics, students achieve their goals autonomously and in their own time, favoring social skills, reflective attitude, and scientific literacy [12].

Figure 4. Initial Cardboard Prototype

4.2. Assembly of the Physical Part

With the cardboard prototype in hand and the conviction that the cardboard was not resistant enough to support the installation of the electronic devices, the students received the option to cut the machine's pieces in MDF using a CNC laser cutter. For that, the students involved got to know the Free Software Inkscape and started its handling stimulated by Directed Elaboration. Inkscape is a simple graphical interface software (Figure 5), where the basic commands have clear and objective icons, which makes it possible to raise questions such as: to draw this particular part of the machine, what geometric shape can be used? Which of these software icons allows you to create this geometric shape? If the desired option is not found in the software, is there an answer on Internet search engines?

The next step was to handle the laser cutter and, with this experience, they learned:

- The difference between a vector image and bitmap image;
- How to import the drawing files into the laser cutter software;
- The possible file extensions for this work;
- How to make a cutting plan to save MDF;

- How to change the laser speed and strength settings to cut or engrave parts;
- How to calibrate the laser´s pen height to adjust the focus and the importance of this adjustment.

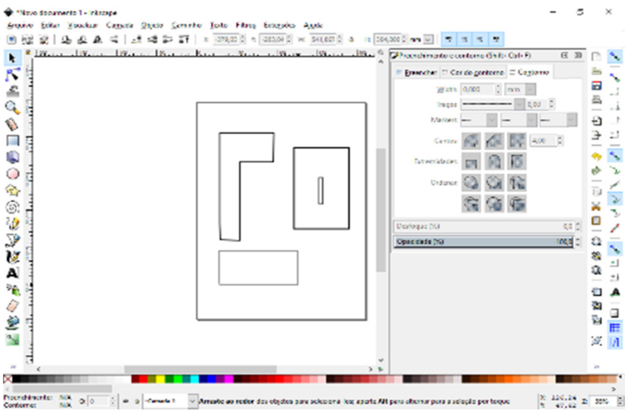

Figure 5. Inkscape Software Interface

Also, the students used the ruler to check the proportions of the prototype parts to draw them on the computer, and the centimeter was the unit of measurement chosen because it was more familiar to them. When handling the Inkscape software, students had to work with converting measurements from centimeters to millimeters. At that time, they did not master this task well, but they learned quickly and naturally because learning to make this conversion was not the ultimate goal, but the means to achieve it.

After assembling the final prototype with the pieces cut in MDF, the assembly of the electronic devices began. At that moment, the students experimented with the work of DC motors and LEDs connected to the batteries, so that they understood the connection and operation of direct current.

To control and automate the project devices, the Arduino prototyping board was chosen because it has Free Software and Hardware. Its schemes for the development of electronic components are freely available for anyone to reproduce them, popularizing and reducing their cost. A crucial aspect of the development of applications that use Free Software and Free Hardware, as opposed to the use of proprietary solutions, is the democratization of access to technology [13].

With the choice of devices, the stage of learning programming began so that the Prototype of Recycled Paper Machine could become something robotic, according to the challenge presented to students at the beginning of this project.

The DuinoBlokcks4Kids (DB4K) visual programming environment (free software) was chosen to teach programming language using the Directed Elaboration technique due to its didactic and intuitive interface. In this way, the development of Computational Thinking [14] gains more importance than the memorization of commands, reserved words, and symbols of programming languages.

5. Teaching Programming with Duino Blocks 4 Kids (DB4K)

DB4K [15] is a kit for learning programming through educational robotics aimed at children from elementary school onwards, based entirely on free technology and recyclable or low-cost materials. The Kit consists of a programming environment for Arduino boards based on plug-in blocks, a set of robotics materials, and a series of teaching activities.

Some of the features that differentiate DB4K from other visual programming environments for Arduino are:

- Interface designed and developed for use since the early years of Elementary School;
- Programming blocks with simple semantics, directly related to the devices that these blocks control, for example, to turn on an LED, there is the “Turn on LED” block;
- Simplification of the parameters used in the blocks, for example, in the “Rotate DC Motor” block, instead of the child having to enter a numerical value to determine the motor rotation speed, he only needs to choose one of the three common possibilities in your universe of knowledge: slow, medium speed or fast;
- Use of iconic language, which facilitates the identification of blocks and makes them more attractive, as shown in Figure 6.

Along with the DB4K Software programming environment, some robotic devices were developed with reusable materials such as plastic pots and PET bottles, however other devices can be created and produced by teachers and students according to their needs.

Figure 6. Programming Blocks DB4K software

One of the examples presents in the DB4K Kit is the Magic Box: small plastic box that contains devices commonly used in introductory robotics classes with Arduino. The Magic Box allows students to develop more elaborate programs to control circuits that would, at first, be difficult for them to build. Through the Magic Box, students learn about the devices and learn to control the actuators and sensors. The contextualization of the use of these actuators and sensors is done through PET bottle robots, which are presented to children as characters in stories, and they need to program the robots to assume the behaviors described during the narratives.

With the DB4K Kit, it is possible to work with children, among others, the following Computational Thinking skills:

- Abstraction capacity;
- Understanding of control flows;
- Use of conditional logic;
- Decomposition of problems;
- Debugging and systematic error detection.

This last skill is especially interesting because it allows children to assume greater autonomy during their programming learning process.

According to Papert [17], programming languages should have a low floor (easy to start) and a high ceiling (opportunities to create projects with increasing complexity over time). In this sense, the visual block-programming environment of the DB4K Kit performs the function of the low floor within the Arduino board programming learning.

In the first contact of students with the DB4K Software, they were asked to set up a program that would make an LED flash, first quickly and then more slowly. Questions were raised, such as: which of these blocks serves to light the LED? Once lit, what is the next block to be added to the schedule so that the LED flashes? Does the computer perform tasks at the same speed as people? Which block can be used to repeat this action?

Thus, facilitated by the friendly interface that DB4K offers, students experiment, check the results and change the program, through reflection motivated by Directed Elaboration, until the goal is reached. In this way, students develop Computational Thinking from their reasoning and transcend L1 and L2, which are cognitive languages that include learning by memorization, which can be lost. When they reach L3 and L4, where the processes of creativity and logical reasoning are anchored, according to the studies of Seminério [3], students achieve significant learning with permanent transformations. This means that even if an individual forgets to solve a problem or how to deal with specific tools, examples of information stored in memory, he will still know the logic of how to solve it, just by reviewing the forgotten tools.

After carrying out several programming challenges, worked with the same elaborate and directed approach, the students were already able to program the activation of all the resources available in the DB4K, such as the lighting of LEDs, the activation of displays, buzzers, DC motors, servo motors, use of the ultrasonic sensor, temperature sensor and luminosity sensor.

At this point in the execution of the entire project, about eight weeks after its beginning, the students had Computational Thinking developed enough to assemble the linear program necessary to operationalize the prototype. According to Papert [15], when the student uses the computer as a tool for building his knowledge, consciously and of his interest, what he called Constructionism, learning happens more effectively.

One of the most important tools that DB4K offers for this moment of work is the presentation of the Arduino code corresponding to the programming that students develop with the graphic interface blocks (Figure 7).

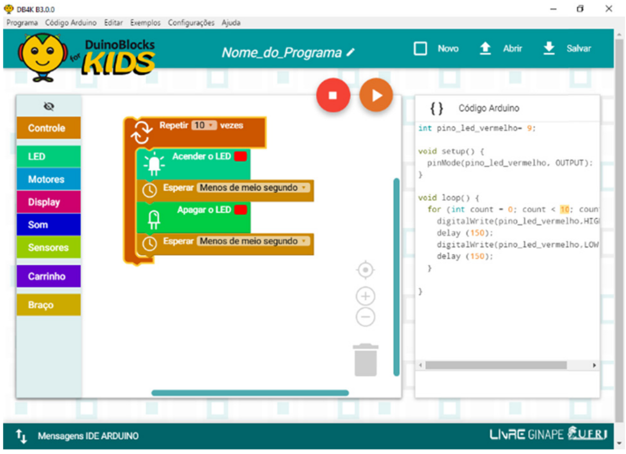

Figure 7. DB4K Software Interface

This translation from the graphic language to the linear programming that DB4K offers promotes a smooth transition in the programming learning of these students because they absorb the commands of the linear programming language without the obligation to memorize them, at the same time that they feel motivated by see their experiences working. Directed Elaboration contributes to this transition when students are asked to make modifications to their programs, for example, changing the speed at which an LED flashes at the same time that they see both programs on the screen (graphical and linear). At the time of Directed Elaboration, the teacher can do questions such as: when a DB4K block is changed, what changed in the Arduino code can happen? If a certain DB4K´s block is removed, which command in the Arduino code will disappear? If a DB4K´s block is added, which command will appear in the Arduino code?

It was possible to observe that students went through this transition naturally because in the first challenges proposed, they felt the need to change the programming blocks in DB4K software, to copy later the code translated into the Arduino language. However, as these actions became trivial, the students themselves wanted to "save work" and changed what they needed directly in the Arduino code. In a short time, they already knew how to activate the simple devices directly in the Arduino code and managed to make the entire prototype work autonomously.

6. Results

As a first result, the Prototype of the Recycled Paper Machine, designed by the students, had its automation completed by them. The prototype represents a machine that must be previously supplied with raw material, shredded paper and water, to perform automatic recycling, consisting of six steps:

1. The prototype is activated via a button that triggers the 9-second timer, counting down, shown on a 7-segment display. It serves to simulate the time needed for the paper to soak, to soften the fibers, before being beaten.
2. When the countdown on display ends, the first DC motor is activated for a few seconds simulating the operation of the blender propeller, representing the paper shredding.
3. After the first DC motor is turned off, a servomotor is activated to tilt the blender, demonstrating that the crushed dough must be poured over a thin fabric and stretched in a frame, which is inside a container with water.
4. A vibration motor is activated to simulate the dilution of the crushed mass in the water in the container.
5. After the vibration motor is turned off, the second DC motor is activated to suspend the screen, using the cables that connect them.
6. Finally, when the screen is already suspended to drain excess water, a fan is activated to accelerate the drying process.

First, the work was presented at the School Science Fair [18], where it was used as a research tool. Students tested the level of knowledge of the paper recycling process among members of the school community. Thus, as a second result, students were initiated into scientific thinking and understood aspects of the quantitative research method. They elaborated a questionnaire that asked, initially, if the participants knew how to recycle paper and asked them to explain the process if the answer was affirmative.

The questionnaire contained all the detailed steps that students took to recycle the paper successfully and marked the steps mentioned, as the participants explained. Then, the students activated the prototype and demonstrated the entire recycling process learned by them and, in the end, asked the participants to explain, again, what they had understood. The responses of the participants obtained after the presentation were also annotated in the second stage of the questionnaire.

Figure 8. Prototype of Recycled Paper Machine

Of the 21 interviewees during the exhibition at the Science Fair, among students, teachers, and employees, 16 participants did not know how to recycle paper, and the others cited less than 50% of the process. After the presentation of the prototype, 75% of the participants verbalized more than 50% of the recycling process.

This research served for the students to have contact, for the first time, with scientific thought. It was an experience where the participating students had the chance to experience aspects of scientific research, whose steps started in recognition of a problem, in this case, the waste of paper. Then they went on to ask the question: do people know how to recycle paper? He went on to formulate a hypothesis, where they estimated that people would learn by observing the working prototype and analyzed the data obtained in the questionnaires. They concluded that the prototype´s presentation was useful because all interviewees mentioned some of the stages of the recycling process. Even those who did not know how to recycle paper before the prototype´s presentation knew the process more clearly.

The project and the results of the research carried out by the students were subsequently presented at the Municipal Fair of the Education Secretariat of Macaé, in partnership with the Federal University of Rio de Janeiro (UFRJ).

7. Conclusions

The present work is the report of an educational process carried out with non-traditional teaching methods, where the technique of Directed Elaboration was used in all stages of the construction of a proposal idealized by the students. The proposed alternative to paper waste came after the dialogue on the bioeconomy theme in work carried out in a constructivist and constructionist manner.

It was found that DB4K is a great tool to teach programming to elementary school students because it has a simple and intuitive graphic interface. This facility keeps the focus of learning on the development of Computational Thinking and in an elaborate and directed interaction between teacher-students. In this way, the schoolchildren can achieve the answers using his knowledge in a meaningful and lasting way.

It was understood that the approaches used in this project for teaching programming, worked in an interdisciplinary way, promoted access to technology and effectively introduced the school contents not previously absorbed by the students. The result was positive because the learning of these contents was not their final objective, but the necessary means for them to put their ideas into practice. During the project, the students' growing motivation to make the prototype work was found. For this, they developed ideas, studied programming, and understood the school content, as the origin of the paper, the paper recycling process, the electric current, and the conversion of measures. These simple tasks that they did not master were quickly learned due to the need to project the entire functioning of their ideas.

Therefore, it was possible to observe that learning the contents worked from a process of significant construction for the student, kept them more interested and engaged than in the traditional method of memorizing content for evaluation. In practice, this conclusion means that students have learned to seek answers and solutions to solve the challenges proposed by the School and, consequently, have prepared themselves to deal with the challenges that will arise throughout their lives.

8. Acknowledgment

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Awareness and Knowledge of Portugal Residents about Natura 2000

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Abstract. Natura 2000 is the European Union's key strategy to address the current sharp decline of biodiversity. However, according to a recent survey, most Europeans never heard about it. The present study intended to further explore the perceptions of residents in Portugal about this network of protected areas through the nationwide implementation of a survey. Results showed that even respondents who knew what Natura 2000 is were not well-informed about it, which is worrisome as public participation is considered a key factor for successful nature conservation initiatives.

Keywords. Wildlife, Europe, Ecological Behaviour, Pro-Environment Behaviour.

1. Introduction

Despite its intrinsic value and its importance for human well-being, biodiversity is being lost at alarming rates worldwide [1-2]. To address this pressing issue, the European Union launched Natura 2000 – a coordinated network of protected areas. This network has a huge coverage, comprising more than 18% of the land of the European Union plus 6% of its sea area [3-4]. Its goal is to ensure long-term protection of the most valuable and threatened species and habitats. This requires taking action to protect, maintain or restore those species and habitats to a favourable conservation status [4-5]. Natura 2000 plans to fulfil its conservation mission through an inclusive and sustainable management approach. Hence, cooperation with all stakeholders is highly desirable. Also, this implies that socio-economic activities compatible with site preservation are encouraged [4].

Despite Natura 2000 intentions to engage stakeholders, according to a survey carried out by the European Commission in 2018, most Europeans are still not aware of the existence of this network (70%, N = 27 643). The same study also reported that only 11% of respondents claimed to know what Natura 2000 is [6]. This suggests that this important network is still unknown to the majority of European Union's population, which is a very worrisome finding as public participation plays a critical role in the achievement of biological conservation goals [2,7-10]. For instance, addressing the current drivers of biodiversity loss requires changes in citizens' behaviour [2]. Plus, people can pressure the government to take action, can get involved in policy discussions and can also facilitate local conservation initiatives [2,7-10].

In Portugal, Natura 2000 is composed by 166 protected areas, covering almost 21% of the land area of the country [10]. Despite devoting such a large area to Nature conservation [10], Portugal has failed to comply with some mandatory requirements regarding designation and management of the sites forming this network [11]. Due to this non-compliance, the European Commission referred Portugal to the Court of Justice of the European Union in January 2018 [11]. Besides, Portugal is also struggling with Natura 2000 monitoring demands. In fact, the country submitted the most incomplete Habitats Directive monitoring report among all Member States for the period 2007-2012. In this report, about 35% of the mandatory data was absent or referred to as unknown [12]. Although Portugal has found it rather difficult to fulfil all its network obligations [11-12], its residents seemed to be more aware of Natura 2000 than the average European. In the prementioned survey carried out by the European Commission, 35% of respondents from Portugal claimed they had heard of Natura 2000 before, which stands 5% higher than the average [6].

Given this rationale, the present study intended to further understand how knowledgeable the Portuguese population is about Natura 2000, including which sites are most well-known and which species are thought to inhabit them.

2. Methods

A questionnaire on Natura 2000 was adapted from the literature [6,13-18]. This questionnaire was divided in two parts: the first focused on unravelling if participants knew what Natura 2000 is, and on with which frequency they engaged in ecological behaviours (e.g. recycling) using a 5-point Likert scale; the second one was composed by multiple open- and close-ended questions aimed at assessing the knowledge of respondents about this network.

Only inquired people that claimed to know what Natura 2000 is fulfilled the second part of the questionnaire. During 2019, this questionnaire was broadly disseminated through the internet (e.g. published in Facebook groups, shared by a citizen science platform) and was also implemented in-person during a few science communication activities somewhat related to Natura 2000. In these events, the questionnaire was applied both before and after activities. All collected data were codified and submitted to a quantitative analysis on Microsoft Office Excel (2002 version) and IBM SPSS Statistics (version 26), consisting on the calculation of percentages, arithmetical averages, standard deviations, and Spearman's correlations.

3. Results and Discussion

Overall, 232 individuals participated in this study: 60 (26%) fulfilled the questionnaires remotely, while 172 (74%) did it at presential events.

3.1. Socio-demographic data

As showed in Fig. 1, most respondents were females ageing within 12-29 (67%, n = 155). Regarding the geographical location of residence, Porto was the best represented district (52%, n = 121), followed by Aveiro (16%, n = 38), Braga (9%, n = 20), and Bragança (9%, n = 20), all from the centre and north of Portugal.

Almost half of the participants were still attending middle school (48%, n = 111); but, a great number of questionnaires were also fulfilled by people who held a university degree (29%, n = 68) or a high school diploma (22%, n = 50). About 30% of participants (n = 70) had jobs or where pursuing studies related to biology and/or Nature conservation.

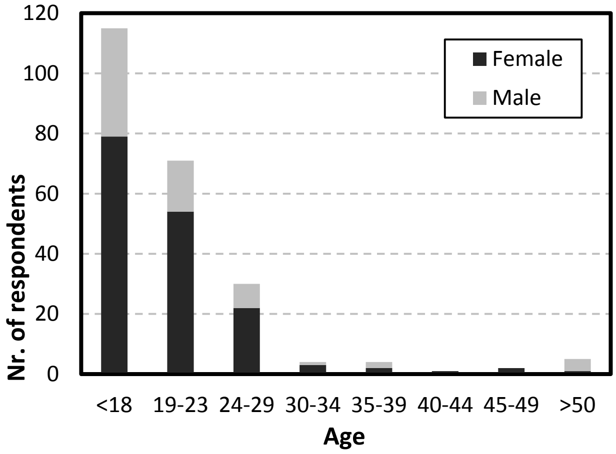

Figure 1. Age and gender distribution of respondents

3.2. Awareness about Natura 2000

As expected based on previous literature reports [6,17-18], most respondents had never heard of Natura 2000 (54%, n = 126). However, 20% (n = 47) had heard of the term beforehand and claimed to know what Natura 2000 is. This percentage is slightly higher than the one obtained for Portugal in the survey carried out by the European Commission (20% > 15%) [6]. This difference in percentages is likely due to a lower representativeness level of the sample, which is supported by the fact that 81% of respondents (n = 38) contributing to the "20% result" studied or worked in fields related to biology and/or Nature conservation. Besides, a high proportion of respondents, who knew what Natura 2000 is, held a university degree (74%, n = 35); in a similar study carried out in Poland, this population segment was shown to be more aware of the network than people who did not attend higher education [17]. Nonetheless, as the goal of the present research was to further explore the perceptions of respondents, this higher percentage of participants aware of Natura 2000 is welcome.

3.3. Knowledge about Natura 2000 sites

The 47 respondents that claimed to know what Natura 2000 is were asked to name between one and ten Portuguese Natura 2000 sites. Overall, 39 distinct protected areas were named, which represented 23% of all network sites located in Portugal [10]. On average each participant correctly named 2.8 ± 2.2 sites; but this was highly variable, e.g., six participants named none and one mentioned 10. Peneda/Gerês (PTCON0014) was the site mentioned by a higher number of participants; Serra da Estrela (PTCON0014) and Montesinho/Nogueira (PTCON0002) came second and third, respectively (Table 1).

Table 1. Portuguese Natura 2000 sites named by respondents, their respective site code and number of participants mentioning each one (N = 47)

Natura 2000 sites	Site code	n
Peneda / Gerês	PTCON0001	33
Serra da Estrela	PTCON0014	12
Montesinho / Nogueira	PTCON0002	9
Alvão / Marão	PTCON0003	7
Ria de Aveiro	PTCON0061	7
Arrábida / Espichel	PTCON0010	5
Litoral Norte	PTCON0017	5
Sintra / Cascais	PTCON0008	4
Douro Internacional	PTCON0022	3
Estuário do Tejo	PTCON0009	3
Malcata	PTCON0004	3
Ria Formosa	PTZPE0017	3
Rio Lima	PTCON0020	3
Côrno do Bico	PTCON0040	2
Costa Sudoeste	PTCON0012	2
Estuário do Sado	PTCON0011	2
Ilhas Berlengas	PTZPE0009	2
Serras da Freita e Arada	PTCON0047	2
Valongo	PTCON0024	2
Barrinha de Esmoriz	PTCON0018	1
Cabrela	PTCON0033	1
Complexo do Açor	PTCON0051	1
Dunas de Mira, Gândara e Gafanhas	PTCON0055	1
Gardunha	PTCON0028	1
Lagoa da Sancha	PTZPE0014	1
Lagoa de Santo André	PTZPE0013	1
Laurissilva da Madeira	PTMAD0001	1
Maciço Montanhoso Central da Ilha da Madeira	PTMAD0002	1
Monfurado	PTCON0031	1
Montemuro	PTCON0025	1
Paul de Arzila	PTCON0005	1
Paul do Boquilobo	PTZPE0008	1
Ria Formosa / Castro Marim	PTCON0013	1
Rio Minho	PTCON0019	1
Rio Vouga	PTCON0026	1
Serras d'Aire e Candeeiros	PTCON0015	1

The record of Peneda/Gerês as the most mentioned site was expected as this is simultaneous the only national park in Portugal [19] and a very popular protected area in the country, as demonstrated by the fact this is the one contacted by the highest number of visitants (more than 1 million visitor contacts/year during the period 1996-2019) [20]. The presence of Serra da Estrela in top 3 was also expected; being the highest mountain range on the mainland [21], this site receives many visitors during Winter to enjoy snowfall [22]. However, the high number of people mentioning Montesinho/Nogueira is harder to explain. This situation may have occurred because this is one of the largest protected areas in northern Portugal [19], where most respondents were from.

Afterwards, respondents were asked to name their favourite Natura 2000 site along with some species that inhabit it (max. 10) as well as to select from a list the main threats that such protected area faces (max. 5). From this point on, unless otherwise stated, besides the 47 participants that said knowing what Natura 2000 is beforehand, the data analysis also included answers given to post-tests by 99 people that claimed to already know what Natura 2000 is. Overall, 21 different sites were designated by participants as their personal favourites: Peneda/Gerês, Serra da Estrela, Ria de Aveiro, and Rios Sabor e Maçãs were the ones selected by most respondents (65%, n = 95); all the other sites were mentioned by up to four individuals.

But how knowledgeable were inquired people about their favourite Natura 2000 protected areas? Regarding the threats, the ones selected by more participants were:

1. Pollution (30%, n = 44);
2. Tourism / recreational activities (28%, n = 41);
3. Climate change (26%, n = 38).

To better understand their perceptions, a detailed analysis was performed focusing on threats to Peneda/Gerês, Serra da Estrela, Ria de Aveiro and Rios Sabor e Maçãs (Table 2).

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Table 2. Main threats to each Natura 2000 site (PG – Peneda / Gerês; SE – Serra da Estrela; RA – Ria de Aveiro; RS – Rios Sabor e Maçãs), as selected by respondents (N = 95)

Threats	PG		SE		RA		RS		T
	R	n	R	n	R	n	R	n	
Agriculture / Grazing	M	8	-	1	M	3	H	2	14
Forest plantations	L	8	L	2	M	2	M	0	12
Mining and extraction of materials	L	3	L	2	M	1	M	0	6
Energy production	L	3	-	4	-	0	-	0	7
Transportation / service corridors	M	9	M	7	H	3	M	1	20
Urbanization	M	7	M	8	H	3	-	0	18
Fishing / Aquaculture	-	6	-	0	H	4	-	5	15
Hunting (incl. collection of wild animals)	H	12	L	5	M	2	M	0	19
Removal of terrestrial plants	M	6	M	1	-	0	-	5	12
Tourism / Recreational activities	M	14	L	10	-	4	M	0	28
Climate change	-	9	-	11	-	4	-	0	24
Invasive alien species	H	13	M	2	H	4	M	0	19
Pollution	L	10	M	12	M	6	L	0	28
Do not know / remember		10		3		1		3	17
Invalid answers		5		9		1		2	17

R: threat relevance to the respective site (H – High; M – Medium; L – Low; "-" – irrelevant threats). **T:** total number of respondents (n_{PG} + n_{SE} + n_{RA} + n_{RS}).

On average, respondents who provided a valid answer selected correctly only 1.7 ± 1.4 threats (out of five). It is important to highlight that a response was deemed correct if the selected threat had a medium or high relevance for the respondent's favourite site. Pollution, tourism/recreational activities and climate change were the threats selected by more participants (Table 2). However, according to the managing authorities, climate change is not a relevant threat in any of the analysed sites; pollution only has a low to medium relevance, and the relevance of tourism/recreational activities varies between none to medium [23]. In contrast, invasive alien species – which represent a highly relevant threat in two of the protected areas further scrutinised and has a medium relevance in the other ones [23] – were selected just by 19 participants (Table 2). Therefore, respondents did not seem to have a clear perception of the main factors threatening their favourite Natura 2000 site.

A detailed analysis of the wild species that respondents thought to inhabit Natura 2000 protected areas was also performed, focusing only on answers given by participants who elected Peneda/Gerês, Serra da Estrela, Ria de Aveiro or Rios Sabor e Maçãs as their favourite site. Overall, 52 taxa were correctly named, with birds being the most well-represented group (Fig. 2). All mentioned taxa were native, except for one: the common water hyacinth (*Eichhornia crassipes*), an invasive alien plant that is present in mainland Portugal and Azores [24].

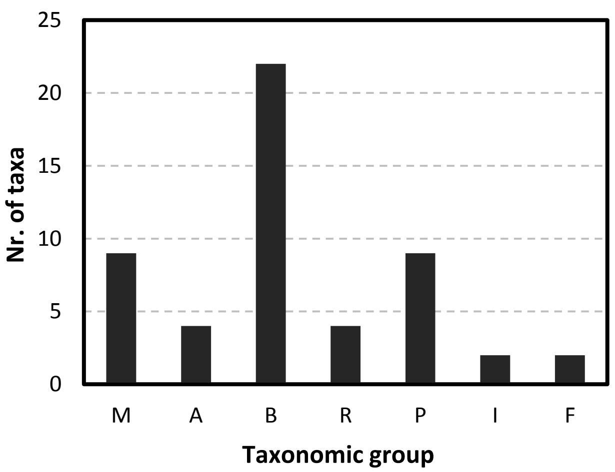

Figure 2. Number of taxa that respondents correctly indicated to be present at their preferred Natura 2000 site, by taxonomic group

Taxonomic group: M – Mammals; A – Amphibia; B – Birds; R – Reptiles; P – Plants; I – Invertebrates; F – Fish.

Most participants (n = 65, 66%) were not able to name any species correctly. n order to assess if a given species was present – or not – in a specific Natura 2000 site, several sources were consulted [23-30]. The remaining respondents correctly mentioned, on average, 3.3 ± 2.5 taxon (out of 10). These numbers suggest they were not very familiar with the biodiversity of their favourite Natura 2000 sites.

It is also worth mentioning that, in this question, many participants provided broad answers, referring to kingdoms, orders or families (e.g. animals, plants, bats, ants); but, for the purpose of this work, only common names exclusively used for genus or species were considered.

These results are in accordance with similar studies carried out in Poland, which also revealed that the majority of people who were aware of what Natura 2000 is knew little else about it [13,16].

3.4. Natura 2000 visits

Most respondents who were aware of what Natura 2000 is only visited it once per year or even less frequently (Fig. 3). Regardless, the number of times participants visited this network was not significantly correlated with their knowledge about it (r = 0.181, p = 0.082). This is a surprising finding as it suggests that spending time more often at Natura 2000 sites has little improvement on visitors' knowledge about them. This may indicate that there is a shortage of Natura 2000 information at the network sites.

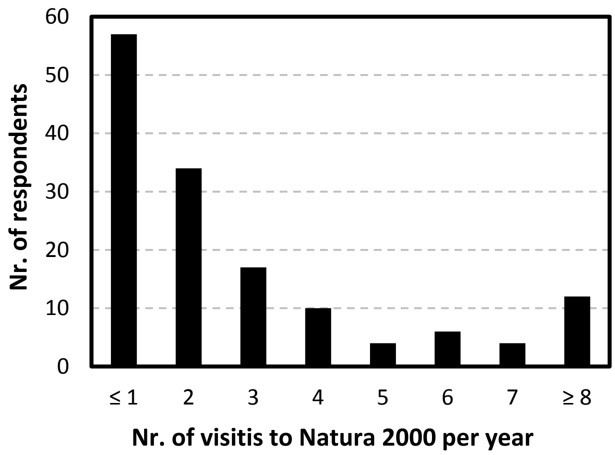

Figure 3. Number of self-reported visits to Natura 2000, per year (N = 144)

3.5. Knowledge about threatened species

Each participant, on average, named correctly 1.7 ± 1.2 taxa (out of 10) that were threatened with extinction in Portugal. Conservation status was checked on Portuguese Red Book of Vertebrates [24] and on Portuguese Red List of Vascular Plants [31]. In total, 33 nationally threatened taxa were mentioned, with most of them being mammals (n = 12, 36%) or birds (n = 11, 33%). However, currently there are 568 taxa classified as threatened with extinction in Portugal [24,25]; which means the replies of the sampled population represent only around 6% of the total specific richness. Iberian lynx (*Lynx pardinus*), Iberian wolf (*Canis lupus signatus*) and Spanish imperial eagle (*Aquila adalberti*) were the ones referred by more participants (Fig. 4). All the other taxa were only named by up to seven respondents. This disparity in awareness about different threatened species in Portugal is very intriguing and should be further studied.

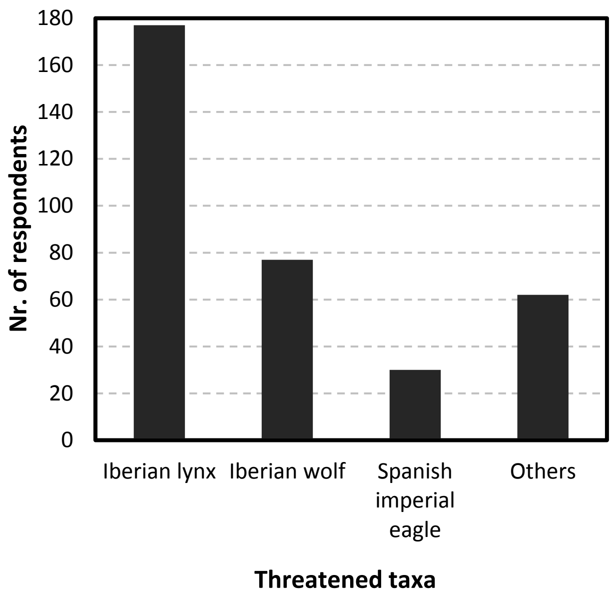

Figure 4. Threatened taxa in Portugal that were mentioned by respondents (N = 232)

The number of threatened taxa mentioned by respondents was once again weakly correlated with their knowledge about Natura 2000 (r = 0.393, p = 0.000).

3.6. Ecological behaviours

Table 3 presents the average frequency of engagement in the following ecological behaviours:

A. Depositing garbage in the appropriate recycling bin;
B. Reusing shopping bags;
C. Avoiding buying single use plastics;
D. Talking to others about environmental issues and Nature in general;

E. Being involved in environmental restoration actions (e.g. tree plantations);
F. Participating in citizen science initiatives targeting Nature and/or the environment;
G. Having a shower instead of a bath.

Table 3. Average frequency with which respondents engaged in the ecological behaviours described above (N = 232)

Ecological behaviour	Average frequency	SD (standard deviation)
A	4.3	0.9
B	4.6	0.8
C	3.6	1.2
D	3.5	1.1
E	2.6	1.2
F	2.2	1.1
G	4.4	1.2

A 5-point Likert scale was used by participants to indicate the frequency with which they adopted pro-environment behaviours (1 - never; 2 - rarely; 3 - sometimes; 4 - often; 5 - regularly)

Taking part in citizen science projects was the behaviour participants showed less frequently (Table 3), which indicates this was the most difficult task to accomplish for the sampled population [15]. In contrast, reusing shopping bags, having a shower, and depositing garbage in the appropriate recycling bins seemed to be easier behaviours to adopt [15]. Nonetheless, the frequency of ecological behaviours was poorly correlated with the respondents' knowledge about Natura 2000 ($r = 0.277$, $p = 0.007$). Despite increasing public knowledge about biodiversity being widely considered necessary to foster willingness to adopt pro-environment behaviours [2,32], this study failed to show a strong correlation between Natura 2000 knowledge and the engagement in ecological behaviours. This may be due to a restriction of knowledge about the network to people highly literate about biological diversity, which is supported by the following statistics:

- In this study, 81% of respondents who were aware of Natura 2000 worked or pursued studies related to biology or nature conservation (n = 38);
- 74% of respondents that claimed to know what Natura 2000 is held at least one university degree (n = 35).

This explanation is also backed up by the results of a survey published by the European Commission in 2015, which revealed that Natura 2000 was unknown even for 39% of Europeans that self-reported to be well-informed about biodiversity loss [18].

4. Conclusion

Natura 2000 is the main instrument of the European Union to tackle biodiversity loss. Although this network of protected areas intends to fulfil its conservation goals while engaging stakeholders in the management process, Natura 2000 is still unknown by a large majority of Europeans. This can undermine its conservation mission as public participation is considered a crucial factor for successful Nature conservation initiatives. The findings of this study confirm this negative scenario, since the literacy about the network was shown to be very low, even for the people who were aware of it. These findings are even more worrisome when considering that the current study has an overrepresentation of people who are expected to be highly literate in biodiversity issues (university diploma holders and biology-related workers/students). Plus, the present study is not the only one reaching to this conclusion: similar research projects carried out in Poland also revealed low Natura 2000 literacy levels among its respondents. Hence, the current paper is another testimony of the urgent need for the improvement of science communication efforts focusing on Natura 2000, with the ultimate aim of enhancing its performance regarding species and habitats conservation.

5. Acknowledgements

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Decree-Law 57/2016, changed by Law 57/2017. Finally, the authors would like to thank all the participants involved in this study for taking the time to fulfil the questionnaire.

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Preliminary Evaluation of a Serious Game on Biological Invasions

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Abstract. Invasive alien species are one of the biggest threats that biodiversity faces worldwide. However, society remains poorly aware of this issue. In order to raise awareness on this matter among middle school students, a strategy board game was developed. A preliminary assessment of the game's ability to improve players' knowledge on this subject was performed based on the experience of 132 participants distributed through 11 game rounds. Results suggest this serious game was successful in engaging students with biological invasions as well as in increasing their literacy on this topic.

Keywords. Science Communication, Ecology, Environmental Education.

1. Introduction

Alien species are defined as the ones introduced outside their native range, directly or indirectly due to anthropogenic activities. When these species can survive and proliferate on foreigner ecosystems, they are often harmful to native biodiversity. In these cases, alien species are deemed invasive and it is said that a biological invasion occurred [1]. Nowadays, invasive alien species (IAS) are regarded as a key cause of biodiversity loss worldwide, along with climate change, pollution, overexploitation, deforestation and other habitat disturbances [1-4]. Plus, IAS have a major negative impact on the economy, health and well-being of human societies [5-8]. For instance, in Europe, they are responsible every year for losses valued in at least 12 billion euros [5,8]. Hence, it is of utmost importance to properly manage biological invasions. Since anyone can be responsible for the dissemination of IAS (e.g., by releasing unwanted pets into the wilderness or by unwilling transporting plant seeds to other locations), everyone can play a role in preventing further biological invasions [9]. But, are regular citizens aware of the threat IAS pose? In 2019, the European Union published a report where they inquired over 27,000 people on their awareness, knowledge and attitudes regarding biodiversity. This report revealed that 72% of respondents thought IAS represented a relevant threat for native biodiversity. Still, this was the threat less participants believed to be relevant [10]. Unawareness about IAS and their broad harmful impacts are present even among key stakeholders [11-12]. For example, a study involving representatives of pet shops located in San Francisco (USA) revealed that only 60% of respondents had previously heard of the term "invasive species" [11]. In Portugal, only 40% of municipalities that replied to an IAS questionnaire recognized these organisms had negative impacts [12]. Given this scenario, it is clear that more efficient science communication and education efforts are needed to tackle this global issue.

Over the past recent decades, serious games and gamification have been increasingly applied to science education [13-14]. Serious games can be defined as the ones which have a clear purpose besides entertainment [14-15], while gamification implies the use of game mechanisms (e.g. leader boards, badges) in non-game contexts [13,16]. Several studies reported that both strategies increase engagement and promote positive learning outcomes in students [13,15-16], including evidence that suggests these may help struggling students obtain better grades [16]. In light of this literature, the current study aimed to assess whether or not a serious game on biological invasions could promote awareness and increase knowledge about this concerning matter among Portuguese middle school students.

2. Board game "Boundary Breach"

To the authors best knowledge, no serious games on IAS were available in the mother tongue of the selected audience (Portuguese middle school students) thus, a new strategy board game was conceptualized. The game can be played by 6 persons or teams, who are responsible to manage a given continent with the goal of preventing biological invasions. The winner will be the player(s) that accumulates less IAS, both in species number and abundance. The gameboard (Fig. 1) is composed by a coloured world map, with six continents connected by a steppingstone pathway. Each continent contains 10 steppingstones: eight normal ones and two special ones. The later can be any of the four different special steppingstones:

- Prevention hub: players that stop in this steppingstone can take a card from the respective deck. Each card represents a specific prevention measure that they can apply to their continent, but they have to decide immediately whether they want to implement it or not.
- Control hub: when players stop at this special steppingstone, they should take a card from the respective deck. Each one describes specific control measures that can be applied in their continent to reduce the abundance of a given IAS. Players can hold on to it for as long as they want, but they should have in attention that they can only retain a maximum of three control/eradication cards on their hand.
- Eradication hub: players stopping at this steppingstone are allowed to take a card from the respective deck and hold on to it for as long as they want. Each card includes detailed eradication actions that can be employed in their land to completely remove a recently introduced IAS.
- Camera: players that stop in these steppingstones receive a postcard with a photograph of a famous landmark from where they are at that moment. The game will be over when one player or team collects all six postcards.

After selecting the continent they would like to manage, each player/team gets a token of the same colour of their continent and a scoresheet where they can register the number of times each IAS is introduced in their land (Fig. 1). Before starting the game, players must position their token on any regular steppingstone within their respective continent. Afterwards, all participants have to roll the dice; the player who obtains the highest number will be the first one to play. Then, a clockwise order will apply. In a single play, first, each participant has to roll a dice inside Boundary Breach's roulette (Fig. 2).

Depending on where the dice stops, the player will need to take different actions before moving its token on the board:

- Transportation: the player has to pick up and transport one IAS that is native to the continent where his/her token stands;
- Introduction: the player will introduce all IAS he/she is transporting into the continent where the token is currently standing on. The manager of the invaded continent must take note of all IAS introduced on his/her own scoresheet.
- None (-): no extra action needed.

Figure 1. Schoolchildren (aged 10-12) playing Boundary Breach during Junior University: a summer school for middle and high school students organized by University of Porto (Portugal)

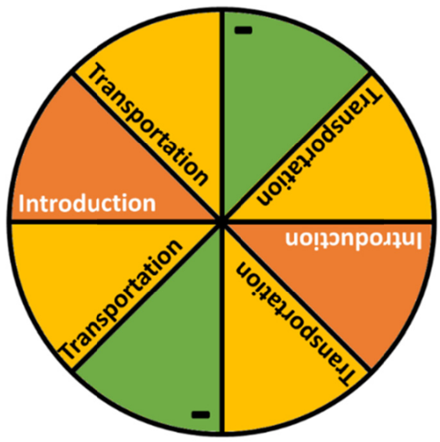

Figure 2. Boundary Breach's roulette

Afterwards, players must move their token according to the number on the dice. Although the token can be moved in any direction following the steppingstone pathway, in a single play it is only possible to move it in one way. Players are allowed to move within and between continents.

Finally, it is also worth mentioning that Boundary Breach comprises one IAS deck with 12 cards; each one includes the name and picture of an IAS species, along with a short description of it and a reference to its continent of origin.

3. Educational potential of Boundary Breach

During June and July 2016, Boundary Breach was included in the programme of a junior summer school ran by University of Porto (Portugal) – Universidade Junior [17]. Overall, eleven game matches were played, involving a total of 132 students aged 10-12 years old (Fig. 1). Participants' knowledge acquisition about IAS was evaluated through the application of pre- and post-tests, being complemented with a group discussion on the best strategy to win the game. Only 128 pre- and post-test questionnaires were properly fulfilled. The pre-test included six close-ended questions:

1. Have you ever heard of invasive alien species?
1.1. Do you know what they are?
2. Which of the following plant species (Table 1) can you recognize?
2.1. Which ones do you think are invasive?
3. Which of the following animal species (Table 1) can you recognize?
3.1. Which ones do you think are invasive in Portugal?

The post-test contained only questions number 2 and 3. Plus, at the end of the activity, students were asked to report on how much they enjoyed Boundary Breach by individually rating it from 1 (not at all) to 5 (very much).

3.1. Previous knowledge about IAS

Before playing Boundary Breach, 51.6% of students (n=66) mentioned they have heard of the term "invasive alien species" beforehand. Nevertheless, only 33.6% (n=43) stated they knew what IAS are. After this individual self-report moment, a slide with 12 photographs portraying different plant species was showed to all participants. The most recognized plant was a native fern, followed by the invaders blue morning glory (*Ipomoea indica*) and giant reed (*Arundo donax*). The plants most participants thought to be invasive were the native Bracken fern (*Pteridium aquilinum*), giant reed (*Arundo donax*) and water hyacinth (*Eichhornia crassipes*) (Fig. 3-A).

Table 1. Plant and animal species showed to students during pre- and post-tests

#	Plant species	Animal species
1	Bermuda buttercup (*Oxalis pes-caprae*)	European hedgehog (*Erinaceus europaeus*)
2	Ice plant (*Carpobrotus edulis*)	Red swamp crayfish (*Procambarus clarkii*)
3	Wattles (*Acacia* spp.)	Zebra mussel (*Dreissena polymorpha*)
4	Pampas grass (*Cortaderia selloana*)	Goldfish (*Carassius auratus*)
5	Bracken fern (*Pteridium aquilinum*)	Common carp (*Cyprinus carpio*)
6	Blue morning glory (*Ipomoea indica*)	Red-eared slider (*Trachemys scripta elegans*)
7	Maritime pine (*Pinus pinaster*)	Asian hornet (*Vespa velutina*)
8	Rockrose (*Cistus crispus*)	Asian clam (*Corbicula fluminea*)
9	Giant reed (*Arundo donax*)	European honeybee (*Apis mellifera*)
10	Blue gum (*Eucalyptus* globulus)	Chinese mitten crab (*Eriocheir sinensis*)
11	Water hyacinth (*Eichhornia crassipes*)	Brown rat (*Rattus norvegicus*)
12	Pittosporum (*Pittosporum undulatum*)	Common blue mussel (*Mytilus edulis*)

Only the taxa highlighted with grey are native to mainland Portugal [18-19]. All the other ones are also present in the mainland, but they are considered IAS [20-22]

Then, a slide showcasing 12 animal species was displayed to each class. Regarding animals, the overall recognition percentages were higher. Red-eared slider (*Trachemys scripta elegans*), European honeybee (*Apis mellifera*) and European hedgehog (*Erinaceus europaeus*) were the ones recognized by a highest percentage of students. Asian hornet (*Vespa velutina*), red swamp crayfish (*Procambarus clarkii*) and brown rat (*Rattus norvegicus*) were the animals most children thought to be invasive (Fig. 3-B).

The percentage of wrong answers (wrong = identifying native species as IAS) was higher for plants (24.7% > 17.8%).

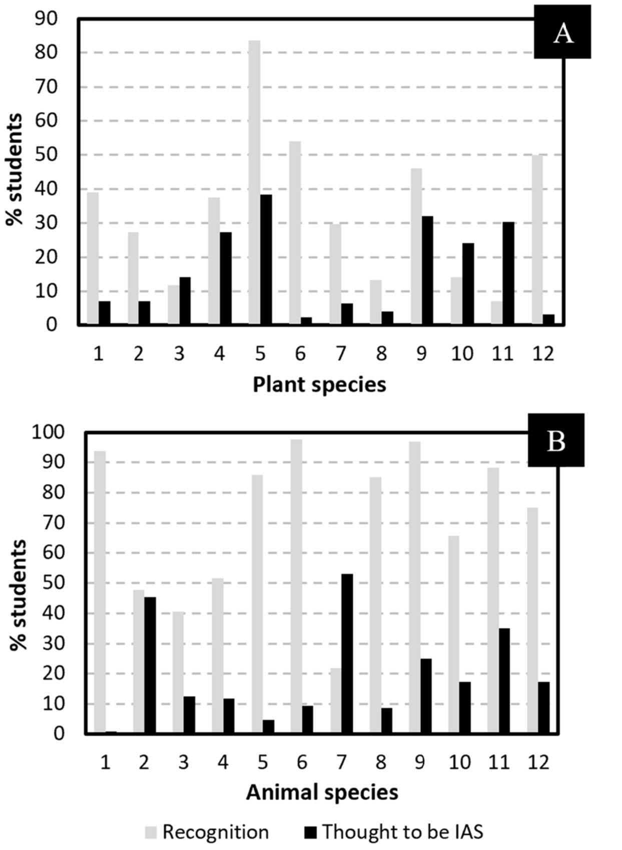

Figure 3. Percentage of students that recognize each plant (A) or animal (B) species represented in Table 1 and that thought each one was an IAS, before engaging with Boundary Breach

3.2. Knowledge evolution & enjoyment

After playing Boundary Breach, participants were asked to once again look at the slides previously showed during pre-test and to identify which of the displayed species were IAS. This time, a much higher percentage of students was able to correctly identify species involved in Boundary Breach as invasive (Figure 4). It is worth mentioning that although animal species number 1 and 11 were not addressed in the game, they were part of a talk that took place between pre- and post-tests.

During the discussion promoted at the end of each game, participants were asked to give examples of the best strategies to win. Managing IAS was the strategy that most students agreed to be the best (81.8%, n=108); the following most mentioned strategies were introducing IAS into other continents (78.0%, n=103) and celebrate international agreements (53.8%, n=71) (Table 2). Regarding how engaging Boundary Breach is, overall students attributed it an average of 4.7±0.7 (out of 5), which indicates they enjoyed it very much.

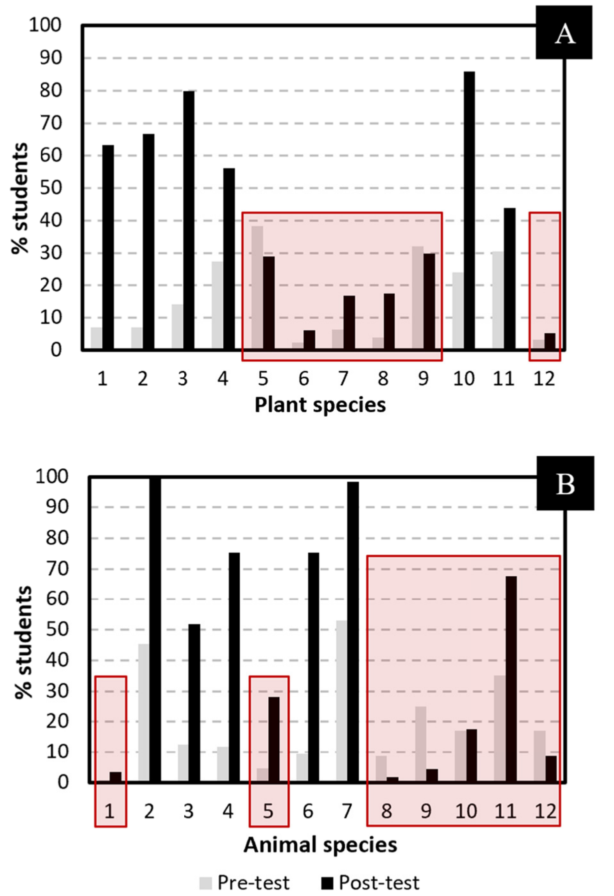

Figure 4. Percentage of students that thought each plant (A) or animal (B) species was an IAS, before and after playing Boundary Breach. The numbers 1 to 12 correspond to the taxa named in Table 1. The bars inside boxes represent native and invasive alien species that were not incorporated in the board game

4. Discussion

The choice of performing a preliminary evaluation of Boundary Breach during Universidade Júnior was mainly motivated by the possibility of having a huge number of participants over a short period of time. However, this approach introduced some constraints to the current study. First, the purpose of this event is not to carry out a scientific research, but to entertain kids and teenagers with educative activities. Hence, the design of the activity had to be carefully planned to make sure that the questionnaires were felt as part of the activity rather than a test. Besides, the activity must last one full day. For both reasons, another IAS activity

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(unrelated to the board game) was implemented between pre- and post-tests.

Table 2. Best strategies to win Boundary Breach, according to players (N=132)

Best strategies to win	n	%
Management of IAS	108	81.8
Prevention is the best management option	61	46.2
Celebrate international agreements	71	53.8
Strategically choosing your continent at the start	53	40.2
Introducing IAS into other continents	103	78.0

Before playing Boundary Breach, only about 1/3 of participants self-claimed they knew what IAS are. Plus, many animal species with high recognition percentages were wrongly thought not to be invasive (e.g. red-eared slider, brown rat) (Fig. 3-B). Regarding plants, the species most students recognized (bracken fern) was also the one most thought to be invasive (Fig. 3-A). However, their beliefs were wrong as the bracken fern is actually native to mainland Portugal. This rationale suggests the majority of participants in this study was poorly informed about biological invasions. Nonetheless, after playing Boundary Breach, their knowledge seemed to have improved. For instance, in post-tests, there was a much higher percentage of students that correctly identified each species involved in the board game as an IAS (Fig. 4). Besides, native species and IAS not mentioned in the game (e.g. maritime pine, giant reed) had similar results in pre- and post-tests (except the brown rat) (Fig. 4), which strengthens the idea that Boundary Breach was indeed the responsible for the improvement of their knowledge about IAS. The brown rat was the only species not included in the board game that experienced a much higher number of correct identifications as IAS, which is likely explained by the fact that this species was addressed in another activity that participants were involved in-between tests. In addition to increase players' ability to recognize some IAS, the present results suggest Boundary Breach was also successful in increasing players' literacy on pathways and management of biological invasions (Table 2):

- Most participants highlighted the need to manage IAS to win the game, as this strategy t will allow them to accumulate less IAS in their continent. Some went further and claimed prevention is the better management strategy. These ideas are in line with current scientific literature that unanimously urges the responsible authorities to manage biological invasions and that undoubtedly states prevention should always be the first option as it is the most efficient action [1,23-24];
- A large number of players also said that transporting IAS to other continents instead of their own was one of the best strategies to win, suggesting that they were aware that transportation of IAS might result in future introductions. Again, their ideas are supported by scientific evidences that show transportation is an important pathway of biological invasions [25-26];
- About half of the students also stated that celebrating international agreements would help them win. In the game, this was simulated by players/teams being able to trade control/eradication cards and by them avoiding going to certain continents when transporting IAS. The need for international cooperation is widely acknowledged, e.g., the European Union has recently implemented a common policy on biological invasions [1];
- A few students also mentioned that strategically choosing a continent at start would help them win. After being asked to further explain their rationale, they said continents with more pathways connecting them to other ones are more subjected to introductions. Once again, their reasoning was correct. As explained above, transportation is a major pathway of IAS [25-26]. So, places with higher transportation capacity (e.g. number of airports and seaports) and more dependent on imports are under a higher introduction risk [26].

Boundary Breach is not the only serious game on biological invasions described in the literature [27-30]; however, it is one of the few for which educational outcomes were quantitatively assessed and reported.

5. Conclusion

Previous literature on serious games reported that, when applied to science education, this approach was considered very engaging by students and often led to positive learning outcomes. The results obtained with the current work are another evidence of such. Boundary Breach turned out to be a very engaging way to inform middle school students about biological invasions. Nonetheless, a more thorough evaluation of this board game should be performed in order to assess if players can retain this newly acquired knowledge for longer periods of time. Despite its potential to engage students with IAS, Boundary Breach covers only their recognition, pathways, and management; hence, its application in formal and informal education should be complemented by an activity on the harmful impacts IAS cause on biodiversity and on human societies.

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Education During the COVID-19 Lockdown: Does the Pandemic Extend the Scope of Distance Learning?

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Abstract. The reasons for and importance of readiness for distance learning in higher education are identified, especially regarding some aspects of teaching in higher medical education. The history of introduction of distance learning components in educational process at the I. Horbachevsky National Medical University in Ternopil (TNMU) is shown. Purpose of online cloud services that TNMU has been subscribed to as well as self-hosted by TNMU distance education tools are explained. The experience gained during the implementation of full-scale distance education at TNMU during the COVID-19 quarantine is presented. The analysis of students' performance during the full distance educational period in comparison with a blended part of the Medical Informatics course is presented.

Keywords. Distance Education, Learning Management Systems, LMS Moodle, Google Suite for Education, Office 365, Medical Education, Open-Source Software, Scheduler Plugin, Software Development, Version Control System.

1. Introduction

Medical education should provide training for specialists who have to be able to effectively use available 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 the 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).

Latest challenges like threat of bioterrorism and global pandemics (like COVID-19) had introduced new demands and requirements for organization and providing tye educational process. Higher education institutions should be ready and capable to migrate into a fully online and remote educational model.

2. Distance education solutions at TNMU: history, technologies and tools

Distance Education (DE) technologies were introduced at Ternopil National Medical University (TNMU) in 2006. At that year Learning Management System (LMS) Moodle [2] was introduced to evaluate the results of students' self-preparation for practical classes. The assesment was provided by using the Moodle “quiz” activity only.

The use of the Moodle LMS was continuously expanded during the following years [3-7]. Finally, at the end of 2019, all training materials of all TNMU courses were fully presented in Moodle in various formats of training activities ("workshop", "assignment"), or as Moodle resources (“files” and “folders”, typically filled with pdf documents) or even as external links (links to video lectures on YouTube).

Important changes took place in 2012. The Microsoft Office 365 [8] and Google Suite for Education [9] services were introduced almost simultaneously at TNMU.

From 2012 and up to now Google Suite platform is used as a centralized user authentication tool for all TNMU information services. It provides corporate e-mail service for TNMU as well.

Microsoft Office 365 was introduce to provide video conferencing. Skype for Business (former Lync) supported a large number of participants (from 50 to hundreds). This service was replaced with MS Teams now.

New safety and health threat involvr new challenges and demands for the organization and implementation of the educational process in higher medical education to improve distance learning and support a students' self-education mode.

The aim of paper is to present TNMU experience regarding the various aspects of implementating distance education technologies and tools into medical education under global pandemic threats.

3. Organization of distance education process at TNMU during the COVID-19 lockdown

Since March 12, 2020, when the COVID-19 quarantine in Ukraine was introduced, TNMU has been using all available distance learning services on a full scale. Students are allowed to:

- use training materials posted on the Moodle platform [10] for training;
- post their answers in electronic form through Moodle activities ("workshop", "assignment");
- communicate with teachers through Google services (texting via Gmail / Chat, and have video-conversations via Hangouts / Meet).
- watch educational videos and video-lectures on teachers' YouTube channels (for example [11])

Video-conferencing tools like Google Meet tools [12], MS Teams [13] and even Zoom [14] are used to support academic collaboration during tutoring seminars, training conferences and sessions of academic councils.

As a part of IT general infrastructure development, TNMU Microsoft Office 365 account was finally integrated with TNMU Google Suite platform. It became possible via Single sign-on (SSO) approach based on Security Assertion Markup Language (SAML) for user account data provisioning as it were described in [15]. Finally, it give all TNMU users (students as well as faculty) instant and transparent access to all applications and features of both cloud-based services.

The TNMU Moodle platform [10] is used to perform a final control at the end of 2020 spring semester. Exams were presented in form of test assessment. Unlike previous times, more different types of questions and forms of quizzes were used. For example, an "essay" Moodle question type was used to accept students' answers for "oral" part of exams.

4. Teaching the Medical Informatics course at TNMU during COVID-19 quarantine

The Medical Informatics (MI) course at TNMU is offered to 2nd year students at the medical school. Currently it includes 14 hours of lectures, 32 hours of practical classes and about 60 hours assigned to self guided work. In fact, the MI course is designed as a "blended" course since LMS Moodle inception at TNMU [16]. Students have to perform some amount of online activities in addition to classroom studies.

As a rule, a topic of the MI course in LMS Moodle includes the elements shown in Fig. 1).

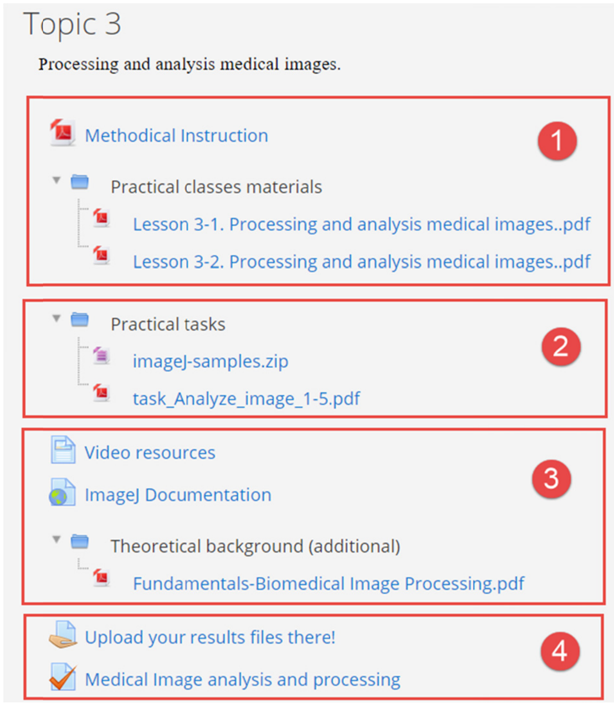

Figure 1.Structure of a topic of the MI course in LMS Moodle

They include:

1. Required practical classes materials and methodical instructions.
2. List of tasks that must be completed (during class hours or individually).
3. Recommended additional educational materials.
4. Assessment tools. Using "assignment" activity students have to submit results of their practical works. A "quiz" activity has been used to perform assessment of theoretical knowledge.

This extensive background allowed easily change from the “blended” mode to a full scale distance education workflow when the lockdown was introduced in Ukraine on March 12, 2020.

Main changes provided in the course to support a full scale online educational process:

1. Almost all time limitations for quizzes and assignment activities in LMS Moodle were eliminated to make students’ work more comfortable.
2. Extra timeslots for online meetings with groups and / or individual students were introduced by using customized Moodle “Scheduler” module [17]. All appointments were provided with links to corresponding video-meetings, scheduled by MS Teams cloud service.
3. Process of recording of additional video-lessons was initiated and conducted by faculty members. MI department’s YouTube channel [18] was used to host these videos among other video-lectures [19].
4. Usage of online demo [20] and open-source alternate software [21] was introduced to fulfill requirements of specific topics.
5. Gmail-based TNMU corporate email service was used to communicate with students too.

Statistics gathered from LMS Moodle confirms that the activity of students within the platform grew about three times during the quarantine (Fig. 2). It is important to note that about 2/3 of the MI course topics were already completed when the quarantine was introduced (10 topics out of 16).

The analysis of results of teaching the Medical Informatics course to foreign students (173 students in 14 groups) is used to present practical outcomes of migrating from the blended education model to full scale DE workflow.

The average scores achieved by students during the blended part (topics 1 to 10) of the MI course in 2019/20 academic year is shown in Fig. 3. The next figure (Fig. 4) presents the average scores for the full scale DE part of MI course during March / May 2020 (6 topics). Finally, the total MI course average scores are shown in Fig. 5.

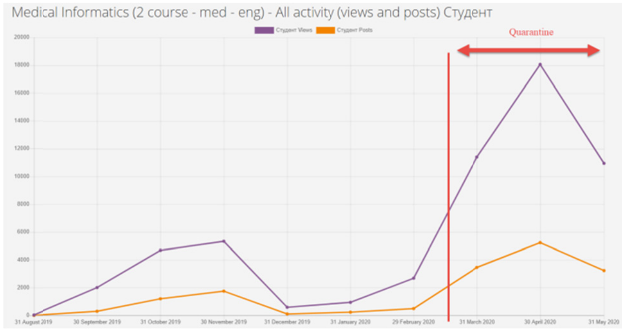

Figure 2. Activity of students studying the MI course in LMS Moodle during 2019/20 academic year

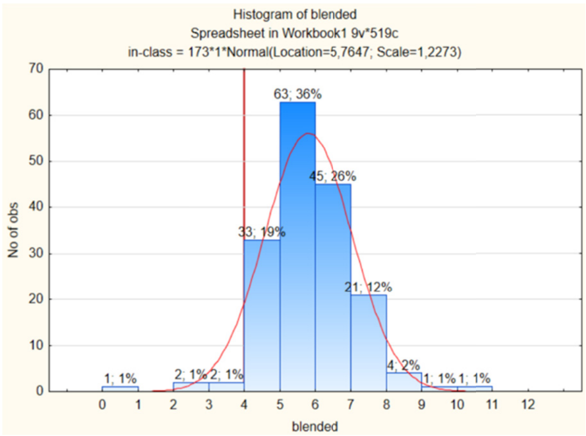

Figure 3. Students’ average score for the blended part of the MI 2019/20 course (topics 1-10)

It should be noted that TNMU uses a common Ukrainian academic grading system with 12 levels of students’ achievements, where “4” is a minimal positive grade.

Charts (Fig. 3-Fig. 5) show a relatively low performance of students in the MI course. Migration from the blended mode to the full scale DE educational workflow made the situation worse when about one half of students (84 of 173 or 48%) failed to earn even a minimal positive grade (“4”). Low basic educational skills and poor educational background of foreign students at TNMU may be a possible explanation of above unsuccessful results. This is quite obvious because most students come from developing countries with low income and high poverty (Africa, Middle East and South Asia). Low common digital literacy competencies along with basic computer skills of students provide additional obstacles which make educational process quite difficult due to significant complexity of the Medical Informatics syllabus.

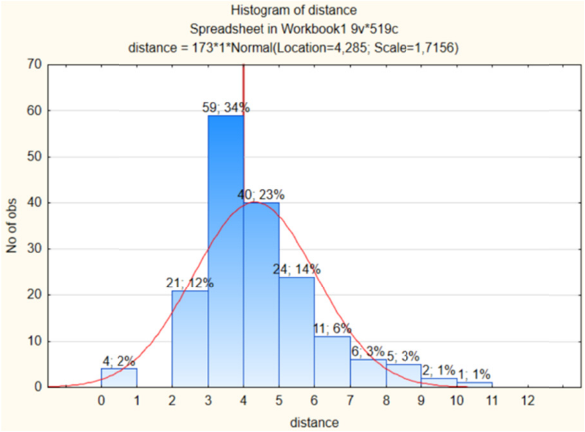

Figure 4. Students' average score for the DE part of the MI 2019/20 course (topics 11-16)

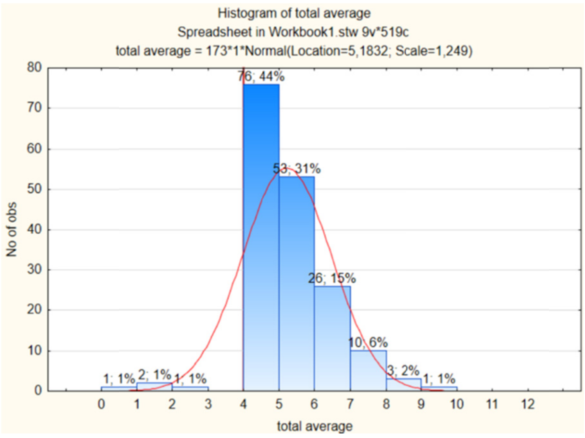

Figure 5. Students' total average score for the total MI 2019/20 course

4. Conclusions

The importance of readiness for full scale distance learning in higher education is obvious. This is illustrated by a history of introducing the components of distance learning in education process at the I. Horbachevsky National Medical University in Ternopil. The purpose of online cloud services that TNMU has been subscribing to as well as self-hosted by TNMU distance education tools are explained too. The experience achieved through the implementation of full-scale distance education at TNMU within the COVID-19 quarantine period in Ukraine is presented. The analysis of students' performance during a full distance educational period in comparison with a blended part of the Medical Informatics course was performed. Low performance of foreign students during online learning of the MI course was noted and explained.

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Mycotoxins in Popcorn Kernels

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Abstract. An Ultra-High Performance Liquid Chromatography combined with Time-of-Flight Mass Spectrometry (UHPLC–ToF-MS) method has been developed for determination of nine mycotoxins, namely aflatoxins (AFB1, AFB2, AFG1 and AFG2), ochratoxin A (OTA), zearalenone (ZEA), toxin T2 (T2) and fumonisins (FB1 and FB2) in maize. The different concentrations tested take in account the Maximum Levels (ML) for maize (Commission Regulation EC no. 1881/2006).

Keywords. Aflatoxins, Aflatoxins B1, Fumonisins, Maize, Mycotoxins, UHPLC-ToF-MS.

1. Introduction

Maize (Zea mays L.) is a staple food, responsible for more than third of calories and protein intake in some countries. In 2016, maize production in the European Union (EU) about 21% of the total production of 301 million tons (Eurostat, 2017). Under a wide range of favorable environmental conditions (humidity, oxygen, adequate temperature, pysical damage and the presence of fungal spores) and poor hygiene conditions, some fungi, mainly Aspergillus, Fusarium and Penicillium, can produce naturally occurring fungal toxins, so-called, mycotoxins. Climate change can also influence the occurrence of mycotoxins due to extreme rains and drought events that favor the formation of deoxynivalenol and fumonisins, respectively. Mycotoxins can contaminate food products, such as maize, consumed by humans and animals and they can be harmful [6]. Contamination of goods can happen at different stages in the period before to harvest, post-harvest, storage, processing and post-processing [3]. Mycotoxins are associated with vast adverse health effects, including carcinogenesis, mutagenesis, hepatotoxicity, genotoxicity, immunotoxicity, among others. Mycotoxins can also induce immunosuppression [7].

1.1. Objective

The aim of this study, carried out in the frame of a stay of three students from Escola Secundária da Maia at INIAV, was to determine mycotoxins (aflatoxins, AFB1, AFB2, AFG1 and AFG2), ochratoxin A (OTA), zearalenone (ZEA), T2 toxin (T2) and fumonisins (FB1 and FB2) in cornpopocorn kernels. The results of the analysis of 12 different samples of maize was carried out by Ultra-High-Performance Liquid Chromatography coupled with Time-of-Flight Mass Spectrometry (UHPLC-ToF-MS) [1-2]. Maximum levels (ML) according to the Commission Regulation (EC) No. 1881/2006 and its amendments.

2. Materials and methods

The work was accomplished in a laboratory at the National Institute for Agricultural and Veterinary Research (INIAV).

2.1. Chemicals and reagents

All chemicals and reagents were supplied to us by the National Institute for Agricultural and Veterinary Research (INIAV) laboratory. During this Project, we used methanol, acetonitrile (both HPLC gradient grade), formic acid and purified water. Mycotoxins standards and internal standard (zearalenone, ZAN) were dissolved in acetonitrile (AFB2, AFG1, ZEA, T2 and ZAN), methanol (AFB1, AFG2 and OTA) or acetonitrile: water (50:50, v/v) (FB1 and FB2).

2.2. Samples and sampling procedure

We bought twelve samples of popcorn kernels at various supermarkets, hypermarkets and producers for quantification of multi-mycotoxins. These samples were intended for human consumption. In the laboratory, the samples have been homogenized by grinding.

2.3. Extracion

About 2 g of crushed maize (2.0 ± 0.1 g) was weighed in 50 ml polypropylene tubes. Internal standard (zearalanone) (100 µl of 10 µg / mL). Subsequently, the corn was extracted with 10 mL of 80% (v / v) acetonitrile for 1 h at 110 rpm. After centrifugation at 3000 rpm to 10 min, the supernatant was removed to another Falcon tube and samples were re-extracted with the same volume of 80% (v / v) acetonitrile for 1 h. After centrifugation (3000 rpm, 10 min), supernatants were collected. For analysis of fumonisins, one ml of the extract was diluted with 1 ml of ultra-pure water. For the analysis of the other mycotoxins, 8 mL of the extract was transferred to a 15 mL Falcon tube and evaporated to dryness under a gentle stream of nitrogen at 40 C. The residue was redissolved with 1 ml of 40% (v / v) acetonitrile, vortexed for 30.

Figure 1. Ultra-High-Performance Liquid Chromatography, internal standard (Zearaleone), maize centrifugation, and all samples

2.3.1. Spiking experiment

Calibration standards were prepared by spiking blank sample of maize with 6 different concentrations of multimycotoxins standard solution prepared in acetonitrile 80% (v/v), thoroughly mixed and kept at ambient temperature in the dark for 30 min. Afterwards extraction was performed as described in sub-section 2.3.

2.4. Identification of mycotoxins

The identification and data processing were made through the PeakView™ and MultiQuant™ (SCIEX, Foster City, CA) softwares.

3. Results and discussion

3.1. Development and validation of UHPLC-ToF-MS method

OTA and ZEA could be studied under positive and negative mode electrospray ionization (ESIþ and ESI) [5]. However, the other studied mycotoxins were determined in ESI þ mode, consequently, this mode was selected in order to determine all the studied mycotoxins. The developed method included a two-step extraction with acetonitrile 80% (v/v). Peak resolution of the twelve mycotoxins was achieved in a chromatographic (Fig. 5, 6 e 7). The optimized method was validated according to the criteria defined by Commission Regulation (EC) No, 401/2006 which establishes the methods of sampling and análisis for the official control of the levels of mycotoxins in foodstuffs. Comparison between the assigned contamination levels of the CRMs and the measured values by UHPLC-ToF-MS is presented in Table 1 and shows excellent agreement for the evaluated mycotoxins (aflatoxins, fumonisins and ZEA).

Table 1 Contamination levels of the certified reference materials (maize)

Certified control material	Mycotoxin	Assigned contamination level (μg/kg)	Satisfactory range (μg/kg)	Measured value (μg/kg)
MA1750–1/ CM	AFB1	9.34	5.23–13.4	8.66
	AFB2	0.42	0.24–0.60	0.52
	AFG1	1.57	0.88–2.26	1.06
	AFG2	traces		
	AFB1+ AFB2+AFG1 +AFG2	11.5	4.32–18.8	10.2
	FB1	2545	1272–3817	2370
	FB2	608	399–818	482
	FB1+FB2		1714–5143	2852
MA1764/ CM	ZEA	190	112–269	199

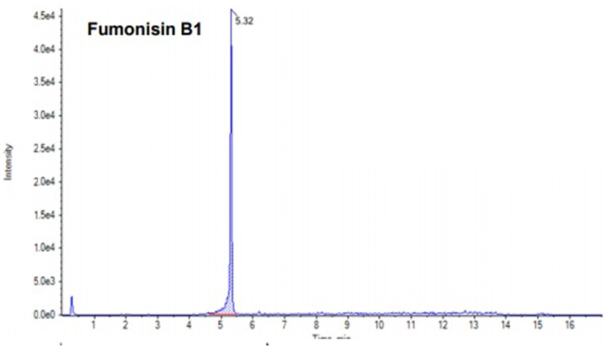

Figure 2. Chromatogram of a blank maize sample Fumonisin B1 (FB1)

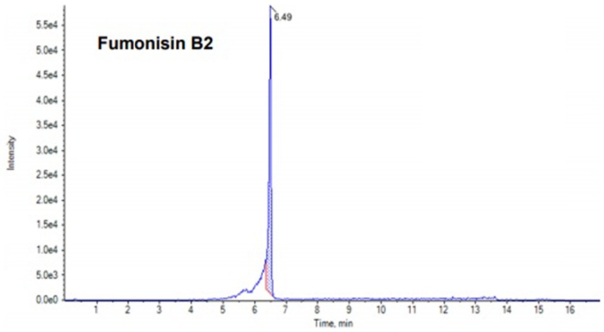

Figure 3. Chromatogram of a blank maize sample Fumonisin B2 (FB2)

3.2. Occurrence of mycotoxins in maize

FB1 was detected in four samples (in the second, third, fifth and tenth samples). FB2 was present in the second, third and tenth sample. The last mycotoxins we found were Aflatoxins B1 in the second sample. All the samples were negative for the other mycotoxins under study. Table 2 compiles the results of these samples for FB1, FB2 and Aflatoxins B1.

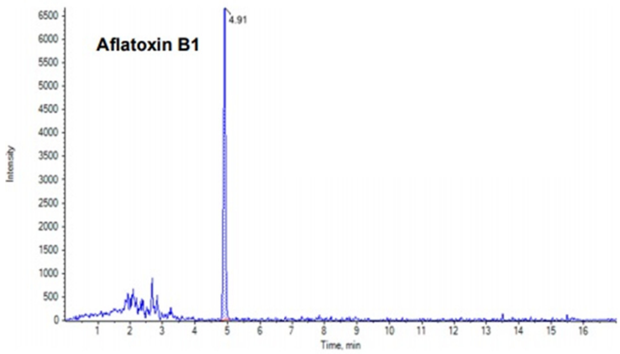

Figure 4. Chromatogram of a blank maize sample Aflatoxin FB1 (AFB1)

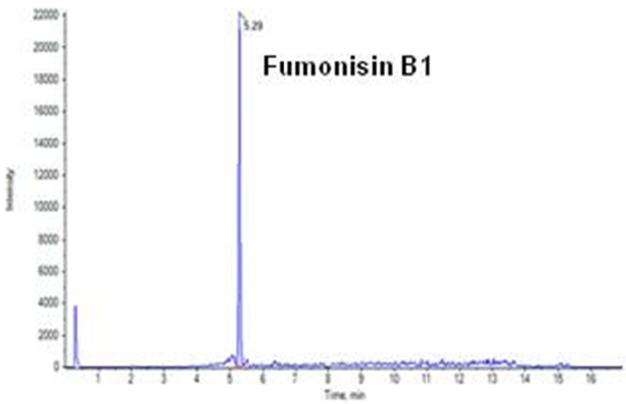

Figure 5. Chromatogram of a third sample (positive)

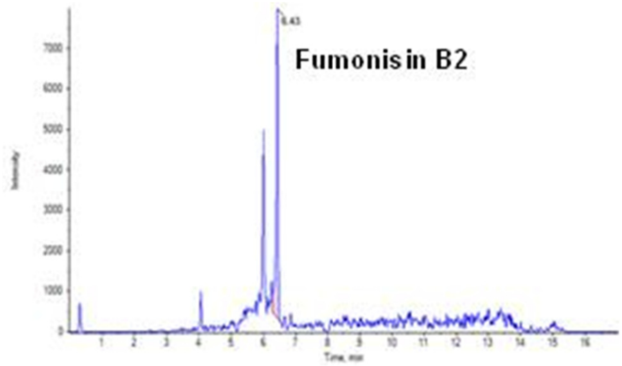

Figure 6. Chromatogram of a third sample (positive)

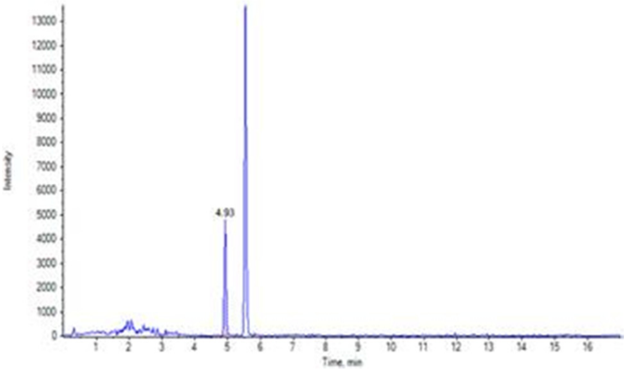

Figure 7. Chromatogram of a second sample (positive)

Table 2 Result of the twelve samples of maize LoQ-125 µg/kg; LoD-62.5 µg/kg; Undf.- Undefined

Mean ± SD (µg/kg)	Samples #		
	FB_1	FB_2	AFB_1
1	1332,0	354,2	0,56
2	519,9	74,6	Undf
3	<LoD	Undf	Undf
4	137,35	Undf	Undf
5	<LoD	Undf	Undf
6	<LoD	Undf	Undf
7	<LoD	Undf	Undf
8	<LoD	Undf	Undf
9	618,5	154,4	Undf
10	<LoD	Undf	Undf
11	<LoQ	Undf	Undf
12	<LoD	Undf	Undf

Figures 5, 6 and 7 are examples of positive chromatograms and Figures 8, 9 and 10 are negative examples.

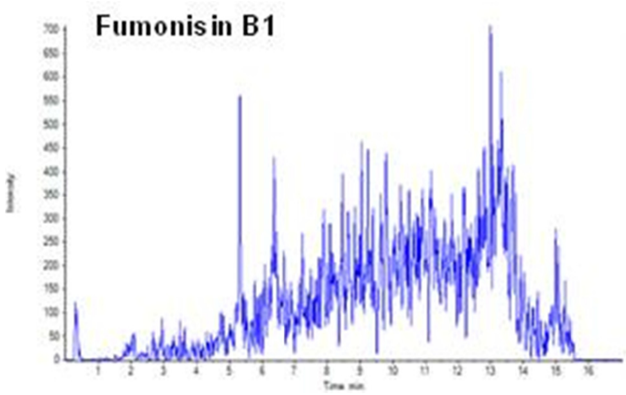

Figure 8. Chromatogram o fan eleventh sample (negative)

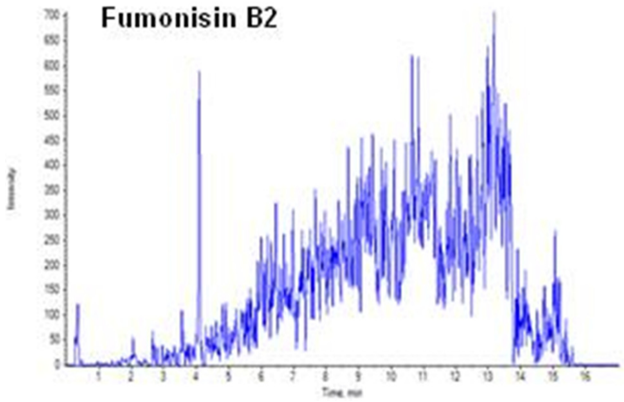

Figure 9. Chromatogram of an eleventh sample (negative)

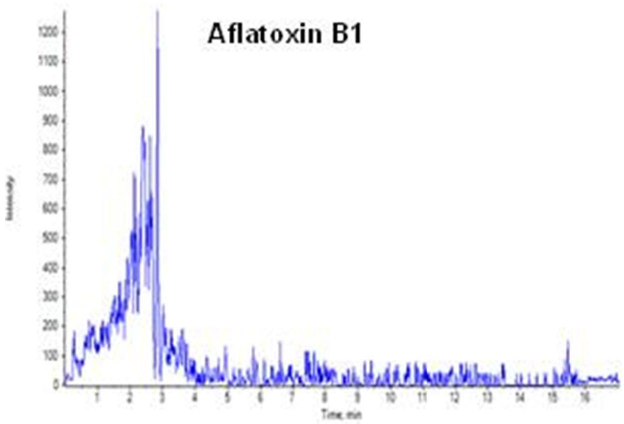

Figure 10. Chromatogram of a fifth sample (negative)

4. Concluding remarks

It is of utmost importance to control mycotoxins in food chain due to the severity of adverse health effects, from toxic acute to chronic, in both animals and humans [4,8]. The update of legislation is also important to meet. The update of legislation is also important to meet the advances of high-resolution analytical techniques and to assure the protection of individuals. The analytical UHPLC-ToF-MS method developed and validated in maize is an excellent tool to monitor the levels of mycotoxins in this cereal [5].

5. Acknowledgements

The authors are especially grateful to INIAV and Dr. Ana Sanches Silva for making the establishment available and for all the help in the development of this project.

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Fernão de Magalhães: A STEAM Activity to Celebrate the 500th Anniversary of Circum-Navigation around the Globe

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Abstract. This paper presents a case study of a workshop that have used the celebration of 500 years of circum-navigation of the globe, by the portuguese navigator Fernão de Magalhães, as a *motif* to develop some hands-on activities integrating history and STEAM topics, including physics and geography. The participants were 7th grade students from Oeiras public schools. The results showed the interest and envolvement of the students with the activities and some of them demonstrated a strong desire in participating in future activities with robotics and programming.

Keywords. Educational Robotics, Sciences Education, STEAM, Education Technologies.

1. Introduction

The celebration of the 500th anniversary of the first circumnavigation of the terrestrial globe by the Portuguese Fernão de Magalhães, has been celebrated in Portugal through various artistic and cultural events.

With the objective of drawing the attention of students and teachers to this important event in global history, as well as showing different possibilities of using digital resources in teaching and learning situations, the Clube de Ciências do Liceu de Oeiras, in partnership with the startup Inovlabs, developed the STEAM activity reported here.

The activity aimed to demonstrate to the school community other possibilities of using ICT in different subjects of the school curriculum.

Section 2 presents the motivation and relevance of this activity. Section 3 describes the pedagogical strategy adopted, as well as the details of the tasks developed. Section 4 presents the collected data and partial results. Section 5 refers to the conclusions and future work.

2. Motivation and relevance

The stimulation of creativity associated with scientific knowledge often depends on a solid knowledge base in the STEAM areas. Different authors argue that most jobs of the future will require a deep technological knowledge associated with the areas of Science, Mathematics and the principles of engineering and design [1, 3].

Therefore, it is important to arouse the interest of our students in these areas of knowledge as a way to prepare a future based on knowledge and sustainable for any nation.

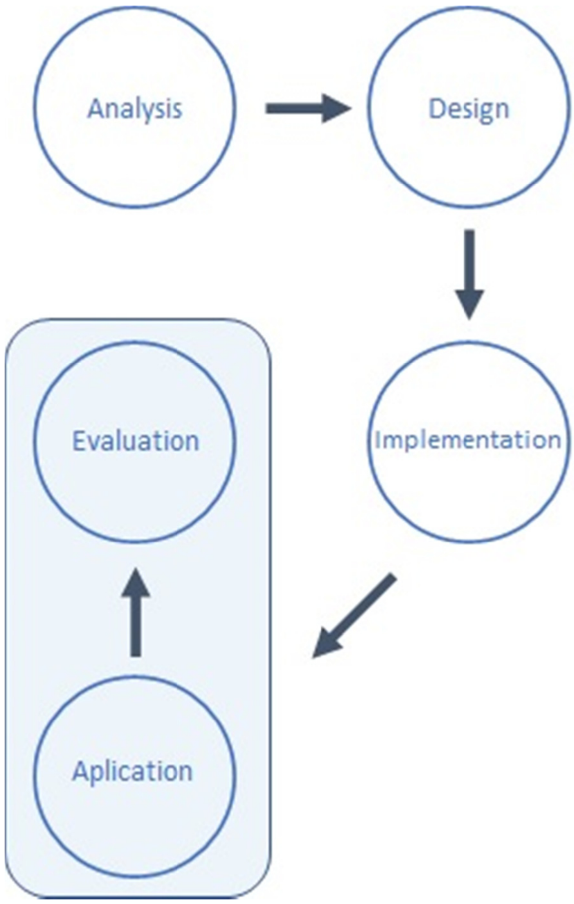

Figure 1. Stages of development of the workshop (area marked in green is the focus of this work)

On the other hand, the scientific literature has shown that students' interest and understanding of new concepts is more effective if we associate the new concepts with the knowledge and interests that are already part of their daily lives [2-3].

Thus, based on the structuring ideas presented above, the InovLabs team, together with secondary school teachers at Liceu de Oeiras, developed the *Hands-on* activity "Fernão de Magalhães - 500 years of circumnavigation of the globe" for students from third cycle, involving history, programming and other information and communication technologies (ICT) [4].

3. Materials and methods

The work was developed as applied research aiming to produce knowledge that can be effectively applied in the real world and with the objective of contributing to the training and interest of students involved in the STEAM areas. The development of the activity followed approximately the cycle shown in Figure 1.

3.1. Participants and the workshop

The workshop was developed to be applied during two consecutive classes, making a total of about 90 minutes. It was repeated 8 times, for 4 days.

The participating students belong to classes of 7th grade (aged 13 to 14) and, on average, were mixed groups of about 25 students and their accompanying teachers (1 to 2 teachers for each class).

3.2. Materials

For the application of the Workshop, two caravels were printed in 3D coupled to a flexible spring in order to simulate the oscillation of the waves. The objective was to simulate the possible movements of the vessel (on the X, Y and Z axes, known as *Roll, Pitch* and *Yaw,* respectively) when sailing on high seas (Fig. 2).

In the vessel model, a micro:bit board was installed, used to record the rotation values around the X, Y and Z axes, and to plot the respective graphs to be explored over time.

During the tasks developed (*see* section 3.3.) The following software were used: *Google Earth,* to explore the maritime navigation route and the main places visited by the fleet; programming environmente for blocks of micro:bit (*editor makecode*); *MU Python IDE* (for acquiring the values of acceleration in the rotation axes); and MS Powerpoint®.

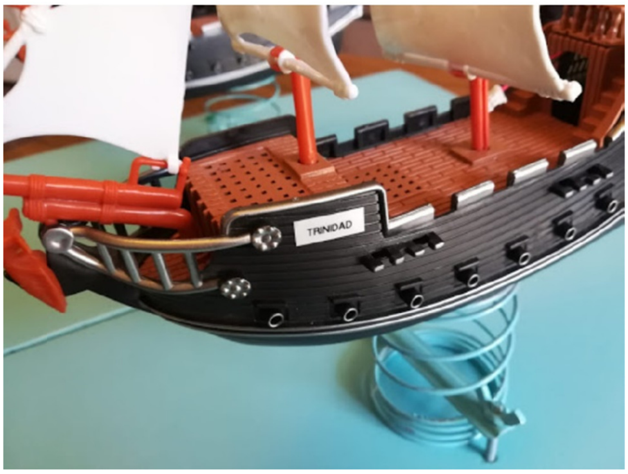

Figure 2. Model of the 3D printed caravel mounted on a spring and wooden plate (simulating the movement of the caravel in the sea)

Each group of three students had a personal computer with internet access. As the activities were being presented, students were encouraged to explore information on the Internet and/or use the aforementioned applications to develop specific tasks.

3.3. Tasks performed

The four proposed actiivities were developed using a narrative as the "guiding thread", where students were led to reflect on the circumnavigation carried out in the year 1509, the technologies existing at the time, the challenges faced and, finally, how the event would be if the fleet of vessels had access to some technological devices existing today.

After a brief introduction of our team and the objectives of the workshop, the following four activities were presented:

- Google Earth, the teaching team provided a set of geographic data (in.KML format) with the entire circumnavigation path, also georeferencing the main places visited. For each location and route, students were able to explore and complete information about the locations and were encouraged to investigate and enrich the information with new relevant complementary data.
- Calculating the cardinal points - During the second part the teacher inquired the students about the technologies employed at that time in order to guide

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the vessels. After that the students programmed in the MakeCode environment the intervals of angles corresponding to the main cardinal points (North, South, East and West). The code generated in the online application was subsequently downloaded to the micro:bit of each group of students, in order to be tested. From the ideas and opinions presented by the students, a discussion started about the four main cardinal points and how we could find them (intervals) using angles and the Cartesian plane.

- Programming and the micro:bit board, next, the micro:bit board was presented to the students and referenced that it had an internal compass. There was also talk about the possibility of the cards being able to communicate via bluetooth. The main programming commands of the board were presented and, in a supervised way, the students were led to create programs that could communication between the micro:bits and to implement the functioning of the compass (Fig. 3).

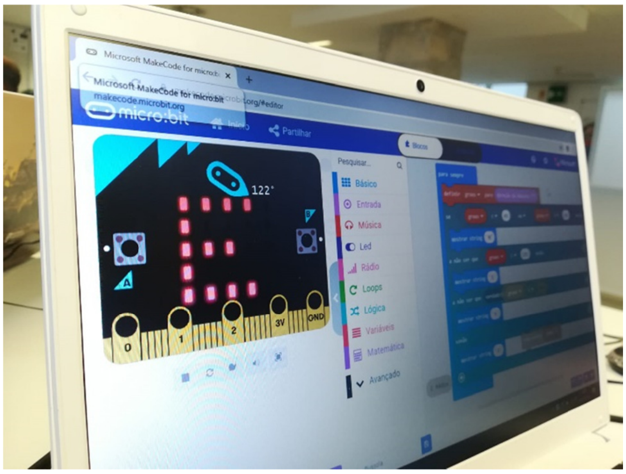

Figure 3. Micro:bit showing one of the cardinal points (East) from a program partially developed by the students

- Using the micro: bit in the ship model - The last stage of the Workshop tried to couple the 3D model of the caravel, a micro:bit with a working compass program. Once the vessel was supported by a spring – and could move in the three coordinate axes XYZ (Fig. 2) - students tried to move the model around these three axes to see the changes in the direction drawn in real time on a computer screen coupled (Fig. 4). The moment was taken to introduce students to some other important navigation movements (*Roll, Pitch and Yaw*), culminating in a final reflection on the possible consequences to the first circum-navigation of the globe, if *Fernão de Magalhães* had programmable boards at his disposal like the micro:bit.

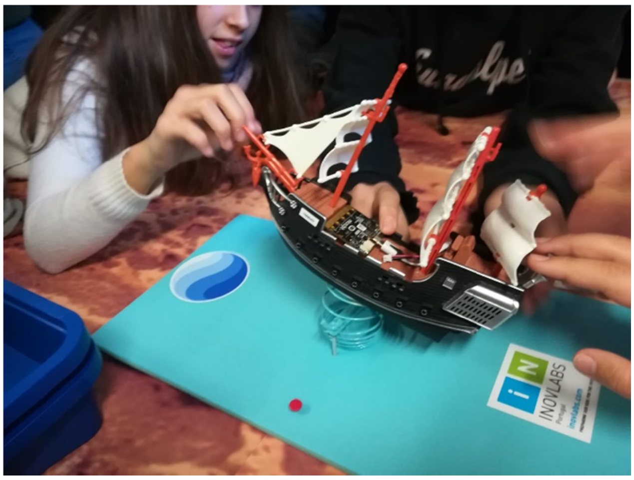

Figure 4. Students interacting with the model of the fleet's ships, where the port (red) and starboard (green) sides were also marked

4. Data acquisition, evaluation, and partial results

For the evaluation of the project carried out, some criteria were listed that sought to identify the participation and interest of the students (involvement in the activities, resourcefulness in the programming) and the feasibility of the proposed activity (Table 1).

- The ability to work in a team was also developed during the workshop, since students were instructed to organize themselves to cooperate with each other. During the experiment, the teacher provoked the teams with questions such as:
- Which direction was chosen by the *Fernão de Magalhães* fleet?
- What interests (economic, political) existed behind the circumnavigation?
- How was done the orientation of the ships at that time?
- How can we represent the cardinal points in the programming of the micro: bit? - With

the technology we have today, what can we say about a project of this scope?

Table 1. Main evaluation items and main questions: Topics taken into consideration and Guiding questions

Topics	Guiding questions
Captivation	Did the students get involved in the proposed activities and ask questions?
Resourcefulness in programming	Were students able to understand the basic programming structures presented? Were they able to change the codes to achieve their objectives and challenges proposed by the teacher?
Viability	Is it possible to carry out an activity of this nature in a real classroom / laboratory situation?

It is worth mentioning that for the age group of those involved, all the evaluated criteria took into consideration elements related to STEM and the essential learning goals defined by DGE-Portugal [5].

5. Conclusions and future work

Different authors have been recognized that experiential, hands-on activities provide superior engagement for learning new subjects. The main reason seems to be the real-world meaning these activities provide instead of the otherwise abstract knowledge. Particularly educational robotics has been shown to provide an important support for these activities specially in STEAM areas.

The workshop described in this paper allowed us to demonstrate (to organizers and other teachers), the potential of working with students using an active educational approach, with the support of computational platforms and software.

It also showed us that interdisciplinarity is possible, involving content perceived by many as having little relation with the use of information and communication technologies and with disciplines in humanities.

This work, developed at the *Sebastião e Silva secondary school*, has allowed the creation of new partnerships and projects involving other research institutions and the expansion of didactic activities in the School Science laboratory.

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Emergency Phosphorescence

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Abstract. "Emergency phosphorescence" is a project that emerges in the context of inter-disciplinarity of the Chemistry and Biology courses, in the final year of High School attendance, with the intention of giving a glimpse of the research activities that students are expected to perform in the University. Aiming at the reduction of electricity consumption by emergency signs so as to keep them lit all day long without having to waste electrical energy, there has been an attempt to optimize the brightness arising from the phosphorescent properties of europium and dysprosium doped strontium aluminate ($SrAl_2O_4$: Eu, Dy), by investigating the conditions for which the emission of light is more intense and for a longer period of time. For that purpose, the commercially available phosphor was dissolved in an oil-based preparation and recycled wood test boards were painted with a varying number of layers. In a second stage, having met such conditions, the waste of reagents could be avoided whilst fabricating phosphors in a laboratorial environment. 11,066 g of $SrAl_2O_4$: Eu, Dy for 10 mL of HS Akzent Oil and 0,1 g of dispersing agent, proved to be the most efficient combination, of those tested, in an attempt to create a prototype, as sustainable as possible, of an emergency sign that does not work on electricity.

Keywords. Emergency Sign, Luminance, Phosphorescence, Phosphors.

1. Introduction

In a world where it is urgently required to become "green", it is fundamental to identify the situations in which the reduction in energy consumption does not radically impair our comfort, otherwise, any such measures will be ill accepted or not accepted at all. "Emergency phosphorescence" is a project that, by intending to better prepare High School students for the University, in the Chemistry and Biology fields of work, suitably addresses this problem. Electricity has been presented to us, for a long time, as a solution for artificial lighting all over the world. However, the procedures involved in producing it require either the use of non-renewable and pollutant resources, or the extensive and very expensive use of renewable resources. There is obviously a need to find alternative methods of illumination, to save electricity. The phenomenon of phosphorescence, commonly known as "glow in the dark", is increasingly being used for that purpose: from the beginning, this project has sought to be another step in this upward spiral.

1.1. Objective

The main objective to be achieved is to reduce the consumption of electricity by emergency signs, so that they can remain illuminated at all times without consuming electricity.

1.2. Jablonski diagram and phosphor-rescence

Atoms in the molecule, when illuminated by a light beam, absorb the energy transported by its photons, resulting in the excitation of the atoms' electrons. These electrons, occupying orbitals in the atoms, "jump" from the ground, equilibrium, energy state to an excited, higher and non-equilibrium, energy state. The electronic energy states are named after their spin angular momentum configuration. In quantum mechanics, the spin angular momentum [6] is an intrinsic property of particles, is quantized and given by the expression $\boldsymbol{S} = \hbar \sqrt{\boldsymbol{s}}\ (\boldsymbol{s} + \mathbf{1})$, where $\hbar$ is the reduced Planck constant (h/2π) and the spin quantum number s equals n/2, being n any non-negative integer (the electron has spin quantum number 1/2). The singlet state (denoted by S) refers to a system in which all electrons are paired in the atom, which gives a total spin angular momentum of zero; while the total spin angular momentum of triplet states (denoted by T) is 1, as there are two unpaired electrons. S_0 is the ground singlet state, that is, the state of lowest energy of the atom, also resulting in the lowest internal energy of the molecule to which it belongs. S_n is the n th excited singlet state; similarly, Tn is the nth excited triplet state. The Jablonski diagram (Fig. 1) maps all the energy transitions that may occur when the atom's electrons are excited

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through interaction with photons. Non-radiative transitions (waving arrows) occur between two different molecular states without photon absorption/emission, whilst in the radiative transitions (straight arrows) the energy difference is accountable by photon absorption/emission. In the case of absorption, the energy of photons is converted into internal energy of the molecule through the transition from the ground state S_0 to one of the excited, higher energy, singlet states, represented by the straight blue arrows. Direct transition from S_0 to a triplet state is not allowed due to conservation of angular momentum.

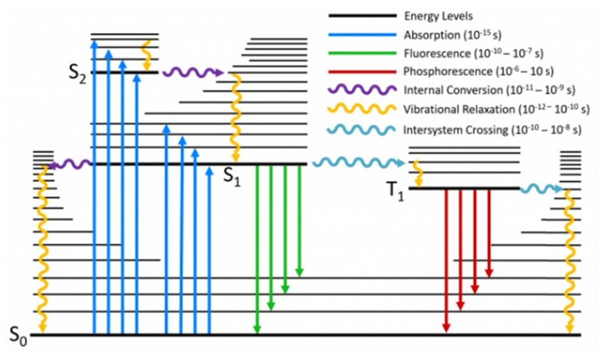

Figure 1. Jablonski diagram [1]

Photoluminescence is the process of emission of light associated to the energy of excitation received through the absorption of radiation. As said before, the excited states are non-equilibrium states, for there is energy in excess in the system (the atom). It therefore tends to give it away, in order to loop back to its initial, stable, state, either through vibrational relaxation (the non-radiative transition to a lower energy level within the same electronic state – yellow waving arrows), internal conversion (the non-radiative transition between two different electronic states with the same spin – violet waving arrows), or through photoluminescence processes. These processes comprise fluorescence (green straight arrows) as well as phosphorescence (red straight arrows). While the first is a basic radiative transition between two same spin electronic states, generally from S_1 to S_0, the second [4] is more complex, because it depends on a transition that would be forbidden in principle, the intersystem crossing (a non-radiative transition between two states with different spin – blue waving arrows), due to the conservation of angular momentum, but becomes possible, though rarely "allowed", by the coupling of the spin angular momentum and of the orbital angular momentum (the other type of angular momentum to be considered in quantum mechanics). One way of favoring the occurrence of such a transition is by incorporating heavy atoms (with a lot of nuclei particles), which increases the influence exerted by the spinorbital coupling. As such, thanks to the intersystem crossing, the molecule is now in the first triplet state, though still excited, having to lose internal energy in order to go back to its equilibrium state. This loss will thus occur through phosphorescence, that is, a radiative transition between two states with different spin, in this case, between T_1 and S_0. As this transition is theoretically forbidden, but again, weakly allowed through the coupling of spin and orbital angular momenta, it will need a much longer time to occur than fluorescence (from 10^{-6} to 10s). As a consequence, even if the stimulation light stops beaming on the molecule, it will go on emitting light for a relatively long time, due to the phosphorescence phenomenon.

1.2. Phosphors and luminance

Phosphors [5] are the substances capable of showing the phenomenon of luminescence, comprising fluorescent as well as phosphorescent materials. To carry out this project, only the latter ones should be considered. They are normally composed by an adequate host material, to which an activator is added. The host material is responsible for yielding light, being usually an oxide, nitride, oxy-nitride, sulfide, selenide, halide or silicate of zinc, cadmium, manganese, aluminium, silicon or various rare-earth metals. By doping the host material with an activator, the emission time is extended. The phosphor used in our project and produced in the laboratory is strontium aluminate doped with europium and dysprosium ($SrAl_2O_4$: Eu, Dy), a recent material used in the manufacture of glow in the dark toys, which has proven to be more stable and efficient in the intensity and persistence of glow, and less toxic than its predecessor zinc sulfide.

Finally, to evaluate the efficiency of the use of this phosphor, luminance has to be measured [3]. It is the photometric measure of the intensity of light, per unit area and along one direction. For the purpose of this project, a suitable meter will be used, by which the amount of light emitted by a certain area, along a certain direction, is normally expressed in millicandela per square meter (mcd/m^2). Before taking readings, the sample has to be "charged" by a xenon lamp. The characterization then proceeds, with measures of luminance being made 10 and 60 min after stopping illuminating the sample, and also of the among of time between the moment the stimulation ceases and the moment when the luminance attains the value of 0,32 mcd/m^2, which is ten times the luminance perceived by the human eye (Fig. 2). Letters standing for the colours that are perceived during the stimulation and afterwards are also added. Given that the peak of sensitivity of the human eye occurs in the green colour region of the spectrum, in the case of day vision, and in the bluish green colour region, in the case of night vision, manufacturers of phosphorescent materials always prefer green to obtain the most striking "glow in the dark" effect.

Class	Luminance mcd/m2 After 2 min	10 min	30 min	60 min	Time to 0.32 mcd/m2
G	3,000	650	190	80	
F	2,300	520	155	70	
E	1,800	400	120	55	
D	1,100	260	85	35	2,000 min
C	690	140	45	20	1,800 min
B	210	50	15	7	900 min
A	108	23	7	3	450 min

The characterization is carried out by means of symbols such as: 28.0 / 3.6 - 520 / w - k [2]

- 28.0 = luminance in mcd/m2, 10 min. after the end of excitation
- 3.6 = luminance in mcd/m2, 60 min. after the end of excitation
- 520 = time in minutes from the end of stimulation after which the luminance has fallen to 0.32 mcd/m2
- w = perceived color at stimulation (white)
- k = perceived color of the afterglow (green)

Figure 2. The characterization of luminance [2]

2. Methodology

2.1. Phase 1 – Optimization in the use of phosphors

After pouring 10 mL of HS Akzent Oil into a 100 mL beaker, this is placed on a scale pan and 0,1 g of dispersing agent Bentone are added with the help of a scraper. The solution thus obtained is mixed with a brush until there is no visible sign of the solute. 11,066 g of the phosphor $SrAl_2O_4$: Eu, Dy are then added (weighed through the same procedure as in the case of the dispersing agent) and dissolved in the same manner. Two other solutions are similarly prepared, dissolving the same amount of phosphor in, respectively, 15 and 20 mL of oil plus dispersing agent in the same proportion. The surface of a few recycled (pressed) wood boards is painted with these different preparations (Fig. 3), also varying the number of layers applied. By illuminating these boards for 10 min, and recording, after ceasing illuminating, how brightness decreases overtime, we can find out the best proportion of phosphors in relation to the remaining reagents.

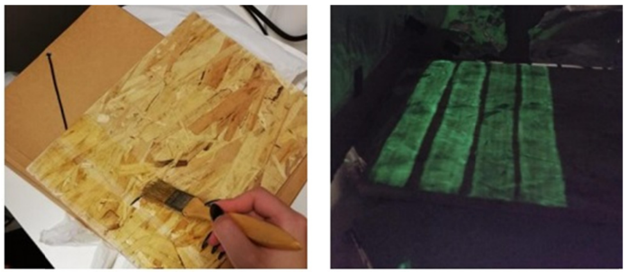

Figure 3 Applying the preparations on the recycled wood boards (left); painting stripes with a different number of layers (right)

2.2. Phase 2 – Preparing phosphors

Figure 4. On the left, the reagents used in the production of $SrAl_2O_4$: Eu, Dy; on the right, the already produced phosphor

With five small casings made beforehand out of aluminium foil, each one, in turn, is laid on the scale pan, to receive the following reagents: strontium carbonate (1,299 g), aluminium oxide (1,0196 g), boric acid (0,06184 g), europium oxide (0,1408 g) and dysprosium oxide (0,2984 g). These casings were made with the sole purpose of carrying the reagents, joining them together in a metallic cylinder already with three small metallic spheres inside. The cylinder is then sealed and put in high speed rotation for 10 min – this system, known as mill, grinds the reagents through the tumbling of the spheres, breaking the bonds inside their crystals, facilitating the mixture. After the grinding process is over, the resulting powder is transferred to a suitable container and heated in a high temperature oven, from room temperature up to 1500°C and back, for 19 h. By then, the end product is already showing phosphorescence but, for better results, it is advised to further grind it in a mortar to assure a homogeneous mixture (Fig. 4).

3. Results and discussion
3.1. Phase 1

All the boards, following exposure, for 10 min, to light from a fluorescent energy saver “stick” bulb (where UV radiation, more energetic than visible, is present), showed the sought for phosphorescence effect. The board painted with the first preparation was shown to yield greater brightness; it was also observed that, the greater the number of layers of the solution applied, the brighter the sample becomes. The duration of the emission phenomenon was also visibly longer in the case of the board painted with the preparation with least oil for the pre-determined amount of phosphor, and with the greatest number of layers applied. Therefore, the best ratio of phosphor to the remaining reagents to use when creating a prototype of an emergency sign should be 11,066 g of $SrAl_2O_4$: Eu, Dy for 10 mL of HS Akzent Oil and 0,1 g of dispersing agent, given that this proved to be the most efficient one, of those tried and tested (Fig. 5).

Figure 5. On the left, a wood board painted with the 11,066 g phosphor:10 mL oil solution; on the right, another board, painted with the 11,066 g phosphor:15 ml oil solution, both under “black light”. Brightness is significantly

3.2. Phase 2

When analyzing the phosphor that was produced in the laboratory with a suitable meter, as described in section 1.2 of the Introduction, a luminance value of 32,0/11,0 mcd/m^2 – 462 min/ w – k (please refer to Fig. 2) was obtained, which acknowledges it as a class A phosphor, capable of assuring an acceptable brightness, even in a solution, to orient people in an emergency situation, in case it is used in signage.

4. Concluding remarks

Having defined the composition of the oil-based solution to be used, and produced in the laboratory the phosphor with the quality required to fulfil its purpose, the construction of a prototype (Fig. 6) as an end product of this project was thus achieved, first coating the recycled wood board with several layers of the photo luminescent oil paint thus obtained, then finishing with the familiar shapes of emergency symbols painted in white. By carrying out this project, the students allowed themselves to leave their comfort zone and acquire relevant abilities, such as teamwork and scientific paper writing, whilst having a taste of the challenges awaiting them in College.

Figure 6. On the left, the finished prototype sunlit, charging; on the right, the same prototype in the dark, glowing, exhibiting the phenomenon of phosphorescence

5. Acknowledgements

For the support granted to this project, through scientific supervision and provision of both material and human resources, the authors wholeheartedly thank the Departamento de Geociências, Ambiente e Ordenamento do Território (Department of Geosciences, Environment and Territory Planning) of the Faculty of Science of the University of Porto, particularly its director, Professor Joaquim Carlos Esteves da Silva, and researchers Luís Pinto da Silva and Diana Crista.

They would also like to thank Chemistry and Biology teachers of the 12^{th} grade of Maia’s Secondary School, Isabel Allen and Luísa Santos, for granting them this opportunity.

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[3] https://en.wikipedia.org/wiki/Luminance

[4] https://en.wikipedia.org/wiki/Phosphorescence

[5] https://en.wikipedia.org/wiki/Phosphor

[6] https://pt.wikipedia.org/wiki/Spin

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Teaching Science and Technology through Service Learning Experiences

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Abstract. This paper describes two Service Learning experiences developed this academic year 2019/2020 in the Technology itinerary of a Master of Professorship of Secondary Education. The first experience is related to build new objects with recycling material, and the second one is based on constructing objects with some type of autonomous movement. The realization of both projects has allowed students to acquire competences directly related to the curricular, professional and transversal skills by means of a service to society.

Keywords. Methodology, Professional and Curricular Skills, Science and Technology, Service-Learning.

1. Introduction

Service-Learning (SL) experiences allow simultaneously the learning of curricular contents and the provision of a service to the community as a response to the needs of a group [1-2]. This is not a classical methodology strictly oriented to perform practices nor a volunteering activity oriented to community service. Instead, SL is an educational proposal that allows for training in skills and values, promoting an inclusive, active, participatory and committed education, through a practical experience in a real environment with specific needs, which contributes to their education for citizenship [3-4].

Function and Cognitive Diversity (FCD) affects to students of any educational level, and since certain capabilities and skills could be diminished is a hot topic to be considered especially in university studies devoted to train new education professionals [5].

Although it may seem surprising, Master's courses on teachers training usually present important shortcomings in training for the attention of specific needs in the classroom. On the other hand, entities are increasingly demanding SL projects like this, which respond to needs of their groups, while the latter welcome new initiatives in which they have marked interests.

For these reasons, the authors of this paper have transformed in this academic year the traditional methodology of tutored work and oral presentation to SL experiences.

Our SL experiences are related with different thematic in science and technology through the construction of objects from different types of materials. These projects have been performed considering the specific needs of people with Autism Spectrum Disorders (ASDs).

This paper is organized as follows. Section 2 presents the context of the subject of the Master's degree. Section 3 includes the details of both experiences. Section 4 shows the method used to assess the impact of these experiences. Finally, Section 5 contains the main conclusions of this work.

2. Master's Degree of Professorship of Secondary Education

The Master's Degree of Professorship of Secondary Education of the University of A Coruña (UDC) [5] is a degree from the Faculty of Educational Studies that belongs to the area of Social and Legal Sciences.

The Master's curriculum has 60 European Credit Transfer and Accumulation System (ECTS) credits, which include all the theoretical and practical training that the student must acquire. These credits are distributed as follows: a Generic Module of 16 credits while the remaining 44 are divided in a Specific Module of Specialty of 26 credits, a Practicum of 12 and a Master's Final Work of 6. In this Master's studies six teaching specialities with some itineraries in each one are included only sharing the Generic Module. Attendance is mandatory in both modules. Notice that the Practicum takes place in the secondary schools established by agreement with the Xunta de Galicia.

One of these six teaching specialities is the referred to as *Experimental Sciences, Mathematics, Technology and Physical Education*. This speciality covers very diverse teaching areas, so it is necessary to introduce

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training itineraries in the Specific Module and in the Practicum. The teaching specialisation itineraries planned by UDC are Experimental Sciences, Technology and Physical Education. The Technology itinerary is devoted to train new secondary teachers of Technology. For this aim, the curricular contents are devoted to complements for disciplinary training, technology didactics and teaching subjects and teaching innovation and initiation to educational research. In particular, the subject of Technology for professorship of Secondary Obligatory Education falls into the second type of subjects i.e., technology teaching subjects, and it has 5 ECTS credits.

Table 1 summarizes the content of this subject, where we have marked the items related to the SL experiences. Table 2 presents the competences related with both SL experiences.

Themes	Items
Technology in Secondary Obligatory Education	1.1. Introduction. 1.2. The subject of Technology in Secondary Obligatory Education. 1.3. Historical review **1.4. Life Quality and Technology: contexts and situations.** **1.5. Impact of technology on society**
Technologies	2.1. Technological problem solving process. **2.2. Technology and society.** 2.3. Mechanisms and structures. 2.4. Electricity and electronics. **2.5. Control and robotics.** 2.6. Pneumatics and hydraulics 2.7. Expression and communication techniques. **2.8. Materials for technical use.** 2.9. Hardware and operating systems. 2.10. Communication technologies. Internet.

Table 1. Contents of the subject

3. Service-Learning Experiences

In this section we describe the two SL experiences carried out during the teaching of this subject in the academic year 2019/2020.

3.1. Control and robotics

This project is related to item 2.5 in Table 1. The objective is to develop a service adapted to the collective where people can build a small object with some type of movement.

Types	Competences
Specific	✓ To know the formative and cultural value of the subject. ✓ To know the contents of this teaching. ✓ To know the history and the recent developments of the subjects and their perspectives to be able to transmit their dynamic vision. ✓ To know contexts and situations where are used or applied the curricular contents.
Transversal	✓ To express oneself correctly, both orally and in writing, in the official languages of the Galicia region. ✓ Use the basic tools of Information and Communication Technologies (ICT) necessary for the exercise of their profession and for lifelong learning. ✓ To assess the importance of research, innovation and technological development in the socio-economic and cultural advances of society.

Table 2. Competences of the subject

Each student participating in this project must, individually, do the following:

- Propose a small robot (for example, a painter robot) for its construction with recycling material.
- Get the necessary material for the construction of his/her proposed robot.
- Make an A4 sheet (plasticized) with the step-by-step description of the making of the object with this material, and also deliver it in digital format. This sheet must include the list of materials needed to build the object. It should be very simple, with clear instructions and pictures, if possible.

These students must also, collaboratively and working as a team, make a short oral presentation or video explaining the implications of the introduction of robots in today's society and how this fact can help us or has been able to do it for improving our quality of life, or how it may have negatively affected some aspects as well, according to item 2.2 in Table 1. The duration of this activity should not exceed five minutes.

The students developed their projects through the construction of the following objects: a mechanical money box, a swimming robot from a syringe, a windmill car and a giraffe robot. Figure 1 shows the final object made by one of the students and the end-beneficiary, respectively.

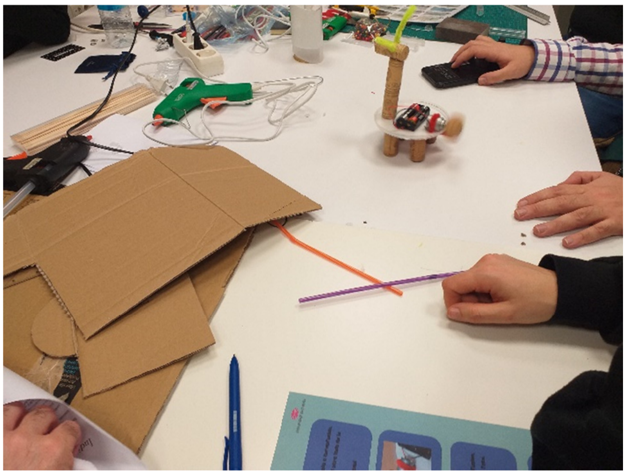

Figure 1. Control and robotics

3.2. Materials for technical use

This project is related to the item 2.8 in Table 1. The objective is to develop a service adapted to the collective where people can elaborate an object using recycling material that allows the receiver of the activity to critically evaluate the environmental impact of some technological advances i.e., contributes to the Environmental Education (EE) of both, students and end-beneficiaries, also according to item 2.2 in Table 1.

Each student must, individually, do the following:

- Provide any object for its construction with recycling material.
- Obtain the necessary recycling material for the construction of his/her proposed object.
- Make an A4 sheet (plasticized) with the step-by-step description of the making of the object with this material, and deliver it also in digital format. This sheet should include the relation of the necessary materials for the construction of the object. It should be as simple as possible, with clear instructions and images.

All the students must be conjoined elaborate a small presentation or video where they explained the environmental implications of the technological evolution and the objectives of the activity, according to item 2.2 in Table 1. The duration should not exceed five minutes.

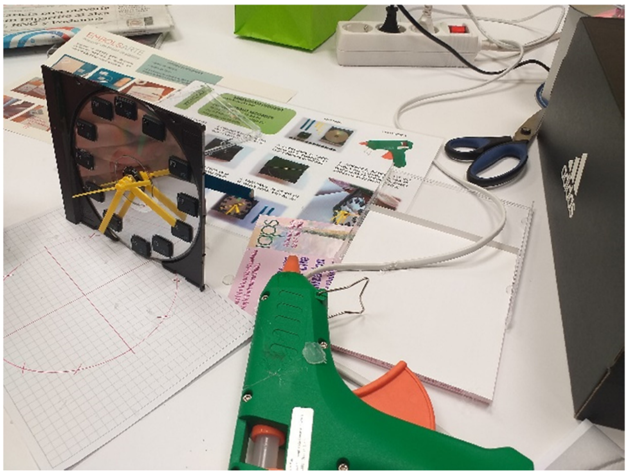

Figure 2. Materials for thechnical use

The students developed their projects through the construction of the following objects: a decorative pompom with pieces of paper, a coaster with plastic straws, a bowl with newspaper, a wheel with rubber band and a clock from a CD box and an old clock mechanism. Figure 2 shows the final object made by one of the students and the end-beneficiary, respectively.

4. Assessment results

This SL project, as any other teaching activity, must be qualitatively and quantitatively analyzed, including all the participants, in order to identify possible improvements and to know results and performances of the activity thus carried out. However, it is clear that, when the activity is SL, it is an educational challenge to find reliable quality indicators for its assessment [7-8].

A total of 10 students have participated in both projects (5 in each one). These projects have been developed in an organization of people with ASD. A total of four people performed both projects along two sessions of one and a half hours, so each of them had the guidance of at least a student to carry out their project.

The tools used for this assessment were the following [7-8]:

- Surveys. This is a tool of easy implementation and execution, which allows to collect the assessments of the people participating in the experience. Therefore, both the students and the beneficiaries of the entity and its own staff carried out their corresponding surveys designed by us. The surveys which have been designed for an easy and agile answer from all the users involved in the experience: the entity staff, the end-user and service beneficiary and to the UDC student.
- Rubrics. This tool allows the assessment of the activity carried out by the students. Our rubric evaluates: 1) Quality of material presented in relation to the contents of the course and adaptation to the users of the entity; 2) Originality of the material and 3) Planning and organization in the development of the activity.

Using these tools, we have obtained the following results. Firstly, from the rubric we have to say that the scores achieved by all the students have been optimal, obtaining all of them the maximum score of 2.5 points out of a total of 10. Secondly, we can state that the results of the surveys were very satisfactory. With respect to the survey of the end-users, the quantitative results have been also very good:

- Control and robotics: 4 students of 5 made the project to 4 end-users in attendance and all of them voted for the maximum rate (green emoticon in the first question in survey of Figure 4).
- Materials for technical use: all the students have performed their corresponding projects to 4 end-users in attendance and 3 of them gave the maximum rate as a result (green emoticon in the first question of Figure 4). Only one voted for the medium rate (i.e. the yellow emoticon).

All both the entity staff and the students voted for the maximum rate in both experiences i.e., the green emoticon in their respective surveys of Figures 3 and 5 was marked.

From a qualitative point of view, the surveys collected the following impressions from all the agents involved in the process. We summarize in the following those comments.

Thus, the SL experience has received these comments from the entities:

- Exceptional student involvement.
- Good organization of the workshops.
- Variety of proposals adapted to the needs of the group.
- Need for more SL projects.
- Contribution to the improvement of the students' training.
- Good quality of the proposals, being practical and educational.

From the point of view of students, their surveys showed the comments as follows,

- Very interesting and repeatable experience.
- Need for pre-processing of some partial components.
- Need for more time to complete the project.
- Experience that helps to know the needs of this group.
- Lack of training in interaction with this group.

Finally, the end-beneficiaries of this service included these comments into their surveys;

- Very fun and creative experience.
- Manual activity, different from the usual ones in their group workshops.
- Great work of students to help.
- Possibility of realization of the chosen robot.
- Nice to use "household stuff" to make electronic toys.

5. Discussion and conclusion

We have presented two SL experiences performed to develop specific competences in a subject of a Master's degree and to give a service of a collective with ADS. Both projects have been very well received by all the agents involved: university students, entity and end-users.

The teachers involved in this project, authors of this work, have met to carry out a self-assessment and to critically analyse the development of the SL project and their roles in it. The authors consider that the biggest difficulty has been to find the adequate entity and the definition of the SL project adapted to their needs.

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Examining the Use of Traffic Lights Technique to Enable Students to Self-Evaluate

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Abstract. Feedback in education strengthens learning and ensures that errors are corrected on time. Students' ability of self-evaluation prevents wrong learnings by giving feedback in a short time. However, students should be encouraged to give feedback in a short time. In this study, the traffic lights technique was applied to students to evaluate their progress and inform their teachers about their applications while making applications on computer software in information technology. In practice with ten participants from 6th grade students, each student was provided to make an assessment about himself, according to these results, the teacher gave feedback and corrected quickly.

Keywords. Traffic Lights, Self-Evaluation, Action Research.

1. Introduction

Since the end of the 20th century, constructivism has become increasingly important by associating it with research done by researchers such as Bruner, Vygotsky, Asubel and Piaget [1]. Constructivism has become unique and application-oriented in many areas, from organizing learning practices to structuring assessment processes. This has led the learning environments to turn towards the student centered from traditional practices where the teacher is active and the student is passive and more receptive. Evaluation processes, on the other hand, started to include innovations to question the learning process and one's own learning in addition to the usual examination techniques [2].

Learning should be carried out by learners and organized internally. Therefore, it should be paid attention to students' self-regulation information. The learning and assessment activities and tools used should be directed towards developing metacognitive skills such as self-analysis, self-regulation, self-reflection and self-awareness. For a multi-faceted perspective, different assessment activities should be used and students should be provided with practice areas on self-assessment [16]. In this sense, self-assessment has become an indispensable place for students.

Feedback is expressed as the whole of the information given to the student about the correctness or wrongness of their learning, and the correction is to eliminate the student's behavior that is different from the expected and to teach the student the expected behavior. In the education process, feedback and correction are generally applied together [4]. Considering that feedback has three main functions as a guiding, motivating and reinforcing in an educational environment, that is, when using feedback, hints, corrections and reinforcers can be applied together, it is even more important among the variables that determine the quality of feedback education service. Feedback is the most important application that determines the quality and learning level of feedback education service [12]. The process of providing information about the outcome of an individual's behavior is expressed as feedback. In other words, in the teaching-learning process, it is informing the learners about the level of the desired behaviors. Feedback is a commonly used word in education. Feedback tells the student whether or not he or she is acting in accordance with the goals of education. Feedback is information about how the learners' current learning and performances are according to the desired learning and performances. If there is a difference between the real level and the desired level, it aims to reduce it. Feedback increases academic achievement level, strengthens self-efficacy and motivation and supports the development of metacognitive skills [3].

In the research, the traffic lights technique was used in order to develop the students' self-assessment skills so that the teacher can give feedback to the students effectively.

2. Traffic Lights Technique

In the activities carried out in the classroom, the student plays an active role and the teacher guides. It is expected from the teacher to assist the active student by giving immediate feedback to the problems and obstacles encountered during the learning process. Traffic lights technique is very useful to meet these needs. It encourages students in a simple way to demonstrate what and how well they did during a lesson. It allows students to instantly review what they have learned and teachers to help at the same time. This activity provides an immediate assessment of how good a class or group can be in understanding and practicing a topic. The teacher gives each student three cards. These cards are green, yellow and red. The green card indicates that the subject is understood or that the activity continues without any problems, the yellow card indicates partial continuing and some problems and the red card shows no progress. At various times in the lesson, students have the opportunity to show a yellow or red card if they feel that the explanation is not clear or they do not understand [14].

3. Purpose of the Research

The main purpose of this research is to examine how the traffic lights technique affects students' self-assessment skills in the Information Technologies and Software Course Support and Training Course of Middle School 6th grade students. Another purpose of this research is to share the observations on the application of the traffic lights technique used to contribute to the development of self-assessment skills. For these purposes, answers to the following questions were sought:

a) How did the traffic lights technique affect the development of students' self-assessment skills?
b) How did the traffic lights technique affect classroom control and effective feedback from the teacher?
c) What are the suggestions of the students regarding the problems encountered in the development of self-assessment skills?

4. How Did I Apply It?

This action research was conducted with a total of 10 students from the 6th grade, who attended the Support and Training Courses from Afyonkarahisar Province Secondary School students in the 2019-2020 Academic Year. The researched school is located in a town center. Parents of students are generally in the middle and lower income groups. The school, which is the majority of students belonging to extended families, has been providing education for five years.

Traffic lights technique was used in computer applications in information technology and software course support and training course. The school does not have a computer workshop, and the lessons are taught using ten computers in the library that are provided by the teacher. The academic success level of the students attending the course shows a homogeneous distribution. Six of the course students are girls and four are boys.

Three action plans were developed in the study. The subject of the course in which the first action plan is applied is search engines and effective search techniques, and the subject of the second and third action plan is word processor. The lessons are mostly taught by the teacher using the demonstration technique and by making applications to the students. In the introductory part of the course, students follow the lesson quietly. However, the feedbacks and self-evaluations given by the students are problematic when applying. Shy and introverted students remained silent while the students were practicing on the computer. The students who could do the applications said "I did it" and the other students who could not do it, said "Sir, look at me,please?" and there were some noisy expressions like "I don't succes" or “It is not true”. The noise generated had a negative impact on both the classroom environment, the students who continued to practice, and the teacher trying to give feedback. The traffic lights technique, which is an effective and simple self-assessment technique, has been eliminated by preparing and applying three implementation plans, and the course flow has improved.

5. Method

5.1. Research Type

This research has been prepared on the basis of action research, which is one of the qualitative research patterns, which aims to increase the self-assessment skills of the students by using the traffic lights technique in information technologies and software lessons, and allows the in-depth study of the researched problem. In such researches, the questions of "why" and "how" are dominant, but answers to the question of "what" can be obtained. By this means, in the research it will be handled in the application dimension, which will benefit the students' learning, and will enable the identification of points that make their learning easier or more difficult.

5.2. Working Group

It was conducted with ten students who attended the 6th grade Information Technologies and Software Course Support and Training Course. The specified class students have chosen Information Technology and Software course over the Eba course system and attend the course as two hours per week (80 minutes).

5.3. Application Environment

Since the school does not have an information technology laboratory, the course is taught in the multi-purpose library. Lessons are taught by using ten laptops belonging to the school and the teacher. There is also a desktop computer and a projection library that the teacher will use. The seating arrangement is not standard and it is indicated in Fig.1.

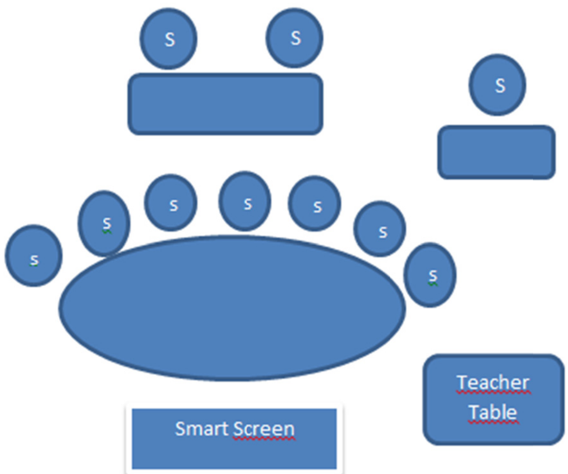

Figure 1. Students' Seating Plan and Classroom Layout

5.4. Collection of Data

In this research, interview and observation methods, one of the data collection methods included in the qualitative research process, were used. In this research, reliability was tried to be increased through diversification in data collection by using observation and interview.

According to Stewart and Cash (1985), the interview is an interactive process based on the method of asking questions and receiving answers for an aim that is planned and that is an attempt to gather information for this purpose [15]. In this research, a post-application focus group interview was conducted to determine the problem and to diversify the data obtained before an application in order to evaluate the study and to determine what students' views are and how they change.

During the interview, the following questions were asked to the students;

a) Did the Traffic Lights Technique make it easier for you to express yourself while doing computer applications?
b) Have you had difficulty applying the traffic lights technique? Why?
c) What are the benefits of the traffic lights technique to the lesson? Why?

After the application, the observation made by the teacher was noted in the teacher diaries. The process of collecting target-oriented data by using a set of tools or by directly monitoring the data, which is needed for the research, by examining individuals, society or the environment is called observation [8]. If the researcher wants to obtain a detailed, comprehensive and process-oriented picture of the behavior that occurs in any environment, he uses the observation method [15]. Since the researcher was a participant in the action research, the participant made examinations as an observer and created teacher logs.

5.5. Data Analysis and Reliability

This research is an action research and interview and observation technique was used. The research was listed for the purpose of it by removing the codes and themes of focus group interview with students.

Validity and reliability are the most important factors that determine the quality of a research. In order to create a holistic picture of the case or event investigated, some additional methods (such as diversification, participant confirmation, expert confirmation and so on) should be used to help the researcher confirm the results [8].

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During the research, student interview forms were analyzed by content analysis method and compared with expert opinion. Afterwards, the codings that the researcher and the expert made independently were specified as "consensus" and "difference of opinion". After reaching a consensus on coding, reliability between encoders, reliability formula of Miles and Huberman (1994) was applied and inter-code reliability was calculated as 100%. The interviews made by the students as a result of the first interview and study were compared and included in the findings.

6. Application

6.1. First Action Plan and Its Implementation

Table 1. First Action Plan

Actions	Time
1. Introducing the technique, presenting the colors and instructions visually on the board and distributing the prepared green, yellow and red cards to the students.	20 minute
2. Making applications by using laptops with the demonstration method. During the application process, students use the colored cards included in the Traffic Lights technique to express their progress and provide feedback and feedback from the teacher.	50 minute
3. Getting the opinions and suggestions of the students about the Traffic Lights Technique	10 minute

Application stage:

1. The students' opinios were briefly received about the lesson processing using the demonstration method in the information technology lesson.
2. The Traffic Lights Technique, which will be used continuously during the course, was introduced to the students. The colors and explanations explaining the technique were transferred to a corner of the board visible to all students.

Figure 2. Transferring the Technique on the Class Board

3. Students were asked to make applications prepared in computer environment by using demonstration method.
4. The students were asked to perform self-assessment by placing the card that expresses themselves the most correctly from the red, yellow and green cards they put on top of each other while they were performing computer applications.
5. The students were given feedback and corrections were made according to the card colors in the applications they made in the computer environment.
6. Students' progress was monitored and feedback and correction continued until all students turned green in each application.
7. It was seen that there were a lot of red and yellow cards in some subjects and

the application was shown and demonstrated from the beginning.

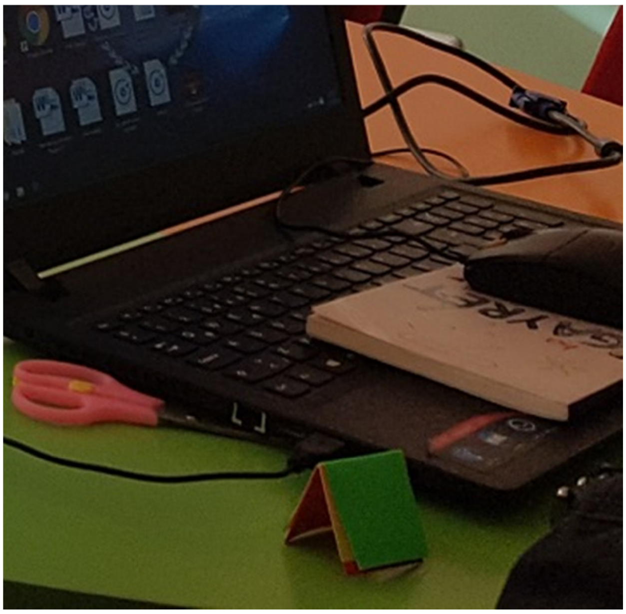

Figure 3. Using Traffic Lights Cards

8. Answers were received to the interview form containing the opinions of the students about the Traffic Lights Technique, which aims to increase the self-assessment skills of the students.

6.1.1. Teacher Diary

Positive Aspects of the Application:

- In the previous lessons, students who have high self-expression skills "I have done", "I have finished, Sir", "I can not do it, Sir." or "Sir, look at my application, please?" speeches such as expressing the lesson aloud and causing distractions from other students. Students with low self-expression skills and self-confidence were silent and did not give feedback. The teacher made efforts to follow the progress of the students in their computer applications by constantly traveling among the students in the classroom.
- With the application of the Traffic Lights Technique, it has been observed that students are provided with a quiet classroom environment based on finger-lifting or word of mouth when making self-assessment in computer applications in the Information Technologies and Software Course.
- In previous lessons, it was observed that students who were shy and silent can express themselves comfortably by means of colors and that students expressed it verbally in the evaluation of the technique.
- While the teacher gave feedback, it reached the students faster and the time to complete the applications was shortened. Thus, more learning has been realized.
- The teacher's tiredness during the lesson period decreased and it was observed that he was teaching more eagerly.

Negative Experiences During The Application:

- It was observed that some students who finished the application raised their fingers or called the teacher to show the green color. Similarly, it was observed that some students who saw red color called the teacher next to the computer. This shows that the technique is not fully understood by some students.
- While the yellow color is a sign of slow progress or some problems in the Traffic Lights Technique, it was observed that some students could not fully understand this, only using red or green.
- Since the place where the lesson is taught is a library that is not suitable for multiple computer use, the colors that students express themselves cannot be seen by the teacher in some respects.

Suggestions for the Second Action Plan:

It is necessary to ensure that students place the color cards in a way that the teacher can see more easily. Students should be encouraged to express themselves using only Traffic Light Cards and wait until the teacher arrives for feedback. In each application, a portfolio can be created by preparing a schedule according to the Traffic Light Colors specified by the students in each application and by taking notes.

6.2. Second Action Plan and Its Implementation

Application stage:

1. Students are asked to write the Turkish National Anthem in accordance with the

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instructions given with the word processing program.

2. The Traffic Lights Technique, which will be used continuously during the course, was reminded to the students. The colors and explanations explaining the technique were transferred to a corner of the board visible to all students. Students were reminded to be more careful in the application of the technique.

Table 2. Second Action Plan

Actions	Time
1. Reminding and re-introducing the traffic lights technique to increase students' self-assessment skills.	10 minute
2. After the content of the course is presented to the students via the prepared presentation file and projection, the applications are done with laptops in the form of demonstration. During the application process, students use the colored cards included in the Traffic Lights technique to express their progress and provide feedback and feedback from the teacher.	60 minute
3. Getting the opinions and suggestions of the students about Traffic Lights Technique.	10 minute

3. Students were asked to make applications prepared in computer environment by using demonstration method.
4. The students were asked to perform self-assessment by putting the card that expresses themselves most correctly from the red, yellow and green cards they put on top of each other while they were performing in the computer environment, as shown in Figure.4. In the first action plan, the possibility of the teacher not seeing the traffic lights card was eliminated.

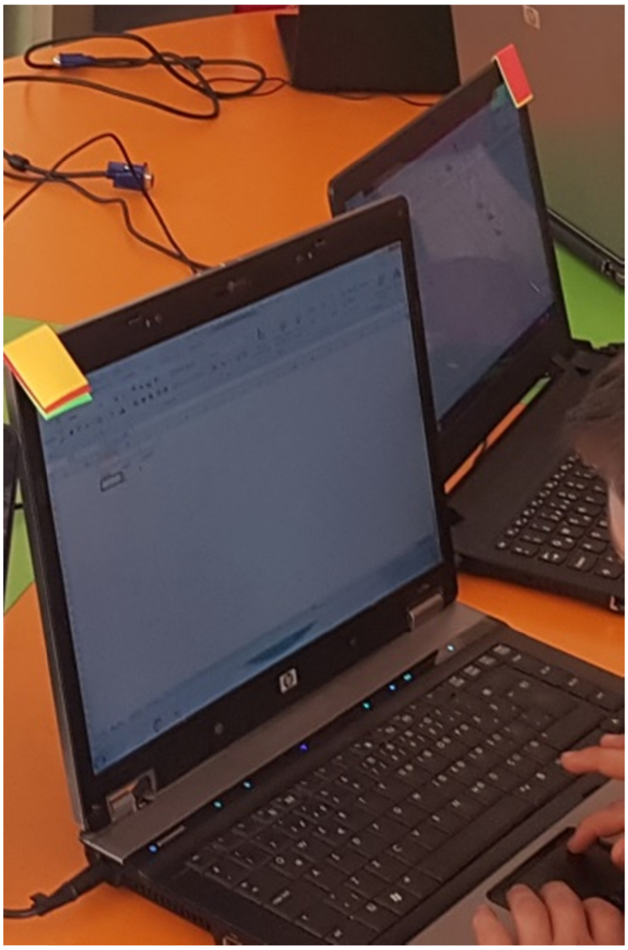

Figure 4. Using Traffic Lights Cards

5. The students were given feedback and corrections were made according to the card colors in the applications they made in the computer environment.
6. Students' progress was monitored and feedback and correction continued until all students turned green in each application.
7. Students 'opinions were received about the Traffic Lights Technique, which aims to increase students' self-assessment skills.

6.2.1. Teacher Dairy

Positive Aspects of the Application:

- With the implementation of the Traffic Lights Technique, it was seen that students raised

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their fingers and asked for oral help from the teacher only a few times while performing self-assessment during the applications with the word processing program in the Information Technologies and Software Course.

- The teacher's inability to see the color cards in the first application ended by placing the cards in the upper corners of the screens as in figure 2.
- The teacher created a student schedule based on the suggestions in the first action plan, noted the colors of the traffic lights used by the students for the portfolio and created a record for the students.
- When the teacher gave feedback, it reached the students faster and the completion time of the applications was shortened. Thus, more learning has been realized.
- The teacher's tiredness during the lesson period decreased and it was observed that he was teaching more eagerly.

Negative Experiences During The Application:

- It was still seen that some students who have finished the application raise their fingers or call the teacher to show the green color. In the same way, it was seen that some students who saw red color called the teacher near themselves. This shows that the application of the technique is not fully established.
- While the yellow color is a sign of slow progress in the Traffic Lights Technique or some problems, some students' failure to fully understand this continued to see that only the use of red or green color continues.

Recommendations for the Third Action Plan;

- In order to prevent some students from verbally expressing themselves instead of expressing themselves with color cards, students who follow the rules of the application can be rewarded.

6.3. Third Action Plan and Its Implementation

Table 3. Third Action Plan

Actions	Time
1. Reminding and re-introducing the Traffic Lights Technique to increase the Self-Assessment Skills of the students, expressing that the students will be rewarded by adding the traffic lights technique to the prepared users.	10 minute
2. In the application process, the students use the colored lights of the Traffic Lights technique to express their progress and the teacher gives feedback and feedback, and the teacher notes the progress of the students.	60 minute
3. Getting the opinions and suggestions of the students about the Traffic Lights Technique.	10 minute

Application stage:

1. Students were told to write Declaration By Atatürk To The Turkish Youth in accordance with the instructions given with the word processing program.
2. The Traffic Lights Technique, which will be used continuously during the lesson, was reminded to the students. The colors and explanations explaining the technique were transferred to a corner of the board visible to all students. It was said that more care should be taken in the application of the technique and the colors of the students will be noted by the teacher.
3. Students were asked to make applications prepared in computer environment by using demonstration method.
4. The students were asked to perform self-assessment by placing the card that

expresses themselves most correctly from the red, yellow and green cards they put on top of each other while they were practicing in the computer environment.

5. The students were given feedback and corrections were made according to the card colors in the applications they made in the computer environment.
6. Students' progress was monitored and feedback and correction continued until all students became green in each application.
7. Students 'opinions were received about the Traffic Lights Technique, which aims to increase students' self-assessment skills.

6.3.1. Teacher Diary

Positive Aspects of the Application:

- With the application of the Traffic Lights Technique, it was observed that the students did not lift their fingers and did not ask for oral help from the teacher while performing self-assessment during the applications with the word processing program in the Information Technologies and Software Course.
- The students who asked for oral help that the teacher experienced in the second application no longer asked for oral help, waited for the teacher to give feedback according to the colors.
- The teacher noted the students' colors on the student follow-up chart prepared in line with the suggestions created at the end of the second action plan and made evaluations.

Negative Experiences During Application:

- It has been observed that after the application of the traffic lights technique, no students asked for oral help. When the students who completed the application used the green color, they did not go out of the rule with the effect of the table and the award.

7. Findings and Interpretation

At the end of the three action applications carried out within the scope of this study, which aims to improve students' self-evaluation and to activate the lesson, with the traffic lights technique, the students gave a positive opinion about the traffic lights technique applied in the course. Silent and shy students were able to express themselves comfortably. In student interviews, it was stated by the students that the students who made a lot of noise were prevented from effecting the teaching quality negatively in the classroom with this technique. In the first application, students underestimated the power of colors. During the lesson, the teacher frequently warned students to use colors. The first application was very important for understanding the technique. The teacher had a hard time seeing the colors due to the scattered seating arrangement of the class. With the change made in the second application, this problem was solved and the colors of the students expressing themselves were easily seen by the teacher and quick feedback was given. At the end of the second application, some of the students could not give up voice expression. As a solution to this, this problem was solved by giving awards to students who applied the technique silently according to the rule. In the third implementation plan, a schedule was prepared for the students to be used in their portfolios. It was stated that the students were introduced to the chart and their progress was recorded by noting the colors they used. After this stage, there was no problem in the application of the technique to the students. The teacher provided the silence during the lesson, and the students were able to express themselves easily and the teacher was able to save the students’ progress with the Traffic Lightc Technique providing the self-assesement abilty to the students. All of the students were satisfied with the technique as a result of the interviews and expressed it clearly. Before the application, interview questions were prepared for the students. The interview questions with the students were recorded by the researcher in short sentences by making a focus group interview. As a result of the focus group interview, the answers given by the students with the diaries kept by the teacher were provided to be systematically conveyed in order to ensure a healthy reliability. During the research, student interview forms were analyzed with content analysis method and compared with expert opinion. Afterwards, the codings that the researcher and the expert made independently were specified as "consensus" and "difference of opinion". After reaching a consensus on coding, reliability between encoders, reliability formula of Miles and Huberman (1994) was applied and inter-code reliability was calculated as 100%. The interviews made by the students as a result of the first interview and study were compared and these were included in the findings. Codes and themes are presented in Table 4.

Table 4. Codes and Themes

	1.Questions Codes	2.Questions Codes	3.Questions Codes
Determined Codes	Easy, Confortable, Positive	Simple, Not hard,	Quiet, Noiseless, Funny, The Teacher isn´t tired
Theme	Self Expression	Apply	Teach a lesson

Table 5. Codes and Themes

Themes	Vision Union	Visibility	Average
Self Expression	3	**0**	**%100**
Apply	3	**0**	**%100**
Teach a lesson	3	**0**	**%100**

Interpretation of teacher logs and interviews according to sub-problems;

1. How did the traffic lights technique affect students' self-assessment skills?
   It has been observed that silent and shy students can express themselves comfortably. In this way, students with low class participation were able to express themselves in colors. When students were shy and silent while expressing the status of the problems, they encountered in their studies in information technologies and software lessons, they gained the gains comfortably after the application of traffic lights.
2. How did the traffic lights technique affect classroom control and the effective feedback of the teacher?
   As a result of the application of the traffic lights technique, silence was provided in the classroom. The teacher gave effective feedback behind avoiding students' unnecessary speech. By reaching more students in a short time, students were enabled to learn effectively. When the teacher gave feedback to a student, the problem of intervention of another student and division of correction was eliminated with the traffic lights technique.
3. What are the suggestions of the students regarding the problems encountered in the development of self-assessment skills?
   During the meeting with students who were silent and shy in the classroom, they said that "it was more comfortable than talking", "I can easily express" were answered about the traffic lights technique. Students had problems using the yellow color, which means "I am moving slowly" and "I have some questions". This problem has been eliminated by giving more information about the use of this color.

8. Discussion Result and Suggestions

In this study, when the findings of this action research, which was carried out to increase the self-assessment skills of the students by using the traffic lights tecnique in the information technologies and software lesson, it was ensured that the classroom environment was quiet and the self-evaluation skills were improved for the students in terms of teaching lessons. Since the literature was examined, it was seen that no studies had been carried out in our country yet with the traffic lights technique.

In a study conducted by Nash et al. (2016) in Australia, the use of a traffic lights technique for Pharmacy undergraduate students to evaluate their own performance has gave positive results. Students should be supported to create an environment where students can express themselves comfortably [7].

There is a strong correlation between learning cognitive knowledge and learning and lifelong learning. Since metacognitive knowledge is defined as the questioning of the individual's own learning, it can be said that self-evaluation has an important role in the development of this skill [16]. Self-assessment is an important skill that contributes to individuals making inferences about themselves [11]. Many researchers have suggested that partner, portfolio, and peer assessment are essentially contributing to the development of learning and self-assessment skills. In this regard, alternative assessment techniques need to be viewed as part of the learning process in order to achieve their goals. In this process, teachers are expected to guide their students to acquire skills in defining or introducing assessment criteria, how to evaluate and use the results. In order for the practices to reach their goals, there is a need to improve the knowledge, skills and interest levels of the practitioners in alternative evaluation methods.

In our research, which is a rooted solution to the problems that will arise during the evaluation, feedback and correction, which is one of the most important elements of performing classroom activities, the students used the Traffic Lights Technique while expressing their self-efficacy and the teacher achieved effective learning by giving effective and quick feedbacks. In-class interaction has increased, each student has been contacted and a quiet classroom environment has been provided. In addition, the Traffic Lights Technique used for monitoring students and evaluating the process has proven its effectiveness.

Plastic glasses, rods and rosettes containing traffic lights colors suitable for the classroom environment can be used as a recommendation for researchers in future studies. It should be remembered that there are colors that are important in this regard and should be flexible. The use of yellow, which means "I am moving slowly" and "I have some questions", can be emphasized more than other colors, so students can embrace it. The gains in which red color is seen should be repeated and reevaluated. By creating a chart with the list of students, the colors they use can be saved and used in student assessment.

9. Acknowledgements

Thanks to the school management, the teachers and the students for their contributions of this study.

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Removal of Heavy Metal Ions from Contaminated Water

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Abstract. The presence of heavy metal ions in wastewater treated by incorrect forms can generate impacts for the environment and human health, since these contaminants stay accumulated for years, they are not biodegradable, and can be toxic or can cause damage to various organs of the human body (such as lungs, kidneys and even the brain) when consumed. Additionally, currently used technologies for the removal of heavy metal ions are difficult to implement and involve high costs. Therefore, there is a need to develop new processes that are more economically viable, simple, sustainable and easy to use. 12th grade Chemistry students, working in partnership with the Faculty of Science of the University of Porto, used the Project-based learning (PBL) methodology to develop a project for the removal of heavy metal ions from contaminated waters, through magnetic separation. The project consists in synthesizing and characterizing nanoparticles composed by iron oxides (magnetite) surrounded by porous silica in a core-shell configuration $Fe_3O_4@SiO_2$. By doing so, it`s possible to combine the high adsorption ability of porous silica with the magnetic separation from the magnetite nanoparticles. The system allows, after treatment, the efficient and simple removal of the adsorbent from a large volume of water by applying an external magnetic field.

Keywords. Iron Oxides, Environmental Remediation, Magnetic Separation, Nanoparticles, Project-Based Learning.

1. Introduction

The presence of heavy metals in wastewater is a problem in the treatment of effluents, as these contaminants, unlike organic pollutants, are not biodegradable, therefore they accumulate in the environment for years and affect public health and the ecosystem. [1]

One of the most common heavy metals in waters that are not treated properly is copper, which is essential for living beings in small doses (daily dose of 2-3 mg - reference value used by the FDA (Food and Drug Administration)) [2]. However, at higher concentrations, it can cause poisoning, liver damage, vomiting, abdominal pain, dysentery and nausea (children are more susceptible to side effects) [3]. According to CETESB (Environmental Company of the State of São Paulo), this metal is even more harmful to fish, since a concentration of 0.5 mg / L is lethal for catfish, red fish, trout and carp [4-5].

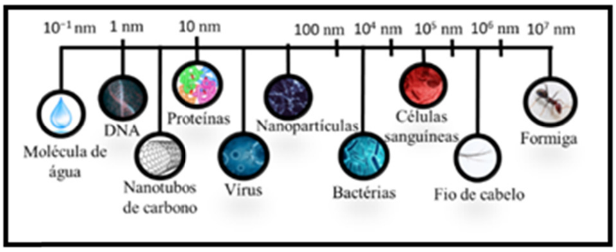


Figure 1. Representation of the nanoscale

Among the methods used to remove heavy metals in industrial effluents, the main ones are separation by filtration membrane (macromolecules fix metal ions, increasing the size of these macromolecules and, therefore, they are retained in the filter and the water is purified), biosorption (the heavy metal is contained in a biomass or biomolecule and separated from the aqueous solution) and chemical precipitation (the metals precipitate according to the conditions of the environment, such as pH). [6]. However, these methods, in addition to not being simple and taking a long time, are neither sustainable nor economically viable. Another method for removing heavy metals from effluents is adsorption, which is a simpler method and has a more flexible operation compared to other methods. [5-9] Adsorption can be defined as a process in which material (adsorbate) travels from a gas or liquid phase and forms a superficial monomolecular layer on a solid or liquid condensed phase (substrate). This can occur because of physical forces or by chemical bonds. [7,9]. However, many of the known adsorbents have limited adsorption capacity, are difficult to regenerate (a term used to refer to the Desorption process) and separate these materials from contaminated water and the costs involved are high. Therefore, the main challenge that researchers face in this area is the development of new adsorbents that have high adsorption capacity, rapid separation of a large volume of the treated solution and regeneration capacity and low production cost [1,5].

Nanotechnology is the study and manipulation of materials on the nanoscale, in a range from 1 to 100 nm (Figure 1).

Currently, the synthesis of materials on a nanometric scale has been developed due to the interest in different technological applications and in biomedicine. This progressive interest observed in nanotechnology can be explained by the relationship between the dimensions of nanomaterials and the properties presented by them, which can be adjusted by controlling the size and morphology of the nanoparticles. For these reasons, these materials have a high potential for different applications, such as catalytic processes, magnetic fluids, magnetic inks, environmental decontamination, etc [5,8].

1.1. Objective

Nano4Green is a project that aims to remove heavy metal ions from contaminated water in an efficient and economically viable way, through magnetic separation. For this, magnetic nanoparticles composed of iron oxides surrounded by mesoporous silica will be used in a core-crown structure $Fe_3O_4@SiO_2$. Therefore, it is intended to combine the high adsorption capacity of porous silica with the magnetic separation of the magnetite nanoparticles. [9] This system allows, after the treatment, the efficient and simple removal of the adsorbent from a high volume of water through the application of an external magnetic field.

Magnetite nanoparticles can be obtained from iron sources, a low-cost material, and it is possible to reuse them in consecutive water treatment cycles. These characteristics combined with excellent adsorption and strong magnetism make Fe3O4@SiO2 nanoparticles a promising material to be used in water remediation. In addition, the proposed method for the synthesis of the adsorbents follows the principles of Green Chemistry, avoiding the use of highly toxic solvents [9-10].

In this perspective, it is intended with this project to create a solution that incorporates these requirements, according to the following objectives:

- Reduce chemical pollution.
- Reduce the number of cases of heavy metal ion poisoning.
- Use of an inexpensive and effective process.

2. Materials and Methods

The work was accomplished in a laboratory at the Faculty of Sciences of the University of Porto (FCUP).

2.1. Preparation of magnetic nanoparticles of magnetite

We started by preparing 25,00 mL of an aqueous solution of hydrochloric acid (HCl) ([HCL] = 0,5 mol / dm3) and 100,00 mL of an aqueous solution of sodium hydroxide (NaOH) ([NaOH] = 1,5 mol / dm3).

After preparing the solutions, we weigh 2,1624g of iron chloride(III) hexahydrate (FeCl3.6H2O) and 1,1120g of iron sulfate (II) heptahydrate (FeSO4.7H2O) and solubilize each one in 5,00 mL of the aqueous solution previously prepared HCl.

We mixed the iron salt solutions and added to the aqueous solution of NaOH under vigorous stirring at room temperature for 30 minutes.

After 30 minutes, we pour the resulting solution into 3 Falcon tubes, we magnetically separated the resulting black precipitate and wash twice with 50,00 mL of deionized water.

Finally, we dispersed the precipitate in a stabilizing medium (tetramethylammonium hydroxide solution).

2.2. Characterization of iron particles (Fe_3O_4)

We place 1,00 mL of the precipitate that we disperse in a stabilizing medium in 3 eppendorfs. Then, we placed the eppendorfs in a centrifuge and removed the solution that surrounded the particles.

Afterwards, we wash the particles twice with ultra-pure water, with the help of the ultrasound machine. We placed 2 eppendorfs to dry in the desiccator for characterization by infrared spectroscopy and disperse the content of an eppendorf in ultra-pure water to analysis of particle size and surface charge, with the help of a Capillary zeta cell and a Zetasizer.

We added KBr (potassium bromide) to the solution we had left in the desiccator, which was in a solid state, and mixed it in a mortar with the pestle until homogeneous. Then, with the help of the press, we prepared a pellet that afterwards we use to characterize by infrared spectroscopy.

2.3. Preparation of $Fe_3O_4@SiO_2$ particles

We start by placing about 20,00mL of the particles (precipitate that we disperse in a stabilizing medium) in a Falcon tube.

We wash with 20,00mL of ethanol, and separate, with the help of a magnet, the particles from the solution, which we then remove with a pipette and then, we transferred the particles with 80,00mL of ethanol (it was divided into 4 of 20,00mL) for a 3-tube flask. We add 6,00mL of 25% ammonia and, with the help of a micropipette, Tetraethoxysilane and leave the solution under vigorous stirring for 2 hours. Then we transferred about 20,00mL of the solution to Falcon tubes and, with the help of a magnet, we separate the particles from the solution, which we then remove with a pipette and put it in a bottle (Decantation). We put the Falcon tube with the particles in the desiccator.

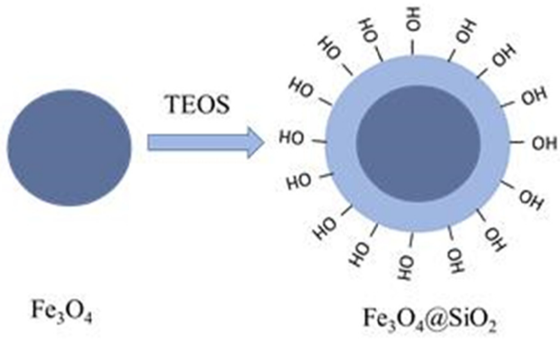


Figure 2. Tetraethoxysilane

2.4. Involve the particles in silica twice

We started by weighing the nanoparticles that were in the Falcon tube and then we put ethanol in the tube. After stirring, we transfer the particles with ethanol to the 3 tubers flask that we later placed on the ultrasound for 15 minutes.

Later, with the help of a micropipette, we add Tetraethoxysilane to the flask and the solution is left under vigorous stirring.

Then, we transfer about 20,00mL of the solution to Falcon tubes and, with the help of a magnet, separate the particles from the solution, which we then remove with a pipette and place in a bottle. Finally, we place the Falcon tube in the desiccator.

2.5. Characterization of Core-shell nanoparticles with different thicknesses

We added KBr (potassium bromide) to the dried powder and mixed it in a mortar with the pestle until homogeneous.

Then, with the help of the press, we form a pellet that we use to characterize by infrared spectroscopy.

We repeated the same process for the solution that was in the Falcon tube (2x).

Then we put the solution (which we separate from the particles and removed when preparing $Fe_3O_4@SiO_2$ particles), with the help of a syringe, in a cell (previously rinsed with ultra-pure water) and put it on the Zetasizer, which allowed us to measure the zeta potential and particle size by dynamic light scattering.

We repeat the same process for the solution that we separate from the particles (2x).

2.6. Observation of particles in the Scanning Electron Microscope (SEM)

We remove a little bit from each particle sample (without, 1x and 2x of silica), that were in an eppendorf and in Falcon tubes, and we put each in an eppendorf with ethanol, which was agitated on ultrasound.

We clean and prepare the Aluminum supports, which will be used in the Scanning Electron Microscope (SEM). To prepare them we put a carbon tape on each silicon wafer, where we put 1 drop of each solution.

Finally, we observed the particles in the Scanning Electron Microscope.

2.7. Preparation of a copper solution

We started by preparing 100,00mL of a 1ppm Cu_2+ solution. Then, we divided the solution into 3 beakers, each with 20,00mL of the prepared solution.

We adjusted the pH of the solution in each beaker to 4, 7 and 10, with the help of a pH meter and HCl and NaOH solutions (both with concentration of 0,1 mol / dm3)

In 6 bottles, we put 3 with about 20mg of particles $Fe_3O_4@SiO_2$ (1x) and the other 3 with particles $Fe_3O_4@SiO_2$ (2x), then we put 10,00mL of the solutions with previously adjusted pH.

We put the particles in agitation for 2 hours and then we place them in a centrifuge to separate them from the solution surrounding them.

2.8. Atomic absorption spectroscopy with flame

We observed the behavior of the particles in the copper solution, with the help of flame atomic absorption spectroscopy.

2.9. Preparation of a copper solution, with pH = 7

We started by preparing 100,00mL of a Cu_2+ solution (1 ppm). Through a pH meter and HCl and NaOH solutions (both with a concentration of 0,1 mol / dm3), we adjusted its pH to 7.

Figure 3. Zetasizer results (Fe_3O_4)

In 2 bottles we put 19,5mg of $Fe_3O_4@SiO_2$ particles (2x). With the help of a volumetric pipette and a pompet, we put 10,00mL of the copper solution with the pH previously adjusted in the bottles.

Finally, we placed them in a centrifuge and then, with the help of a magnet, we separate the particles from the solution, which we then remove with a pipette and put it in a Falcon tube.

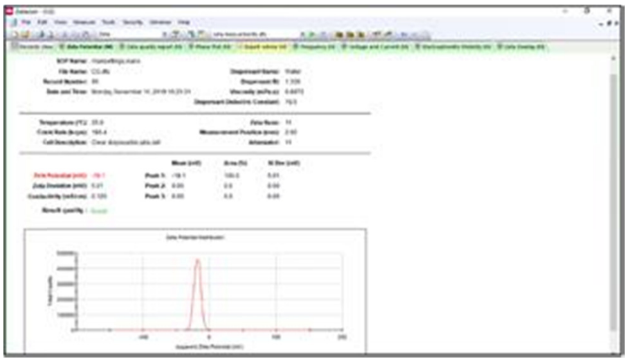


Figure 4. Zetasizer results ($Fe_3O_4@SiO_2$ - 1x)

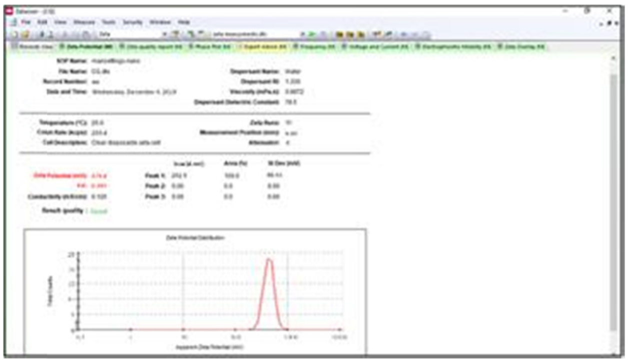


Figure 5. Zetasizer results ($Fe_3O_4@SiO_2$ - 2x)

3. Results and Discussion

3.1. Zetasizer

The table 1 shows the size of the particles, as well as the polydispersity index (PdI) and Zeta Potential.

The size of the particles involved twice with silica, it's almost twice the size of the particles involved once with silica, as expected, since the particles were involved twice with silica, providing particles with diameters larger than those coated only one.

The PdI is the polydispersity index, varies from 0 to 1, and indicates the homogeneity of the particle diameter- the smaller the value, the more uniform is the particle diameter.

For our nanoparticles that were involved once with silica, the PdI is relatively large, therefore, there are particles with different diameters. But the PdI of the nanoparticles involved twice with silica is lower, so the nanoparticles have similar diameters.

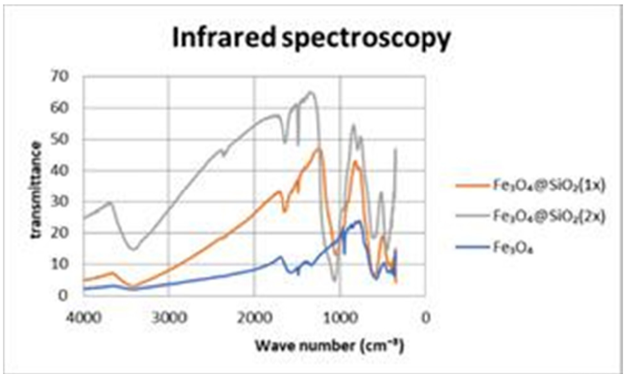
Zeta potential is a useful indicator that can be used to predict and control the stability of solutions. The higher the zeta potential, the more likely the suspension is stable.

Table 1. Comparison of Zetasizer results ($Fe_3O_4@SiO_2$ - 1x and 2x); d.nm – diameter value in nanometers; PdI – polydispersity index; Zeta Potential - potential difference between the phase limits between solids and liquids. It is a measure of the electrical charge of particles that are suspended in liquid

	Particle size (d.nm)	PdI	Zeta potencial (mV)
1x	71.53	0.515	211.2
2x	202.9	0.267	275.9

3.2. Infrared Spectroscopy

Infrared spectroscopy is a type of absorption spectroscopy, in which the absorbed energy is in the infrared region of the electromagnetic spectrum.



Graph 1. Results of Infrared Spectroscopy

As can be seen in Graph 1, the Fe_3O_4 particles have a lower transmittance unlike those that are involved with silica.

Therefore, we can conclude that the particles involved with silica have a larger thickness compared to the Fe_3O_4 particles, which was expected.

3.3. Scanning Electron Microscope (SEM)

The Scanning Electron Microscope, SEM, is an electron microscope capable of producing high-resolution images of the surface of a sample, which allows us to check its morphology. SEM microscopes are usually coupled with Energy-Dispersive X-ray spectrometers that allow to evaluate the chemical composition of samples.

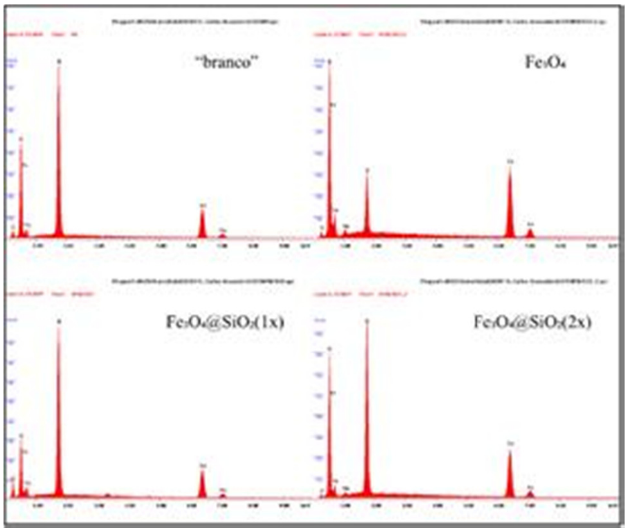


Figure 6. Result of Scanning Electron Microscope (SEM)

When observing the particles with X-ray electroscope, we noticed that they had the following constituents:

- <u>Particle Fe_3O_4</u>: Fe; O;
- <u>Particle $Fe_3O_4@SiO_2(1x)$</u>: Fe; O; Si; C; Na;
- <u>Particle $Fe_3O_4@SiO_2(2x)$</u>: Fe; O; Si; C; Na;

It was also possible to observe them in Figures 7 and 8.

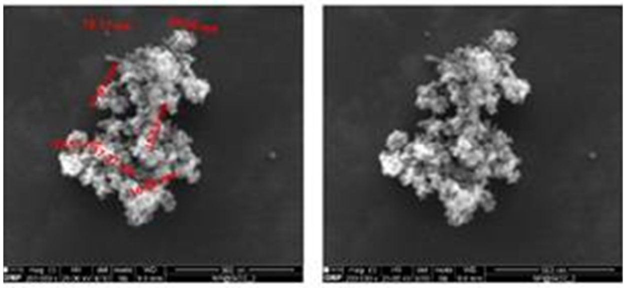


Figure 7. Result of SEM -$Fe_3O_4@SiO_2(1x)$

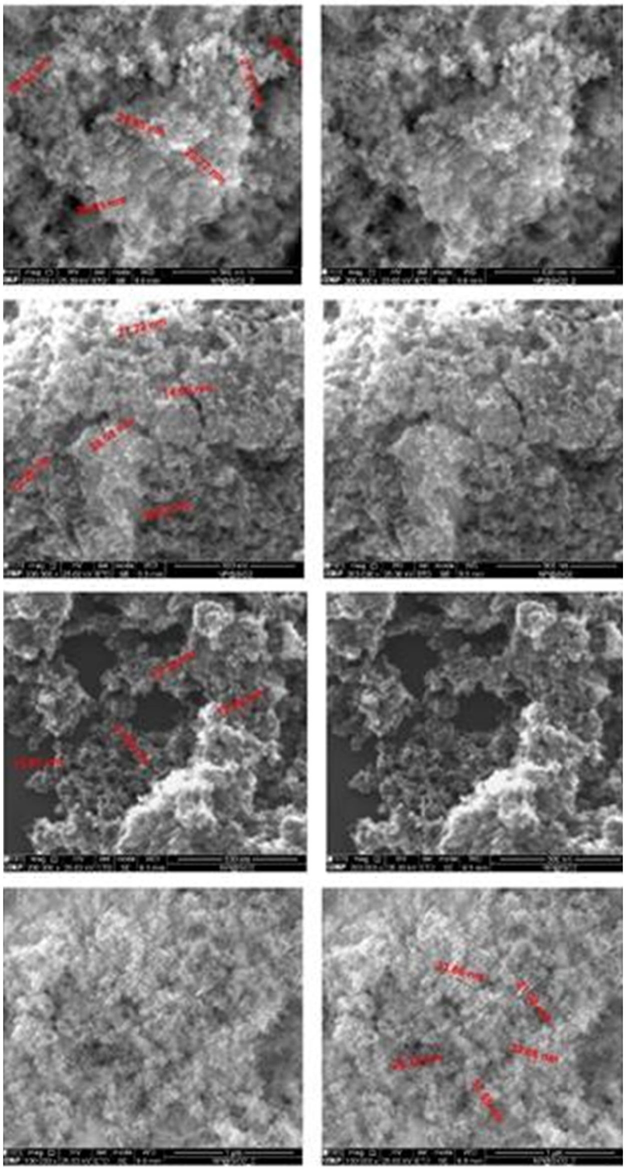
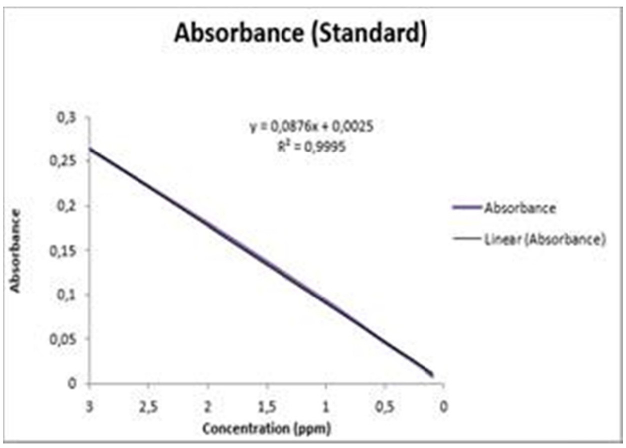


Figure 8. Result of SEM -$Fe_3O_4@SiO_2$(2x)

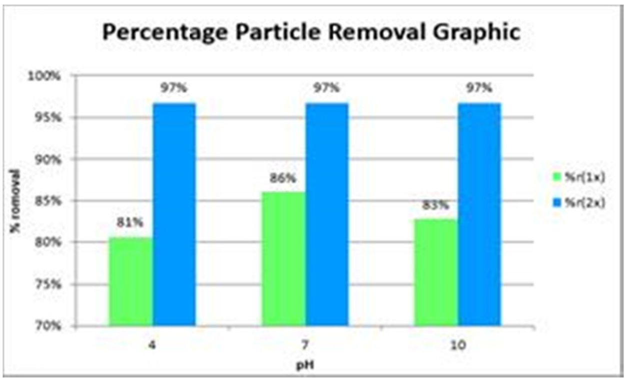


Graph 2. Absorbance (Standard)

3.4 Atomic absorption spectros-copy with flame

The calibration line is necessary to establish the relationship between the measurement (absorbance) and the Cu concentration. It was performed by measuring the absorbance of standard copper solutions with a known concentration

In order to observe how the adsorptive capacity of the prepared materials behave in a copper solution, we use the atomic absorption spectroscopy with flame which, through the Absorbance Graphic (Standard) (Graphic 2), the amount of Cu that remained in solution was determined and through the difference with the initial concentration of the Cu solution, the removal percentage was calculated.



Graph 2. Percentage Particle Removal Graphic

From the visualization of the percentage particle removal graphic, we notice that particles involved only once with silica show a greater removal at pH 7 (neutral) with 86%, at pH 4 (acid) an 81% removal and at pH 10 (alkaline) 83% removal.

The particles involved twice with silica show the same percentage of removal for the acidic, neutral and alkaline solutions, 97%.

Therefore, we can conclude from this procedure that the particles involved twice with silica ($Fe_3O_4@SiO_2$ (2x)) show a better removal than the particles involved only once ($Fe_3O_4@SiO_2$ (1x)) and that at neutral pH there is a better removal, which was expected because there is a greater amount of mesoporous material and therefore allows to accommodate a greater amount of Cu ions.

4. Acknowledgements

The authors would like to thank Professor Carlos Granadeiro from Chemistry and Biochemistry Department of the Faculty of Sciences of the University of Porto, their comments and suggestions made about this work.

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Maker Education: DuinoGraph Platform applied to a Track with Sensors in the Mousetrap Car Project

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Abstract. This work presents a case study, involving a maker education project, with a group of 24 high school students. The project involved the implementation of a track with sensors in the construction of cars powered by mousetrap. The STEM approach sought to verify the potential for using the project in exact science activities. With the study it was observed that the proposal created student engagement, and that, during its realization, concepts of mathematics and physics were explored, through activities that evaluated the design of the built car, the creativity in proposing the artifact and the feasibility of the proposal.

Keywords. Maker Education, Active Learning, STEM.

1. Introduction

The performance of experiments in basic education allows students to experience in practice subjects covered in the classroom, stimulating interest and engagement in the studied subjects [1].

Although traditionally the Natural Sciences deal with problems that involve practical activities, disciplines such as Languages, Geography and Mathematics have found space to appropriate "hands-on" activities through teaching-learning strategies involving the use of educational technologies.

Actions involving programming, physical computing and robotics allow educators to develop storytelling practices through visual block programming platforms, create experiences involving earthquakes, with sensors connected to low-cost electronic prototyping platforms, or create robots that perform movements in the form of geometric figures, expanding the educational possibilities in the classroom, dialoguing significantly with those demanded by a technological and connected society.

To advance towards a meaningful education, the 21st century educator needs to go through a process of transformation of mindset, leaving the role of knowledge holder to become curator of educational resources and manager of the teaching-learning process.

Active learning, in which the student is co-author of his academic process, presents very relevant results. Activities carried out in laboratories and collaborative spaces develop in the student the investigative and creative attitude [2].

With the creation of spaces for digital manufacturing and rapid prototyping, where tools and supplies are available, and the use of equipment such as laser cutter, 3D printer, CNC milling machine and plotter, combined with electronic components, scientific experiments are now created and adapted by the students and educators themselves, significantly expanding the learning possibilities.

The Maker Movement has played an important role in this regard, by valuing autonomy in learning and the creativity of the student. Performing practical tasks gives greater importance to the activity developed, and performing the task of creating your own learning object generates a bond with the built product, as well as preparing the young person for an autonomous attitude, facing a future in which the means of production and employment relationships will be constantly changing [3].

Thus, when the activities carried out in the classroom are in the predominantly expository format, learning is meaningless and becomes a mechanical process. This reality has caused discomfort in the student-educator relationship, discouragement on the part of students, and is therefore one of the challenges for schools in this century.

This picture is particularly reflected in the learning of Science and Mathematics concepts in several countries in Latin America and, especially in Brazil, which occupies the 68th position in the Mathematics exam in the PISA assessment test. [4].

This scenario points to the need to develop pedagogical strategies of an exploratory nature involving the New Information and Communication Technologies (NTICs), which can be easily implemented in the classroom, and which are of low cost, in order to reach educational institutions from all social classes.

Thus, this article seeks to contribute to the aforementioned debate, presenting a work in progress - a mousetrap project associated with the DuinoGraph Platform - with the aim of exploring, from practical activities, concepts involving “hands-on” education in activities of exact sciences.

In section 2 we present the theoretical foundation of the work developed. Section 3 explores some ideas regarding maker education. In section 4 we present the materials and methods used in the experiment. In section 5 we present the activities carried out with students. In turn, section 6 deals with the conclusions and section 7 presents the references.

2. Theoretical foundation

In this section we will present the main challenges in the teaching-learning process of exact sciences, discuss the STEM approach and the potential of physical computing for meaningful education.

2.1. The challenges of the exact science teaching-learning process

Relating the learning of Mathematics topics to concepts in the disciplines of Natural Sciences is a challenge that many educators have faced and been frustrated by not being successful in its execution. Although one area of knowledge is a tool and example for the other and their school curriculum are directly related, this conversation has not happened.

Due to the lack of integration of the curriculum structure and of a traditional and non-reflective banking education [5], learning exact sciences has caused disinterest in part of the students, because historically it was associated with the capacity for abstraction, because of the lack of practices, experiments and association with the reality of the learning subject.

This situation is also a consequence of a reality of higher education in Brazil. During academic training, teachers in the disciplines that make up the areas of Mathematics and Natural Sciences do not have the opportunity to perform hands-on activities, and the lack of this practice reflects on their student action in the classroom. In addition to the difficulties generated in the initial education of the educator, the lack of support in processes to improve educational practices prevents this situation from being reversed. To improve this situation, proposals and incentives for a continuing education contributed to a better development of the classes and activities proposed.

Consequently, the learning of exact science topics by high school students is marked by difficulties such as the lack of experiments carried out by the students, the high cost of experimental materials for use in practical classes and the low interest in learning the content by young people [6], since students need to abstract the use of formulas and learn a difficult vocabulary without correlation with reality [7].

2.2. STEM Approach: Disruptive approach in the teaching-learning process of exact sciences

In education, disruptive actions initially generate mistrust and uncertainty, both on the part of parents and students, and on the part of educators.

Leaving the comfort zone, from an apparently consolidated educational format, to a liberating and flexible approach, in which the educator is no longer the center of attention in the classroom and the exclusive holder of academic knowledge, causes discomfort in the actors of the established system and apparent risks the balance of roles that traditionally must be respected.

In an innovative educational approach, the teacher only needs a control zone, which is nothing more than playing the role of manager of the educational environment, such as supporting students, guiding and being co-curator in research actions, leaving the role of center of attention to a collaborative attitude in the classroom.

Within this framework, and as mentioned in the previous item, the teaching of exact sciences has been a matter of concern for both educators and school managers, due to the lack of interest of many students in this area of knowledge. On the other hand, with the advancement of technologies, professionals with skills in these areas of knowledge will be increasingly needed.

An example of government action to improve this situation has emerged in the United States. In order to improve the learning of exact sciences, in November 2009, former President Barack Obama presented the Educate to Innovate initiative as a collaborative effort between the federal government, the private sector and the nonprofit and research communities, thus recognizing STEM education as an approach that brings greater relevance to the teaching of Science and Mathematics concepts.

STEM education is considered a new paradigm in the teaching of Science and Mathematics, and this model emerges as a response to the conservative and fragmented educational model. This approach provides the student with a role in his learning and helps to develop important skills for the 21st century professional. This professional will find a job market that will demand a new set of cognitive skills and abilities, previously accessible only to specialists, promoting the democratization of various tasks [8]. This new educational possibility contributes to an active and meaningful learning.

Within this teaching-learning approach, physical computing is a valuable instrument for prototyping and experimentation, contributing to give reality to the projects developed by students and educators.

2.3. Physical computing in the STEM approach

Currently, we live between the physical environment and cyberspace. If we consider this reality of our daily lives, hands-on educational activities, involving bits and atoms, become increasingly relevant. Interacting with these spaces in an integrated way, expands the possibilities of proposing problems closer to the real world [9].

In fact, by associating bits and atoms, physical computing makes it possible for data collected in the environment to interact through sensors that capture digital and analog inputs. The collected entries are transformed into data that make it possible to create graphics through which analyzes can be performed.

Pimentel et al. (2015) present an Educational Mechatronics activity to enhance the teaching of Physics and Mathematics, through an activity involving Physical Computing, using the Arduino electronic prototyping platform, in addition to some sensors and actuators. The authors proposed the Problem Based Learning methodology to guide the project called Automated Parking, through which students were challenged to build a prototype whose programming of sensors and actuators are part of a construction that reflects a real-world situation. The students' engagement when faced with a replicable problem in reality gave significance to the project and, in the evaluation of the activity, it was found the learning of Mathematics concepts, as a consequence of the study carried out by the students during the construction of the model, in addition to concepts of electronics and programming, which were part of the scope of the proposed problem [10]..

It is important to note that, when it comes to physical computing, Educational Robotics (RE) has been a valuable resource for accessing prototyping.

Martins (2006) [11] defines robotics as the science of systems that interact with the real world, with or without human intervention. In the school ontext, the environment in which the teacher performs with the student activities of assembly, automation and control of mechanical devices, through a computer, is called Educational Robotics [12]. ER has been a potential instrument to motivate and involve students in the study of Mathematics and Science concepts, enabling a multidisciplinary experience and creating new forms of interaction with the environment.

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3. Maker education: expanding access to experimentation

In schools, Digital Fabrication Laboratories are spaces dedicated to hands-on activities, which provide students and educators with equipment such as 3D Printers, Laser Cutters, CNC Milling Machines, Plotters, and rapid prototyping tools, allowing the development of individual or collective projects. Students can collaborate with each other and share their creations, providing a meaningful learning environment.

This space enhances and dynamizes the production of learning objects, allowing projects that are closer to reality to be prototyped in a space of time that suits the reality of school routine and curricular structure.

An active and meaningful teaching-learning methodology, attentive to what Paulo Freire expresses as breaking with “limit situations”, in his work *Pedagogia do Oprimido* [4]. Both educators and students leave an uncritical and merely repetitive position in the teaching-learning process and envision overcoming an apparently solidified reality, breaking with the brakes of a traditional and non-reflective classroom.

In this way, the student becomes a co-author of his academic itinerary and is directly involved in his learning process. The teacher assumes the role of advisor and manager of the classroom environment, allowing the student to experience routines closer to the reality for which the school proposes to prepare them. Thus, the Maker movement allows the elaboration of knowledge structures, defined by Papert (1986) [13] as Constructionism, an approach according to which the student builds his own knowledge through the use of technological resources. He points out that, when the student puts his “hands on” through doing and producing something of interest and for which he is motivated, there is the consequent affective involvement with the developed project, contributing to a meaningful learning.

Therefore, education needs a set of models and actions that demonstrate the impact of Papert's ideas of execution in schools and show that the implementation of this approach brings benefits that point towards a modern, disruptive and innovative education.

4. Methods and Materials

This project aimed to understand how students would behave in a kinematics study activity, through the modeling of Mousetrap Cars moving on a track with Sensors. The students' actions were evaluated according to three pillars: creativity in the creation, design and viability of the artifact. In this sense, this work sought to understand how the DuinoGraph Platform associated with the Track with sensors, applied to the Mousetrap Car project, enhances the students' interest in Exact Sciences activities, through activities carried out in the Maker Space of a secondary school.

4.1. Methodology

As a methodology to support the approach that this work presents, we opted for a case study with a qualitative approach, through “hands-on” workshops. The evaluation of the activity was carried out according to the following pillars: creativity in creation, prototype design and feasibility, according to the questions in Table 1.

Table 1. Skills and objectives framework

Skills	Goals
Creativity	Did the project implement different elements?
Design	Are the relationships between wheel sizes and main **stem** consistent? Were the calculations performed correctly? Was the proposed model properly executed in the CAD software?
Viability	Is the proposed prototype feasible? Was the car able to travel the track with sensors effectively?

Although the approach adopted was qualitative, each of these evaluated criteria considered intrinsic mathematical and physical concepts in each one. The learning considered in the project addresses the integration of knowledge and brings the development of an academic project closer to reality.

4.2. Mousetrap car

The construction of a car powered by a mousetrap (Figure 1) is a challenge that provokes students to prototype a vehicle that uses only the energy that can be stored in a mousetrap for its displacement. The project allows the development of concepts of mathematics, physics and design.

Figure 1. Car powered by mousetrap

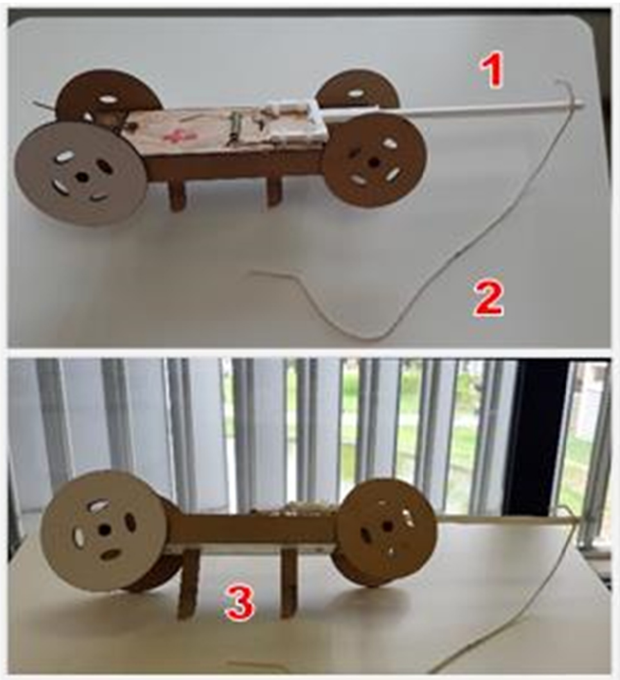

Figure 2. Elements of the mousetrap car: 1. Rod (whose size is defined by the student); 2. String, to connect the rod to the rear wheel axle; 3. Keel, so that it could move around the Track and the sensors could identify its passage

Mousetrap cars have been used in higher education institutions to introduce math and physics concepts to engineering students. The mousetrap transforms elastic potential energy into kinetic energy, setting the car in motion [16].

Basic education schools also use the mousetrap car for school activities, including competitions to check the best performing car [17].

In one of these actions with high school students, it was possible to measure the car's performance using sensors, such as the physics experiment air rails, and for this purpose, the DuinoGraph project applied to the Track with Sensors was prototyped, which will be presented in the next section.

For its proper functioning, the prototypes created would need to have the elements shown in Figure 2.

4.3. DuinoGraph applied to the Track with sensors: the learning object.

For the development of an experimentation class with cars powered by mousetrap, a sensor track coupled to the DuinoGraph Platform was developed.

4.3.1. DuinoGraph

DuinoGraph [18] is a project that was created to be easily replicated. It consists of low-cost electronic components, allowing accessibility for educational institutions of different social conditions.

The creators of the Platform developed a simple system, easy to replicate, and people without knowledge of electronics could properly connect the wires and components. For the creation of the DuinoGraph, 9 8x8 LED Matrix modules, a 16x2 LCD, an Arduino Nano and some wires were used (Figure 3).

For the creation of codes for use in different applications, the Platform has a library of routines, which promotes an interface between DuinoGraph components and the user. In addition, users can also make changes to the code to create new possibilities for the DuinoGraph.

The authors developed five possibilities of themes that can be explored with the environment: graphics of mathematical functions, drawing and animation, Logo language (simplified or working with angles), 2D cellular automata and manipulation of vectors and matrices.

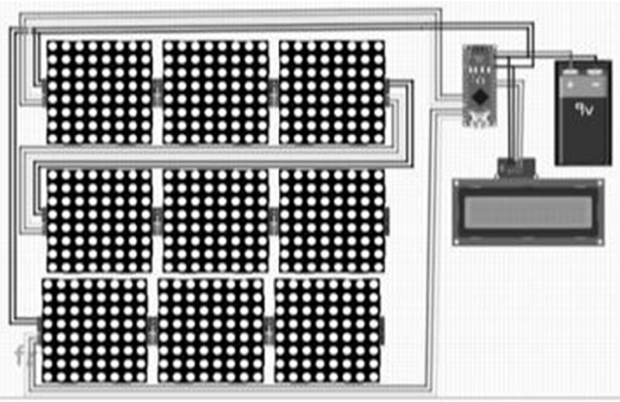

Figure 3. Scheme for building the DuinoGraph [18]

For the development of the DuinoGraph for the work mentioned in this article, an Arduino Mega was used because GPIOS ports were needed for the sensors of the created Track (the Track will be presented in the next section). In addition, a box was built so that the LED arrays and the LCD were side by side, the Arduino Mega was visible through an acrylic display. In this box, the wires that came from the sensors implemented in the Track were organized (Figure 4).

Figure 4. DuinoGraph box

For this reason, a code was developed to collect data from the sensors and create a graphic of discrete values.

In this proposal, the LED screen deals with the first quadrant of a Cartesian plane where 0 <x <23 and 0 <y <23, with x and y belonging to the set of natural numbers (N) (figure 5). At each pass through the sensors, the Arduino code performs an approximation calculation for natural values, which are represented on the LEDS screen.

Figure 5. Physical representation of the 1st quadrant of a Cartesian plane of natural coordinates

4.3.2. Track with sensors

The track was designed with ultrasonic sensors attached to its base (Figure 6), connected to the DuinoGraph Platform. In this work, the LED Matrix screen aims to graphically present the relationship between distance and time through ordered pairs.

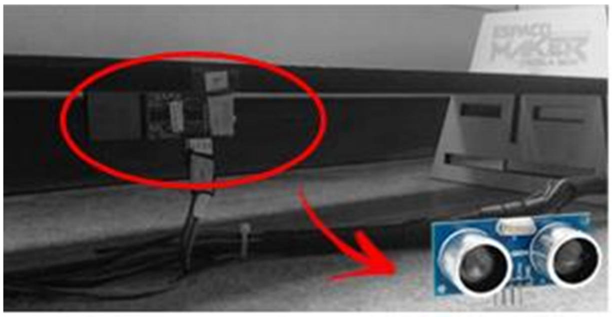

Figure 6. Highlight: sensor that starts the stopwatch

This track aims to be an artifact to support learning, as a means of evaluating the prototyping of cars powered by mousetrap. The prototyping of a cart that takes off on this track allows the development of learning that ranges from the design of the artifact to the analysis of its performance.

Although the project refers to a traditional physics experiment, the air track, it is important to note that, for both students and educators, the difference of this track for a traditional air track is that the air track is designed to disregard the frictional forces, causing a body to move over a layer of air, which eliminates direct contact between the rail surface and the body surface. Already on the track with sensors, the car moves and the friction generated by the contact of the wheel with the track is not taken into account.

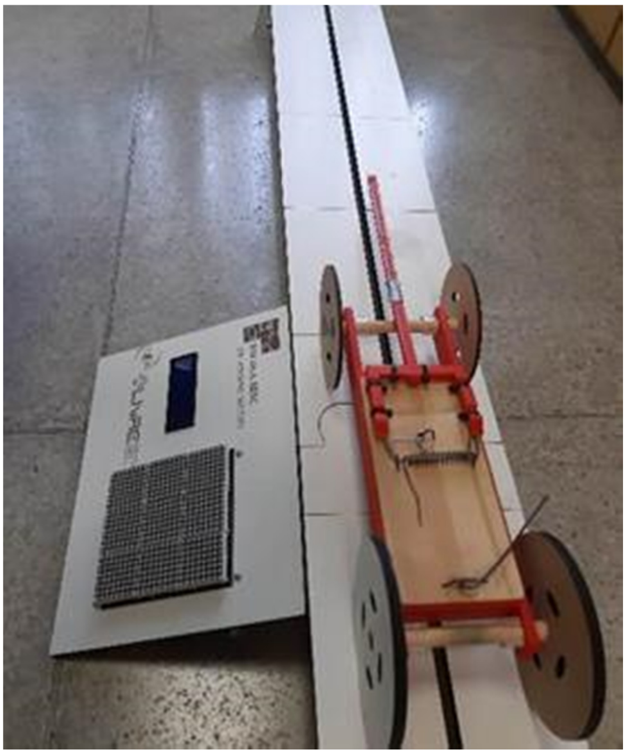

Figure 7. Track (longitudinal section)

The construction of learning objects fosters an investigative and research attitude in students, arousing curiosity and promoting implicit learning. Implicit learning can be defined as "[...] learning that occurs largely independent of consciousness, both in the process and in the acquisition and content of the knowledge thus acquired" [19]. During the modeling of the mousetrap car, skills are activated, promoting the acquisition of new knowledge.

The track was produced on the laser cutter at the Digital Manufacturing Laboratory, and is 360 cm long, has 1 ultrasonic sensor to start a timer programmed in the Arduino IDE and 8 other sensors of the same model installed every 30 cm to record the time that it takes for the car to reach each of them. The sensors identify the moment when the car passed the point where it is fixed.

It has a longitudinal opening (Figure 7) that contemplates its entire length, where the keel, a mandatory element in the construction of the car, passes and allows the registration of the ultrasonic sensor.

5. Student activities

The implementation of the DuinoGraph Platform applied to the Track with Sensors for the Mousetrap Car Project was carried out with a class of 24 high school students, in a transdisciplinary class held at the Digital Manufacturing Laboratory.

The challenge was launched (Figure 8) during an activity that proposed the prototyping of the vehicle whose only source of energy to move, was a mousetrap.

During the prototyping phase of the car powered by the mousetrap, students were provoked to reflect on the following elements of the artifact, which could impact performance on the track:

- The diameter of the car wheel;
- Mousetrap size (spring size);
- Wheel casing (traction);
- Weight;
- Rod size.

Figure 8. Presentation of the proposal to create a car powered by mousetrap - motivational class

The students were organized in teams of 4 components, each group received a wooden-based mousetrap and was instructed to develop original car designs. The activity involved everything from drafting on paper

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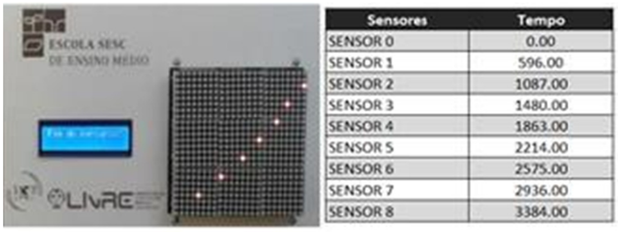
through modeling in CAD software, CNC laser cutting and assembly.

Figure 9. Students working on prototyping the car powered by mousetrap

The performance of the cars was measured on the DuinoGraph Platform applied to the Track with Sensors, and it was possible to observe the graphic generated by the displacement of the car (Figure 10).

Cars built properly showed an accelerated behavior and this data was represented by the points generated in the Cartesian plane of the LED screens.



Sensores	Tempo
SENSOR 0	0.00
SENSOR 1	596.00
SENSOR 2	1087.00
SENSOR 3	1480.00
SENSOR 4	1863.00
SENSOR 5	2214.00
SENSOR 6	2575.00
SENSOR 7	2936.00
SENSOR 8	3384.00

Figure 10. Graphic generated from the data collected by the sensors

5.1. Evaluation of activity performed by students

For the assessment of learning through the project carried out, we listed criteria that sought to identify the skills developed by students during the execution of the project. Among them, creativity, design and feasibility.

The ability to work in a team (Figure 11) was also developed during the action, as students were instructed to organize themselves so that each of the group's components had a well-defined function.

During the experience, the mediating teacher provoked the students involved in the project with the following questions:

- Which car performed better?
- Does the behavior of the points on the DuinoGraph reflect the data in the table?
- Does the size of the wheel influence the performance of the car?
- If the rod on which the rope is wound on the rear axle is of a different size, what happens with the performance of the car?

Figure 11. Teams conducting investigations on the track

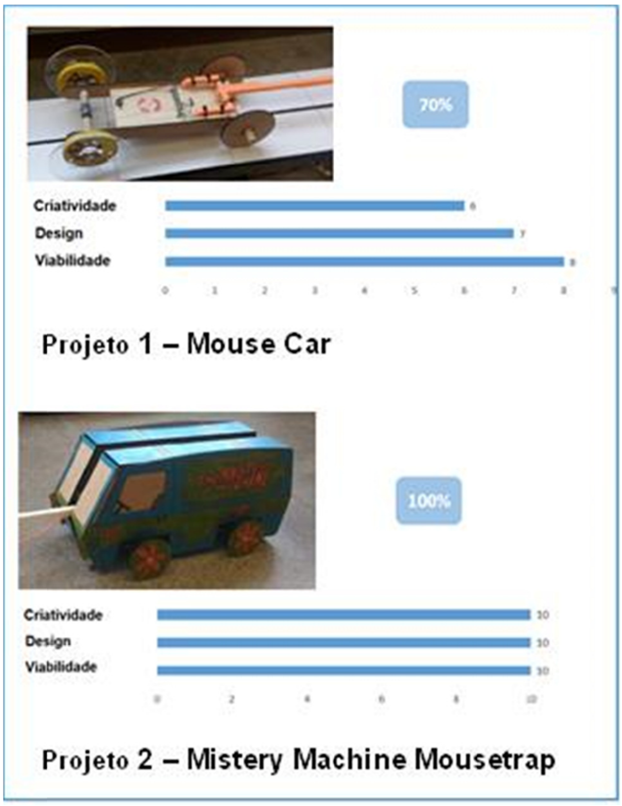


Figure 12. Feedback given to students

The teams gave names to their creations and, as a result of an activity that involved performance, in the end, the students proposed a race with their respective cars in order to choose the one that achieved the best result.

At the end of the activities, each team of students received feedback regarding their prototype. Figure 12 shows the results of the Projects of two teams

6. Conclusions

This article presents the implementation of the DuinoGraph Platform, a project developed for teaching Mathematics, Science and Arts, in an activity involving the prototyping of Cars Powered by Mousetrap.

This implementation involved the construction of a track with sensors, connected to the Platform, so that performance graphics of the Cars were presented and the students could evaluate the performance of the prototypes created.

The use of the Track expanded the possibilities for evaluating the prototypes created by the students, allowing the groups to have an imaginary experience in relation to the performance of the created car.

In addition, creativity, the creation of an appropriate design and the feasibility of the project could be evaluated, and presented to students as feedback for their achievements.

The project shows the potential to be applied in other contexts of STEM activities, inserted in program content of basic education. For future work, the objective is to develop activities of a quantitative character, with the objective of measuring student learning in mathematics and physics activities, within the context of the study of functions.

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The Progression of Children in Learning about 'Nature', Our Living World

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Abstract. Play in the earliest years is studied in teacher training for practitioners particularly who seek to work with this age of children, birth to formal school. However, such studies tend to focus on development of literacy and numeracy and socialisation. science is not a particular focus other than when it appears in play, such as water play, painting, mud kitchens.[1]. Numeracy is featured, but not particularly in relation to play. yet through play the emergent learner acquires both knowledge and skills that from a basis for later development into formal STEM. Whilst different genre of play has been recognised [2-3], there is little written about the development of science from play, Although, as Tunnicliffe and Gkouskou [2] showed, it is inherent in much of play in nursery and outside. However, play is to a case of one size fits all. Skills, competency and concepts development are progressive.

Keywords. Biology, Drawings, Children's Understanding, Research Methods.

Children begin learning biology through experiences from the moment of birth. The first animal about which they learn through observation and experience and provides them with a template with which they interpret other living things as they become aware of them of is themselves. Children begin learning biology through experiences from the moment of birth. The first animal about which they learn through observation and experience and provides them with a template with which they interpret other living things as they become aware of them of is themselves. Consequently, the needs, actions and feelings of other living organism are deduced it in an entirely anthropomorphic way. Whilst they learn something through play particularly in physical science [2,4], much of their beginning biological literacy, like that of other sciences, is learnt through direct observation and personal experiences. However, learning biology has challenges. There are three interrelated dimensions:

- observations identification of organisms, naming, personal names, everyday names and scientific perhaps, locations, criterial attributes;
- systems interrelationships horizontally and vertically;
- time dimension, evolution, life cycles, change in form and function. Which for the early years is a very difficult idea. Furthermore children become aware of the living world, where different things particularly animals and plants are found [5].

Children begin life with biological needs which are met by usually the mother. Babies begin to recognise sensations of functions and experience their external body anatomy and its properties. They develop rapidly and acquire independent movement.

Asking children to are themselves and other people, thus producing an expressed mental Model [6], they produce more realistic drawings of both external and internal anatomy. Using drawings and subsequent interviews with the child and their drawing yields most information and the use of such data can show the development of that child's understanding. Such research has also shown that despite what formal school curricula imply, with certain topics being taught at certain sages and stages, that is not how children actually learn [2,7].

One of the earliest activities carers introduce to babies is the naming of external parts of their bodies. These activities are often associated with various rhymes, through which they also learn the rhythm of their first language. Babies learn as they encounter various external parts of their own bodies, and those of others, particularly their mother.

Children hear references to parts of the body, internal and external. For instance, people say 'stomach' or 'tummy', and rub over its internal location or touch the child's head and say 'use your brain'. They can point to an external part if asked, even before they can speak. We observed that when asked to put a small card featuring an external body part, for example, a nose, a foot, the head, an ear, on a cut-out of a child's shape, very young two-year-old children took great delight in placing the card on the actual named part of the body. Older children in this pre-school group placed the cards on the picture. After we noticed this progression, we made a sticky note with the name of the part written on it and gave it to a child when we had shown them the picture card. The sticky notes proved an interactive, fun and effective way of teaching early learners to recognise and name body parts. Young children took great delight in walking around as a 'sticky-note' person.

Figure 1 Tadpole Man - one of many similar drawing created by Luc. All were identical

Children also hear references to some parts of the body through daily life instructions. They begin to associate requests such as 'please wash your hands' with that body part before they can speak. One of my grandsons, when he was 4 years old, kept drawing himself.

Children also hear references to some parts of the body through daily life instructions. They begin to associate requests such as 'please wash your hands' with that body part before they can speak. One of my grandsons, when he was 4 years old, kept drawing himself. (Figure 1). I have many copies of these drawings, all similar. He could not explain the symbol 'M' which he drew. This drawing is typical of young children, the 'Tadpole man'. We have found similar drawings in many parts of the world irrespective of language and culture. essentially, they start with marks on paper, or elsewhere, such as walls. They enjoy making marks and controlling the crayon or whatever implement they pick up. Development through these stages has been described by various researchers [7]. When children begin formal school, they already understand something of animal forms. Their drawings abstract out the basic shapes of component parts. For example, drawings of 'tadpole man (Figure 1) drawn by a 4-year-old boy has a circle for a head, a vertical rectangle for the torso and two pairs of stick rearranging the two pairs of arms and legs. [3]. Watching thinking, listening to their narrative will yield more. Insights into a child's understanding. There are published accounts of children's understanding of vertebrates, themselves, birds, fish, and invertebrates, namely crabs, earthworms and snails, derived from analysis of drawings [3]. Children will draw a basic, but scientifically inaccurate, 'butterfly shape. If asked or a stereotyped caterpillar with many legs. When asked to draw a plant they invariably draw a simple Compositae flower, and a lollipop shape if asked to draw a tree. Trees in the understanding of young child at least, 'are not plants'.

Biological literacy thus develops from these earliest years, as children are biological beings; they acquire an understanding of basic life functions from first-hand experience as well as a rudimentary understanding of the biological form and function of organisms in their relationship with the environment [9]. However, even in the first quarter of the 21st century, the situation has not improved since Tunnicliffe and Reiss [10] stated that, '…. to date, insufficient work has been carried out on how children view living organisms in the environment'. Korfiatis and Tunnicliffe [3] records that a two-year-old boy had five words for animals in his first fifty words and observes that observing animals feeding, as well as what they do and where they live, is a frequent pastime of very young children and this biology becomes part of a child's conceptual framework from the earliest years. The early years of recognising biology all around and its interaction with the environment and adaptions to habitat is recognised as essential foundation experiences. Tunnicliffe and Uckert [11] maintain such is the critical age for children's biological learning A study in England of pre-school children's taxonomic knowledge, Allen [12] found that they held

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simple but fundamental ideas, but hey may build on such with careful teachers, but such naïve ideas do persist without competent, accurate biological education. Allen also concluded that children learn about animals in a variety of places, formal and informal. School is but one source of a child' biological education.

We little understand how children perceive plants, yet they are a key part of the environment. Plants are key members of the environment, yet plant blindness is a recognised phenomenon, Plants are frequently neglected in formal study, yet without plants there would be no animals. Because plants are an integral part of our world. open ground, the soil, is covered by them and kept in place Plants and are used by a group of animals, all eaters and plant eater, including humans. Some animals e.g. birds, beavers, and humans use them in constructions. and as a supply for humans of fuel. However, some, humans also regard them as aesthetically pleasing and cultivated them for pleasure. Children, and adults, usually notice plants as a background to other objects of interest such as moving animals. If children see specimens of plants as part of the scenery of their everyday lives they may exhibit 'plant blindness' [13]. However, plants are usually the background for more interesting living things – animals. The recognition of plants and animals, their habitats, adaptations and interactions are vital in maintaining a sustainable world [10].

Children learn about living organisms gradually. There is a distinct progression in an emergent learner's noticing, observing, interpreting in constructing their knowledge of the living world as well as input s from peers, adults and other media which they receive. All such inputs are accommodated and constructed into their model of their living, and non-living, world.

A tentative attempt to document this is shown in Table 1. It is very rudimentary and the beginning of a study. There is distinct progression in the development of observations and understanding of their biological world and the associated pertinent influences, physical and planetary such as weather. These data are progressions based on observations

Table 1. Progression animal and plant understanding: a draft

STAGE	Animals	Observation
1	Move, different ways. Fly, swim, walk, crawl and independently	Toys move through child's will
2	Have different shapes, coverings, appendages, disruptors to outline	Learn can not grab at fur but need to stroke in one direction
3	Have basic shape- front end back end, sensory organs	See basic shapes e.g. stick animals, round bodies no segments- e.g. butterflies' drawings
4	Animals have same basic needs themselves- anthropomorphisms	Think all animals meet life needs in same wat, anthropomorphic interpretation until learn different kinds solve same need in particular and different way
5	Different animals live in different places (habitats) land, water, land/ air	Live on land, or in sky, in water, under the soil
6	Shapes, colour, habits etc may change as animal grow – metamorphosis, aging	Gradual metamorphosis - stages in complete metamorphosis seem to be two distinct animals e.g. caterpillar/butterfly
7	Start recognising and naming e.g. Animals, but our dog, Birds but seagull, butterfly but 'bugs'.	Name all similar by name learnt of first animal e.g. dog, first flying object if it is a plane is used for all until the other objects in air- learn birds, (except butterflies etc)

		Plants	Observation
	1	Flowers recognise and call plants unless know name e.g. rose	Anything else has an everyday category name- tree weed, bush, vegetable
	2	Plants have basic shape	Lollipop tress daisy-like flowers drawn
	3	Flowers and other organisms outside e.g. trees have green parts	Flowering plants
S	4	Some plants have flowers. Flowers ae coloured, have parts which can be pulled off.	Bees and other animals visit plants Plants need water or they wilt
T A	5	Plants have parts under ground	Different kinds of roots e.g. tap, adventitious, spread
G E	6	Plants don't always look the same during a year or over some years There are not always have flowers, flowers die, above ground parts of some plants die back, or leaves in some trees Change through the year. Seasons.	The idea of Life cycles and growth similar to animal metamorphosis TIME
	7	Seeds are parts of plants and grow into new ones made by parent plant	Root grows first downwards need water to absorb look different then will grow

Whilst our living world is dependent on the earth. Without earth science there would be no biology, no living things as we know them, no us. The recognition of the role of earth science in creating the biological world is neglected, like plants, there is an acute ‘earth science blindness ’ [3] and the realisation and recognition of features that have formed our environment is part of learning biology. The seasons or monsoons affect the living world but are created by the planet, as are the types of soils. Children learn to recognise different types of landscapes and the plants and animals that occur there. They learn that snow on the ground indicates a certain type of climate and when it is permanent, certain kind of animals adapt to that environment, they observe, for example, the colour of a mammals’ fur. When they see pictures or reconstructed scenes (as in dioramas), with sand and particular vegetation, such as cacti, they recognise desert and water features such as ponds and lakes and determine the types of things that live in those habitats. We find that this learning can occur though media representations, in particular, the books they read as well as through museum visits and observations in actual locations.

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Micropropagation and *Agrobacterium*-mediated Transformation of Plant Model *Marchantia polymorpha* L.

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Abstract. We developed a project for high school and college students pertaining the concepts and procedures involved in plant micropropagation and plant genetic transformation using the model plant *Marchantia polymorpha*. Genetic engineering, the process of manipulating the DNA of an organism often including DNA from a foreign organism, relies on complex molecular techniques. Students conduct hands-on experiments involving establishing plant tissue cultures in aseptic conditions and DNA-based technologies including Agrobacteria-mediated transformation of plants, and observation of fluorescent recombinant proteins by fluorescence microscopy. The impact of these technologies is discussed enabling students to address these controversial issues and justify their decisions on scientific-based balanced appraisals.

Keywords. Agrobacteria-mediated transformation, *Marchantia Polymorpha*, Micropropagation, Green Fluorescent Protein (GFP).

1. Introduction

1.1. Biotechnology Education

Biotechnology has an increasing social impact in daily lives requiring citizens to be able to understand its main concepts and make informed decisions regarding its applications. However, an extended survey on Portuguese high-school students 'perceptions about biotechnology showed that the students displayed misconceptions about fundamental concepts and principles [1].

The field of biotechnology relies on complex molecular techniques, such as genetic engineering, as a process of manipulating the DNA of an organism often including DNA from a foreign organism. The subject of genetically modified organisms, or GMOs, has sparked public controversy but most current misconceptions derive from nonscientific acquired from sources other than scientific education.

Science teaching, namely in the biotechnology field, must include innovative teaching strategies and the discussion of social and environmental consequences of biotechnology applications. Students should be engaged in hands-on-laboratory classes and involved in investigations over long periods of time in the context of inquiry.

We developed a project for 16 years over students (high school and college levels) aimed at conveying the principles involved in plant genetic transformation. Combine cutting-edge science with simpler activities the students conduct hands-on experiments involving plant tissue culture, plant genetic engineering via *Agrobacterium tumefaciens* bacteria and observation of expressed fluorescent recombinant proteins in plant cells at the fluorescence microscope. Additionally, students learn how to aseptically cultivate bacteria and obtain axenic culture of plant tissues.

1.2. *Agrobacterium tumefasciens* as "Nature's own genetic engineer"

Agrobacterium tumefasciens is a bacterium that occurs naturally in the soil and is able to transfer a region of its own DNA into the plant cells causing rapid cell division and the formation of tumors. This led to the denomination of *Agrobacterium* as "Nature's own genetic engineer". In plant genetic engineering *A. tumefasciens* is used as vector to transfer genes of interest into plant cells. The process of transformation involves engineering, the bacteria Ti plasmid (Ti for Tumor – induction) inserting a genetic construct containing the gene of interest coding for the protein to be expressed [2].

1.3. *Marchantia polymorpha* as an emerging plant model

Until recently, research in the laboratory using transgenic plants relied mainly in the model plants *Arabidopsis thaliana* and *Nicotiana tabaccum*, both flowering plants. With the increasing number of sequenced plant genomes, other species are being used for transformation, including other emerging model plants such as *Physcomitrella patens* and

Marchantia polymorpha, both bryophytes, an early group of land plants [3]. *Marchantia polymorpha* is a widely distributed liverwort that grows in somewhat shaded moist soils and rock surfaces, often in greenhouses.

The life cycle involves an alternation between the a dominant gametophytic haploid fase and a short lived diploid sporophytic phase, Fig. 1. The mature plant body, the gametophyte, is a simple thalloid structure consisting of many differentiated cell types. Plants can be asexually propagated through gemmae that are produced from single epidermal thallus cells and cluster inside gemma cups. The species is diploid, producing male and female gametophytes. The sexual reproduction involves the development of sex organs, archegonia and antheridia in stalked structures developed at the surface of the thallus. Fertilization is strictly dependent on the presence of a water film through which the male gametes reach the oosphere inside the female sex organ, the archegonium. The fertilized oosphere develops into a short lived sporophyte consisting of little else other than a sporangium. Inside the sporangium the spore mother cells undergo meiosis producing haploid spores, which, upon germination produce new thaloid gametophytes.

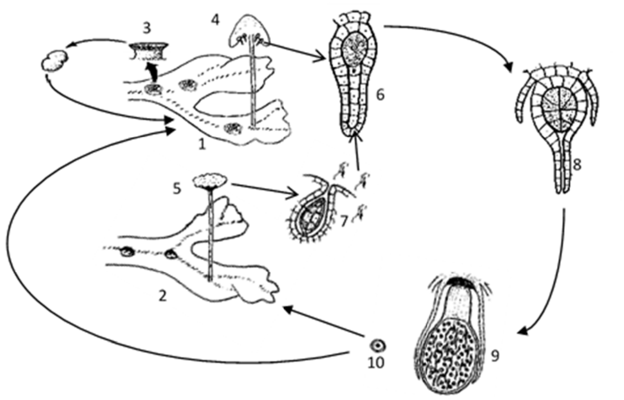

Figure 1. *Marchantia polymorpha* life cycle: 1 – female gametophyte; 2- male gametophyte; 3 – gemma cup producing haploid gemmae; 4 – archegoniophore; 5 -.antheridiophore; 6 – archegonium; 7 – antheridium; 8 – fertilized archegonium; 9 – diploid sporophyte with a sporangium; 10 – spore

Reproductive growth can be induced under laboratory conditions. A change in light quality induces sexual reproduction, and male and female plants differentiate sexual organs [4].

M. polymorpha is progressively becoming a model system for plant transformation because of its haploid vegetative growth, small genome size (approx. 280 Mb) and no evidence of ancient genome duplications [5]. In addition, the short life cycle, the ease of clonal propagation by means of the multicellular gemmae, the ease of crossing and the high frequency of genetic transformation allowing for a rapid verification of the question under study, are further advantages to use this species as a system for plant transformation [6]. The *M. polymorpha* thallus can be maintained and propagated asexually by transferring excised thallus fragments or gemmae into liquid or solid synthetic growth media without vitamin supplements or the application of growth regulators. Material from axenic cultures can then be propagated using the same procedures which allows the maintenance of genetic homogenous individuals and lines at lower costs that that for flowering plants [7].

1.4. Molecular tools and *Agrobacterium*-mediated transformation

Molecular tools become increasingly available, namely fluorescent proteins and selectable markers [4]. Availability of molecular techniques, including transformation technologies are available for *M. polymorpha*, making this model plant suitable for evolutionary, molecular, cellular and developmental studies [4,7].

Simple and efficient protocols of *Agrobacterium*-mediated transformation have been established allowing introduction of reporter constructs and overexpressing proteins. Transgenic haploid lines can be produced in four to six weeks [7]. Common binary vectors developed for other plant systems, can be used for *M. polymorpha* transformation. Widespread CaMV 35S constitutive promoter has been shown to be capable of driving strong expression in *M. polymorpha* and various marker genes have been used for selection with hygromycin, gentamicin, chlorsulfuron and G418 [7]. With *Agrobacterium* - mediated transformation protocols, it takes 2–3 weeks to obtain a transgenic plant on the first selection plate, and additionally 2–3 weeks to establish isogenic G1 lines [7].

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In this work, students will culture *Agrobacterium* clones kept in the laboratory harboring constructs coding for fluorescent protein GFP (green fluorescent protein) fused with different intracellular targeting domains, specific for intracellular compartments such as Endoplasmic Reticulum (ER). We used a common construct (Fig. 2) with widespread use as endoplasmic reticulum (ER) marker. This yields green fluorescence protein (GFP) localized in the ER. The GFP variant used, mGFP5-ER, is suitable for expression in plant cells. The addition of a N-terminal signal peptide (SP, Fig. 2) induces translocation across the ER membrane and a C-terminal C-terminal fusion of the amino acids HDEL results in retention of GFP within the lumen of the endoplasmic reticulum. The coding sequence of the ER-localized GFP variant (mGFP5-ER) is cloned in a binary transformation vector pVKH18 behind an enhanced cauliflower mosaic virus (CaMV) 35S promoter to generate pVKH-GFP-HDEL available from Oxford University [8].

Figure 2. Construct coding for fluorescent protein GFP fused with intracellular targeting domains, specific for targeting and retention in the Endoplasmic Reticulum (ER). SP,Signal peptide for targeting to the ER; GFP, Green Fluorescent Protein; HDEL, aminoacidic motif in the C-terminal end for ER-retention

2. Materials and Methods

2.1. Axenic cultures of *Marchantia polymorpha* from gemmae

Marchantia polymorpha specimens were collected in the University campus in Porto.

Gemmae were extracted from gemma cups by adding a drop of sterilized hydrogen peroxide solution 3% (v/v) to allow the emergence of the gemmae from the cup [9]. Gemmae were then collected with a small sterilized brush into a 1 % (v/v) solution of sodium hypochlorite, shaken for 1 min and further rinsed twice in sterile deionized water. The gemmae cultures were established in half-strength Gamborg's B5 (1/2 B5) basal medium, without vitamin supplements (Duchefa Biochemie), 0.5 % (w/v) MES, 1 % (w/v) sucrose, 1.3 % (w/v) agar, pH 5.7 in 90-mm disposable sterile Petri dishes [10]. The gemmae were delivered over a drop of sterilized water previously placed on the solid medium surface and spread evenly over the plate. *M. polymorpha* gemmae cultures were illuminated with 110 µmol/m².s under continuous white light (OSRAM L 36W/77 e OSRAM L 36W/840), in a culture room maintained at around 22 ° and approximately 60% humidity.

2.2. Tranformation of gemmae by G-AgarTrap technique

Like the general *Agrobacterium*-mediated transformation procedure, AgarTrap consists of three steps: (1) pre-culture of *M. polymorpha* tissue, (2) co-culture of the tissue with *Agrobacterium* containing recombinant T-DNA, and (3) selection of transgenic cells. A unique feature of AgarTrap is that none of these steps requires liquid medium culture; rather the appropriate solutions are simply poured onto the solid medium in a single Petri dish [9,11]. AgarTrap involve three major steps: (1) plating of *M. polymorpha* tissue, (2) pouring transformation buffer, and (3) pouring selection buffer. A flowchart of the AgarTrap procedure and post-operations is shown in Fig. 3.

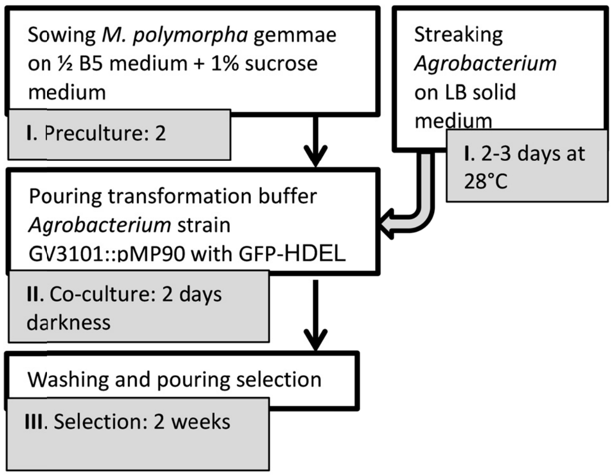

Figure 3. Flow chart of the Agar Trap method for *M. polymorpha* gemmae transformation. I- Pre culture of gemmae in ½ strength B5 medium with 1% sucrose and *Agrobacterium* cultures in LB medium; II – Co-culture of *M. polymorpha* and *Agrobacterium* in ½ strength B5 medium with 1% sucrose in darkness; III - Washing of the gemmalings and selection of transgenic cells on the same culture medium (Adapted from [9])

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2.1. Pre-culture of gemmae and *Agrobacterium* culture

M. polymorpha gemmae were precultured for three days in ½ strength B5 Gamborg's growth medium with 1% sucrose (see 1 for details and growing conditions). *Agrobacterium tumefaciens* strain GV3101::pMP90 with GFP-HDEL marker was grown in LB growth medium supplemented with gentamicin (20 mg/L) and kanamicin (50 mg/L), overnight at 28 °C shaking.

2.2. Infiltration of gemmae with *Agrobacterium*

The infiltration step consists in the uptake of the *Agrobacterium* carrying the GFP-HDEL marker the by the *M. polymorpha* cells This uptake is facilitated by an infiltration buffer (10 mM de $MgCl_2$, 10 mM de MES-NaOH, pH 5,7; 10x) The *Agrobacterium* culture was centrifugated at maximum speed for 3 minutes. The supernatant was discarded and 1mL of the infiltration buffer was added, followed by another centrifugation step during 1 minute, as a wash step. After adding acetosyringone (150 µM) to the infiltration buffer, 1 mL of this buffer was added to the bacterial sediment and the bacteria re-suspended. Optimal optical density (λ= 600 nm) for the infiltration mix was adjusted to 0.5-1. Into the gemmae plates was pipetted 1 mL of the infiltration mix and the plates subjected to vacuum for 1 minute, to improve infiltration success. The excess of infiltration mix was pipetted out from the plates and these were left to grow in darkness, at 22°C, for 3 days.

2.3. Selection and isolation of transformed gemmae

The plates were first washed twice with sterile deionized water, followed by the addition of 1 mL of selection buffer (10 mM $MgCl_2$, 10 mM MES-NaOH, pH 5,6, supplemented with hygromicin (10 µg/mL) and cefotaxime (1 mg/mL). The gemmae were grown in the same conditions described in 1, for two weeks. After this period the gemmae were transfered to plates with ½ strength B5 Gamborg's growth medium without sucrose (see 1 for details and growing conditions) and supplemented with hygromicin (10 µg/mL) and cefotaxime (1 mg/mL), and left to grow for another two weeks in the same conditions as above. Gemmae with visible growth of helathy green tissue were then isolated in plates containing ½ strength B5 Gamborg's growth medium without sucrose (see 1 for details and growing conditions) supplemented with just hygromicin (10 µg/mL).

3. Results

3.1. Established axenic cultures of *M. polymorpha* from gemmae

Gemmae were extracted from gemma cups (Fig. 4), sterilized and sown in ½ strength B5 with 1% sucrose. After 2-3 days it is visible that the gemmae start to regenerate thallus tissue by activating cell division at the notches (Fig. 5A arrows), and, after 2 weeks, the initial gemmae had grown into fully differentiated thalloid gametophytes (Fig. 5B). These new gemmae or thallus can be used for further propagation, allowing the production of genetic homogeneous clones.

Figure 4. Detail of the surface of the thalloid gametophyte showing gemma cup with gemmae

3.2. Transformation of *M. polymorpha* gemmae by the Agar Trap method

Precultured gemmae (Fig. 4) were transformed pouring an *Agrobacterium* culture containing GFP_HDEL marker and infiltration solution into the growing plate and incubated in darkness for two days.

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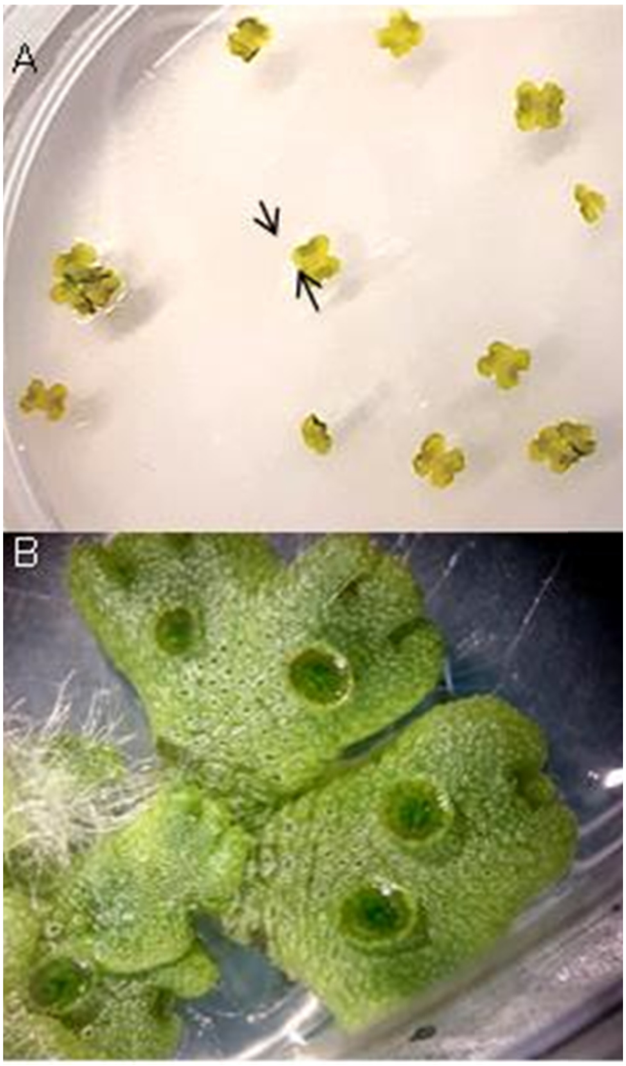

Figure 5. A: gemmae growth after 3 days in culture (arrows: growth points at the notches); B – regenerated thalloid gametophytes with gemmae cups after two weeks in culture

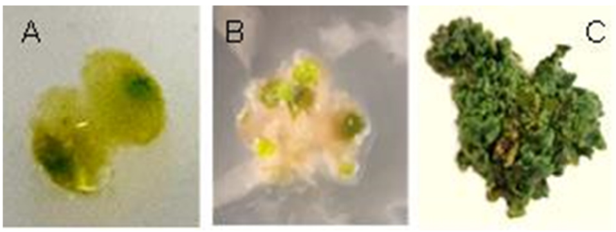

Figure 6. Different aspects of the gemmae during the transformation process: A – precultured gemmae; B – Gemmae after the selection step showing large parts of necrotic tissue and growth of the transformed cells; C – Fully developed gametophytes 2 weeks after isolation of the positive clones

After adding the selection solution and resuming growth under standard light and temperature conditions the tissues suffered several alterations, from the initial green healthy gemmae (Fig. 6A) to mostly necrotic tissue as the antibiotics in the selection solution killed all non- transformed cells, leaving a small unnoticeable percentage of cells alive. After 2 weeks the transformed cells started to produce green photosynthetic tissues (Fig. 6B). Fully developed gametophyte thalli were obtained two weeks after selection and isolation of positive clones (Fig. 6C).

Fragments of transformed *M.polymorpha* thallus were observed under a fluorescence microscope to visually confirm the incorporation of the GFP-HDEL marker into the cells during the transformation process. Even though these photosynthetic tissues have a high degree of auto fluorescence, in Fig. 7 it is possible to observe GFP fluorescence within the endoplasmic reticulum. The fluorescence marking of GFP appears as a network across some points of at cell surface which is the characteristic location of the endoplasmic reticulum within the cell.

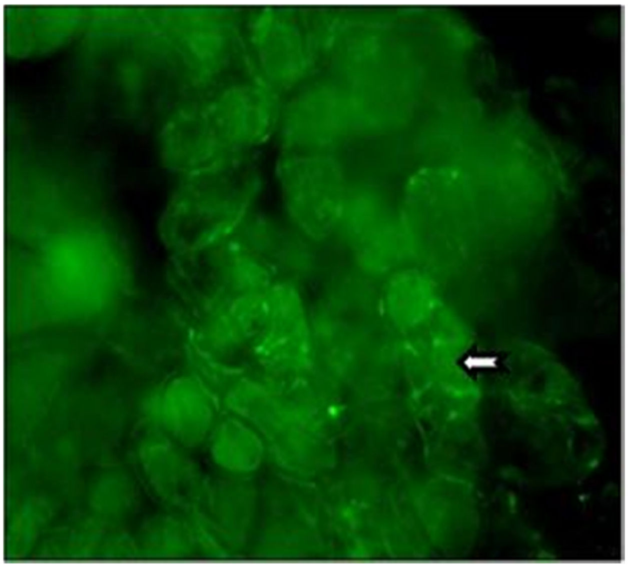

Figure 7. Transformed *M.polymorpha* gemmae tissue observed under the fluorescence microscope. Note the characteristic marking of the endoplasmic reticulum as the network marking of GFP (arrow)

4. Discussion

In this work, we propose a multidisciplinary long hands-on,project for students of high school and college levels aimed at conveying the principles involved in plant micropropagation and genetic transformation, as well an approach to plant cell structure and cell biology. Students will be involved in bacterial cell cultures, plant culture techniques in aseptic conditions, genetic manipulation, recombinant protein expression, fluorescent protein reporters, and fluorescence microscopy. This laboratory activity will introduce students to a broad array of concepts and applications.

Plant tissue culture represents a most promising area and ranges from micropropagation of economical important species like ornamental and forest trees, production of pharmaceuticals, and improvement of nutritional value of crop plants. In vitro cell and tissue culture methodology is also a mean of germplasm conservation to ensure the survival of endangered plant species. The concept of cloning organisms is particular evident with the applied technique of micropropagation in which isogenic lines of genetically identical cells are obtained and cloned plants produced that are genetically homogeneous individuals, identical to the original genotype [12].

All biotechnological approaches like genetic engineering, depend on an efficient *in-vitro* plant regeneration system. Genetic transformation relies on plant cell and tissue culture and allows the transfer of genes with desirable trait into host plants and recovery of transgenic plants [12].

The endoplasmic reticulum (ER) of the *M. polymorpha* cells could be easily visualized using green fluorescent protein (GFP) fused with a ER targeting signal peptide and the HDEL retaining signal. This not only allowed an easy, direct means of observing the result of the transformation process and but also to discuss plant cell structure and determinants of intracellular protein trafficking.

Depending on students' level and time available, the project can be extended to detect transgene insertion in plant genome by PCR using available primers to GFP. This extension can be used to introduce GMO (Genetic Modified Organisms) and simple molecular techniques available for GMO detection.

Encompassing the laboratory process, students are invited to list and discuss the pros and cons of these technologies as several uses of transgenic plants have great impact, namely the production of beneficial proteins in agriculture, the production of plant manufactured pharmaceuticals used as therapeutic compounds, and basic cell and molecular biology research. Ethical issues of the impact of these technologies can be further discussed, namely the possible social and environmental consequences.

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Pollution Soil Perception and Biodiversity Impact: Can Students Enrich their Scientific Knowledge Using Problem Based Learning?

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Abstract. It's necessary the improvement of quality and efectiveness in school science education promoting a growing level of scientific literacy. Currently in essencial learnings of natural sciences, beyond sgnificant construction of knowledge, it is also important the development of cognitive processes and attitudes related with science applied in technologie, society and environment that can bring sustainable development to our societies. Thus, learning based on problem solving is recommended from a Inquired Based Science Education perspective, where the development of reasoning and the development of investigative capacities are essential. Students, faced with a real and current problem, develop their ability to question in order to learn new knowledge [1].

Faced with the exponential growth of the world´s population, natural resources have been exploited without any measure or control, causing disruption and incalculable damages. We can highlight pollution in most variated ecosystems, including the soil, which is a primordial ecosystem to defend and preserve, as targeted in the 15th goal of the 2030 Agenda.

In order to counter such dangers, it is urgent to raise awareness among generations, particularly the younger ones. It becomes essencial for students to be educated as conscious citizens, active and commited to solve real problems, based on problem based learning in a social constructivist perspective of knowledge in an autonomous way.

Thus, a Research Project was developed in the context of initiation to Professional Practice of the Master's degree in Biology and Geology Teaching in the third cycle of primary and secondary education, during 2018/19, in order to evaluate the student learning about the impact of soil pollution on biodiversity. This theme is part of the Natural Sciences curriculum of the 8th year of schooling, so the project sought to evaluate the contribution of this methodology, in the cognitive and attitudinal domains of students (n=28) of the 8th year of the discipline of natural sciences.

Students in group work, proceeded to the investigation of materials provided by the teacher. Conclusions obtained in all working groups were subsequently discussed allowing the sharing of the learning achieved, reflecting a little of the scientific process. Finally, each of the groups drew up a poster containing their conclusions, and the information contained in them was then gathered in a single global poster.

In this investigation, the mixture of methods (QUAN-QUAL) was used [2]. Within the scope of the quantitative method, a pre-experimental study was carried out that focused on the application of cognitive tests at different times: the first of diagnosis and the second of the reassessment. The qualitative evaluation resulted from the content analysis of individual and group observation grids.

This study provides good indicators of the efectiveness of the Problem Based Learning methodology (PBL) and its efficiency in the cognitive and attitudinal development of the students regarding the theme investigated, because the results obtained in the cognitive tests were higher in the 2nd evaluation test (90,71%), in comparison with 1st (40,42%). To obtain more robust data the Wilcoxon test was performed, obtaining statistically significant differences, demonstrating that the educational methodology had a positive cognitive impact. Regarding attitudinal evaluation, using a scale with 3 performance levels, the result obtained was very close to the maximum, overall, develloping skills as interaction and cooperation among students, promoting motivation for discussion and debate, from a social constructivist perspective.

In summary it can be concluded that in addition to the construction of knowledge by the students it was achieved also the development of other essential skills, so important to citizen´s behaviour troughout life.

Keywords. Biodiversity, Inquired Based Science Education, Pollution, Soils.

1. Introduction

As teachers, we daily confront with students who have different needs and problems, which request different methodologies that can help each of them to improve their skills in order to better live in our society. So, knowledge acquisition is not enough, other skills need to be enhanced with the help of investigation practicing and social constructivism relationships.

In this work, sustainable development is a central and extremely important challenge which is approached as an important goal for any actual citizen. Sustainability education "will provide everyone with an informative and knowledgeable source, which will allow him to develop and exercise full active citizenship in a context of participatory democracy" [3].

The project the students participated seeks to evaluate the contribution of using the PBL methodology in the cognitive and attitudinal/relational domains of students in the perception of the impact of soil pollution on biodiversity as a demonstration of sustainability concerns. The relevance of this theme was highlighted with the preparation of the 2030 Agenda by several world leaders. This theme is referenced by different authors, of which Sachs (2015) points out that the purpose of this 2030 Agenda: "guide humanity to security and prosperity". This Agenda integrates 17 Sustainable Development Goals (SDG) [4]. This work is related with the 15th goal of the 2030 Agenda: protect terrestrial life.

Ecosystems are an important link for the development of life, being understood as "a set of living organisms that occupy a given area, also described as communities that continuously interact with each other and with the physical environment (abiotic factors), the biosphere being the largest ecosystem" [5].

The problems associated with the contamination of ecosystems are an example of a constant sub-issue of current curricula that, having an abstract nature, can be perceived by students in a more concrete way, if they contact with a current and real problem, with relevance to them, increasing the effectiveness of the teaching-learning process.

The changes that cause pollution in the soil ecosystem are the target of this study as well as the impact in biodiversity and may be due to natural causes such as volcanoes, earthquakes and fires, which are responsible for the release of some natural polluting elements, such as heavy metals, matter in particles and toxic gases [6], which infiltrate the soils. There are also anthropic causes for these changes which, in a synthetic way, include, from pollution with contaminants (solid or liquid waste) abandoned in the soil in an unethical manner, intensive agriculture and forestry using fertilisers and pesticides, resulting in consequences for biodiversity [7], where the richness of annelid and oribatid mites species are negatively affected by intensity in agriculture [8]; deforestation, and burning, leading to the loss of a large amount of forest keeping soils permanently under great pressure, with the consequent loss of biodiversity; uncontrolled mining exceeding, in many cases, the toxic limit of various metals [9], during mining, not always with due care in the treatment of waste and combiners resulting from such exploitation; the expansion of urban areas with soil waterproofing and, preventing them from performing their productive function for agriculture; wars with the consequent radioactive contamination of soils, contamination that originates from various diseases; fires, caused by human action. All these factors have implications for trophic chains such as habitat destruction and biodiversity reduction.

We can list several mitigation measures, from reducing the main causes of pollution listed to the construction of landfills and recycling, promoting the policy of 3 R'$_S$: Reduce, Reuse and Recycle [10].

At the moment there is a biodiversity crisis [11], motivated mainly by climate change and habitat destruction, combined with the lack of interest in taxonomy [12], leading Biology to a new challenge: humanity is helplessly witnessing the extinction of thousands of species, many of which will never be known due to the lack of specialists for its identification.

Although unknown, the number of species will be around 10 to 100 million. The IUCN (International Union of Conservation of Nature) "continues in the process of classifying the species that are being discovered, having the

Red List of the most endangered species" [7] (Fig. 1).

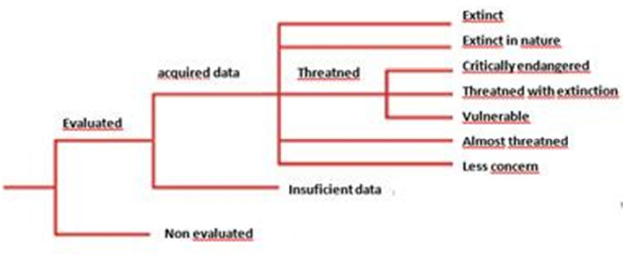

Figure 1. Classification system of species from IUCN [7]

The perspective of Research Oriented Teaching is based on a post-positivist epistemological dimension and a socio-constructive aspect of learning, intending to contribute to the personal and social development of all young people, preparing them to face, in a critical way, the technologically advanced world where they are.

In this construction, research (or small research) plays a crucial role in this process, by seeking a solution to a given problem. The acquisition of new knowledge takes place in the process of searching for content to solve the initial problem. As this process develops, students have the need to learn certain concepts, without which they will not be able to build a viable solution to the problem [1]. Research is a set of interrelated processes, from which scientists and students ask questions about the world and investigate phenomena. Thus, research is more than asking questions, translated by the ability to question, to research books and other sources of information, to put hypotheses, to design investigations, to analyze and interpret data, to seek solutions to problems. PBL promotes the activation of previous knowledge and the development of new knowledge. The evidence shows that these processes occur in small tutorial groups and that the processing of new information is actually facilitated by the discussion of a relevant problem. Problem-based learning (PBL) can also have positive effects on students' social, emotional and civic development. The goal is to increase the commitment and motivation of students in solving problems important to society in general. The negotiating capabilities of opinion on the various problems addressed are different, not least because, in problem solving, these capabilities are not only useful, but absolutely necessary [13]. PBL objectives include: questioning, problematizing, investigating, working collaboratively, based in Inquired Based Science Education. The final objective is to enhance significantly teaching effectiveness.

2. Method

It was implemented an intervention program in the classroom (2 to 3 classes of 50 minutes), to students of an 8th year class of natural sciences schooling and applied cognitive tests at different times of the intervention. At first, a pre-test or evaluation test was applied before the start of the educational methodology administration. The post-test or re-evaluation test was applied at the end of it. According to Yoon, Treagust and Chandrasegaran (2015), learning, supported by an PBL methodology, can be built individually or in groups, promoting discussions and sharing opinions collaboratively, research, reflection and presentation of the final product [14]. Students, in the presence of the research problem, will be asked to ask questions to give answers to the causes, consequences and measures to mitigate soil pollution that affect biodiversity, with the guidance of the researcher. At the end, a debate took place on the conclusions of each of the groups in which participation was analyzed in order to respond to the initial problem, and this collaboration/group participation was analyzed with the help of observation grids of cooperative work in class, the last moment of data collection. In this project occured the mixture of methods (methodological integration), seeking synergy and the strength obtained from the combination of the two methods in which quantitative and qualitative data are integrated [2].

2.1. Data collection techniques and instruments

The document analysis technique focuses on the researcher's perspective and involves research and reading of written documents that constitute a good source of information.

In the use of tests as documents, cognitive assessment was performed using a mind map (Fig. 2) elaborated by the researcher to fill out spaces to complete, according to the information seized. The choice of a mental map for the cognitive test had as its objective, a non-traditional evaluation of the usual answer question, in which associations of concepts can be performed, without hierarchizing; evaluation that is carried out with a test that allows the synthesis of a high amount of information, in a playful but productive way, since they have a special relationship with memory, providing rapid acquisitions of knowledge. Its construction begins with the collection of information from various sources, making the information available in keywords, in a colorful, interesting way. Mind maps are described as an effective study technique when applied to written material, acting as an important resource in teaching [15].

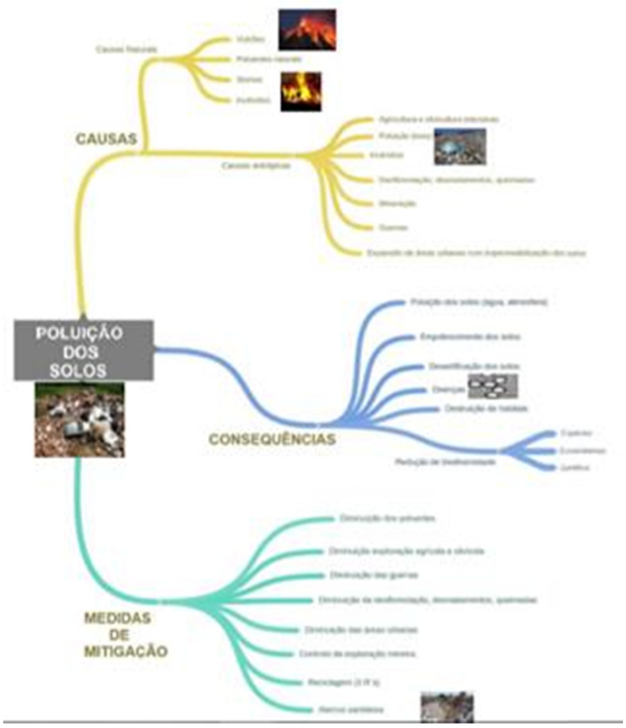

Figure 2. Mind map of soil pollution and biodiversity impact

The traditional mind map has several advantages with its own creative rules, designed by Buzan, allowing you to share it with others; has a high visual appeal; facilitates quick reviews, good retention of information and overview of the subject, providing a sense of "duty fulfilled". As for the visual appeal, we can affirm that an image is worth more than 1000 words, because visual stimulation occurs that allows an almost perfect image recognition. This is because a wide range of cortical skills are used: color, shape, line, dimension, texture and imagination [16].

The observation technique is centered on the researcher's perspective, in which he observes, in direct and face-to-face, the phenomenon under study" [17]. This technique allows to understand the natural environment, as it is experienced by the participants, collecting relevant information without alteration or manipulation of it. The instrument for qualitative analysis were the observation grids.

As to the data analysis technique, a statistical analysis of data (pre-test and post-test results) was performed using IBM software® SPSS Statistics® (version 25). A qualitative analysis was also made based on the results of individual and group observation grids in relation to collaborative work, and a content analysis was performed. Both analyses are described in the results and conclusion.

2.2. Participants

An available group of students was used, selected according to the researcher's convenience – convenience sample [18]. The sample is composed of students from the 8th year of primary schooling of a school in the urban center of the North of the country, in the Porto area. Class 8 A.F is a class with a large number of students, consisting of 28 students, mostly female, 17 girls and 11 boys. The students of this class are between 13 and 14 years old, with the average of the class being 13.1 years. All students are Portuguese nationals and residents in the district of Porto.

2.3. Planification

During the planning, the following general objectives were defined for the students: learning to work cooperatively; know how to self-regulate their learning; develop investigative capabilities in solving the problem; discuss causes and consequences of changing ecosystems, justifying the importance of dynamic balance of ecosystems and how their management can contribute to achieving the goals of sustainable development; explain how pollution, deforestation, fires, volcanoes, habitat destruction can affect ecosystems; interpret the influence of some polluting agents on ecosystems, starting from local or regional problems and critically analyzing the results obtained; discuss measures to reduce the impacts of disasters of natural origin and anthropic origin on ecosystems in general. The

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purpose for the teacher focuses on promoting the development of cognitive skills and cooperative and autonomous work of students with educational methodology PBL.

2.4. Educative resources

Several auxiliary documents were constructed, such as educational resources to be used (Fig.3) for research, reading, analysis, interpretation and conclusion of their relevance for solving the problem (texts, adapted newspaper news, images for reflection, viewing of 2 videos). The students were divided into 4 working groups, each with their own materials to solve each aspect of the global problem.

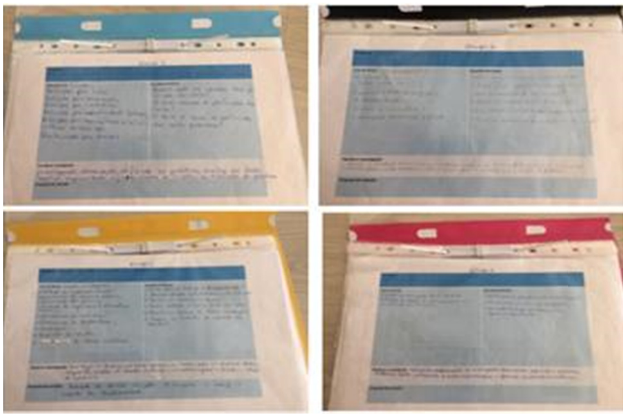

Figure 3. Dossies of research material for the 4 groups

Group 1 was in responsible for research, analysis and communication of the natural and anthropic causes of soil pollution; group 2 took care of the consequences; group 3 of mitigation measures; and group 4 on biodiversity reduction. At the end of the investigations of all groups, the discussion and sharing of information of the conclusions of each group took place, contributing to the resolution of the initial overall problem.

Each group elaborated a summary poster of the conclusions of each, providing cooperative work among all actors. In the end, all the 4 posters were added to give an overview of the joint investigative activity (Fig.4).

To reward the performance of each group, each group was offered a diploma of participation, according to its best performance (better debate, better elaboration of the problem issue, better poster preparation and better team cooperation (Fig. 5).

Figure 4. Posters of 4 groups

Figure 5. Performance diplomas

3. Results

The quantitative results obtained by the students in the assessment and reevaluation tests of conceptual contents with mental map are shown bellow (Fig. 6, Fig. 7) and Table 1.

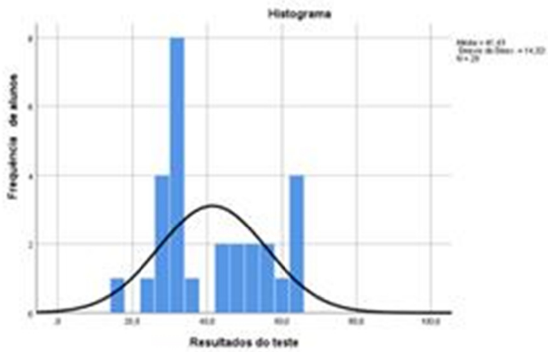

Figure 6. Graph 1 of the percentage ratings obtained by students in the assessment test of conceptual content

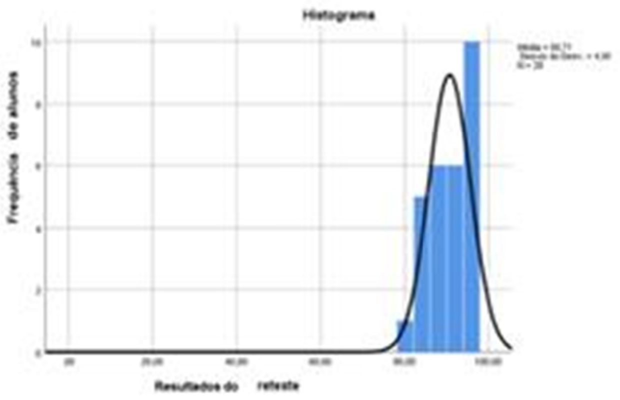

Figure 7. Graph 2 of the percentage ratings obtained by students in the reevaluation test of conceptual content

Table 1. Comparison report between the statistical values of the Assessment Test and the Reevaluation Test

	AT	RT
Media (%)	41,42	90,71
n	28	28
Deviation error	14,32	4,99
Minimum	16,00	80,00
Maximum	64,00	96,00
Medium	34,00	92,00

In order to analyze the data more robustly, the Wilcoxon statistical test was performed to test the validation (acceptance or rejection) of the hypothesis of this investigation. The Wilcoxon test is a nonparametric statistical test. Although the nonparametric tests are not as reliable as the parametric tests, we can affirm that, with the results obtained ($Z = - 4.63$, $p = 0.000$), the results of the revaluation test translate a statistically significant increase in the score, with a confidence interval of 99%. Thus, we can reject the null hypothesis and accept the directed hypothesis that states that the PBL methodology has a positive influence on the results obtained in the cognitive assessment tests, considerably improving the understanding of conceptual contents by the students.

The qualitative results, obtained during the application of the project, by the two observers are shown bellow (Fig. 8).

In the attitudinal/relational domain, in the group observation grid it can be concluded that all groups obtained the same performance, reaching level 3 - Very Satisfactory in almost all parameters evaluated.

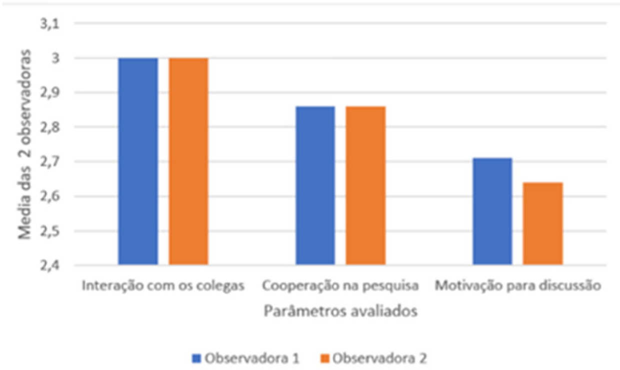

Figure 8. Graph 3 of the average of the observations made by the two observers

In the attitudinal/relational domain, in the group observation grid it can be concluded that all groups obtained the same performance, reaching level 3 - Very Satisfactory in almost all parameters evaluated.

4. Conclusions

This investigation is a good indicator that PBL educational methodology contributes positively to the cognitive and attitudinal/relational development of students within the general objective of percesting the imbalance that occurs in ecosystems due to soil pollution and its impact on biodiversity. The improvement of quality and effectiveness of learning in school science education was achieved. The problem that unders opened up to this project was a real, current and very relevant problem in the daily lives of students, societies and the planet in general.

Awareness-raising to maintain sustainable development was also achieved by contact with the 2030 Agenda and the relationship of this work with objective number 15 of this Agenda - Protection of terrestrial ecosystems. As for the students, it allowed them to develop their critical thinking and analysis, as well as their autonomy of work (individual and group), in an interactive perspective. Finally we achieved that teachers can walk alongside with students on their "road of knowledge", evolving together towards an integral education, forming citizens conscious, autonomous, supportive and committed to the issues and challenges of the world.

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Project Eco-STOP: Implementation of Green Roofs in the Urban Space

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Abstract. Within the scope of the subjects of Biology and Chemistry, we developed a project which seeks the preservation of the environment that finds itself in a worrying state due to industrialization. Thus, the foundation of ECO-Stop. Our main objective consists in implementing a multi layers system (green roofs) that would be placed on bus stop's roofs located in high traffic places. The natural process of photosynthesis will allow oxygenation of the polluted air nearby due to traffic and industrial pollution. Allied to ambient efficiency, the esthetic contribution to the cities idealize this project as innovative and revolutionary in this field.

Keywords. Air Pollution, Biodiversity, Green Roof, Bus Stop.

1. Introduction

In the present days, the atmospheric pollution is one of the biggest ecological problems with the highest impact on the Nature. Whether it involves the gas from cars exhausts or emission of greenhouse gases, the truth is that this problem comes from a distance past and, together with the industrial advancements, this is one of the reasons of why it has such a big impact in human or nature well-being, contributing to the formation of acid rains and aggravating the greenhouse effect. The climate change is a direct consequence of the air pollution, since the intensification of the greenhouse effect causes the global warming, in other words, the alteration of the global temperature. This has negative impacts in Nature, especially in ecosystems and biodiversity, provoking instability in those and putting in risk the fauna and flora [1]. Our project intends to soften these dangers in an esthetically and creative way, flattering the urban space.

Green roofs are the base of our project. These will be the responsible for the air oxygenation and for countless other advantages that comes from it. Green roofs are all the type of vegetation installation over an already built structure, regardless the type of construction or vegetation. They consist in a multi layered system compost by several materials that must secure a good develop of the vegetative layer that stands in the top and, at the same time, should promote the physical integrity of the structure on which it is supported. We can differentiate three types of green roofs [2]:

1. Extensive green roof: Lighter Green roof system, usually with a reduced thickness of substrate where is installed smaller vegetation that should require little maintenance care for a good development. The vegetation layer is composed for plants like succulents and herbaceous, given their reduced size and weight. The weight of the system must be roughly between 80-180 kg/m^2.
2. Semi-intensive green roof: Usually used in buildings or constructions. It presents mixed vegetation (intensive and extensive) which the most used type of plant is herbaceous, subshrubs shrubs. Requires moderated maintenance and the supported weight is between 150-4350 kg/m^2. The thickness of this system must be between 15 and 20 cm, which shall not be exceeded to not collapse the structure due overweight.
3. Intensive green roof: Green roof that usually presents thickness over 25 cm and requires regular maintenance, like a garden where cleaning, watering, fertilization and pruning must be frequent. The vegetation layer is available to a great diversity of trees, namely arboreal, not having any restriction related to height or weight, provided that they are not exacerbated values. The weight over the structure can reach over 350 kg/m^2

2. Methodology

Through this project, we seek the implementation of green roofs on a bus stop. In fact, since bus stops are fragile infrastructures whose weight limit is small, the more appropriate type of green roof to place in the roof of a bus stop would be an extensive green roof. Being a lightweight multilayered system, its placement would be safe, without damaging the infrastructure in question.

An extensive green roof is divided in different layers with distinct functions which the main objective is to maintain all the necessary conditions for a correct growth of the vegetation placed on top (Fig. 1). Therefore, an extensive green roof is constituted by the following layers [3]:

Vegetation – Consists in the group of plants that have the propose of air purification through the conversion of carbon dioxide in oxygen (photosynthesis). The plants that will be installed on the top of an extensive green roof shouldn't require a lot of maintenance and should be able to adapt to the limiting conditions where it is positioned, keeping in mind the variables of the region (temperature, rainfalls, dryness, solar explosion, among others). Beyond that, the plants should have a shallow root system, good regenerating capacity and a normal growing height bellow 15 cm. Thus, the succulent plants are the most used, mainly the Sedum species due to their high tolerance to extreme climate situations, big availability in the market, easy installation, low growing rate and flashy flowering. It also has the capacity to hold big quantities of water in their leaves, used only at night when the temperature is lower. The hardness of the leafs gives it the quality before mentioned also gives the plants a great wind resistance. The fact that these plants are small (it weights around 10 Kg/m2) and don't usually grow over 20 cm, making them perfect for the construction of an extensive green roof without taking the risk of the collapse of the infrastructure due overweight [4].

Substrate - Technical substrate, not regular soil, that composes the main support element for the growth of the vegetation. The substrate must allow good penetration and development of the plants' roots and subterranean organs. It should also have all the basic physical, chemical and biological properties that are indispensable, especially a stable structure. It must be capable of storing and providing water to plants, and allowing the excessive water to be drained to the draining layer. The substrate should also be capable of containing enough air for the aeration of the plants' roots, even when it's saturated of water. It should never contain thin particles (silts and clay) in quantities that may compromise the drainage of the green roof. Finally, a substrate must be able to stabilize its weight when saturated of water. For extensive green roofs, there are two types of systems: a single layer construction system and a multi-layer system where the materials that compose this layer may vary between clay/expanded slate and lava/pumice stone/dolomite.

Filtration layer: Geotextile membrane that prevents the leachate of particles of sediments of the substrate layer and go to the draining layer, insuring the flow of the water in an appropriate and enduring way. The filtrating layer must be placed completely over the draining layer in a way to avoid clogging or obstruction of the draining system, compromising in this way the structure of the green roof in question.

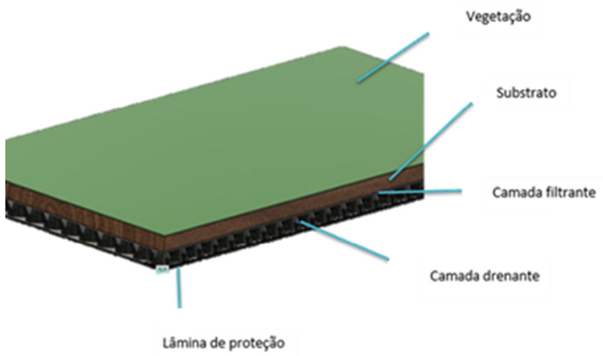

Figure 1. Technical design of an extensive green roof

Draining layer- python plate that must fulfil the following tasks: drainage, ventilation, water retention and protection. The python plates must be pierced to allow gas exchanges between the respective infrastructure where the green roof is supported and the exterior. The stored water should never be in direct contact with the substrate, due to the differences between the draining system's final quota and the water retention quota. This discrepancy will create superior and inferior ducts that allow water flow. The height of the plate must not be shorter than 20 mm. The draining layer should include draining devices, for example, draining grids, capable of draining all of the excessive water in the green roof avoiding waterlogging or accumulations in the radicular development layers. As a precaution, there should be discharge holes what allow water, in case the main draining system is obstructed, to be drained.

Anti-root mechanical protection-geotechnical fabric resistant to the roots' penetration acting as a barrier of physical or chemical nature, also being able to perform a double task: firstly, mechanically protecting the upper layers; secondly, increasing the green roof system's water storing capacity through absorption and retention.

3. Application

This project seeks the construction of a city full of green roofs that, beyond embellishing the urban space, would oppose the contemporary problems of air pollution. However, the viabilization of such a large-scale project is utopic, so we aim for its implementation in a bus stop to demonstrate that these structures are the key to a greener future. In fact, green roofs are beneficial due to the following advantages [3]:

- Esthetic improvement of the urban space;
- Increase of the patrimonial value, treasuring the city chosen as the pioneer in innovation and sustainability;
- Improvement of the appearance of buildings in the urban landscape;
- Benefit to the population's health, due to the positive psychological effect of the presence of nature in the inhabited places;
- At an urban scale, reduction of the heat island effect through the creation of "green corridors", connected by green zones that renovate the air;
- Reduction of the pollution levels, retaining dust and particles in suspension;
- Oxygen production and uptake of carbon dioxide;
- Enhancing biodiversity, allowing diversified flora and fauna to settle down, contributing, for example, to provide food, habitat, refuge and places to rest to numerous animals such as birds and butterflies;
- Increase in biomass;
- Conservation or recovery of habitats for animals, insects and plants- oasis where they can find refuge in humanized spaces.

As citizens and residents of the city of Maia, we have all the interest that the bus stop used in this innovating pilot project in located there. In this way, we would use the bus stop located in Avenida Dom Manuel II, near the Town Hall of Maia (Fig. 2). In contact with the enterprise responsible for the installation of this bus stop, we got to know that the bus stop is a double foster model which the roof has the width of 1700 mm and the length of 8000 mm. Although they don't have factual data, the company told us in advance that the bus stop should be able to support a weight equivalent to 200 kg, whereby the choice of the material must have this parameter in consideration.

Figure 2. Target bus-stop located in avenida Dom Manuel II, Maia [5]

4. Results and discussion

The current state of confinement due to the pandemic of COVID-19 made impossible the concretization of the experimental activity idealized that consisted in the evaluation of the conversion rate of carbon dioxide in oxygen accomplished by the plants which we would use.

However, we found a study made by Silvola (1985), a Finland investigator, that had as objective evaluate the accumulation of carbon dioxide in a Sedum plant, more specifically, in a plant of the specie *Sedum telephium L. subsp. ruprechtii Jalas* [6].

The photosynthetic activity in these plants occur through the night since the stomas are only open at that time of the day, having the normal photosynthetic activity of a CAM plant. Contrariwise, in the daylight the plant closes their stomas due to the heat, preventing gas exchange between the exterior and interior. In this way, it would be expectable that, during the day, the accumulation of carbon dioxide is maxim and at night should be minimal.

Observing the graphic in Fig. 3 where are reported the experimental results obtained, we can deduce the veracity of one of the benefits of the green roofs, that consists in the decreasing of atmospheric pollution due to the decreasing of carbon dioxide. Thus, a natural photosynthesis made by the plants will help the reduction of the concentration of this gas in the atmosphere.

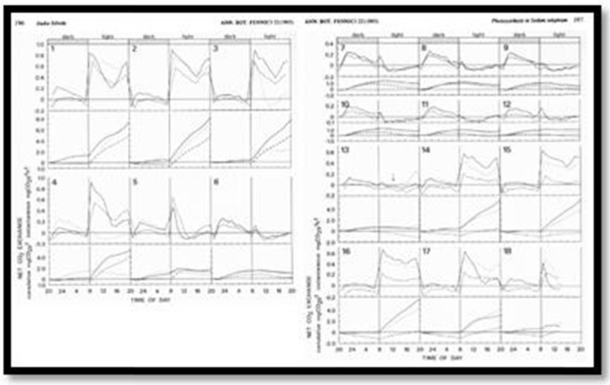

Figure 3. Graph of the obtained experimental results (Source: [6])

Complementarily, we were able to find out that a study made by the Catarinense Federal Institute proved that the installation of green roofs creates a thermal isolation on the inside of the infrastructure where, at times of greater thermal amplitude, the temperature on the inside of the building does not present great variations of temperature like in the exterior, corroborating another one of the benefits of this project: reducing the heat island effect (when the climate is hotter, the difference between the temperature in the exterior and the interior almost reaches 2 ºC, being fresher on the inside, and when the climate is colder, the temperature on the inside is greater than on the outside by about 4ºC) [7].

5. Conclusion

To sum up, this project will not only give a new life to urban spaces consumed by the industry and urban waterproofing, through the emergence of verdant landscapes, rendering the cities more appealing to the common citizen, as well as the ambition of reducing the consequences of climate change and diminishing air pollution, due to the photosynthetic potential of the plants used in green roofs, purifying the air, especially in zones with increased road traffic, where there usually are more bus stops. The tomorrow is in our hands, and ambitious projects like this are the roots of a future with a well preserved nature.

6. Acknowledgements

We would like to express our gratitude towards: our biology and chemistry teachers Isabel Allen and Luísa Santos for all the help provided and the suggestions given; teacher Manuel Paulo Teixeira Nunes Cunha from ISMAI for the cooperation and enlightenment offered in this theme that was previously unknown to us; all of Green Roofs National Association for the creation of the technical guidebook, which was a very useful tool for the elaboration of this abstract, especially Dr. Cristina Calheiros, environmental engineer at CIIMAR and Arch. Jéssica Fogueiro for all the availability and effort in our project and, finally, to JCDecaux, the company responsible for the bus stop in which we want to implement this innovative idea, for the help and readiness in answering all of our questions.

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Bloodrop SOS (Save our Society/Science)

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Abstract. In recent years, health conditions in Portugal have been deteriorating. Lots of patients do not receive treatment due to lack of blood supply in the hospital blood bank. This happens because there isn't an incentive for blood donation at a large scale, which provokes a shortage of blood availability.

This is the reason why our project aims at appealing to blood donations, wanting to increase the number of people who donate blood, particularly young adults. Aimed at solving the problem of blood unit shortage in the hospital blood bank, if our project succeeds, we will see an increase in donations by young people (18-25 years), guaranteeing the number of donations not only for the present needs, but also for the future. In order to achieve this goal, we created a kit, which contains a lot of materials that will be distributed, firstly, to all the state secondary schools in Vila Nova de Gaia, secondly throughout the metropolitan area of Porto and then, all along Portugal. On the other hand, we want to develop an investigation about the evolution of the blood type dispersion by continent and why it happened that way, because in the future we would like to see other countries use our divulgation method, implementing it in the education system, especially in Education and Health Promotion.

Keywords. Interdisciplinarity, Donation, Blood, Promotion, Self-Sufficiency.

1. Introduction

According to the New Larousse Encyclopedia [1], blood is a "red liquid which circulates in the veins, arteries, heart, and capillaries that irrigates the organism tissues" "blood takes nutrients and energy elements to all the organism's cells, removing its waste, defending it against infections and diffusing hormones. The blood consists of two parts: a liquid one, plasma, and the other is constituted by several figurative elements, suspended on the plasma", thus, blood helps the body to maintain certain functions, such as digestion and respiration, being very important for the cellular metabolism.

As stated by Lacerda (2014) [2], where it is said that blood can only be produced by the human being, in other words, only humans can donate it and, considering that blood is an irreplaceable good, depending solely on its reserves of "100% given from unpaid Donors in Portugal", it is imperative that, due to lack of self-sufficiency of the Hospitals' blood banks, that these services, licensed by the National Blood System, carry out "donor raising activities and donation promotion", in order to achieve self-sufficiency.

The Stedman Medical Dictionary [3] defines donor as: "Individual from whom blood is obtained... for transplantation" referring to transplantation as a transfusion whose definition is: "Transfer of blood or blood component from one individual (donor) to another (donee)". It is evidenced by studies that have been conducted in several European countries that surgical and cancer patients are the patients that receive transfusions the most. Nevertheless, a large proportion of transfusions happens in multiple episodes of hospital treatments, interventions, diagnoses, and in elderly patients with complex medical situations, being administrated different transfusion preparations to patients with different diagnoses [4]. Thus, it is concluded that a large amount of donations is necessary for them to meet the precise expenses for the treatment of more serious clinical scenarios, saving individuals.

Blood typing, blood type determination, is very important to blood transfusions due to the compatibility between different blood types. The typing takes place according to the classification of the ABO System and the presence of the Rhesus factor [5]. Taking into consideration these two antigens, blood types can be classified into eight categories. The typing of an individual's blood among the eight blood types allows transfusions to be successful, as transfusion preparations contain the blood of one of the blood types compatible with the patients. In addition, as a result of antigenic differences between individuals, blood groups are also important in fetal-maternal incompatibilities (fetal erythroblastosis), tissue and organ transplantation, and in genetic and anthropological studies [3].

Thus, it is important that this process happens, since not all blood types are compatible with each other.

Centro Hospitalar de Vila Nova de Gaia-Espinho is our area's Hospital Centre, therefore, this study has, as the main objective, to make it self-sufficient. Encouring blood donation is the vehicle to achieve this goal.

The aging of the blood-donation population makes the future of providing this essential good an area of considerable concern [6]. So, to ensure a secure future for blood banks, we set out to promote the donation among the youngest.

Evidence from studies conducted in the United States of America reveals that one-third of first-time donors have a higher education or bachelor's degree [7] and that about 45% of recurrent donors have at least higher education [8]. In the same vein, another study carried out in Greece concluded that the "standard" donor had high levels of education regarding the donation and need for blood [9].

In these terms, since the information about blood donations and the imprescriptibility of it has a direct effect on the number of donors and, as it is important to raise more individuals to the donation, we find that the explanation of what is the blood-donation all its related concepts, to young people from an early age, will, hopefully, mean the instigation of the donation in the younger ones, with the goal that when they reach the age that allows them to donate - between 18 and 65 years old – they became donors. We also believe that the enthusiasm of the younger ones in this regard, and their influence on their families, the adult population, will also captivate more donors [9].

We concluded that the reapplication of a questionnaire to make a quantitative analysis would be ideal. Last year, we applied a questionnaire to the families of our school (pre-test) that included donation, so we decided to re-perform the same questionnaire (post-test), to find out if there was any awareness of an increase in donations, with the objective of a quantitative analysis pretest and posttest.

Based on the conclusions drawn from the answers to this questionnaire applied, combined with information from scientific articles, particularly "Blood Donors and Factors Impacting the Blood Donation Decision" in which it is exposed the reasons that lead a citizen to donate blood or not, we try to incorporate in our materials aspects that would meet the "positive motivators", trying to clarify and eliminate the "negative motivators" [10].

In order to captivate the younger ones, playful things that they can take home or even wear on a daily basis, will do the most. Following this, we created bracelets and t-shirts to give them that used frequently, helping to promote our cause. We also concluded that we had to create something that would cover the whole country. With the help of our teacher, who is a blood donor, it turned out that it might be interesting to change the donor card to a more captivating and informative one. A school kit was developed to promote and disseminate our project, but we needed the opinion of someone who was within this area; it was at this moment that the contact was established with the Vila Nova de Gaia-Espinho Hospital Center that, since then, has been fundamental partner helping us developing and implementing our project. We had several meetings with doctors, nurses and directors to improve our ideas and knowledge on the subject that were also focused on our investigation of the distribution of blood groups around the world.

For the scientific certification of the kit materials, the Centro de Ciência Viva de Vila do Conde, with which contact has already been established, will validate the scientific aspect of our materials, specially the quiz, among others.

With a greater reason than ever, at this fragile time for the entire world population, but even more instable for the health sector, the importance of donating blood has to be reaffirmed. At Centro Hospitalar Universitário de São João (CHUSJ), blood donations have decreased by half, thanks to the donors' fear of suppressing Covid-19. The service's director has already admitted that if nothing is made to increase the blood supply, in only one week of this pandemic situation, the Blood Bank of the same Hospital Center could break down. Similar panoramas in several Portuguese

Hospital Centers (source SIC News). However, both Portuguese Blood and Transplantation Institute (IPST) and Federation of Blood Donor Associations (FAS) state that the reserves did not resent because there was happened a decrease in the number of surgical interventions in hospitals. Joaquim Silva, president of FAS, questions if when this situation of pandemic ends it will possible to maintain and guarantee the supply of blood banks and how it will be possible. It is expected the withdrawal of some donors and it will be necessary to re-raise them. This leads to the following affirmation: now more than ever, the implementation of our project is crucial and can be very beneficial to sustain the blood supply.

In the past, the susceptibility to contracting a viral infection related to the ABO system had been proven and, as recent data seems to refer to the fact that the incidence of infection by the new coronavirus may be more aggressive and in bigger numbers in some blood groups, it is important to make a relationship with these findings and the geographic distribution of blood groups around the world, since it can help answer some questions about the development of the pandemic state.

This way, we want to solve, in the long term, the problem that is the lack of blood self-sufficiency in some of the Portuguese Hospital Centers, answering Lacerda's Question (2014) [2], "(...) What is the importance of attracting young people as donors?". As a starting point, with the support of Vila Nova de Gaia’s City Hall, it is intended to offer all public schools in Vila Nova de Gaia (VNG) a kit, so that, in the future, with the support of the Ministry of Education, a kit is offered to all public schools in Portugal.

2. Materials

What is the best way to captivate young people to donate blood?

Along these lines, a kit and several posters were designed for encouraging blood donation. This way, people who access the kit will increase their knowledge about blood-related topics, while promoting its donation.

The implementation of the project will be done in a progressively way, as mentioned in the introduction.

2.1. Kit

Considering the kit, the following materials have been developed:

2.1.1. Quiz and Bloodpolis

This quiz contains several questions concerning blood donation and global knowledge about blood. In the questions about blood donation, some increase knowledge about the conditions necessary to donate blood, its history, and how it occurs. When it comes to the questions referring to blood, we try to teach about its constituents and the different blood types. To give a better use of the quiz, we decided to create a game, similar to a game of glory, to encourage the acquisition of knowledge about blood.

2.1.2. Blood type compability game

In this game, it is intended to teach about the compatibility between the different blood types. We created a wooden prototype with the partnership of Fourcontract (wood and furniture company) so that blood compatibility between the different blood types would be easier to understand, which was scientifically approved by Dr. Manuel Figueiredo, director of the Center for Immunohemotherapy of the Hospital. Thus, we focused on replicating sugars and agglutinogens simply and attractively, making the game something accessible and interactive, characteristics that appealed to countless teachers in the area.

2.1.3. T-shirts

We created t-shirts with the symbol of the project and where it is also said: “I will donate blood”. In such a way, we advertise the project, attracting people who are curious about the slogan and want to know more about this initiative

This quiz contains several questions concerning blood donation and global knowledge about blood. In the questions about blood donation, some increase knowledge about the conditions necessary to donate blood, its history, and how it occurs. When it comes to the questions referring to blood, we try to teach about its constituents and the different blood types. To give a better use of the quiz, we decided to create a game, similar to a game of glory, to encourage the acquisition of knowledge about blood.

2.1.4. Bracelets

Bracelets that identify the blood type of each person and have the project slogan and hospital's symbol, to attract people to visit the Hospital Blood Service.

2.1.5. Donor cards

Cards that indicate the donor's blood type, showing what blood types each donor can donate and receive blood. These cards exist physically, and, at this time, we are committed to applying them in the APP of the *Ministério da Saúde* "MY SNS CARTEIRA".

2.1.6. Blood type identification device

This device has been incorporated so that students can easily find out their blood type.

2.1.7. Posters

The Posters inform about the problem of lack of blood self-sufficiency at Hospital Centers and how it can be solved. It is indicated how one can help to solve it and what are the benefits of blood donation.

2.1.8. Anti-stress, Key chain, Bloody

These two materials are drop-shaped and were developed to advertise the project, the key chains could be distributed to teachers and the anti-stress could be placed in each of the classrooms of the schools. The Bloody is also an interactive blood drop, so students can play with it.

2.1.9. Website

To promote the dissemination of our project in a very simple way, we decided to create a website [11] where we briefly summarize our goals and products.

2.2. Presentation on the importance of blood donations

After the bridge between this project, the Program to Support Health Promotion and Education (*Programa de Apoio à Promoção e Educação para Saúde) and* The Profile of Students Leaving Obligatory Schooling (O Perf*il dos Alunos à Saída da Escolaridade Obrigatória) also pr*epared a presentation and a script, with the aim of reinforcing the appeal to donations, highlighting the importance of self-sufficiency in Hospital Centers, which crystallizes in the disciplines: Natural Sciences (6° grade), Nature Sciences (9º); Physics and Chemistry (10º), Biology (12º). In this way, the speakers, with this new tool, can appeal to their students for this cause.

3. Results

What is the best way to captivate young people to donate blood?

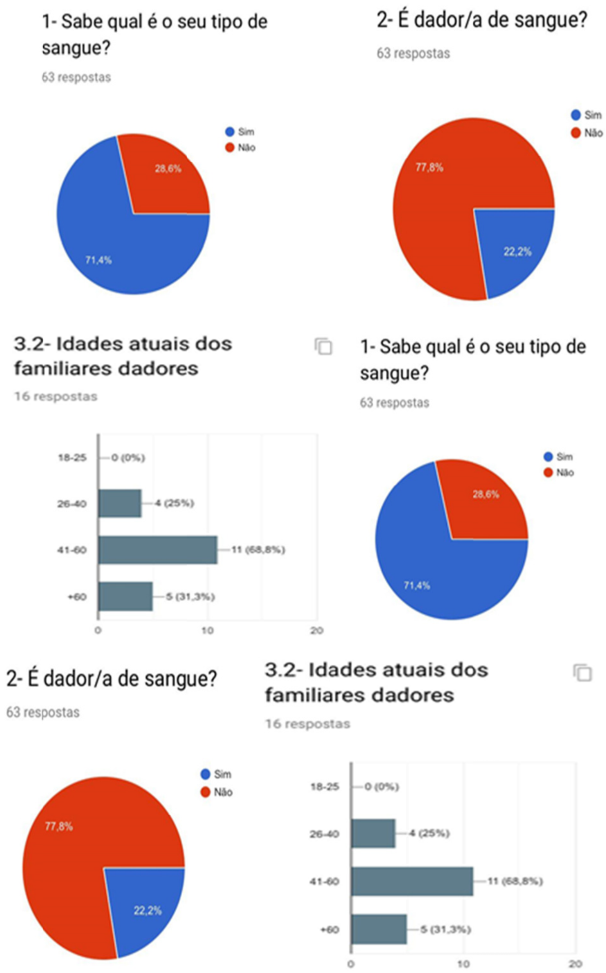

Figure 1. Pre-test applyied to our school's families

Along these lines, a kit and several posters were designed for encouraging blood donation. This way, people who access the kit will increase their knowledge about blood-related topics, while promoting its donation. The implementation of the project will be done in a progressively, as mentioned in the introduction.

3.1. Pre-test/Post-test

In order to collect some information from donors or potential donors, we decided to conduct a questionnaire (Pre-Test) on blood donation to gain an insight into people's general knowledge about blood (Fig. 1). By comparing last year's test results with this year's, we were able to draw some conclusions.

3.2. Distribution of blood groups per country

Table 1. Distribuiton of blood groups by country with the hights number of COVID-19 cases (04.07.2020). [12-15]

	O	A	B	AB
USA	44,00%	42,00%	10,00%	4,00%
Spain	45,00%	42,00%	10,00%	3,00%
Italy	46,00%	42,00%	9,00%	3,00%
France	42,00%	44,00%	10,00%	4,00%
Gremany	41,00%	43,00%	11,00%	5,00%
China	48,00%	28,00%	19,00%	5,00%
UK	35,22%	40,35%	11,11%	4,72%
Iran	37,50%	30,00%	24,7%	7,80%
Turkey	33,70%	42,50%	15,8%	8,00%
Belgium	45,00%	40,00%	10,10%	4,90%
Suitzerland	41,00%	47,00%	8,00%	4,00%
Netherlands	47,00%	42,00%	8,00%	3,00%
Canada	46,00%	42,00%	9,00%	3,00%
Brazil	45,00%	42,00%	10,00%	3,00%
Portugal	42,30%	46,60%	7,70%	3,40%

3.3. Analysis (Results)

Although most people know their blood type (71.4%), an even greater majority of people (77.8%) are not donors, which reveals a great ignorance on their part about blood donation and its importance! We can also analyze that the donor generation is the oldest people, so there is a great risk that in the future the number of donations will drop dramatically since the maximum donors' age is 65 years old. One proof that knowledge about donation is extremely scarce is the fact that only 12.7% of people know how many lives a simple donation can save! From another point of view, we can see that the difficulties in preventing people from donating are easily solved. At the end of our questionnaire, we concluded that there is an interest of people in our project and in one of our ideas (donor card), but especially in the donation of blood when they took some of their time to answer our questionnaire, when they contacted us about their answers, wanting to know if they were right or wrong.

In Zhao and al. [16], it is proposed that the results of a study comparing the distribution of blood groups in 2173 positive patients with COVID-19 from 3 hospitals in Wuhan and Shenzhen show that individuals with blood group A have a higher risk of contracting COVID-19 compared to other blood groups. On the other hand, it is also suggested that individuals with blood group O have a lower risk of testing positive for the same virus. It is also claimed that the high risk associated with group A and the low risk associated with group O is also found in dead patients, so those infected with COVID-19 in blood group A are at a higher risk of dying from the disease when compared to patients with other groups, and those in group O are at a lower risk of dying. Therefore, the susceptibility to contracting COVID-19 and the violence/consequences of the infection may be related to the presence of antibodies A in red blood cells (groups O and B) [17].

As for the geographical distribution of the blood groups, it has been inferred that:

- Group O is most common in North-East Asia and Africa and the Middle East;
- Group A is most common in Europe and North America;
- Group B is most common in India and Southeast Asia;
- The AB group is most common in India, South East Asia, and Northern Europe.

4. Discussion

Efforts to capture and maintain a sufficient number of regular voluntary donors to ensure an adequate and safe stock of blood and blood components are being made worldwide. The constant concern to create a balance between supply and demand in order to meet demands for blood and components is caused by the fact that only a small percentage of the population with eligible donation characteristics choose to be a regular blood donor and also because within the regular donor group there is a significant percentage of donors who are temporarily or permanently suspended due to the careful donor selection criteria. This happens at the same time as the demand for blood and its derivatives continues to increase, partly due to the increase in average life expectancy, but also due to the implementation of more aggressive surgical techniques and therapeutic methods that require large numbers of transfusions to be carried out [18].

On the other hand, after our personal contact with some health, and marketing, professionals we were able to draw some important conclusions. We note that our games are the most important pillar of our kit, as it can be played by different age groups (from young to old). We have also noticed that people after playing our games have dramatically increased their knowledge about giving, as they have been confronted with simple and complex questions. In our opinion, marketing is based on 4 fundamental pillars [19]:

1. Identify - It is necessary to identify the needs of donors and understand how our product can succeed in the most effective way.
2. Anticipate. Study the behavior of donors and predict how this may affect the future success of the product.
3. Satisfy. Not once! Donors need to feel that our kit generates some benefit (satisfaction) for those who have contact with our project.
4. Profit. "Profit" is the main objective and helps in the survival of a project, since it is not easy to obtain investment in a school and social project.

However, another key aspect of our project is our commitment to schools and teaching methods. In our opinion, if we manage to capture the attention of teenagers about the importance of donation in people's lives, we have managed to drastically increase the number of donations (from 2018 to 2019, in the Vila Nova de Gaia/ Espinho Hospital Center, we found that there was an increase of 15% (from 80% to 95%) in the hospital's self-sufficiency, and our goal is to make the hospital 100% self-sufficient by the end of this year.

Therefore, we decided to bet heavily on our wristbands and cards, since it was until now the two elements that we had the opportunity to receive quite positive feedback. Another very important aspect is the promotion of the intergenerationality that our games provide to their players. Finally, we will hold lectures for the students of the secondary schools in the municipality of Vila Nova de Gaia. These lectures will be carried out by doctors and nurses from the hospital, thus carrying out a very significant awareness campaign in our municipality. In the future, we would like to extend these lectures all over the country.

In short, we are quite confident that after the implementation of our kit including games, bracelets, posters, T-shirts, and cards, in schools, hospitals and, finally in public centers we will be able to get the renewals of donations in the young and middle populations, as well as we will bring many donors to help maintain a stock of blood and components for the various medical procedures and treatments.

On the other hand, the countries whose health authorities consider that they have already exceeded the peak of those infected by COVID-19 are Italy, Spain and China, whose mortality rates are 12.79%, 10.10%, 4.07% respectively. In this sense, looking at the percentages for blood groups that have antibodies A in red blood cells (China, 67%; Italy and Spain, 55%) and for the findings in Zhao [16], can infer that the mortality rate of the disease is higher in countries where there is a large number of individuals of blood groups A and AB. In this sense, it is very important that these countries have even stricter measures aimed at protecting their citizens and that individuals from these groups take greater care [17].

5. Acknowledgements

The authors would like to express their gratitude to all the institutions that helped to develop this project. Particularly to Dr. Manuel Figueiredo who helped us with the investigation about the evolution of the blood type dispersion by continent and to Vila Nova de Gaia's Hospital Center staff that assisted us, since they allowed the usage of their facilities and always demonstrated a great availability taking care of all our doubts.

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Toxetamol: Paracetamol Ecotoxicity Evaluation Using *Daphnia magna*

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Abstract. With the growth of pharmaceutical industry and the human population, more drugs are used each day. Since Paracetamol is one of the most used drugs worldwide, these pharmaceuticals enter wastewater and prevalence in aquatic systems, due to their incorrect use. To study the effects of Paracetamol on aquatic organisms, we investigated its influence on reproduction of a bioindicator species, *Daphnia magna.* Therefore, we performed a chronic exposure to paracetamol using different concentrations. Our study shows that long term paracetamol exposure lowered the number of neonates produced, which is one of the typical reactions of D. Magna to the environmental stressors.

Keywords. *Daphnia magna*, Ecotoxicity, Paracetamol, Reproduction.

1. Introduction

Paracetamol is one of the most used pharmaceutical drugs worldwide. It is used in human therapeutics either as an analgesic and antipyretic drug [1].

However, their incomplete metabolization [1], along with their incorrect use and discharge, lead to their accumulation in the environment, particularly in the aquatic compartment, due to their high solubility and hydrophilicity [2]. Paracetamol have been detected in a wide variety of samples, including in sewage, surface waters, and residues from veterinary and hospital usage.

The misuse of this compound represents a serious health problem, especially in the aquatic environment. It has been found in European sewages with a concentration of up to 6 $\mu gL^{-1,}$ in the natural waters from USA the concentration is up to 10 μgL^{-1} and, in the Tyne River in the UK, it has been found more than 65 μgL^{-1}. Nevertheless, in hospital effluents, the concentration of Paracetamol can exceed 150 μgL^{-1} [2].

Since it can represent a dangerous to the ecosystems, it is important to perform some studies regarding aquatic organisms reaction to the presence of this drug. *Daphnia magna*, usually known as water flea, is a microcrustacean, who inhabit standing waters [3]. They are commonly used as a model organism in ecotoxicity tests due to its sensibility and also due to the fact that they mature in a short period of time, thus, it does not take long to grow a culture of test. It is possible to control their genetic variability, as a result of their parthenogenetic reproduction, leading to an organism genetically equal to the progenitor and a precision in the test performed. Regarding their nutrition, it is based on small particles into suspension, such as microalgae and bacterias.

For the evaluation of the ecotoxicity, two parameters are taken into account: the time of the exposition and the parameter to be evaluated. Therefore, the test of accute toxicity evaluates short exposures with high concentrations and the mortality. On the other hand, chronic toxicity evaluates long exposures with low concentrations and the effects that can be studied are: reproductive, biochemicals and behavioural [4].

This study aims to understand the effect of Paracetamol on the reproduction of *Daphnia magna* using different concentrations.

2. Materials and Methods

2.1. Maintenance of *Daphnia magna* Culture

The standard organism used in this study was *Daphnia magna*, that were provided by the Faculty of Sciences of the University of Porto. It is essential to keep the cultures in certain conditions to make sure that the production of neonates is in a propicious environmental. The culture of *Daphnia magna* was maintained using a synthetic medium ASTM (American Society for Testing and Materials) Hard Water sythesized in the laboratories of the Escola Secundária da Maia. It was prepared with destilated water and chemical compounds that are presented in Table 1.

Table 1. Chemical compounds used in ASTM Hard Water. (*) This solution must be prepared separately, and the pH of the medium must be at the range of 7-8

Reagent	Mass (g)	Final Concentration (mg/L)
$NaHCO_3$	0,960	192
$MgSO_4$	0,600	246
KCL	0,040	8
$CaSO_4 \cdot 2H_2O$	0,600	120*

Figure 1. Maintenance of Daphnia Magna culture

Since this medium is low in nutrients, we used an organic additive, which contained microalgae that allowed a better growth. It was also used the microalgae *Raphidocelis subcapitata* as the main food. In this experiment, the *Daphnia magna* culture was divided into twenty four 50mL-flasks of ASTM Hard Water. The culture medium was changed every two days. In this process, the *Daphnia Magna* culture was transferred to other flasks with the stipulated values of ASTM Hard Water, microalgae *Raphidocelis subcapitata* and organic additive. Each flask contained one *D. magna* to be able to more easily observe the number of neonates and see more clearly the effects of different concentrations of Paracetamol.

2.2. Concentrations of Paracetamol

The 24 flasks were further divided by the respective concentration (Low- 0,000484 mg/L; Medium- 0,00484 mg/L; High- 0,00968 mg/L). A control assay (i.e. no paracetamol was added) was performed. Five replicates were used per each concentration.

Figure 2. Volumetric flask containing a stock solution of Paracetamol

2.3. Ecotoxicity Test

Before starting the experiments, it was necessary to grow the organism for a week, in order to promote their reproduction. Following this initially period, the reproduction experiment was started and kept for twenty one days. During this period, the number of neonates was enumerated everyday during the whole experiment.

3. Results and Discussion

In this study, *D. magna* was exposed to different concentrations for twenty one days, measuring chronic effects on reproduction and population performance. In Figure 3, it is possible to observe the results regarding this chronic ecotoxicity experiment. This study demonstrated that the exposure to these concentrations of paracetamol creates a decrease in *Daphnia magna* reproduction. However, when using the higher concentration of paracetamol it is possible to observe that the number of neonates produced by Daphnia decreases when compared to other concentrations.

Therefore, it is shown that there is a very specific effect of Paracetamol on the reproduction rate of *Daphnia magna.*

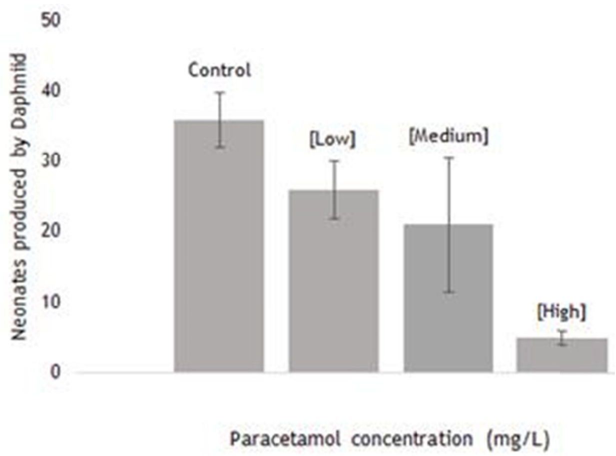

Figure 3. Representation of the number of the neonates according to paracetamol concentrations

Figure 2. Adult organism of Daphnia magna under the microscope

4. Conclusions

The presence of pharmaceutical residues for human use in waters represents a serious environmental problem. The ability of these compounds to change the characteristics of many organisms can lead to the extinction of several species. Thus, this project evaluated the effect of the species *Daphnia magna* after chronic exposure to Paracetamol. It was found that Daphnia magna is a species very sensitive to the presence of this drug, since it has suffered a decrease in the reproduction rate. In the future, it is important to give more importance to these problems, since the demand for other drugs is increasing and, consequently, the contamination of aquatic environments will also increase.

5. Acknowledgements

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Observation of Cognitive Structure of Primary Students towards Values

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Abstract. The ever-changing and developing demands of the education among the new era children require to somehow adopt the value education into the curriculum to meet the interests and the needs of the students identified as the internet grosshoppers to be able to prevent the social conflict. As the nature of the human wanted to be educated is not same as the decades ago, we need to know their cognitive structure first to somehow design our instruction. In this study, it has been aimed to observe the cognitive structure of the primary students towards the specific social values in the social science lesson by a survey research using word association test as a data collection tool from 45 4th grade primary students during spring semester of 2019-2020 education year. The students have been given word association test including values: responsibility, respect. It has been concluded that the concepts used for the values by the students are restricted and the sentences created by using the concepts have shown that the students have internalized the social values which are their close environment.

Keywords. Primary School, Social Values, Word Association Test.

1. Introduction

The most basic differences between the human being and the other living is the social contact. This social contact somehow creates a value system that shape our behaviours, attitudes, world view and so on. As the value is such an essential factor in determining the people’s most important features, it has been a research subject for a long time in social sciences. The concept of value is tried to be explained in many ways as it is hard to explained every human aspect so it is vital to point out what value is. Simply, values are defined as the belief that something is desirable or not [1], the way in which an individual or a community considered ideal or act [2-3], while defining the value, emphasized the social dimension of the values and defined the values as beliefs whether a behavior should be accepted socially or not.

Values can vary from society to society, as well as from individual to individual. However, individuals are expected to acquire social values in order to ensure peace in the society. Values are not absolute, but they require a long time to change and are often closed to change. Values are a goal that guides them in adjusting the priorities of a person or a group in their lives and can vary from situation to situation [4]. Similarly, values are defined as a scale for guides [5] and behavior that enable people to choose between alternatives [6].

2. Aim and importance of the study

As the values are so important in determining so many factors in a person life, it is inevitable to know the values of a person and to arrange a suitable instruction environment for the value education. Accordingly, the purpose of this study is to observe the cognitive structure of the primary students towards some basic social values; responsibility, cultural heritage awareness, respect, environmental awareness.

3. Method and the sample of the study

In this study, survey method has been employed. Survey researches are employed to describe objects, structures of societies and process of events and in this kind of researches, generalization is made in the light of the data gathered from a sample. The sample of this study consists of 46 students (24 male, 22 female)

4. Data collection tool

In this research word association test has been used as data collection tool. It is a kind of alternative assessment and evaluation instruments which have been became common especially with the constructive approach in the education. In word association test, a concept is listed and students are asked to write the first concept they think when they see this concept and a senteces related that concept in a given time. In this study, students have been asked to write 5 concepts, they are said they can write more if they can, and a sentence in one minute. It is generally given thirty seconds to the participant, however, as the sample of the study consists of primary school students, they will need more time.

In the analysis of the data, firstly frequency table has been created for the concepts the students produced and then the they have been shown on a concept map. While creating the concept maps, the cutting point suggested by [7] has been used. As the students cannot interrelate between key concepts, two different concept maps have been created by using different cutting point. The example of word association test for one value is given in Table 1.

Table 1. Example of word association test

Respect………………………………………

Respect………………………………………

Respect………………………………………

Respect………………………………………

Respect………………………………………

Sentence: ……………………………………

5. Findings

A frequency table has been created to show how many times a word has been used for the key values. This frequency table has been used as to create the concept maps. While cretating the concept maps, the cutting points have been used suggested by [7]. This technique recommends that a point below the most repeated concept is accepted as the cutting point and this process goes on until all the concepts are on the concept map. The frequency table is given Table 1.

The frequency table showing the related sentences about the key concepts written by the students given in Table 2.

When the students' sentences related to the key concepts have been evaluated, it has been cocluded that the sentences about the 'respect' value are generally about the most desired behaviours. For example; 'we should respect handicapped people', 'I am a very respectful person'. However, the other sentences show that the students have created sentences showing the traditional behaviours and 13 sentences out of 21 are about kissing hands, a traditional way showing respect to the adults. For example; 'I kissed my grandparents' hands in the eid', 'I kissed my father hands to show my respect'. The sentences show that the students associate the respect value with the traditional behaviours not generally universal level.

Table 1. Frequency of the concepts created for key values

Produced Words	Key Concept	
	Respect	Responsibility
Love	21	-
Kissing hand	17	-
Toleration	14	-
Friend	10	-
Mother	8	-
Sensitivity	8	-
Father	7	-
Cooperation	4	-
Nature	4	-
Happiness	3	-
Siblings	3	-
Neighbours	3	-
Peace	2	-
Society	2	-
Environment	2	-
Handicapped	2	-
Tidy up room	-	45
Homework	-	37
Family	-	14
School	-	12
Studying	-	8
Reading book	-	7
Setting table	-	5
Flowers	-	4
Duty	-	4
Pets	-	3
Garbage	-	2
Praying	-	1
Total	**114**	**142**

The sentences created by the students about the responsibility value are generally about their daily routines. For example; 'I should tidy my room', 'I shoul help my mother setting up the table', 'I should go to the school'.

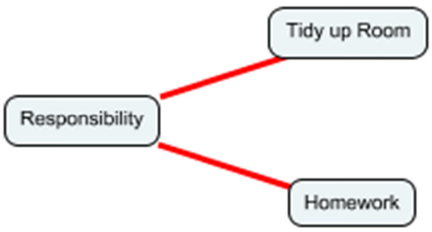
Table 1. Frequency of the sentences created for key values

Key Concept	*f*
Respect	21
Responsibility	15

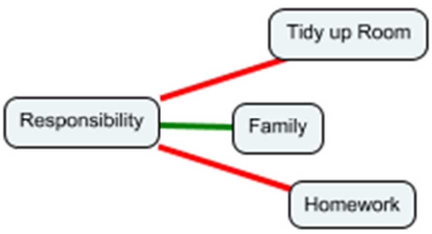
The concept map related the responsibility value has been given in Fig. 1.

Figure 1. The concept maps of key concepts for responsibility

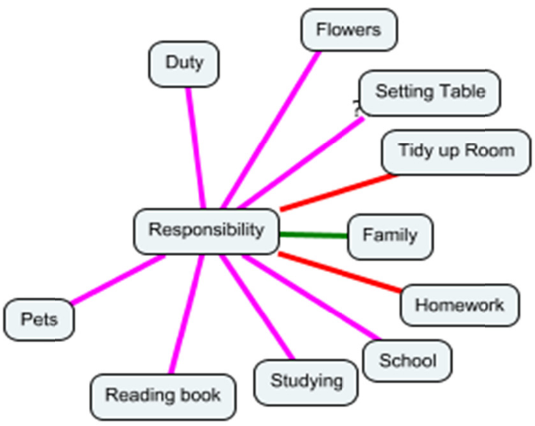
Cutting point 35 and above



Cutting point between13-23



Cutting point between 3-12



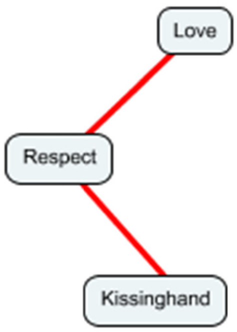
The concept map of respect value has been given in Fig. 2. The concept map for responsbility value has revealed that:

1) The key concepts created for 35 and above by the students are about their daily routins from their school and house routine (homework and tidy up room). These are the most basic duties of a child at that age and are related to their school and house life.
2) The key concept created for 13 and 23 by the students is just seen as the family. It means that students still perceive their close surrounding as their responsibility.
3) All the key concepts by students are available at the cutting point 3 and 12 (just two of the key concepts (Garbage and praying) are not included in the concept maps as they have the least frequency). The key concepts at that level shows that the close surrounding of the child has an important factor on determining his/her responsibility circle.

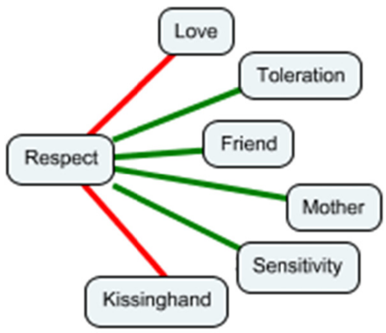
4) The key concepts created for 15 and above by the students are love and kissing hand. While the first one is a universal concept for respect, the second one is a traditional respect.
5) The key concepts created between 8-14 interval has the concepts which are both at universal level such as toleration and sensitivity and close surrounding like friends and mother.
6) All the concepts have become clear at the level of cutting point 3-7. It reveals that all the concepts created are the most close surrounding of the people such as father, sibling, neighbour and universal values such as nature, happiness and cooperation.
7) The key concepts created for 15 and above by the students are love and kissing hand. While the first one is a universal concept for respect, the second one is a traditional respect.
8) The key concepts created between 8-14 interval has the concepts which are both at universal level such as toleration and sensitivity and close surrounding like friends and mother.
9) All the concepts have become clear at the level of cutting point 3-7. It reveals that all the concepts created are the most close surrounding of the people such as father, sibling, neighbour and universal values such as nature, happiness and cooperation.

Figure 2. The concept maps of key concepts

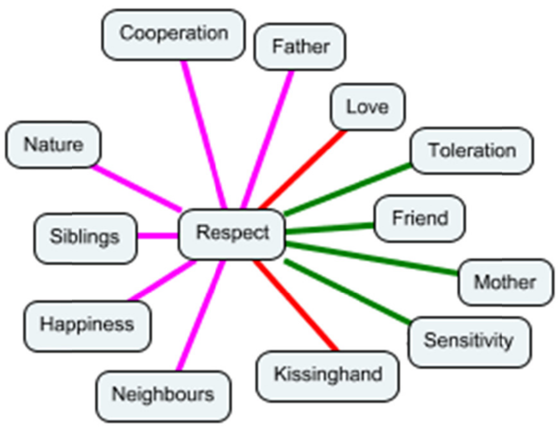
Cutting point 15 and above



Cutting point between 8-14



Cutting point between 3-7



10) The key concepts created for 15 and above by the students are love and kissing hand. While the first one is a universal concept for respect, the second one is a traditional respect.
11) The key concepts created between 8-14 interval has the concepts which are both at universal level such as toleration and sensitivity and close surrounding like friends and mother.
12) All the concepts have become clear at the level of cutting point 3-7. It reveals that all the concepts created are the most close surrounding of the people such as father, sibling, neighbour and universal values such as nature, happiness and cooperation.

6. Results

The values of a person determine his attitudes, behavior, world wiev and even his social statue in some way. The values have been always a debate in social science. The social scientist put forward many idea and definition about the values. As the value, the value education has been a matter since the early 20th century. Hence, it is important to determine the cognitive structure of the students towards the value to be able to design the courses much more effectively.

The findings of the study revealed which concepts students have in their cognitive structure and whether these concepts have relations between themselves. The results show that the students' cognitive structure towards especially to the value of responsibility is mostly their close surrounding such as family, homework and tidying up room. In the literature, it has been emphasized that the human is surrounded by the value in his nature and a human create himself with these values [8]. So, it is a natural finding that most of the concepts related the respect in students' cognitive structure are about his close surrounding.

The findings of the value respect show that one of the most repeated concepts is a traditional action. It is stated in the value studies that some values such as respect, love and privacy can gain more different meaning with the universal values [2]. Neverthless, the concepts and the sentences created by the students shows that the value concepts are restricted with the traditional level mostly. Accordingly, it is advised that the universal values should be taught and somehow should be adopted by the students in such a world that is very fragile to conflict.

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Implementation and Evaluation of Cooperative Learning Technıques to Increase Inter-Class Communication of German Course Students

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Abstract. This is an action research aimed at increasing classroom interaction for the German language course. The study group consisted of 10 students who took courses in a language school in Afyonkarahisar. The research data were collected through a focus group interview and their opinions and diaries. In addition, the data was supported by the researcher's diary. The collected data were presented by the content analysis method. In total, 3 action plans were implemented. It was observed that the group studies for the application increased student communication. The study also showed that the difficulty of learning the German Language for the students negatively affected the classroom atmosphere. They also emphasized that the class interaction increased.

Keywords. Action Research, Classroom Interaction, Cooperative Learning, German Language.

1.Introduction

Social life is an element based on communication. Communication is an important concept that enables the exchange of emotions, thoughts and information. Communication in the context of education is an important tool that influences the classroom atmosphere and learning. Communication ability in teaching programs is a skill that must be acquired and used effectively in all disciplines [1]. In order to create a communicative classroom atmosphere, the teacher must encourage students to collaborate. Encouraging the students to work collaboratively in all processes from the setting of classroom rules to the applications has a great role in learning [2].Therefore, in addition to the personal characteristics of the student, the atmosphere of the class is important for the communication in the classroom. In-class communication can be enhanced with student-centered practices and learning groups. Cooperative learning is one of the group works used to increase communication in the classroom.

In a cooperative learning environment; It is known that there are activities open to communication, that the students are active, open to social learning, pedagogically contemporary and preparing the individual for real life [3].In this learning environment, the individual is responsible for his / her own learning as well as for his / her groupmate's learning. Positive solidarity among students increases students ' communication and positively affects learning.

When the literature is examined, Yıldız stated that cooperative learning is a teaching method that enables students to use their mental abilities and allows them to make decisions about their own learning [4]. Bozavlı, emphasized that the main reason why a child is learning his native language and is willing to speak is the interest of those around him [5].

Çaycı, Demir, Başaran and Demir stated that with the discussion of the subject in the course, knowledge was tried and tested more frequently and the basis of new knowledge was formed [6].This study should therefore be seen as an important guide for binding heterogeneous groups together. In this study, not only one technique was used, but different group studies were applied. German lessons were shaped with immediate feedback from the student.

1.1. The Importance of research

Group work in the education program is a factor affecting the classroom atmosphere. The combination of different age groups and individuals with different personality characteristics causes negative interactions in the classroom from time to time. Mark Twain stated that learning German as a foreign language is a difficult and very exhausting [7]. In this context, it is important that the classroom atmosphere creates a positive feeling for the student. Therefore, the interaction of students with each other in the classroom environment should be considered. As the positive learning environment in the classroom was targeted with the techniques used in the research. It is expected that the positive and negative situations experienced in this process will be exposed and the research will be a source for the following other studies.

1.2. Purpose of the research

In the language school where the research was conducted, it was observed that the students did not establish any dialogue inside and outside the classroom. This situation affects German language learning, especially speaking skills, in foreign language teaching. For this reason, in this action research, it is aimed to increase classroom interaction through activities that require cooperation. For this reason, in this action research, it is aimed to increase classroom interaction through activities that require cooperation. These activities are integrated into the course as called "Memory Game, Think-Pair-Share, Tableau" according to German subjects [8].

1.3. Research problem

How do cooperative learning techniques applied to students coming to the German course affect their classroom interactions?

1.3.1. Sub problems

a. Can the cooperation problems of the course students in learning be solved by using some techniques?
b. What is the effect of the techniques used?
c. Which techniques have positively affected the atmosphere of the classroom?
d. Does the atmosphere of the classroom have a positive effect on learning German?
e. How are the positive and negative reflections of group work on classroom interaction?
f. How was the reflections of the techniques used to the German lesson?

2. Method

2.1. Research design

In the study, action research, one of the qualitative research designs, was applied. According to Akkaş Baysal and Hocaoğlu, action research is one of the research methods that educators (teachers, managers, experts, etc.) can use to find solutions to education problems or to ensure their development [9]. This research focused on solving the problem of classroom communication based on a collaborative approach throughout the application. It has been determined that the difficulties in classroom communication negatively affect the learning and teaching activities. For this reason, this study was designed as an action research.

2.2. Working group

The language course where the study took place consists of 10 students who want to learn German in Afyonkarahisar province. The students who do not know German Language are taken to A1 German class. The students are qualified according to the initials of their names. For example: Sabine (S.) etc. There are 6 male and 4 female students in the classroom.

Table 1. Characteristics of the working group

Participants	Gender	Age	Profession
1- M.	M	22	Electrical Eng.2nd grade
2- B.	M	30	Anesthesiologist
3- S.	F	24	Map E. 4th grade
4- O.	M	23	Automotive E.2nd grade
5- K	F	24	Mechatron. E.3rd grade
6- G.	F	20	Sociology 2nd grade
7- R.	M	14	High school student
8- D	M	25	Mechan. Eng 3rd grade
9- H.	F	21	Medicine 2nd grade
10- F.	M	20	Physiotherapy 3rd grade

2.3. Collection of data

In order to reach more detailed problem solving in the action research, diversity has been made in data collection tools. Therefore, data collected through focus group interview, the students' and the researcher's diaries were used. Six volunteers in the class participated in the focus group interview. Focus group interview questions prepared by taking expert opinions are as follows:

a. What do you think about the process of the course?
b. Which group work did you like more?
c. How did the techniques used in the lesson affect the lesson?

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d. How did the applied techniques / games affect your social communication in the classroom?
e. Which technique made you become more socialized with your friends?

The same technique was not used in the other action plan, as immediate feedback was received about the techniques used after each application. The students were observed during and after the lessons. The students were asked to keep a diary about the lesson. 3 action plans were implemented in this research.

2.4. Analysis of data

The answers given to the interview questions applied were transferred to the computer environment and analyzed through descriptive and content analysis. Appropriate themes and codes for descriptive and content analysis were determined to analyze qualitative data and responses were examined. For the reliability analysis of the determined sub-themes and themes, the compatibility ratio among the researchers is determined [10].Issues with disagreement and consensus are identified and the Reliability = Consensus / (Consensus + Disagreement) x100 formula is used [11].In addition, teacher and student diaries are given through a descriptive analysis in terms of study reliability.

3. Application

3.1. Action Plan I (For German lesson)

Introduction (10 min.)

a. Watching a video with the subject of ' Mein Haus (My Home)', which is the 4th unit of the German course, draws attention to the subject and provides infrastructure for vocabulary.
b. The meanings of unknown foreign words are examined from the dictionary. Then, with the 'Memory Game' technique, the class is divided into 2 groups for the word-visual pattern.

Development (25min.)

a. Memory materials related to household items are used. The student matches the visuals of the household goods he sees in the course with the German meaning. The group that has matched the materials at first wins as soon as possible.
b. The same groups compete with the sentence recall event, which is the second stage of the '*Memory Game'* event. Two groups look at the relevant image for a short time and write what they see on the paper. The group that creates the sentences in the most correct way wins the competition.
c. Finally, a student is given a ball. ' Was gibt es in deinem Haus ? / What's in your house?' If the student wants to ask the question pattern, he throws the ball to the target classmate. The student holding the ball gives a few examples of the items in his home.

Result (10 min.)

a. The lessons are finally completed by making the listening sections.
b. After the application is completed, the course is ended by asking the students to write their opinions and thoughts about the application.

In the action plan implemented, the students determined and competed for their teammates themselves. In this case, introverted students had difficulties in team building. For this reason, only the applied technique was changed in other action plans and the implementation process continued exactly. In other plans, "Tableau and Think-Pair-Share" activity was used.

4. Results and comments

The answers given to the interview questions were coded according to the content analysis. The codes reserved for themes are given in the Table 2.

In addition to the codes and themes mentioned above, co-observer application was applied. Within the scope of student responses, codes and themes were redefined. The averages of consensus and differences of opinion are given in Table 2.

Considering the reliability results, the answers given by the students were measured as 78.54%. According to Miles & Huberman, the average reliability value was stated as 70% [12].Therefore, it can be stated that the application is reliable.

Table 2. Code and themes list of opinions

Themes				
Classroom Atmosphere	Sense of Competition	Benefits of Activities	Communication Provider	Cooperation
Codes	Codes	Codes	Codes	Codes
beautiful	memory game	permanent in mind	we didn't talk much	different people
funny	like a contest	do n't forget easy	we spoke when there was a competition	team spirit
difficult but good	tableau	activities are funny	no communication in the class	business division
nervous		active course	sharing notes	giving quick decision
satisfied		competitions good	low communication	we get together
		learning with activities	being a part of the team thanks to the race.	we did it quickly
				it was like racing
				we discussed

Table 3. Inter-researcher compliance table

Themes	Consensus	Disagreement	Average
Classroom Atmosphere	7	2	77.7%
Sense of Competition	6	2	75%
Benefits of Activities	8	1	88%
Communication Provider	7	2	77%
Collaboration	6	2	75%
Average Value			78.54

When the interview data were examined, M2 and M3 students stated that they participated in activities outside the class. This situation shows that the action plans worked very well in a short time.

As indicated in Fig. 1, both the student's energy and their emotional states showed that the action plans were effective. All of the students stated that they got closer with each other.

In Fig. 2, H's diary says that only focusing the lessons is more crucial than the communication in the class to avoid being failure in the lessons.That H doesn't using such a statement in the focus group interview creates contradiction with H' statement in her diary. However, the student stated that H integrated with the whole class.

Figure 1. Memory game activity

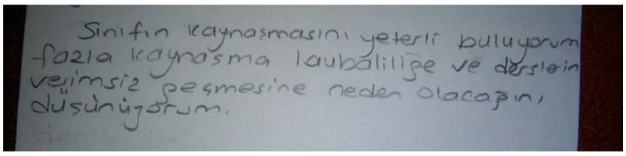

Figure 2. H's Diary

6. Conclusion and discussion

The techniques applied in the study were found to be effective with the diary and interview expressions of the course students. Before the action plans were implemented, the students stated that they had no communication with their friends in the classroom. M student even stated that they did not share their course notes.

The problem statement of the research is "How do cooperative learning techniques applied to students coming to the German course affect their classroom interactions?". The answer to the question was solved by group work and ice-breaking activities. In the focus group interview data of the students, student F said, “We did not speak much in the classroom before. When the game or race became, I was immediately socialized, I tried to organize and win.” This shows that cooperative learning techniques are effective. They increased their communication by creating a team spirit and work share with their group friends. There are studies indicating that a sense of competition enables students to progress and is an effective way to increase student performance and motivation [13]. Ökmen, Şahin, Boyacı and Kılıç stated that most of the students felt excited and happy before the competition. [14].

Regarding the interview questions, M3 said: “There was no communication in the class before. I wanted a note, sometimes nobody shared it. Sometimes, when I wrote to the Whatsapp group, nobody answered. Now they were giving notes from direct message.”These expressions shows that the class is socialized and the sharing among the individuals increases. Yasul and Samancı stated that group work improved student's feelings of solidarity and enabled students to develop socially [15]. This situation is consistent with the results of the action research. It was seen that the students who liked cooperation, competition or discuss, liked the activities that provided these situations. In conclusion, the group activities were a step that increased communication in the classroom.

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Drawing of 1st,2nd and 3rd Grade Students on the Concept of Non-Livings

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Abstract. In this study, the perceptions of elementary school 1st, 2nd and 3rd grade students about the concept of non-living have been tried to be determined. Phenomenological model has been used in the research. The sample of the study consists of 233 first, 308 second and 397 third grade students, totally 938 primary school students who were selected by the simple random sampling method in primary schools in Afyonkarahisar. 'Form of Determining Non-Living Perceptions by Drawing Technique' has been used as data collection tool. Chi-square test was used to analyze the relationships of students' drawings related to variables. It has been determined that students' perceptions about the concept of nonliving differs according to gender, place of residence, number of siblings and duration of using digital media.

Keywords. Drawings, Non-livings, Primary School.

1. Introduction

Young children create new concepts by associating new information they learn every day with the concepts they have already gained. With the experience they have gained and the development of vocabulary, the concepts of children begin to develop. The first concepts of children in preschool age are characterized by simple and most prominent features of beings. In the future, children make conceptual analyzes by reasoning and the children's information changes from perceptual to conceptual. Children learn new concepts as a result of these analyzes. 2-4 years of age are the ages when the first proofs of concepts appear in the child, and after 4 years of age, progress in the concept formation skills of the children starts to be seen [1-2], the most representative constructivist, argued that the concepts in infancy, early childhood, and school age are qualitatively different. He explained that children at the preoperational stage think in an animistic manner that hinders them to distinguish between living and nonliving objects.

Science that examines life includes the distinction between living and nonliving. Being "living" and "nonliving" requires the division of the world into two components, first to know the concept of living and to know its different forms [3].

The fundamental problem of general biology is the problem of the relation between the living and the non- living. In physical nature we meet with material and systems (unified collocations of matter and energy) of both kinds, although by far the larger part of nature is non-living in the biological sense of the term. The living we find experimentally to be dependent on the non-living in a definite manner; each living organism incorporates material and energy from its non-living environment, and after certain internal changes returns the material and the energy (at a lower potential) to the environment [4].

Young children often have difficulty characterizing things as living or nonliving. For example, they tend to describe anything that moves as alive. They also do not yet understand the cycle of life (birth, growth, death), and therefore classify as nonliving anything that has died. In science, living is used to describe anything that is or has ever been alive (dog, flower, seed, road kill, log); nonliving is used to describe anything that is not now nor has ever been alive (rock, mountain, glass, wristwatch). Over time, students will begin to understand that all living things grow, breathe, reproduce, excrete, respond to stimuli, and have similar basic needs like nourishment. Older students may even realize that all living things are made up of cells [5]. This study was conducted to determine the perception of nonliving concepts of elementary school 1st, 2nd and 3rd grade students and to determine whether these perceptions differ in terms of some variables.

1.1. Research Problem

"Do the perceptions of elementary school 1st, 2nd and 3rd grade students about lifeless concept differ according to some variables (gender, number of siblings, place of residence

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digital media usage status, television viewing time)?"

2. Method

This study was done using phenomenological pattern. Since the early 1900s, phenomenology has become an established and respectable methodological approach for conducting educational research Research studies grounded in phenomenology give participants the opportunity to describe their individual experiences. How people interpret their experiences is important because it is related to how they view the world [6-7].

2.1. Data Collection Tool

The 'Form of Determining Living Perceptions by Drawing Technique' developed by the researchers in the collection of the data was given to the primary school 1st, 2nd and 3rd year students (5-11 years old) by giving the final shape after the expert opinion. The children were asked to draw the nonlivings in the areas specified in the 'Form of Determining Living Perceptions by Drawing Technique'

2.2. Participants

The children studying in the 1st, 2nd and 3rd grades of primary school across Iscehisar district center, villages and towns in Afyonkarahisar province in 2014/2015 academic year constituted the general universe of the research and 938 (24.8% (233) 1st grade, 32.8% (308) 2nd grade, 42.3% (397) 3rd grade) students constituted the sample. The data in the study were obtained from students in 14 primary schools.

2.3. Validity and Reliability

In the study, the reliability of the Drawing Technique and the Viability Perceptions Form was calculated as 92.7%. In the study, the consensus-divergence formula developed by [8] (1994) was used for reliability in the study.

2.4. Data Analysis

While performing data analysis, Chi-square test (Chi-Square Test $\chi 2$) was used to determine whether the nonliving perception changes according to the variables determined in the research. Students' drawings are also categorized and coded. "No drawing" category 0, "unpercieved" category 1, "partially percieved" category 2, "completely percieved" category 3 in the drawings are coded. Reliability analysis of the scale was done and approved by 1 expert and 3 teachers.

3. Findings

When the perceptions of all students participating in the study about the concept of nonliving are analyzed, the perceptions of 938 students about the concept are given in Table 1.

Table 1. Nonliving drawing frequency

Drawing of Nonliving	f	%
No drawing	2	0.2
Unpercieved	34	3.6
Partially perceved	513	54.7
Completely percieved	389	41.5
Total	938	100

0.2% (2) of the students did not draw for item 2, 3.6% (34) could not percieve, 54.7% (513) partially perceived, 41.5% (389) completely perceived. Those who did wrong drawings (those who could not perceive) were included in the category that they perceived partially for reliability in data analysis and included in the evaluation. Students generally made drawings of houses, cars, sun, cloud, ball, refrigerator, pencil when they were asked 'what does nonliving remind?' In Table 2, Table 3, Table 4, Table 5, the nonliving beings in the students' drawings are given. When Table 2, Table 3, Table 4, Table 5 are examined; 191 houses, 163 cars, 117 pens, 103 suns, 89 tables, 79 clocks, 68 balls were detemined. When all the drawings were examined, 47 household items, 18 school items, 29 technological tool drawings were seen. In addition, it was seen that students drew works such as the Bosphorus and the Eiffel Tower**.** They stated in their explanations the features of not feeding, not moving, not breathing. In addition, students who touched the nonliving feature such as inability to reproduce stated both by drawing and explaining. In general, the non-mobility feature of nonliving beings came to the fore, and then the non-feeding feature was emphasized.

Table 2. Frequency of Nonliving Beings drawing by students

Categories	NB	f
Household Goods	House	191
	Table	89
	Clock	79
	Wardrobe	44
	Door	41
	Chair	28
	Refrigirator	27
	Painting	17
	Glass	13
	Window	9
	Curtain	8
	Bottle	8
	Vaze	8
	Sofa	7
	Shoes	7
	Pants	7
	Carpet	7
	Tshirt	6
	Bed	6
	Swing	6
	Cloth	6
	Stove	6
	Pillow	5
	Socks	5
	Washing machine	5
	Fish tank	4
	Jacket	4
	Jersey	4
	Suit	4
	Jug	3
	Umbrella	3
	Fork	3
	Skirt	3
	Tray	3
	Pot	3
	Saltcellar	2
	Demijohn	2
	Plate	2
	Basket	1
	Luggage	1
	Puff	1
	Teapot	1
	Chest	1
	Drawer	1
	Shoe cabinet	1
	Mirror	1
	Toilet	1
Total		684

Table 3. Frequency of Nonliving Beings drawing by students

Categories	NB	f
School Materials	Pencil	117
	Bag	22
	Pencil box	12
	Scissors	12
	Paper	12
	Notebook	11
	Desk	6
	Ruller	5
	Rubber	34
	Flag	32
	Ballon	30
	Lead	5
	Skipping-rope	5
	Maps	4
	Blackboard	4
	Class basket	4
	Box	3
	Sharpener	1
Total		319

Table 4. Frequency of Nonliving Beings drawing by students

Categories	NB	f
Technological Tools	Car	163
	Tv	40
	Computerr	26
	Cell phone	13
	Glasses	11
	Plane	11
	Bike	9
	Ship	8
	Lamp	7
	Remote Controller	6
	Train	5
	Rocket	5
	Tablet Pc	5
	Calender	3
	Scooter	3
	Braclet	3
	Dust bin	3
	Tractor	3
	Skateboard	3
	Light	3
	Phone	2
	Motorbike	1
	Earth digger	1
	Helicopter	1
	Floor lamb	1

	Submarine	1
	Mouse	1
	Key board	1
	Thermometer	1
Total		340

Table 5. Frequency of Nonliving Beings drawing by students

Categories	NB	f
Others	Sun	103
	Ball	68
	Cloud	62
	Wood piece	25
	Star	16
	Toy	13
	Stone	25
	Ice cream	5
	Bread	4
	Iron piece	4
	Money	4
	Doll	4
	Brick	3
	Moon and star	3
	Snowman	3
	Road	7
	Kite	7
	Moon	7
	Teddy bear	6
	Soil	5
	Marbles	9
	Mosque	3
	Trinket	2
	School	2
	Rainbow	1
	Pillow	2
	Log	2
	Hat	2
	Cover	2
	Cake	2
	Statue	2
	Letter	2
	Mountain	2
	Earring	2
	Key	2
	Lightining	2
	Salami	1
	Corn	1
	Eiffel tower	1
	Meat piece	1
	Sea	1
Others	Wall	1
	Snow	1
	Tissue	1
	Carton	1
	Plastic glass	1
	Tower	1
	Stair	1
	Bosphorus	1
	Sunbed	1
	Windmill	1
	Cell	1
	Bookshelves	1
	Ring	1
	Gift box	1
	Wind	1
	Black hole	1
	Bath	1
	Towel	1
	Recycling box	1
	Bill board	1
	River	1
	Clasp	1
Total		440

Incorrect drawing frequencies of students about nonliving beings are shown in Table 6.

Table 6. Incorrect drawings frequenies about nonliving beings

Nonliving Drawings	f
Tree	14
Flower	11
Apple	3
Grapes	2
Human	2
Snake	2
Dog	2
Snail	1
Fly	1
Strawberry	1
Banana	1
Piranha	1
Superhero	1

When Table 6 is examined, of the nonliving beings drawings; 32 plants, 2 humans, 7 animals and 1 superhero picture were drawn. In addition, fruit and vegetable drawings were also drawn for nonliving beings. Students also drew pictures of dead animals, human inside the coffin, and faded flowers.

In Table 7, the results of the chi-square test of the students' drawings regarding the gender and the concept of nonliving beings are given.

Table 7. The results of chi-square test accoring to the gender and the concept of nonliving beings

Gender		Nonliving beings drawing Partially percieved	Comp. percieved	χ2	p
Female	N	214	265	4.54	.033
	%	44.7	55.3		
Male	N	237	222		
	%	51.6	48.4		
Total	N	451	487		
	%	48.1	51.9		

When the Table 7 is analyzed, the difference between the students' perception towards the concept of nonliving and gender is significant (p =.033 <.05). According to the results of the analysis, female students made accurate drawings than men, with a rate of 55.3%.

In Table 8, the results of the chi-square test of the drawings of the students regarding the numbers of siblings and nonliving are given.

Table 8. The results of chi-square test accoring to the number of siblings and the concept of nonliving beings

Number of siblings		Nonliving beings drawing Partially Percieved	Comp. Perceived	χ2	p
1	N	70	30	7.15	.028
	%	70.0	30.0		
2	N	195	159		
	%	55.1	44.9		
3 and more	N	284	200		
	%	58.7	41.3		
Total	N	549	389		
	%	58.5	41.5		

When the Table 8 is analyzed, the difference between the number of siblings of the students and their perception of the concept of nonliving is significant (p =.028 <.05). According to the results of the analysis, students with 2 siblings made the right drawings with a rate of 44.9% compared to those with 1 sibling and 3 or more siblings.

In the Table 9, the results of the chi-square test of the drawings of the students regarding the place of residence and the concept of nonliving are given.

Table 9. The results of chi-square test accoring to the place of residence and the concept of nonliving beings

Place of residence		Nonliving beings drawing Partially percieved	Comp. percieved	χ2	p
Village and Town	N	126	156	64.6	.000
	%	44.7	55.3		
County	N	213	62		
	%	77.5	22.5		
City	N	210	171		
	%	55.1	44.9		
Total	N	549	389		
	%	58.5	41.5		

When Table 9 is examined, the difference between the students' place of residence and their perception levels of nonliving concept is significant (p =.000 <.05). According to the results of the analysis, students living in villages and towns made accurate drawings than those living in towns and cities with a rate of 55.3%.

Table 10 shows the chi-square test results of students' drawings regarding the use of digital media and the concept of nonliving.

Table 10. The results of chi-square test accoring to the use of digital media and the concept of nonliving beings

Use of digital media		Nonliving beings drawing Partially percieved	Comp. percieved	χ2	p
Not using	N	35	45	8.19	.42
	%	43.8	56.3		
1-2 hour/s	N	411	280		
	%	59.5	40.5		
3-4 hours	N	56	36		
	%	60.9	39.1		
5 hours and more	N	47	28		
	%	62.7	37.3		
Total	N	549	389		
	%	58.5	41.5		

When the Table 10 is analyzed, the difference between the students' digital media usage and their perception of nonliving concept is significant (p =.042 <.05). According to the results of the analysis, students who did not use digital media made the right drawings than the students using digital media with a rate of 56.3%.

4. Results

In this study, the perception of elementary school 1st, 2nd and 3rd grade students about the concept of nonliving beings has been investigated. As a result of data analysis, 2 students could not perceive the nonliving drawing, 34 students made wrong drawings, 513 students partially and 389 students could completely perceive. When the results are analyzed, it is seen that the students are generally able to distinguish the concept of nonliving but the number of students who perceive it completely is less than the number of students who perceive it partially.

When the factors on the perception levels of the 1st, 2nd and 3rd grade students towards the concept of nonliving are examined, it was found that the variables of gender, number of siblings, place of residence and use of digital media make a significant difference on perceptions. In their study, [9] conducted an empirical study on preschool, first and third grade students (4-8 years old) about the classification of plants, animals and non-living beings. According to the findings of this research, while the animal and plant scores were compatible with age, the non-living beings scores increased significantly, thereby determining that third grade students had higher scores than preschool children. [10], on the other hand, determined that the perception of 118 students between the ages of 4-7 on plant life did not differ by age in their study using drawing technique.

As a result of the analysis made in the research, a meaningful difference was found in terms of the variables of students' place of residence. In the literature, [11] aimed to determine whether the concepts of living and nonliving concepts in the minds of 4th and middle school 5th grade students vary according to gender. As a result of the study, no relation was found between living and nonliving beings and gender. The study's findings differ from this study. In our study, it was seen that students often draw the plants that are actually alive. [9] showed that attributing plants to living area is more difficult than attributing animals to living area and nonliving ones to non-living space.

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The Opinion of Secondary School Students about Outdoor Learning

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Abstract. The goals of science education are to enable students, to understand the natural world and to give them the opportunity to experience. In this context, the school environment is considered as a limited learning environment for the Science course. There are many opportunities for science education in outdoor learning. Qualitative research method has been used. The participants of the research are 150 secondary school students who are 6th and 7th grade, determined by using easily accessible case sampling. An interview form consisting of 13 open-ended items was used. The data obtained were analyzed by content analysis. As a result of the study, we can state that there are many things that students want to do about outdoors learning, but they did not have the opportunity to have enough experience.

Keywords. Science Education, Outdoor Learning, Nature, Secondary School.

1. Introduction

New approaches to learning and teaching processes emphasize that individuals should be trained as individuals who can take responsibility in their own learning processes, think critically, research and use the scientific method in their approach to problems and act independently in line with the decisions they take. For this purpose, it is stated that the formal learning experience in schools and the informal experiences provided in outdoor learning environments together will make important contributions [1-2]. The learning environment, which expresses the external conditions of the concept of learning in general, is defined as the areas where the teaching materials and tasks are structured so that the desired teaching process is realized [3]. The developments in science and technology have expanded the learning environments previously thought to be in-school and classroom, by including outdoor learning environments. It is stated that informal science learning environments, which it deems difficult to define, can be counted as many areas such as museums, zoos, botanical gardens, science centers, nature areas [4]. In addition, it is stated that all nature areas such as school gardens, agricultural areas, nature parks (national parks) can be used as an outdoor learning environment [5]. Museum, botanical gardens, zoos, park, garden-like nature areas are described as field trips within the scope of science learning in the outdoor learning [6]. Most studies show that outdoor learning environments improve students' science skills, explore various scientific topics, academic achievements, attitudes towards science, and learning are easier [7-10]. In addition to these contributions, outdoor learning environments have an important place in the literature in terms of supporting formal education, achieving the objectives of the program and creating environmental awareness [11-15]. In this context, outdoor learning environments are the most suitable learning environments for the student to use scientific process skills and structure information, to embody the concepts in the units covered by the science course, and to provide first-hand resources. The main purpose of this research is to determine the attitudes of secondary school students towards the use of outdoor learning (based on nature experience) approach in science classes.

2. Method

2.1. The Model of the Study

In this study, a phenomenological pattern, which is one of the qualitative research models, has been used to determine the views of secondary school students towards the use of outdoor (based on nature experience) learning approach in science classes. It can be said that for phenomenological pattern, it is a technique that emphasizes the facts that are known but not considered with a detailed and detailed understanding. Cases are frequently encountered in daily life. However, an appropriate environment can be created thanks to the researches aiming the facts for their full understanding [16].

2.2. Sample of the Study

In the study group, there are 70 students from the 6th grade and 80 students from the 7th grade. A total of 150 students participated in the research.

2.3. Gathering the Data

An interview form consisting of 13 open-ended questions was used in order to determine the opinions of the participants towards outdoors learning in science classes. The draft form prepared as a result of the literature review, all items were collected in the form, presented to the expert opinion and finalized after necessary corrections were made. Students who accepted to participate in the study on a voluntary basis were included in the study group.

2.4. Analysis of the Data

For the analysis of the data, the answers given by the students to the interview items were subjected to content analysis. Content analysis technique is an effective technique that helps study written or visual documents in depth [17]. The arranged data are tabulated.

3. Findings

In the research which had been carried out to determine the views of secondary school students about outdoor learning, thirteen themes and codes of these themes were determined. These themes and codes and frequencies of the codes are given in the tables below. While the frequencies of the codes of the themes are given in the tables, the highest ones are given and the less codes are not included in the tables.

The themes and codes related to the first question of the study where students write when they think of nature are given in Table 1. Opinions of secondary school students about learning in the outdoor learning are collected under the “Concepts Conceived by the Concept of Nature in Students” and under 25 codes. The thoughts that come to mind when students say nature are presented in Table 1.

When it comes to nature, secondary school students respond to the most green areas, while ten students responded to the feelings of nature.

“*When I say nature, I think a green world.” (S1), “When I think nature, I think forests, trees and animals.” (S2), "When it comes to nature, I think being peaceful, calm and happy." (S3)*

Table 1. Theme, Code and Frequency Table Regarding Nature Concepts Conceived by the Students

Theme	Code	f
Nature Concepts Conceived by the Students	Green areas (Forests, Picnic Areas etc.)	75
	Different types of plants / flowers	36
	Different types of animals	29
	Water areas (Streams, lakes, seas, waterfalls, etc.) and soil	20
	Fresh air and a clean environment	25
	Different types of insects	12
	Peaceful, calm environment and feeling of happiness, love	10

The themes and codes in the second question in which students write what they think of when it comes to learning in nature are given in Table 2. The data are collected under the theme of Associations of Learning by Nature in Students and under 25 categories, but low frequency categories are not included in the table (Table 2). The thoughts that students think when it comes to learning in nature presented in Table 2 are given below.

Table 2. The Thoughts that Student Think When They Say Learning in Nature

Theme	Code	f
The Thoughts that Students Think When They Say Learning in Nature	Learning to live in nature	23
	Awareness on protecting nature	17
	Observing creatures	16
	Studying in the forest	15
	Observing trees and studying plants	15
	Learning different things in nature and having picnic	10

When it came to learning in nature, most secondary school students responded that they could learn living in nature, while ten students responded that they could learn and different things in nature and have picnic.

“When it comes to learning in nature, I think living freely in nature and learning about nature.” (S2), “I think we can learn to be conscious with nature learning and to be respectful towards nature.” (S4), “When I think of learning in nature, I think of camping and picnic and teaching.” (S5)

The themes and codes related to the third question of the research are given in Table 3. The data are gathered under 29 categories, under the Theme of the Activities Students Want to Do in Nature, but the categories with low frequency are not included in the table (Table 3). Activities that can be done in nature presented in Table 3 are given below.

Table 3. Activities That Can Be Held in Outdoor Learning

Theme	Code	f
Activities Students Want to Do in Nature	Planting seedlings	32
	Camping in nature	20
	Doing activities such as football, volleyball etc. and collecting rubbish	20
	Hiking	16
	Examining the structure of plants and flowers	10

When the activities that can be done in outdoor learning are mentioned, secondary school students responded to planting the most seedlings, while ten students answered as examining the structure of plants and flowers.

"*I would plant thousands of seedlings in the forest if I had it." (S3), "As an outdoor activity, I would like to examine the structure of trees, stones, insects." (S6)*

Themes and codes in the fourth question, which the students want to make in nature, write their discoveries and observations, are given in Table 4. The data are collected under the theme of Discoveries and Observations that Students Want to Make in Nature and under 26 categories, but the categories with low frequency are not included in the table (Table 4).

Students responded most to the study of animal life, while twelve students responded to the study of plant life.

"I would like to learn to see how plants and animals that I want to explore and observe in nature are based on how animals are fed under difficult conditions." (S3)

"I would like to study the life and DNA of stones, trees, insects, fungi, birds and more in nature." (S6)

Themes and codes in the fifth question, in which students write science lessons that can be learned in nature, are given in Table 5. The data are collected under the theme of Science Lessons that can be learned in Nature and under 31 categories; however, the low frequency categories are not included in the table (Table 5). In Table 5, the topics that can be learned outdoors in science course are given below.

Table 4. What Students Want to Explore and Observe in Nature

Theme	Code	f
Discoveries and Observations Students Want to Make in Nature	Examining the life of animals	28
	Bird watching	21
	Observing the life of wild animals and protecting nature	16
	Sky observation	12
	Examination of plant life	12

Table 5. Topics That Can Be Learned Outdoors in Science Course

Theme	Code	f
Science Topics to be Learned in Nature	World of Creatures / Getting to Know Creatures	39
	Force and Energy	12
	All topics	8
	Energy Conversions and Environmental Science / Energy Conversions	8
	Human and Environment / Biodiversity	7
	Reproduction, Growth and Development in Living Things / Reproduction, Growth and Development in Plants and Animals	6

Under the code of the subjects that can be learned outdoors in the science class, the students responded to the topic "The World of Living Things / Getting to Know Themes", while six students responded to Reproduction, Growth and Development / Reproduction, Growth and Development in Plants and Animals.

"We can learn the issues of Force and Energy." (S7)

"I would like to learn the properties of plants and how they grow." (S8)

"We can learn the genetic structures of trees or plants there." (S9)

Themes and codes related to the sixth question are given in Table 6. The data are collected in the theme of Learning Activities in the Nature of Students Previously and under 21 categories, but the categories with low frequency are not included in the table (Table 6). In Table 6, students' experiences of learning activity in nature are given below.

Table 6. Students' Experiences of Learning Activity in Nature

Theme	Code	f
Learning Activities In Nature Made By Students Before	I did not	52
	Planting a tree	24
	Having a picnic	11
	Mountain trip	10
	Examining the plant structure	6
	Collecting garbage	6

Most secondary school students stated that they had no learning activity experiences in nature, six students responded to collect rubbish and another six to study the plant structure.

"*Actually, we learn many things from nature without realizing it." (S10)*

"I did not do any activities related to nature." (S7)

The themes and codes in the seventh question of the students who attended the nature camp and their experiences are given in Table 7. The data were collected under the theme of Number of Students Attending / Not Attending Nature Camp and under 2 categories (Table 7). In Table 7, the number of students attending / not attending the nature camp is given below.

Table 7. Number of Students Attending / Not Attending Nature Camp

Theme	Code	f
Number of Students Attending / Not Attending Nature Camp	Attending	12
	Not attending	128

When we asked secondary school students about their experiences, if there were people attending nature camps, most of the students stated that they did not attend while only 12 students attended.

"I did not participate, but I would love to participate." (S6)

"I attended the nature camp in the third grade and had the experience of staying in a tent." (S11)

"I attended and examined the plants with a magnifying glass." (S12)

Table 8. Things to Do to Protect the Environment in Nature

Theme	Code	f
Activities to Protect Environment	Not to litter places	78
	Planting seedlings	69
	Collecting garbage	65
	Warning trashers	52
	Increasing the number of trash cans	44
	Protecting animals	35
	Increasing the number of recycle bins	32
	Feeding animals	27
	Punishment of those who throw away trash	22
	Less plastic usage	20

Themes and codes in the eighth question, in which what students can do to protect the environment, are given in Table 8. The data are collected under the theme of Environmental Protection Activities and under 26 categories, but low frequency categories are not included in the table (Table 8). In Table 8, activities to protect the environment are given.

When it is said what can be done to protect the environment in nature, middle school students responded to planting the most seedlings, while twenty students responded as using less plastic.

"Recycling bins can be placed next to the trash bins." (S12)

"We can plant tree saplings and create a list of what we have to do and announce them to everyone." (S3)

Themes and codes in the ninth question, which includes what students want to do in forest trip within the scope of science course, are given in Table 9. The data are gathered under the theme of the Students Wants to Do in

Forest Trip within the Scope of Science Course and 29 categories, but the categories with low frequency are not included in the table. Table 9 shows what can be done in a trip organized in science class.

Table 9. What Can Be Done in a Trip Organized in Science Course

Theme	Code	f
What Students Want to Do in Forest Trip Within the Scope of Science Course	Cleaning up	31
	Observing the lives of animals	30
	Birdwatching	25
	Observing animals living in the forest	23
	Researching	23
	Taking a walk in the woods	22

When it is said that what can be done in a trip organized in science class, secondary school students responded as much as cleaning up, while twenty-two students responded as walking in the forest.

“If such an event was held, I would like to have birdwatching.” (S13)

“I would like to examine the creatures and plants around me.” (S14)

Table 10. School Playground That Students Want

Theme	Code	f
Students' Ideas in Organizing the School Garden as a Learning Place	Should be afforested	44
	Should be different types of flowers	31
	Should be clean	24
	Should be wider	21
	Should be the area to experiment	20
	Should be more grass fields	18

When it is said that the school garden should be arranged as a learning place, secondary school students responded as the most should be afforested, while eighteen students responded as the grass areas should be more.

“I wish there was a green area full of trees and flowers.” (S11)

“There must be an area where you can do some lessons.” (S12)

Themes and codes in the eleventh question about students' ideas about outdoor areas near home and school are given in Table 11. The data are collected under the theme of Outdoor Areas Near Home and School and under 12 categories, but the categories with low frequency are not included in the table (Table 11). In Table11, there are data on playing fields near home and school.

Table 11. Playgrounds Near Home and School

Theme	Code	f
Outdoor Areas Near The House and School	Park	82
	Home garden	34
	Schoolyard	29
	Green fields	21
	Roadside, sidewalks	13

When it comes to outdoor areas near home and school, secondary school students responded the most to park, while thirteen students responded as roadside and sidewalks.

There are football and basketball courts in the school garden. There is a park near our house. ”(S15)

“There is a walking path and a park near us.” (S14)

Themes and codes in the twelfth question related to the students' skills to learn while hiking and boating are given in Table 12. The data are collected in the theme of the Skills Students Think to Learn When Hiking and under 21 categories, but low frequency categories are not included in the table (Table 12). In Table 12, the things that students can learn about hiking and boat activities are given below.

Table 12. What students can learn in Hiking and Boating Activities on the River

Theme	Code	f
Skills Students Think to Learn While Hiking and Boating	Examining living spaces of living things	42
	Different types of fish	32
	Awareness that we need to protect our nature	26
	Different types of plants	26
	How the boat is in balance	24

When the nature walk is said to be learned in the activities of boatinging on the river, secondary school students respond to examine the living spaces of the most living creatures, while twenty-four students answered how the boat was in balance.

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"*We can observe aquatic plants, aquatic creatures, birds." (S6)*

"We can learn about living life and oxygen carbon dioxide." (S14)

The themes and codes in the thirteenth question, where the ideas of the students to arrange the school garden as a forest or garden, are given in Table 13. The data are gathered under the theme of Students Organizing SchoolYard as Forest or Garden and under 10 categories, but the categories with low frequency are not included in the table (Table 13). Table13 contains findings on students' arrangement of the school garden as a forest or garden.

Table 13. Students Arranging the School Garden as Forest or Garden

Theme	Code	f
Students' Ideas to Arrange Schoolyard as Forest or Garden	Creating playgrounds	44
	Reforestration	92
	Sewing different flowers	35
	Putting animal kennels	22
	Putting recycle bins	23

When it is said to arrange the school garden in the form of a forest or a garden, middle school students responded to creating the most playgrounds, while twenty-three students responded as putting recycle bins.

"*Reforestation and playgrounds can be made." (S16)*

"Each student can plant a tree." (S17)

"Planting should be done first, and then recycle bins should be placed and everyone should be informed." (S18)

4. Conclusion

In this study, it is aimed to determine the attitudes of secondary school students towards the use of outdoor learning approach in science classes. The activities that students want to do in the theme of the activities that students want to do in nature are planting tree, camping and sports activities. From this point of view, students did not express the activities to be carried out about outdoor learning. However, activities can be done in many fields from mathematics to literature. However, as the children express themselves, they are not very aware of what they can do outdoors because they do not have enough these experiences. Looking at the theme of the Students' Learning Activity in Nature theme, it is understood that many students have not done many outdoor activities before. When we look at the Number of Students Attending / Not Attending Nature Camp, students generally did not attend any camps. Those who stated that they attended stated that they did not receive a detailed nature education.

Looking at the students' Ideas for Organizing the School Garden as Forest or Garden theme, we see that most of the students want the school garden to be wider, to be reforested and to be clean. In parallel with this finding, it is stated that outdoor learning environments allow observation [7]. It is among the observed results that the science subjects which are abstract with outdoor learning environments are made concrete by means of one-to-one interaction. It is stated that the support of education and training activities carried out with formal education with outdoors learning environments, reinforcing existing learning, affecting students' affective characteristics and scientific process skills will improve positively [18]. It is emphasized that the trips planned and repeated for a purpose support both in-class education and the development of students' scientific process skills [8]. By associating the science program with the activities to be performed in outdoor learning environments, students can be better understood the issues, learning the concepts by embodying them and gaining various gains. Outdoors learning environments are very important in raising students as individuals who can research, question and reach a result [19].

Outdoors learning provides permanent learning to children, where they can feel comfortable and peaceful and gain first-hand experience. In recent years, educational activities related to outdoor learning have gained importance in many countries around the world. Especially Finland, Denmark, Singapore are very successful in this regard. But Turkey is not in a very good situation in this regard. Looking at the literature, there are some preschool activities. Very few forest schools and nature camps are held. The reason for these deficiencies may be due to teachers' attitudes, the structure of the education system, crowded classes and socio-cultural factors.

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1st, 2nd and 3rd Grade Primary School Students' Perceptions of 'Living Organism' Concept

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Abstract. In this study, 1st, 2nd and 3rd grade primary school students' concept perceptions of "living organism" have been investigated and phenomenological design has been. The sample of this study has been selected through simple random sampling method. Drawing technique has been benefited to collect data and "Form of Identification of 'Living Organism' Concept through Drawing Technique" as data collection tool has been used. Chi-square test has been used to analyze students' drawings with the relations between determined variables. There are differences between students' perceptions of 'living organism' concepts in terms of gender, number of siblings and living space.

Keywords. Drawing, Living Organism, Perception, Primary School Students.

1. Introduction

One of the main purposes of science education is to bring up individuals, who can do research, investigate, criticize as a requirement of modern age they are living in, make connections with science in their daily lives and see life through the eyes of a scientist. Therefore, learning science means to learn investigation, techniques and methods. Skills of reaching information and knowledge generation through using scientific methods are scientific process skills used in science [1].

The role of science education is to enable students to learn science concepts and develop thinking skills [2]. For this reason, the problems related with instructional methods should be identified. Children at young ages should learn science concepts accurately because this will facilitate science education in their later steps of education.

Teaching concepts is an important process starting from the first years of primary school [3]. Teaching science information, which cannot generally be concretized, accurately and completely is quite significant for students' understanding the concepts which they encounter in secondary education and later periods.

Science studying life covers the difference between living and non-living organisms. Separating world into two components as living and non-living organism requires firstly recognizing living organism concept and knowing different types of it [4]. According to the description of living organism in Science lesson, a creature requires to move in order to become a living thing, be nourished in order to survive, create other living beings similar to itself, grow up after being born and lose its life after living for a specified time since its birth. Creatures which don't have these features are described as non-living things [5].

Liveliness can be defined through comparing and contrasting the things which live with the non-living things which were once alive or has never lived. Nevertheless, these two acknowledgements are not always separated from each other at all researches. Pioneer studies related with the ideas of children about living organisms were developed by Piaget. He observed that children had the ability of sensation, feeling and intention about a number of living organisms and they named them as "living organisms". He found out that children had an idea for where the things like sun, cars, wind, time and fire goes and they mentioned about the feeling of "pinprick". When they were asked what they knew about living and non-living organisms, they made judgments on the livings of similar things. Children below 10 years old perceived non-living organisms as natural physical events like in this example: "Sun is hot because it wants people to keep warm".

According to Piaget, one of the features of preoperational stage is animatisms. Children at this stage can think the non-living organisms as living organisms. They establish a dialogue with their toys like they are living beings and can think that toys can hear and understand them. In spite of this, they can think living organisms as non-living organisms and behave accordingly. They can treat a living cat like a toy. In short, children cannot distinguish between living and non-living organisms at this stage [6]. Therefore, the stage in which children experience should be taken into consideration at the situations where the living and non-living concepts cannot completely be understood.

The learning domain called as "Livings Things and Life" in Science lesson and the unit called as "Life in Nature" at Life Science lesson, deals with living organisms as a basis. Various scales and evaluation forms can be used in order to measure 1st, 2nd and 3rd grade primary school students' concept perceptions of "living organism". However, because of children's young age drawing technique or picturing will enable students to express themselves accurately and this will also increase the motivation towards lesson. Children's drawings express their experiences, opinions and interpretations. The things which are expressed through games and speeches can be expressed through drawings, as well. Children who draw are the ones who are happy and satisfied. Children benefit from drawings while expressing their relations with the world, fear, joy, dream, pain, etc. Drawing is a starting point for communication and art work represents an appearance of students' personality. Children rarely prefer not to draw and this can be a reflection of a trauma [7].

This study has been carried out to identify 1st, 2nd and 3rd grade primary school students' concept perceptions of "living organism" through drawing technique for the application of beneficial science education and to determine whether these concepts differ in terms of some variables.

2. Research question

What are the effects of some variables (gender, the number of siblings and living space) on 1st, 2nd and 3rd grade primary school students' concept perceptions of "living organism"?

3. Method and sample of the study

In this study, phenomenological design has been used. Phenomenological design emphasizes phenomenon which are recognized but cannot be thought with the deep and detailed understanding. In daily life, people usually come across with phenomenon but through researches aiming at studying phenomenon, a convenient environment can be created to explain the phenomenon [8].

The population of this study is consisted of 1st, 2nd and 3rd grade primary school students in the city of Afyonkarahisar, district of Iscehisar and its villages and towns at 2014-2015 school year and the sample of this study is consisted of 938 students. Data has been collected by the students studying at 14 different primary schools. The frequency of students' grades is given in Table 1.

Table 1. The Frequency of students in terms of grades

Grade	f	%
1st Grade	233	24.8
2nd Grade	308	32.8
3rd Grade	397	42.3
Total	938	100

According to Table 1, 24.8 % (233) of the students are 1st grade students, 32.8 % (308) of them are 2nd grade students and 42.3 % (397) of them are 3rd grade students.

4. Data collection technique and tool

In this study, drawing technique has been used as a data collection tool. "Form of Identification of 'Living Organism' Concept through Drawing Technique", prepared by the researchers has been used as a data collection tool. Before carrying out this research, necessary permission has been obtained for the use of "Form of Identification of 'Living Organism' Concept through Drawing Technique" at the primary schools in the city centre, at the districts, villages and towns for 1st, 2nd and 3rd grade primary school students'. During application, students were told about the points that they should be careful while completing the data collection tool. Researchers waited for students' completing the forms and made necessary explanations when it was required. Students were free to draw anything related with living organisms and they were asked to draw on "Form of Identification of 'Living Organism' Concept through Drawing Technique". There weren't any limitations on students' drawing. Therefore, it was thought that students were able to express themselves freely on their drawings.

Chi-square test has been used to analyze students' drawings with the relations between determined variables. Data which were obtained through "Form of Identification of 'Living Organism' Concept through Drawing

Technique" have been analyzed and saved at computer. Reliability analysis of the scale has been done by 1 expert and 3 teachers and the scale has been approved. The analysis has been done through following the steps respectively below:

- Elimination and Coding Stage
- Computerizing Data Stage
- Developing Categories Stage
- Ensuring Reliability Stage

5. Validity and reliability of the research

Inter-rater reliability formula which was developed by Miles and Huberman was used in order to analyze and categorize students' drawings [9]. Miles and Huberman suggest that there should be more than one researcher who will code and this coding should be checked by a different person in order to measure consistency. According to Miles and Huberman, if reliability calculations are above 70 %, the analysis is accepted as reliable. In this study, the reliability of "Form of Identification of 'Living Organism' Concept through Drawing Technique" has been calculated as 90.3 %.

6. Analysis of Data

Chi-square test (Chi-Square Test $\chi 2$) has been used to analyze students' drawings about living organisms for finding out whether drawings differ or not in terms of determined variables. The significance of the relationship between two categorical variables or between one numerical variable and one non-numerical (categorical) variable is determined through Chi-square test [10].

7. Findings

Students' concept perceptions of "living organism" are given in Table 2 after analyzing their concept perceptions.

According to Table 2, 0.2 % of students (f:2) didn't draw anything for Item 1. 1.3 % of them (f:12) drew something wrong so couldn't perceive the concept. 46.6 % of them (f:437) partially perceived the concept and 51.9 % of them (f: 487) fully perceived the concept. Students who drew wrong (the ones who didn't perceive) were included in the category of "partially perceived" in order to ensure the reliability in data analysis.

Table 2. The Frequency of students' drawings of living organism

	f	%
No drawing	2	0.2
No perception	12	1.3
Partially perception	437	46.6
Fully perception	487	51.9
Total	938	100

The frequency of students' drawings of living organism is given in Table 3.

Table 3. The Frequency of students' drawings of living organism

	f
Human being	302
Tree	283
Flower	251
Bird	123
Butterfly	108
Cat	102
Dog	81

This question was asked to the students: "What has come into your mind when living organism is said? Please draw the living things that come to your minds." According to Table 3, students in general drew human being (f:302), tree (f:283), flower (f:251), bird (f:123), butterfly (f:108), cat (f:102) and dog (f:81). However, there were many various drawings. In students' drawings, it is seen that there are 1080 animal figures, 302 human being figures, 550 plant figures and 1 microbe figure. When the frequency of students' drawing of living organism is examined, it is observed that animal figures are more than plant figures. It is thought that drawings have this kind of tendency because animals can be easily observed while moving and being fed when they are compared with plants. Moreover, there is also one drawing in which there is a flower eating carnivore (bug).

Students wrote about the features of living organisms such as nutrition, movement, respiration and growth. Moreover, students who wrote about excretion as a feature of living organisms both drew it and explained this system. In general, students wrote about the feature of movement living organisms and they also emphasized the nutrition.

The frequency of students' wrong drawings of living organism is given in Table 4.

Table 4.The Frequency of students' wrong drawings of living organism

	f
Cloud	12
Sun	10
Snow man	1
Cleats (crampon)	1
Television	1
Television remote control	1
Fridge	1

According to Table 4, there are some wrong drawings of living organisms which include 12 clouds, 10 sun, 1 snow man, 1 cleat, 1 television, 1 television remote control and 1 fridge.

The most made mistakes about the perceptions of living organisms are related with the concepts of "cloud" and "sun". Students used "sun" as a living organism in their drawings. When these drawings were examined, it was seen that there were also eyes and mouth of the sun. It can be said that the sun is personalized and has a smiling face. Moreover, students often drew "fruits" and "grass" at both areas. Students drew the trees' falling leaves and growing grass in order to express the concept of living organism.

When the impacts of gender, the number of siblings and living space on 1st, 2nd and 3rd grade primary school students' concept perceptions of "living organism have been examined, it is seen that there are significant differences between groups.

Chi-square test results of students' drawings of the concept of living organisms according to gender are given in Table 5.

According to Table 5 as a result of the analysis, there is a significant difference between the groups in terms of gender and the level of perception of "living organism" concept (p=.033<.05). According to the analysis results, female students with a rate of 55.3 % drew right in comparison with male students.

Table 5. Chi-square test results of students' drawings of the concept of living organisms in terms of Gender: Partial Perception and Fully Perception

G		PP	FP	χ2	p
Female	N	214	265	4.54	.033
	%	44.7	55.3		
Male	N	237	222		
	%	51.6	48.4		
	N	451	487		
Total	%	48.1	51.9		

Chi-square test results of students' drawings of the concept of living organisms according to the number of siblings are given in Table 6.

Table 6. Chi-square test results of students' drawings of the concept of living organisms according to the Number of Siblings: Partial Perception and Fully Perception

NS		PP	FP	χ2 p
1	N	151	203	4..54.000
	%	65.0	35.0	
2	N	65	35	
	%	42.7	57.3	
≤3	N	235	249	
	%	48.6	51.4	
	N	451	487	
Total	%	48.1	51.9	

According to Table 6 as a result of the analysis, there is a significant difference between the groups in terms of the number of siblings and the level of perception of "living organism" concept (p=.000<.05). According to the analysis results, students who have 2 siblings with a rate of 57.3 % drew right in comparison with the students who have 1 sibling and the ones who have 3 and more siblings.

Chi-square test results of students' drawings of the concept of living organisms according to living space are given in Table 7.

According to Table 7 as a result of the analysis, there is a significant difference between the groups in terms of the living space and the level of perception of "living organism" concept (p=.000<.05). According to the analysis results, students who live in villages and towns with a rate of 62.1 % drew right in comparison with the students who live in district and city.

Table 7. Chi-square test results of students' drawings of the concept of living organisms according to Living space: Partial Perception and Fully Perception

LS		PP	FP	χ2 p
Village/Town	N	107	175	56.3.000
	%	37.9	62.1	
District	N	184	91	
	%	66.9	33.1	
City	N	160	221	
	%	42.0	58.0	
	N	451	487	
Total	%	48.1	51.9	

8. Discussion and conclusion

In this study, the question of "How are 1st, 2nd and 3rd grade primary school students' concept perceptions of living organism?" has been investigated. The forms which have been gathered from 938 students have been evaluated after data analysis. Two students cannot perceive the drawing of living organism, twelve students have made wrong drawings, 437 students have partially perceived the concept of living organism and 487 students have fully perceived the concept of living organism. According to these results, it is seen that students in general are able to distinguish the concept of living organism and express their feelings about it.

When the impacts of gender, the number of siblings and living space on 1st, 2nd and 3rd grade primary school students' concept perceptions of "living organism" have been examined, it is seen that there are significant differences between groups. According to the analysis, it is found out that there is significant difference in terms of students' living space. In Ulu's study, in which students' understanding of science education was studied through the individual drawings of 4th and 5th grade students, significant difference is found out in terms of gender [11]. This finding supports one of the findings of this study of students' perceptions of "living organism" in terms of gender.

Bahar studied the opinions of students about the concept of living organisms and there were 100 students whose ages were between 11-16 years old [12]. They were asked questions through pre-prepared grids. According to the results, it was stated that students had various ideas about living and non-living things, students at all age groups knew main features of living things but a significant number of students didn't know the concept of dormant. In their study, Villarroel and Infante aimed to determine the knowledge of 118 students between the ages of 4 and 7 on the concept of living things on plant life using two types of tests [13]. As a result, they couldn't find any difference between the students according to the age variable. According to these results, it can be said that students in general distinguish the concept of living with non-living but they don't have enough information about some special situations, which is one of the results of our study.

However, there has not been enough research on the concept of living organism in early childhood. Various experimental designs can be made to contribute for uncovering concepts. There are many researchers related with this subject but the ability to accurately distinguish living things from non-living things may be related with the developmental process and the studies are not enough to examine the characteristic features of the drawings of the young children. Considering the important reasons supporting the thesis that the most competent technique is drawing to explain the thoughts of young children, surprisingly, the lack of alternative working methods is emphasized [13]. In order to achieve the objectives of the Science lesson completely, the concepts in the course content must be learned correctly. Various studies should be carried out in order to understand the concept of living organisms correctly. These studies should be prepared and enriched by considering students' levels.

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Elimination of the Problems in English Reading Skills with Pre-Reading Strategies

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Abstract. Many students learning English complain that they understand English, but don't feel confident enough to join a conversation. Well, how the learners fix it? In fact, the answer is not so difficult. They can try to use pre-speaking strategies before the start a conversation. So, in this study it is aimed to contribute of students speaking skills by teaching them pre-speaking strategies. The study group consists of 34 students attending 9-D class in a high school in Afyonkarahisar during 2018-2019 academic year. Research data were collected by semi-structured interview form, observation form, researcher-practitioner and student diaries. Descriptive analysis was used in the analysis of the data. Data indicate that students have successfully completed speaking activities with pre-speaking strategies. This study was extracted from "The Preparation, Implementation, and Evaluation of Language Learning Strategies Curriculum Draft" Doctoral Thesis.

Keywords. Pre-speaking, Speaking Skills, Strategy.

1. Introduction

Speaking, among the four major skills, seems mostly favored as every English language learner aspires to be effective in communication. In other words, speaking has always been the most challenging skill for most of students. The importance of teaching speaking skill is that language is acquired through speaking and listening before one learns reading and writing.

Speaking is defined as an interactive process of building meaning that includes producing, receiving and processing information [1]. The main goal when teaching speaking is oral fluency, which is defined as the ability to express oneself intelligibly, reasonably accurately and without too much hesitation. Speaking serves important and several purposes in language learning. To interact socially consists of being able to communicate with other people, and having the competence to adjust language appropriately to the context. To develop self-awareness means being able to explore personal thoughts, emotions and opinions. Finally, to inform obviously consists of providing information and being able to present the information appropriately to context, with consideration to listeners' benefit. speaking leads to increased skills in other areas of language learning, in addition to leading to further growth in speaking abilities. Thus, speaking and conversation are not just the aim of learning English, but the means for language development [3].

Studies demontrate that speaking skill is the most neglected skill in language instruction. Most students do not even have the opportunity tospeak in the classroom or outside it. Moreover, speaking is not a part of the examination in most language courses. As it has been discovered by many researchers, foreign language learning best occurs through interaction, teachers should provide learners with the opportunities to communicate English at the lesson. Since many learners' goal in language learning is to be able to communicate fluently in formal and informal interactions, classroom activities should be designed to promote oral fluency. However, the ability of speaking is a complex process in its nature; many of the learners are anxious to speak in the classroom or outside to due to different social or psychological reasons so they keep silent. Therefore, it is necessary for language teachers to implement some natural strategies such as: role plays, group work, projects, etc. to avoid shyness and unwillingness of the learners so that they can participate in the speaking activities in the classroom [4]. It is important if teachers teach students how to speak strategically for effective communication. Strategy based instruction is a process oriented approach to teaching which focuses on the learning process, and results in improvements both in the process and product of learning. Strategy means a plan, step, or conscious action toward achievement of an objective [5].

It is stated that the ability to speak a language is synonymous with knowing that language since speaking is the most basic means of communication [6]. Teaching speaking is also crucial because it can also help improve other language skills; it can help learners build vocabulary, improve grammar, listening and writing as well. Undoubtedly, learning to communicate in the foreign language requires a lot of time and efforts. Since students already know one or sometimes more than one language, they might have some expectations about how a language works consciously and unconsciously in the human mind. Although this knowledge can help students acquire another language easier, some studies show that for language learners knowing another language can get in their way as they try to speak in the new language. Considering this, teachers should encourage learners to use their own cognitive abilities to help them activate the conscious process of learning another language [4].

The ability to speak in English gives the learner a cultural perspective, experience, knowledge and useful information through texts. However, teaching speaking English is sometimes more difficult than other skills in second language teaching. Because English has different features compared to Turkish in terms of grammar, vocabulary, pronounciation. These differences can cause problems among learners. Therefore, teachers teaching foreign languages or second languages should use various techniques and methods to help learners in the process of teaching English speaking skills. There are many strategies, methods and techniques that can be used in the English language teaching process. One of them is pre-speaking strategies. The teachers need to help the students get along with the text since the beginning of the speaking process. The teachers can prepare the students before they start to speak.

From time to time, teachers encounter a number of problems in the classroom learning process during the teaching of speaking skills. One of these problems is related to learning strategies. Teachers do not always find it effective to use direct expression method in speaking. Using different pre-speaking strategies in the learning environment will contribute to the solution of the problems that students will encounter while speaking.

Therefore, teaching pre-speaking language learning strategies to students or using them in learning environments offers a different perspective on the development of speaking in English. It contributes to the increase in student performance in English speaking skills by motivating students to learn and decreasing anxiety. It helps the development of student performance in communication skills. It enables language teachers to establish a new link between English speaking skills and communication skills. For these reasons, in this research, it is aimed to eliminate the problems faced by students in their English speaking skills by teaching their students pre-speaking language learning strategies. In this context, the answers of the following research questions will be sought in the research:

1. What are the positive contributions of using pre-speaking language learning strategies in English speaking skill activities?
2. What are the negative aspects of using pre-speaking language learning strategies in English speaking skill activities?
3. What is the contribution of pre-speaking language learning strategies to the development of English speaking skills?

2. Method

The research was handled with the action research method, which is one of the qualitative research methods. Action research critically addresses the development and implementation of educational workers' own schools, classes, educational studies and initiatives, and the assessment of their effectiveness. Thus, it offers a different perspective in dealing with educational problems [7]. This study includes teaching pre-speaking language learning strategies in order to improve the speaking skills of students who have problems in the development of speaking skills in the English learning process. Therefore, it is aimed to contribute to the development of speaking skills of students by using action research in these applications.

2.1. Sample of the Study

The study group of the research was determined with the purposeful sampling method, which is one of the non-random sampling methods in order to conduct in-depth research and to reach data rich in accordance with the research problem. The study included 34 students, 20 females and 14 males, who continued their education in the 9-D class in a high school in the city center of Afyonkarahisar in the 2018-2019 academic year.

2.2. Data Collection Tools

As the research was designed as a qualitative research, qualitative data collection tools were used in the data collection process. A qualitative method does not have to be used for data collection or data analysis in qualitative research [8]. One or more of the various data collection tools can be used from observation to interview. The data collection process of this research was carried out in two stages. The first data related to the research were collected during the implementation of the action plans. In this process, observation form and researcher diaries were used as data collection tools.

The second step of collecting data for the research is to conduct interviews. At this stage, the data were collected through semi-structured interview forms. Interview questions direct the dialogue with the interviewee and provide an opportunity to express their views and experiences about the situation [9]. For this reason, interview forms were used after the implementation of action research.

2.3. Analysis of Data

In the research, descriptive analysis was made by coding the data obtained from the interviews in accordance with the themes and sub-themes determined before the interviews. In addition, content analysis was carried out by coding in accordance with the new themes that emerged during the examination of the data. Therefore, in the research, the data were analyzed with a mixed method by using both descriptive and content analysis. Data obtained from the researcher-practitioner diary and observations were included in the research by making direct quotations. In qualitative research, direct quotations will contribute to the understanding of social events, as this will enable in-depth discovery of the subject.

2.4. Reliability and Validity

One of the methods that can be used to ensure the reliability of the data collected in qualitative research is triangulation [10]. Triangulation is the comparison of the results of two or more data collection methods, two or more data sources. Thus, weaknesses of one of the methods can be compensated by the strengths of the other method [11]. In this study, the reliability of the study was ensured by diversifying the data collection tools during and after the action research application.

2.5. Implementation of Action Plans

The varieties of pre-speaking activities are implemented in 9/D class in the academic year 2018/2019. The teacher starts the speaking class with the varieties of pre-speaking activities before giving the students a speaking subject. Within the scope of the research, a total of five different activities were held in two weeks with the students. The researcher is also a practicing English teacher. The practitioner treats the problems he / she detected in his / her lesson as a researcher and aims to eliminate the problems. A number of pre-speaking language learning strategies were taugt before speaking activity.

3. Findings

Research findings are handled in two stages as the data collection process takes place in two stages. In the first stage, the notes of an observer in the class during the action plan implementation process and sample statements from the researcher-practitioner diary are included. In the second stage, the frequency table of the interviews with the students and sample expressions from the interviews were given after the implementation. Sample expressions obtained from observations, diaries and interviews related to the first sub-problem of the research are given below:

Observation:

“Almost all of the students expressed or felt dissatisfaction when the teacher stated that they would consider pre-speaking strategies in the classroom. The negative attitudes of students towards this skill could be felt from their behavior. The teacher calmed the students but it could be done more effectively. The warm-up exercise after the students partially calmed down actually made the students feel more comfortable. The students worked as a group and tried to find the similarities and differences between each other.

It was quite good to prohibit speaking in the mother tongue. The students tried to speak by force.” (05/11/2018)

Researcher-practitioner Diary:

“The warm-up study of the course on pre-speaking strategies was related to the similarities and differences of the students. This created an opportunity for the lesson as it was a subject that students knew and could easily express themselves. Again, it was an opportunity for the activities in speaking activities to proceed in parallel with the subjects in English lessons. In speaking activities, indirect strategies, in other words, affective strategies should be included more. In particular, students need motivation both individually and as a class at every stage of speaking activities.” (05/11/2018)

The students encountered more English speaking topics in these lessons. This situation caused them to be overexposed to the target language. Students saw various pre-speaking language learning strategies in this course. This situation caused a feeling of curiosity in them. Data obtained from observation notes and researcher-practitioner diaries discussed during the action plan implementation show that students encounter these strategies for the first time. However, although the students met for the first time, they had anxiety about speaking avtivities. The frequency table (Table 1) of the data obtained from the interviews made after the implementation of the action plan is given below:

Table 1. Student Views on the Positive Aspects of Pre-Speaking Language Learning Strategies

Theme	Sub-theme	f
Positive Aspects of Pre-Speaking Language Learning Strategies	Preparation for speaking topic	25
	Search information about speaking topic	23
	Decreasing anxiety and feeling relax	22
	Having an idea about where to start speaking	20

Student Opinions:

“All of the activities we did while learning pre-speaking strategies were very fun and efficient. First of all, we did the activity where we said our similar and different features. It was forbidden to speak Turkish. In the group, nobody knew what to speak first, then when our time decreased, we all said something, even if it wasn't a full sentence. It was nice to work in a group. Later, our teacher made a presentation about what we could speak better before the speaking and handed us a worksheet. Our play was very fun. Normally I do not know how to make question sentences very well, but I can now ask a lot of questions on the subject because of the hints on the playing card and because we repeat it in the game many times over. I felt strong at every event we held this week. If you ask why, I have never spoken English so long before.” (05/11/2018)

Sample expressions obtained from observations, diaries and interviews regarding the second sub-problem of the research are given below:

Observation:

“In speaking activities, the teacher should have used more affective strategies. For example, it could be an activity like meditation in the past weeks. The warm-up exercise after the students partially calmed down actually made the students feel more comfortable. It took time to motivate students to speak, motivating them to speak. If affective strategies were included more, it might not pose a threat.” (13/11/2018)

Researcher-practitioner Diary:

“The crowd of class members in speaking activities sometimes caused problems in terms of classroom management. Although each student has a speech card, the students started talking among themselves from time to time, but the problem was prevented by intervening instantly. So, the organization should be done in a perfect way in speaking exercises.” (13/11/2018)

Data collected during the implementation of the action plan shows that students should be given not only pre-speaking language learning strategies but also affective strategies. The frequency table (Table 2) of the data obtained from the interviews made after the implementation of the action plan is given below:

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Table 2. Student Views on the Negative Aspects of Pre-Speaking Language Learning Strategies

Theme	Sub-theme	f
Negative Aspects of Pre-Speaking Language Learning Strategies	Causing time loss	12
	Crowded classrooms	34

Student Opinions:

“This week we learned what we can do during the conversation. Actually, I think the first way to be successful in speaking is to control our emotions, not to be afraid, to be excited. These can be difficult to do, but we can feel good by breathing exercises by thinking about things that calm us or listening to music. But the class must not be crowded to do them.” (13/11/2018).

In the interviews made after the implementation of the action plan, the students were asked what they saw negative about their pre-speaking language learning strategies (Table 2). some of the students stated that pre-speaking language learning strategies have negative aspects. They cause losing time before speaking. And most of the students expressed that in crowded classroom, it doesn’t make sense to learn pre-speaking language learning strategies.

Sample statements obtained from observation, diary and interviews regarding the third sub-problem of the research are given below:

Observation:

“Before starting the lesson this week, an activity called emotion control list was held. First of all, it was tried to determine what kind of negative emotions students experienced during speaking. Then, it was talked about how the students can struggle with these emotions. In fact, this event would be much more efficient if it was held last week, but this week was also very effective. Its effect was clearly visible on speaking activities. The students were more comfortable in the activities. The strategies that could be used during the speaking provided by the teacher were quite clear and understandable. peech cards were used especially in the activities held before and after the presentation. Here, when the student did not want to give information about himself, speech cards were preferred with the idea that he may not want to attend and attend the lesson. This was very good.” (20/11/2018)

Researcher-practitioner Diary:

“Before starting the lesson about strategies that can be used before speaking, there are also suggestions to increase the motivation of students towards speaking. It is noteworthy that the initial prejudices of the students have partially disappeared. Again, in this cycle of action, especially in the warm-up study, a group study and the fact that everyone in the group had to talk both gave the students confidence, reduced their anxiety and enabled them to speak. The students fulfilled the task given to them by acting from the sentence structures they know.” (20/11/2018)

The observation and researcher practitioner diary made during the implementation of action plans shows that when students use pre-speaking language learning strategies, they are more successful in speaking activities and their motivation is higher. The frequencies related to the data obtained from the interviews are given in Table 3:

Table 3. Students' Views on the Contribution of Pre-Speaking Language Learning Strategies to English Speaking Skills

Theme	Sub-theme	f
Contribution of Pre-Speaking Language Learning Strategies to English Speaking Skills	Developing a positive attitude towards speaking	28
	Feeling well before speaking	32
	Helping to recall related vocabulary	29
	Helping to recall simple sentence structure	25

Student Opinions:

“This week we learned the latest of their speaking strategies. For me, language learning strategies that can be used before speaking enable us to speak more easily during speaking. I can identify the places where I feel inadequate before speaking. Pre-speaking language learning strategies are very important. We can make preparations before starting to speak, we can make our speech in line with these preparations." (20/11/2018)

During the interviews with students after the implementation of the action plans, the students were asked how pre-speaking language learning strategies contributed to the development of speaking skills. The vast majority of students stated that the problems they faced in speaking skill have largely disappeared.

7. Conclusion and Discussion

The ability to speak in English is very important and difficult for language learning learning process. Language learners want to understand what is spoken in the target language. However, they also want to speak this target language fluently and accurately. In this study, it is aimed to eliminate the problems that students face with speaking skills in learning environment by using pre-speaking language learning strategies. For this purpose, three action plans covering pre-speaking learning strategies prepared by the researcher-practitioner English teacher, carrying out the research, were applied to the study group of the research. In the first action plan of the research, first of all, it was tried to introduce students to what pre-speaking language learning strategies are and what they will do.

According to the observations, interviews, and analysis of daily data after the completion of the first application, it was observed that the students had an idea and could diversify these ideas before speaking. However, although the students could diversify their pre-speaking learning strategies, they hesitated during the implementation of these strategies, and hesitated how to apply them. For this reason, the researcher-practitioner prepared and implemented the second action plan.

The aim of the second action plan is to enable students to encounter more pre-speaking strategy and to apply these strategies before speaking. In this action plan, it is seen that the students both adapt the pre-speaking strategies to themselves and use these strategies before the speaking. The researcher-practitioner prepared and implemented the third action plan in order to use these strategies more and gain practice.

In the third action plan, various speaking activities were carried out to ensure that the pre-speaking learning strategies learned in the first and second action plans were applied more. As a result of these activities, it was observed that the students tried to apply their pre-speaking learning strategies without any warning or reminder before speaking. They feel relaxed before speaking activity.

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Pre-speaking Strategies for Developing Speaking Skills

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Abstract. Many students learning English complain that they understand English, but don't feel confident enough to join a conversation. Well, how the learners fix it? In fact, the answer is not so difficult. They can try to use pre-speaking strategies before the start a conversation. So, in this study it is aimed to contribute of students speaking skills by teaching them pre-speaking strategies. The study group consists of 34 students attending 9-D class in a high school in Afyonkarahisar during 2018-2019 academic year. Research data were collected by semi-structured interview form, observation form, researcher-practitioner and student diaries. Descriptive analysis was used in the analysis of the data. Data indicate that students have successfully completed speaking activities with pre-speaking strategies. This study was extracted from "The Preparation, Implementation, and Evaluation of Language Learning Strategies Curriculum Draft" Doctoral Thesis.

Keywords. Pre-Speaking, Speaking Skills, Strategy.

1. Introduction

Speaking, among the four major skills, seems mostly favored as every English language learner aspires to be effective in communication. In other words, speaking has always been the most challenging skill for most of students. The importance of teaching speaking skill is that language is acquired through speaking and listening before one learns reading and writing.

Speaking is defined as an interactive process of building meaning that includes producing, receiving and processing information [1]. The main goal when teaching speaking is oral fluency, which is defined as the ability to express oneself intelligibly, reasonably accurately and without too much hesitation. Speaking serves important and several purposes in language learning. To interact socially consists of being able to communicate with other people, and having the competence to adjust language appropriately to the context. To develop self-awareness means being able to explore personal thoughts, emotions and opinions. Finally, to inform obviously consists of providing information and being able to present the information appropriately to context, with consideration to listeners' benefit. speaking leads to increased skills in other areas of language learning, in addition to leading to further growth in speaking abilities. Thus, speaking and conversation are not just the aim of learning English, but the means for language development [3].

Studies demontrate that speaking skill is the most neglected skill in language instruction. Most students do not even have the opportunity tospeak in the classroom or outside it. Moreover, speaking is not a part of the examination in most language courses. As it has been discovered by many researchers, foreign language learning best occurs through interaction, teachers should provide learners with the opportunities to communicate English at the lesson. Since many learners' goal in language learning is to be able to communicate fluently in formal and informal interactions, classroom activities should be designed to promote oral fluency. However, the ability of speaking is a complex process in its nature; many of the learners are anxious to speak in the classroom or outside to due to different social or psychological reasons so they keep silent. Therefore, it is necessary for language teachers to implement some natural strategies such as: role plays, group work, projects, etc. to avoid shyness and unwillingness of the learners so that they can participate in the speaking activities in the classroom [4]. It is important if teachers teach students how to speak strategically for effective communication. Strategy based instruction is a process oriented approach to teaching which focuses on the learning process, and results in improvements both in the process and product of learning. Strategy means a plan, step, or conscious action toward achievement of an objective [5].

It is stated that the ability to speak a language is synonymous with knowing that language since speaking is the most basic means of communication [6]. Teaching speaking is also crucial because it can also help improve other language skills; it can help learners build vocabulary, improve grammar, listening and writing as well. Undoubtedly, learning to communicate in the foreign language requires a lot of time and efforts. Since students already know one or sometimes more than one language, they might have some expectations about how a language works consciously and unconsciously in the human mind. Although this knowledge can help students acquire another language easier, some studies show that for language learners knowing another language can get in their way as they try to speak in the new language. Considering this, teachers should encourage learners to use their own cognitive abilities to help them activate the conscious process of learning another language [4].

The ability to speak in English gives the learner a cultural perspective, experience, knowledge and useful information through texts. However, teaching speaking English is sometimes more difficult than other skills in second language teaching. Because English has different features compared to Turkish in terms of grammar, vocabulary, pronounciation. These differences can cause problems among learners. Therefore, teachers teaching foreign languages or second languages should use various techniques and methods to help learners in the process of teaching English speaking skills. There are many strategies, methods and techniques that can be used in the English language teaching process. One of them is pre-speaking strategies. The teachers need to help the students get along with the text since the beginning of the speaking process. The teachers can prepare the students before they start to speak.

From time to time, teachers encounter a number of problems in the classroom learning process during the teaching of speaking skills. One of these problems is related to learning strategies. Teachers do not always find it effective to use direct expression method in speaking. Using different pre-speaking strategies in the learning environment will contribute to the solution of the problems that students will encounter while speaking.

Therefore, teaching pre-speaking language learning strategies to students or using them in learning environments offers a different perspective on the development of speaking in English. It contributes to the increase in student performance in English speaking skills by motivating students to learn and decreasing anxiety. It helps the development of student performance in communication skills. It enables language teachers to establish a new link between English speaking skills and communication skills. For these reasons, in this research, it is aimed to eliminate the problems faced by students in their English speaking skills by teaching their students pre-speaking language learning strategies. In this context, the answers of the following research questions will be sought in the research:

1. What are the positive contributions of using pre-speaking language learning strategies in English speaking skill activities?
2. What are the negative aspects of using pre-speaking language learning strategies in English speaking skill activities?
3. What is the contribution of pre-speaking language learning strategies to the development of English speaking skills?

2. Method

The research was handled with the action research method, which is one of the qualitative research methods. Action research critically addresses the development and implementation of educational workers' own schools, classes, educational studies and initiatives, and the assessment of their effectiveness. Thus, it offers a different perspective in dealing with educational problems [7]. This study includes teaching pre-speaking language learning strategies in order to improve the speaking skills of students who have problems in the development of speaking skills in the English learning process. Therefore, it is aimed to contribute to the development of speaking skills of students by using action research in these applications.

2.1. Sample of the Study

The study group of the research was determined with the purposeful sampling method, which is one of the non-random sampling methods in order to conduct in-depth research and to reach data rich in accordance with the research problem. The study included 34 students, 20 females and 14 males, who continued their education in the 9-D class in a high school in the city center of Afyonkarahisar in the 2018-2019 academic year.

2.2. Data Collection Tools

As the research was designed as a qualitative research, qualitative data collection tools were used in the data collection process. A qualitative method does not have to be used for data collection or data analysis in qualitative research [8]. One or more of the various data collection tools can be used from observation to interview. The data collection process of this research was carried out in two stages. The first data related to the research were collected during the implementation of the action plans. In this process, observation form and researcher diaries were used as data collection tools.

The second step of collecting data for the research is to conduct interviews. At this stage, the data were collected through semi-structured interview forms. Interview questions direct the dialogue with the interviewee and provide an opportunity to express their views and experiences about the situation [9]. For this reason, interview forms were used after the implementation of action research.

2.3. Analysis of Data

In the research, descriptive analysis was made by coding the data obtained from the interviews in accordance with the themes and sub-themes determined before the interviews. In addition, content analysis was carried out by coding in accordance with the new themes that emerged during the examination of the data. Therefore, in the research, the data were analyzed with a mixed method by using both descriptive and content analysis. Data obtained from the researcher-practitioner diary and observations were included in the research by making direct quotations. In qualitative research, direct quotations will contribute to the understanding of social events, as this will enable in-depth discovery of the subject.

2.4. Reliability and Validity

One of the methods that can be used to ensure the reliability of the data collected in qualitative research is triangulation [10]. Triangulation is the comparison of the results of two or more data collection methods, two or more data sources. Thus, weaknesses of one of the methods can be compensated by the strengths of the other method [11]. In this study, the reliability of the study was ensured by diversifying the data collection tools during and after the action research application.

2.5. Implementation of Action Plans

The varieties of pre-speaking activities are implemented in 9/D class in the academic year 2018/2019. The teacher starts the speaking class with the varieties of pre-speaking activities before giving the students a speaking subject. Within the scope of the research, a total of five different activities were held in two weeks with the students. The researcher is also a practicing English teacher. The practitioner treats the problems he / she detected in his / her lesson as a researcher and aims to eliminate the problems. A number of pre-speaking language learning strategies were taugt before speaking activity.

3. Findings

Research findings are handled in two stages as the data collection process takes place in two stages. In the first stage, the notes of an observer in the class during the action plan implementation process and sample statements from the researcher-practitioner diary are included. In the second stage, the frequency table of the interviews with the students and sample expressions from the interviews were given after the implementation. Sample expressions obtained from observations, diaries and interviews related to the first sub-problem of the research are given below:

Observation:

“Almost all of the students expressed or felt dissatisfaction when the teacher stated that they would consider pre-speaking strategies in the classroom. The negative attitudes of students towards this skill could be felt from their behavior. The teacher calmed the students but it could be done more effectively. The warm-up exercise after the students partially calmed down actually made the students feel more comfortable. The students worked as a group and tried to find the similarities and differences between each other. It was quite good to prohibit speaking in the mother tongue. The students tried to speak by force." (05/11/2018)

Researcher-practitioner Diary:

"The warm-up study of the course on pre-speaking strategies was related to the similarities and differences of the students. This created an opportunity for the lesson as it was a subject that students knew and could easily express themselves. Again, it was an opportunity for the activities in speaking activities to proceed in parallel with the subjects in English lessons. In speaking activities, indirect strategies, in other words, affective strategies should be included more. In particular, students need motivation both individually and as a class at every stage of speaking activities." (05/11/2018)

The students encountered more English speaking topics in these lessons. This situation caused them to be overexposed to the target language. Students saw various pre-speaking language learning strategies in this course. This situation caused a feeling of curiosity in them. Data obtained from observation notes and researcher-practitioner diaries discussed during the action plan implementation show that students encounter these strategies for the first time. However, although the students met for the first time, they had anxiety about speaking avtivities. The frequency table (Table 1) of the data obtained from the interviews made after the implementation of the action plan is given below:

Table 1. Student Views on the Positive Aspects of Pre-Speaking Language Learning Strategies

Theme	Sub-theme	f
Positive Aspects of Pre-Speaking Language Learning Strategies	Preparation for speaking topic	25
	Search information about speaking topic	23
	Decreasing anxiety and feeling relax	22
	Having an idea about where to start speaking	20

Student Opinions:

"All of the activities we did while learning pre-speaking strategies were very fun and efficient. First of all, we did the activity where we said our similar and different features. It was forbidden to speak Turkish. In the group, nobody knew what to speak first, then when our time decreased, we all said something, even if it wasn't a full sentence. It was nice to work in a group. Later, our teacher made a presentation about what we could speak better before the speaking and handed us a worksheet. Our play was very fun. Normally I do not know how to make question sentences very well, but I can now ask a lot of questions on the subject because of the hints on the playing card and because we repeat it in the game many times over. I felt strong at every event we held this week. If you ask why, I have never spoken English so long before." (05/11/2018)

Sample expressions obtained from observations, diaries and interviews regarding the second sub-problem of the research are given below:

Observation:

"In speaking activities, the teacher should have used more affective strategies. For example, it could be an activity like meditation in the past weeks. The warm-up exercise after the students partially calmed down actually made the students feel more comfortable. It took time to motivate students to speak, motivating them to speak. If affective strategies were included more, it might not pose a threat." (13/11/2018)

Researcher-practitioner Diary:

"The crowd of class members in speaking activities sometimes caused problems in terms of classroom management. Although each student has a speech card, the students started talking among themselves from time to time, but the problem was prevented by intervening instantly. So, the organization should be done in a perfect way in speaking exercises." (13/11/2018)

Data collected during the implementation of the action plan shows that students should be given not only pre-speaking language learning strategies but also affective strategies. The frequency table (Table 2) of the data obtained from the interviews made after the implementation of the action plan is given below:

Table 2. Student Views on the Negative Aspects of Pre-Speaking Language Learning Strategies

Theme	Sub-theme	f
Negative Aspects of Pre-Speaking Language Learning Strategies	Causing time loss	12
	Crowded classrooms	34

Student Opinions:

"This week we learned what we can do during the conversation. Actually, I think the first way to be successful in speaking is to control our emotions, not to be afraid, to be excited. These can be difficult to do, but we can feel good by breathing exercises by thinking about things that calm us or listening to music. But the class must not be crowded to do them." (13/11/2018).

In the interviews made after the implementation of the action plan, the students were asked what they saw negative about their pre-speaking language learning strategies (Table 2). some of the students stated that pre-speaking language learning strategies have negative aspects. They cause losing time before speaking. And most of the students expressed that in crowded classroom, it doesn't make sense to learn pre-speaking language learning strategies.

Sample statements obtained from observation, diary and interviews regarding the third sub-problem of the research are given below:

Observation:

"Before starting the lesson this week, an activity called emotion control list was held. First of all, it was tried to determine what kind of negative emotions students experienced during speaking. Then, it was talked about how the students can struggle with these emotions. In fact, this event would be much more efficient if it was held last week, but this week was also very effective. Its effect was clearly visible on speaking activities. The students were more comfortable in the activities. The strategies that could be used during the speaking provided by the teacher were quite clear and understandable. peech cards were used especially in the activities held before and after the presentation. Here, when the student did not want to give information about himself, speech cards were preferred with the idea that he may not want to attend and attend the lesson. This was very good." (20/11/2018)

Researcher-practitioner Diary:

"Before starting the lesson about strategies that can be used before speaking, there are also suggestions to increase the motivation of students towards speaking. It is noteworthy that the initial prejudices of the students have partially disappeared. Again, in this cycle of action, especially in the warm-up study, a group study and the fact that everyone in the group had to talk both gave the students confidence, reduced their anxiety and enabled them to speak. The students fulfilled the task given to them by acting from the sentence structures they know." (20/11/2018)

The observation and researcher practitioner diary made during the implementation of action plans shows that when students use pre-speaking language learning strategies, they are more successful in speaking activities and their motivation is higher. The frequencies related to the data obtained from the interviews are given in Table 3:

Table 3. Students' Views on the Contribution of Pre-Speaking Language Learning Strategies to English Speaking Skills

Theme	Sub-theme	f
Contribution of Pre-Speaking Language Learning Strategies to English Speaking Skills	Developing a positive attitude towards speaking	28
	Feeling well before speaking	32
	Helping to recall related vocabulary	29
	Helping to recall simple sentence structure	25

Student Opinions:

"This week we learned the latest of their speaking strategies. For me, language learning strategies that can be used before speaking enable us to speak more easily during speaking. I can identify the places where I feel inadequate before speaking. Pre-speaking language learning strategies are very important. We can make preparations before starting to speak, we can make our speech in line with these preparations." (20/11/2018)

During the interviews with students after the implementation of the action plans, the students were asked how pre-speaking language learning strategies contributed to the development of speaking skills. The vast majority of students stated that the problems they faced in speaking skill have largely disappeared.

7. Conclusion and Discussion

The ability to speak in English is very important and difficult for language learning learning process. Language learners want to understand what is spoken in the target language. However, they also want to speak this target language fluently and accurately. In this study, it is aimed to eliminate the problems that students face with speaking skills in learning environment by using pre-speaking language learning strategies. For this purpose, three action plans covering pre-speaking learning strategies prepared by the researcher-practitioner English teacher, carrying out the research, were applied to the study group of the research. In the first action plan of the research, first of all, it was tried to introduce students to what pre-speaking language learning strategies are and what they will do.

According to the observations, interviews, and analysis of daily data after the completion of the first application, it was observed that the students had an idea and could diversify these ideas before speaking. However, although the students could diversify their pre-speaking learning strategies, they hesitated during the implementation of these strategies, and hesitated how to apply them. For this reason, the researcher-practitioner prepared and implemented the second action plan.

The aim of the second action plan is to enable students to encounter more pre-speaking strategy and to apply these strategies before speaking. In this action plan, it is seen that the students both adapt the pre-speaking strategies to themselves and use these strategies before the speaking. The researcher-practitioner prepared and implemented the third action plan in order to use these strategies more and gain practice.

In the third action plan, various speaking activities were carried out to ensure that the pre-speaking learning strategies learned in the first and second action plans were applied more. As a result of these activities, it was observed that the students tried to apply their pre-speaking learning strategies without any warning or reminder before speaking. They feel relaxed before speaking activity.

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Investigation of Disciplined Mind Features of Primary School 4th Grade Students in Terms of Various Variables

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Abstract. According to Gardner [9], individuals will be expected to develop some types of mind in the future. These mind types are "disciplined mind", "synthesizing mind", "creative mind", "respectful mind" and "ethical mind". Only individuals who can possess the aforementioned types of mind will be able to produce unique products, and these qualities will be developed in individuals that educators will want to train. The purpose of this study is to examine the disciplined mind features of primary school 4th grade students in terms of various variables. Personal information form and disciplined mind scale (α =.826) were used as data collection tools. Descriptive statistics, t test and one-way analysis of variance (ANOVA) were used to analyze the data. As a result of this research, it was determined that disciplined mind levels of students were "Often" (X = 4.0598) and there was a significant difference in terms of gender, father's education level, mother's job, father's job variables.

Keywords. Disciplined Mind, Disciplined Mind Scale (DMS), Primary School 4th Grade.

1. Introduction

Today, learning is very important, just like in the past. Learning starts when the individual is still in the womb and continues for life [2]. Although the importance of the learning action does not decrease in any period, it grows on the contrary. The expectation of our age from individuals is that they are specialized in their work and have the ability to innovate [15]. Undoubtedly, in order for an engineer to be successful in the fields of production and development, it is necessary to know the nature of the substance on which it will work and to make the necessary calculations to carry out the work completely [9]. Therefore, it is thought that individuals should have full control of the discipline areas that are the subject of learning during their education.

According to Gardner [9], individuals will be expected to develop some types of mind in the future. Only individuals who can possess the aforementioned types of mind will be able to produce unique products, and it will be aimed to develop these qualities in individuals that educators will want to train. These mind types are "disciplined mind", "synthesizing mind", "creative mind", "respectful mind" and "ethical mind". When the characteristics of the type of individual that educators want to train in the future with the five mind areas put forward.

It envisages a human model that has disciplined thinking skills, has been able to develop the synthesizing mind structure and thus acquires creative thinking skills, can demonstrate the skills to respect the rules of ethics and ethical principles while exhibiting these skills, and that can be beneficial to the society, the environment and the world. One of the main goals in the disciplined mind is that individuals are mastered in at least one discipline. This discipline can be a branch of art, profession, history or sociology from the humanities. In one discipline, the process of qualification can take up to ten years [9].

It is stated that children have scientific thinking skills such as observing the facts, recording data, and determining the effects of independent variables on dependent variables around the age of 11 [12]. Gardner [9] states that although he studied psychology, it took ten years to learn to think like a psychologist. Considering that the process of competence in a discipline can last up to ten years, the importance of developing the disciplined mind from primary school becomes evident. Beginning from elementary to last until the end of high school Given that it is being implemented on a mandatory training period of twelve years in Turkey, which is located in the 10-11 age group 4th grade students of the period of primary school starting is considered necessary to develop a disciplined mind features.

The aim of this study is to examine the disciplined level of mind features of students and whether there are significant differences in terms of various variables. This research is important in terms of revealing the levels of disciplined mind features of students and the variables that affect disciplined mind features.

2. Method

In this research, survey research model, which is one of the quantitative research methods, was used. Survey researches are studies aiming to describe the views and features of large masses [1]. Another feature of survey research is that it is generalizing. Survey research makes generalizations about the universe represented by the sample in the light of the data obtained from a sample [5].

The population of the study is 4^{th} grade primary school students studying in both public and private schools in the 2018-2019 academic year in the Central District of Afyonkarahisar Province. The sample of the research consists of 537 students, 271 men and 266 women.

3. Data Collection Tools

In this research, the personal information form aimed at obtaining students' information about the variables to be examined and the Disciplined Mind Scale (DMS) developed by the researchers were used as data collection tools. DMS is a 5-point Likert-type scale consisting of 27 expressions and 5 sub-dimensions. Questions include “5 Always”, “4 Often”, “3 Sometimes”, “2 Rarely”, “1 Never” and the options are scored from positive to negative. There are 27 expressions in the scale, 20 positive and 7 negative. "Structure validity" was used as the method of determining validity in testing the validity of DMS. The reliability of the scale was calculated by calculating the Cronbach Alpha coefficient (.826) and internal consistency reliability was obtained. It can be said that the Cronbach's Alpha reliability coefficient of DMS is.826, since this value is between.60 and.90, it is quite reliable [3].

The data collected with personal information form and DMS were transferred to the computer. In testing the normality of the distribution, the Kolmogorov-Smirnov test was performed, and skewness-kurtosis values of the scores were also examined. According to the Kolmogorov-Smirnov test result, the significance value (p) is greater than.05 means that the normality is achieved [3]. For most psychometric purposes, the kurtosis value between -1.0 and +1.0 is considered to be excellent, but in some cases the value between -2.0 and +2.0 is also acceptable, depending on the specific application [10]. As a result of the analysis of the data, it was accepted that the data showed a normal distribution since the significance value (p) was less than.05 and the skewness kurtosis coefficient was between -1.0 and +1.0 according to the Kolmogorov-Smirnov test. Therefore, in order to determine whether there is a significant difference in terms of disciplined mind features of the students in terms of gender and having internet connection at home, samples t test was conducted independent of parametric tests. One-way analysis of variance (one-way Anova) was applied to determine whether there is a significant difference in terms of mother’s education level, father's education level, subscription to a scientific journal, or follow-up status, mother’s job and father’s job variables.

In cases where there is a significant difference as a result of one-way Anova analysis, LSD (least significant difference) test was used to determine the source of the difference between the groups. LSD test, which can be used when there is no equality in the sample number; It is preferred because it gives more meaningful results compared to other tests that are conducted to determine the source of the difference. The LSD test is the most liberal of the tests, the most likely to differ significantly in comparisons because it is simply a t-test sequence [10]. LSD test is equivalent to performing more than one t test on data [8].

In order to determine the score ranges of the answers given by the students, the items included in the disciplined mind scale (DMS); 4.21-5.00 “Always”, 3.41-4.20 “Often”, 2.61-3.40 “Sometimes”, 1.81-2.60 “Rarely”, 1.00-1.80 were interpreted based on the “Never” intervals. The determination of score ranges in the measurement results is done by dividing the difference between the highest value and the smallest value by the number of groups [11].

4. Results

As a result of the analysis of the data obtained from the research, it was determined that the DMS levels of the 4^{th} grade students in primary school were “Often” (X = 4.0598).

There was no significant difference in terms of DMS levels of the students in terms of “having internet connection at home, subscribing to a scientific journal, mother’s education level" variables.

As a result of the t test, a significant difference was found in favor of female students (X = 4.15, S =.46) in terms of gender and DMS levels of the students.

According to the results of one-way analysis of variance, a significant difference was determined in terms of the DMS levels of the students and the variables of father's education level, mother's job and father's job. LSD test was applied in order to determine between which groups the source of the significant difference was detected.

According to the data obtained from the LSD test, the educational status of the students whose father's education level is at master's / doctorate level (X = 4.34, S =.39) and the education level of the father are literate (X = 3.93 S =.47), primary school graduate (X = 3.89, S =.52), secondary school and equivalent graduates (X = 3.88, S =.50), high school and equivalent graduates (X = 4.10, S =.48) and college / faculty graduates (X = 4.10, S =. 53) Among the DMS scores of the students; It was determined that there is a statistically significant difference in favor of students whose father's education level is master's / doctorate level. The education level of the fathers of the students whose father's education level is high school / faculty graduate (X = 4.10, S =.53) and the high school and equivalent graduate (X = 4.10, S =.48), the father's education level is primary school graduate (X = 3.89, S =.52) and among students who are secondary school and equivalent graduates (X = 3.88, S =.50); It was determined that there was a statistically significant difference in favor of students whose father's education level was graduated from college / faculty.

According to the data obtained from the LSD test, the occupational status of the students whose mother's job status is "public worker" (X = 4.17, S =.52) and the occupational status of the mother and the mother whose job status is "not working" (X = 4.02, S =.48) Among students with "self-employment" (X = 3.81, S =.70); A statistically significant difference was found in favor of students whose mothers' professional status was public employees. In addition, among the students whose mother's occupational status is "trades" (X = 4.17, S =.47), students whose mother's occupational status is "self-employed" (X = 3.81, S =.70); A statistically significant difference was found in favor of students whose mothers' status was "trades".

According to the data obtained from the LSD test, students whose fathers 'occupational status was "public employees" (X = 4.15, S =.49) and students whose fathers' occupational status was "private sector employees / workers" (X = 3.97, S =.51) Among the DMS scores; A statistically significant difference was found in favor of students whose father's professional status was "public employee".

5. Discussion and Conclusion

Individuals who want to succeed in the world of the future will be expected to develop in five types of mind areas [9]. Three of these mind types, called five mind types, consist of cognitive mind types, and the remaining two are relational mind types [14].

According to Gardner, who believes that current formal education prepares students for the possible worlds of the future, but primarily for the past world [7], education for five minds is challenging in all contexts. Developing a disciplined mind requires constant effort over a long period of time. In a context in which test scores guide more and more educational decisions, it is questionable whether training is possible for five minds [6]. The disciplined mind begins only during adolescence and continues for the rest of a person's life [13].

In this study, it was investigated whether primary school 4^{th} grade students differ in terms of disciplined mind features and various variables. When the literature is analyzed, no study related to disciplined mind has been found at primary school level. For this reason, in the discussion of the findings, studies that are similar to the relevant variables are mentioned.

In the study conducted by Can Aran [4], it was determined that there is a statistically significant difference in favor of female students in terms of gender variable on the level of disciplined mind features of seventh grade students in Science course. The research stated is between female students and male students in terms of gender variable of disciplined mind features of 4^{th} grade students;

It supports the result of finding a statistically significant difference in favor of female students.

It was determined that disciplined mind features of 4th grade students did not create a statistically significant difference according to the mother's education level variable. In the study conducted by Can Aran [4], it was found that there was a statistically significant difference in favor of mothers who graduated from university in terms of the educational status variable of the mother in terms of the disciplined mind qualities of seventh grade students in Science course. This finding differs from the study by Can Aran [4].

It has been determined that disciplined mind features of 4th grade students create a statistically significant difference according to the father's education level variable. In the study conducted by Can Aran [4], it was concluded that there was no significant difference in the level of having a disciplined mind in terms of science and technology lesson of the seventh grade students in terms of father's educational status. This finding differs from the study by Can Aran [4].

It has been determined that disciplined mind features of 4th grade students do not make a statistically significant difference according to whether they subscribe to a scientific journal or follow-up variable. In the study conducted by Can Aran [4], it was found that there is a statistically significant difference in favor of students reading magazines in terms of the magazine reading variable related to the field of science in terms of science discipline in terms of science discipline at the seventh grade level. This finding differs from the study by Can Aran [4].

Taking into consideration that the measures and practices that teachers can take may be effective in increasing students' Disciplined Mind Feature levels, it may be recommended to organize informative seminars and in-service trainings on teachers about ways to develop disciplined mind and disciplined mind.

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The Use of Information and Communication Technology in Higher Medical Institutions in Ukraine: Gaining Experience

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Abstract. The use of the most recent information technologies (IT) in all spheres of the life is a very topical issue, and many scientists are engaged in research and implementation of IT accomplishments. Therefore, an important task of modern higher education is the enhancement of a level of information culture in future healthcare specialists as it is required by the rapid development of the information society.

Under continuing changes in all spheres of the life in Ukraine the professional training of future medical workers acquires a special value. The activities of physicians are impossible without the use of modern information technology, which is a necessary and affordable tool for medical research and clinical practice. Education in medical institutions is focused at training highly qualified and competitive professionals who would be responsible, competent, have high creative potential and would be able to work in a certain medical specialty. That is why it is necessary to introduce fundamentally new approaches to the development of learning technologies in the process of training medical professionals in higher education institutions.

The article focuses on the possibilities of information and communication technologies implemented in the educational process at I. Horbachevsky Ternopil National Medical University.

Keywords. Web Portal, Single Comprehensive Test Exam, Information and Communication Technology, “Single Day” Method.

1. Introduction

Systematic implementation of modern information and communication technologies is an urgent need during higher medical and pharmaceutical education to ensure the realization of the Law of Ukraine “On Higher Education” [1]. The problem remains that the active use of such technologies sometimes favorably distinguishes international students or health professionals from domestic ones.

For a long time in the West, higher medical and pharmaceutical education, as well as professional health care responsibilities, have been unthinkable without a computer. That is why Ukraine is implementing a large-scale policy on the formation of the information space of the health care system, the core of which can include web portals of medical and pharmaceutical universities, which were created during the previous period, the structure of which is constantly being improved, the content is being updated, and the work on filling with educational and methodical materials continues.

The purpose of this article is to highlight the introduction of information and communication technologies during the implementation of the educational process on the example of I. Horbachevsky Ternopil National Medical University.

2. Implementation of IT-based learning at Ternopil Medical National University

I. Horbachevsky Ternopil National Medical University is one of the leading institutions of higher medical (pharmaceutical) education in Ukraine for the introduction of information and communication technologies in the educational process. Today the web portal of the university is a substantial element of the information space not only within the health care system of Ukraine, but also worldwide, because it supports the acquisition of higher education by both future domestic and foreign doctors and pharmacists. That is why the web portal of the university provides access to the web pages of each department, which contain all the information necessary for the full-scale preparation of students for classes during all educational periods.

We emphasize that each student at the beginning of an academic year receives a matrix, which contains a list of practical skills to learn in accordance with the standards of higher education in Ukraine (second (master's) level) for specialties in the field of knowledge 22 “Healthcare”. Therefore, I. Horbachevsky Ternopil National Medical University in the process of educating future professionals introduced the technique of “single day”, which is effectively implemented during the training of students in 3–6 years of study [2].

Being at the department for 6–7 hours and using such methods, students have the opportunity to perform a large amount of practical work, more thoroughly master the practical skills, use more time for independent supervision of patients. Therefore, the method of “single day” contributes in the introduction of a cyclical system of education, the creation of thematic classrooms and equipping them with modern facilities, including the use of information and communication technologies, full provision of thematic patients, effective use of material and technical base of departments, especially in clinics. In addition, under such conditions, it is possible to have an in-depth discussion of the most important issues of the topic in the form of a free debate, in which all students and teachers present at the lesson participate. With the appropriate logistics and motivation, students master the necessary amount of information during each lesson, even in the absence of prior preparation for it. The advantages of the introduction of the “single day” method are a significant reduction in the number of student absences without a reason, the possibility of reducing the duration of semesters.

The application of the “single day” method presupposes the availability of proper provision of the educational process with courseware and other information sources. For this purpose, in addition to the university library, libraries with educational literature in paper and electronic formats, as well as with periodicals of Ukrmedknyha publishing house have been created in each educational and scientific institute and at clinical departments. The library collection is constantly replenished with educational CDs, videos, modern periodicals and scientific literature, so all students have the opportunity to receive textbooks and manuals, as well as other information resources needed to acquire knowledge, skills and abilities within the implementation of the “single day” method.

The peculiarity of the “single day” method is that at all departments of the university students have access to electronic educational materials posted on the university web portal, including presentations, lecture texts, guidelines for preparation for practical classes, banks of educational tables and videos etc. The availability of such educational materials significantly facilitates the search for information on each discipline studied, and improves the quality of its comprehension by students.

We emphasize that 40 sets of video systems with widescreen monitors, which are purchased for the departments of the university, during practical classes provide a thorough mastering of educational material by students. In addition, all lecture halls and individual departments have video projectors, computer classes are connected to the Internet, and it is possible to access it using Wi-Fi technology, which provides for the use of laptops and smartphones by teachers and students.

It should be noted that for the first time among the medical (pharmaceutical) schools of Ukraine, I. Horbachevsky Ternopil National Medical University introduced a comprehensive semester control. It involves testing the practical skills specified in the matrix, passing a single comprehensive test, and for senior students – passing an objectively structured clinical exam [2].

In order to test the knowledge, skills and abilities of future professionals acquired during the educational process, the university web portal has a database of text tasks (there are about 500 thousand tests, which are situational tasks and figures), which cannot be memorized mechanically. To master the created base of test tasks, students must have a thorough training, which provides a comprehensive understanding the content of theoretical material, as well as the availability of practical skills and abilities of the appropriate level. The database of text tasks is used during the semester single comprehensive test exam at the departments of the university.

The experience of conducting such an exam confirmed its high objectivity, reduced the workload of the teaching staff of the departments and a volume of routine work during the exams, as well as significantly reduced the time to take exams by students.

We emphasize that the results of a single comprehensive test exams are constantly analyzed, so the departments have the opportunity to improve both test tasks, rejecting those that are non-disabled, and forms of such exams.

In view of this, it became possible to distinguish two parts of the semester single comprehensive test exam, which had a positive effect on its results, because the optimal conditions for the proposed tasks were created.

It should be noted that the organization and implementation of a single comprehensive test exams at the university provides the Educational and Research Department of Independent Testing, which reports to eight standing committees directly involved in preparing materials needed for such exams and conducting them in various courses. Specialists in this department are also responsible for creating test booklets for students.

The Educational and Research Department of Independent Testing is equipped with a server (separate computer), which has both mechanical and electronic system of protection against unauthorized access, to which all computers of the department are connected. This provides complete isolation of the department's computer network from other networks, including wireless. The department also has a video surveillance system with round-the-clock recording of information and it is strictly forbidden to use any devices – mobile phones, flash drives, memory cards, cameras, etc. In addition, the work during the preparation and implementation of the exam is clearly regulated by the approved instructions, compliance with which ensures the transparency of the examination process from the beginning of the formation of booklets until each student receives an objective assessment.

In 2015 year a re-certification audit according to the international standard ISO 9001: 2015 (quality management) took place at I. Horbachevsky Ternopil National Medical University. Based on its results, it was decided that the quality assurance system in our univeristy meets all requirements. TNMU for the second time received a certificate and graverton of the international standard ISO 9001: 2015 for the next three years.

It should be mentioned that on May 26, 2017, Ternopil Medical University received a certificate and graverton of the international standard ISO 9001: 2015 (quality management) for carrzing out educational and research activities in accordance with the requirements of international standards.

The Certificate of Conformity ISO 9001: 2015 is an international document that confirms the achievement of a high level of management quality by a higher education institution. This type of management system certification is an integral part of modern university life.

The activities of TNMU are aimed at improving the quality of education and science, staff skills, constant and timely updating of educational services in accordance with current trends. Certification according to the ISO 9001: 2015 standard provides a priority position of our university in the market of educational services.

3. Conclusions

Practical experience gained during the educational process at I. Horbachevsky Ternopil National Medical University shows that the use of information and communication technologies for the organization and implementation of the “single day” method as well as the semester single comprehensive test exams, which are an objective, independent and non-corrupt component of the system of assessment of students’ knowledge, skills and abilities, can be considered as a key to compliance with higher education standards of Ukraine (second (master's) level) for specialties 22 “Health”.

Therefore, we can assume that the policy of continuous modernization of higher medical (pharmaceutical) education in Ukraine on the basis of information and communication technologies, which began in late 1990s. and continues today to provide the formation of the information space within the health care system, that is necessary to educate future doctors and pharmacists, who would be competitive in the labor market not only in Ukraine but also in Western countries, because medical and pharmaceutical universities of our country are not behind similar European and USA universities regarding the use of information and communication technologies in higher education of health professionals.

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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 in Europe that was created to assist regular dissemination and sharing of information among teachers, researchers, policy makers, parents and anyone interested in science education. Each particular group related with STEM education can obtain important benefits from Scientix, so [1-4]:

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 [5], a non-profit organization and network of thirty-four European education ministries, Scientix now, in its fourth stage (2020-2022), is funded by the Horizon 2020 programme of the European Union for research and innovation. 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) [6].

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. Scientix now have a panel of 377 Scientix Ambassadors from 39 countries that have voluntarily committed to supporting science education in their countries. Several of whom are linked to different European 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 [7], Scientix Moodle courses [8] and in the writing of Scientix blog articles [9].

Scientix currently provides free direct access to over six 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 webinars 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.

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.

3. Activities as Scientix Ambassador during the 2019-2020 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 directly in their pupils. Therefore, during the 2019-2020 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 [10].

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 1). 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. 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.

Figure 1. Activities as Scientix Ambassador in secondary and pre-university centres during the 2019-2020 academic year [10]

During the 2018-2019 academic year, there have been 20 talks that have taken "Learning Physics by Doing Physics" and the Scientix project to around 1450 students and 125 teachers in Galicia-Spain (Figure 1) [10]. Seven talks were cancelled when the lockdown was introduced in Spain on March 15, 2020.

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 [14]/Facebook [15], 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 [16].

5. Disclaimer

The work presented in this document has received funding from the European Union's H2020 research and innovation programme – project Scientix 4, coordinated by European Schoolnet (EUN). The content of the document is the sole responsibility of the organizer and it does not represent the opinion of the European Commission (EC), and the EC is not responsible for any use that might be made of information contained.

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Can We Use Music as a Useful Teaching and Learning Strategy? A Pre-experimental Design Applied to the Study of Fermentation

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Abstract. The great amount of new information accessible to the youngest and the large scientific and technological advances that occur in our society on a daily basis, gives the school the additional challenge of motivating students to learn the established curriculum. Learning happens when students are engaged and empowered, and believe their work matters [1, 2].Thus, it is imperative to adopt more active and dynamic strategies that promote greater teacher-student and student-student interaction in classrooms, in order to enhance their interest, motivation and learning. This can be particularly important when teachers face classes with high levels of agitation and low motivation to learn.

Here we provide a research-based strategy by designing a students' learning experience through music. Music is everywhere. It is considered the universal language, a means of communication around the world and among all people, playing an important role in the development of human beings. In addition, it is one of the culture manifestations and art preferred by young people [3].

Our goal was to verify if the use of music to teach scientific content, could increase students' motivation and learning of scientific concepts in the theme "Transformation and utilization of energy by living beings", particularly the fermentation process. This topic is part of the Biology and Geology 10th grade curriculum. The sample of this study consisted of 30 students, of a private school, situated in an urban area, in the north of Portugal. The class frequents a scientific-technological course, in the sports field. The study relied on quantitative data, with a pre-experimental design.

The fermentation theme was introduced to the class, not only by the expositive method, but also resorting to practical work, using yeasts, so that students could better understand the phenomena involved in the process of fermentation, particularly the alcoholic process of fermentation. Then, students took a small test on the topic (pre-test). After that, a music, well known by the youngest, whose lyrics had been changed, in the scope of the scientific approach to the theme of fermentation, was presented and students had the opportunity to learn and sing the new lyrics in the class, with the teacher. During the following week, students replied a small test on the theme again (pos-test).The obtained results revealed a substantial improvement. Starting from a pre-test average score of 45.8%, with a minimum of 3.4% and a maximum of 85%, the pos-test average score reached 75.5%, with a minimum of 25,9% and a maximum of 100%. A Wilcoxin test was performed ($z = 4{,}47$; $p < 0{,}00001$), showing, with 99% of confidence, that pre-test and pos-test results have statiscally signifficant differences. Moreover, students showed themselves very interested and participative in the class in which the music was presented. Engagement is a key factor for learning [1,2].

Thereby, the outcomes achieved seem to be good indicators of the effectiveness of using music as a teaching and learning strategy, capable of increasing both students' motivation and commitment, as well as the acquisition of knowledge, in a particularly difficult topic, such as the learning of the fermentation process.

Keywords. Fermentation, Motivation, Music, Teaching and Learning.

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Hands-on Colour: an STEAM Project

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Abstract. Colour is one of the main concepts that we can employ if we want to connect Science, Technology, Engeneering, Arts and Mathematics and relate them also with Society and Social Problems, so it will be the principal core in a STEAM project [1-2].

During the situation of sanitary crisis due to the COVID-19, we decided to carry out an online STEAM project in our account of Twitter [3], for our families, our students, our friendships, and for all those people interested in learning science and engineering by doing science and engineering. The proposal supposes the realization of a daily photographic record, realized with materials of our house combined with hands-on activities, that a lot of times link the actuality with the proper values of the dynamics of the scientific and technological thought in multi-language scenarios that combine in most of the cases in an only photograph, mathematics, art, engineering, technology, and science. Trying to show that only, maintaining our feet on the ground, with a creative, critical, original, responsible, solidarity, flexible, open, and ethical attitude in front of opinions or situations like which are living at global level, a crisis like the current one can be overcome. Although several STEAM concepts are involved in this project, colour science is the main concept implicated [4-5].

Colour perception in Education has been intensively examined since there are a lot of misconceptions related with this topic [6-7] that involves, at least, illumination, objects, eyes and brain. Usually colour concepts are taught at the beginning of the elementary-school Art classes and later on at the end of high school in Physics subjects, restricted to a RGB model (using the additive primaries red, green, and blue) and a CMY colour model (using the subtractive primaries cyan, magenta, and yellow).

If we analysed the contents in text books we can see that only a brief and incomplete description is provided where usually complex concepts are presented in abstract context with poor relation with real life. In this work we present an analysis of concepts and contents related with Colour in high-school Physics textbooks, also different classic and new demonstration of colour mixing and colour perception using new technologies [4-5] are provided. For example (Fig. 1), the classic demonstration of color mixing by addition that involves projecting RGB coloured lamps to a wall in a darkened space can be changed if led lamps with proper combination of RGB emission is employed; coloured led lamp emission can be visually analysed with a diffraction grating that divide properly main combined colors; mechanical mixing of colours can be done with new Maxwell discs in RGB or CMY models and compared results with classical Newton disc; the classic demonstration of colour mixing by subtraction that involve overlapping CMY filters on an overhead projector can be improved if we separate the CMY or RGB channels of an image obtained with a raster graphics editor [8], etc.

Figure 1. A selection of hands-on activities

Keywords. STEAM, Physics, experimental science teaching, hands-on activities, colour.

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Is Ecotourism Truly Sustainable? A Review of the Impact of Tourism on Primates

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Abstract. Due to unsustainable human activities, 60% of primate species are on the verge of extinction. Conservation and environmental concern have led to the emergence of ecotourism ventures to protect primate habitats by providing sustainable solutions by raising revenues and awareness among the people regarding primate conservation. However, long-term exposures to tourist presence and tourism activities have caused adverse effects on primates. Numerous studies report the negative effects of tourism related construction activities and tourist attitudes while visiting on primates but to get more insight into the topic it is important to determine the past and present trend of research on primates inhabiting ecotourism destinations. In this study, a literature search of peer-reviewed publications was conducted, focusing on tourist and tourism related impact in ecotourism sites to characterize its trends.

The literature search resulted in 73 publications on 18 primate genera between 1950-2019, and with genus *Macaca* featured in one-third of all the publications. Most of the publications concerned primates in African continent (55%). Behavioural adjustments by primates due to tourist presence contributed 51% of the literature. Only 6% of these studies investigated primarily the health of the tourists.

Characterizing trends of research in ecotourism destinations in primate habitat countries can provide us valuable information about the challenges and drawbacks in management of the sensitive habitats for endangered primates. In order to minimize the negative effects on primates by tourism activities multidisciplinary approach is required to implement education and training programs for the while highlighting the gap in our knowledge and need of actions by authorities and scientists for efficient functioning of ecotourism destinations.

Keywords. Primates, Impacts of Tourism, Tourist Behaviour, Management of Ecotourism Sites.

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Indian Experience on Health and Biodiversity in Post COVID-19 Pandemic

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Abstract. An epidemic is a disease that affects a large number of people within a community, population or region. A PANDEMIC is an outbreak affecting large populations or a whole region, country, or continent. After assessment, WHO characterized COVID-19 as a pandemic and declared it on 11 March, 2020. CORONAVIRUSES are a large family of viruses which may cause illness in animals or humans. In humans several coronaviruses are known to cause respiratory infections ranging from common cold to more severe diseases such as Middle East Respiratory Syndrome (MERS) and Severe Acute Respiratory Syndrome (SARS). COVID-19 is the infectious disease caused by the most recently discovered coronavirus. This new virus and the disease were unknown before the outbreak began in Wuhan, China, in December 2019. The novel coronavirus (COVID-19) cases have been confirmed in large number of countries. The top worst affected countries in the world are China, Italy, USA Spain and Russia. At present 212 countries in the world are affected by COVID-19 virus. Many people with COVID-19 experience only mild symptoms. This is particularly true in the early stages of the disease. It is possible to catch COVID-19 from someone who has just a mild cough and does not feel ill. Several high-profile figures in UK who were diagnosed with the coronavirus revealed they experienced loss of taste and smell. Some reports have indicated that people with no symptoms can transmit the virus. WHO is assessing ongoing research on the topic and will continue to share updated findings. It is not certain how long the virus that causes COVID-19 survives on surfaces, but it seems to behave like other coronaviruses. Studies suggest that coronaviruses (including preliminary information on the COVID-19 virus) may persist on surfaces for a few hours or up to several days. This will depend on some factors like the type of surface, temperature or humidity of the environment etc. If you think a surface may be infected, clean it with any disinfectant to kill the virus and protect yourself and others.

India being the second largest country (population wise) in the world too got affected by Covid-19 but here death casualties are very less and the recovery rate of the covid-19 patients is very high as compare to western world. Reason for the unusual capacity of Indians to fight with covid-19 lies in several factors starting from their food habits, Ayurveda, Yoga and life style. Secondly, Covid-19 pandemic taught us a great lesson that is to go close to the nature and seek for the solutions of many human problems, including corona pandemic for which nature has the answer. The life of the people around the world is not going to be the same for us post covid-19.

This paper is an attempt to make people aware using my unique presentation of scientoons [1] about Coronavirus specially covid-19, its symptoms to precautions, and also how people can keep themselves fit by sharing Indian experience like enhancing immunity by doing yoga, the kind of food/fruits/spices one needs to use. The corona pandemic came out to be a blessing for the nature, that will be discussed like the kind of trees one needs to plant. And finally how life style changes specially by changing our habits, we can learn the art of living with covid-19.

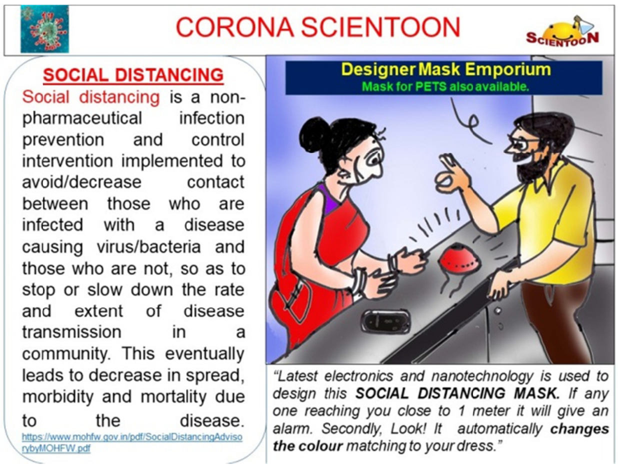

Figure 1

Keywords. Scientoonics, Scientoon.

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Basic Hands-on Introduction to Holography for Ophtalmology and Optometry Undergraduate Students

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Abstract. The three-dimensional visualization of objects and structures is very important in a number of situations also because that is how we normaly see.

Holography is a well-established way of creating 3D images of real objects [1]. The technical and scientific developments over last decades in this field turn holography, either analogue and digital, a very powerfull tool in many different applications including in medicine. Important advances were made also in domains involving eyesight and the eye like optometry, ophthalmology and ophthalmic optics.

Exciting developments are foreseeable on the use of holography on these fields in a variety of situations. Holographic optical elements are in the core of new auto-phoropters that, using three tunable-focus fluidic lenses and thin-film holographic optical elements, are designed to perform automatic refractive error measurement and provide a diagnostic prescription without supervision in an effective way [2]. Holographic multivergence targets are used in the subjective measurement of astigmatic errors [3]. Holographic contact lenses [4] became available as well as holographic lenses that can replace the traditional meniscus ophthalmic lenses. CAD (computer-aided design) tools [5] and new methods of engraving/printing holograms further help the modelling and tridimensional visualization of structures of the visual system and noninvasive characterization.

The introduction of the concept of holography is therefore very important on the training of future optometrists and ophtalmologists. We have designed and briefly present here a basic hands-on approach to introduce holography to undergraduate students.

From the basic concepts of coherence to the understanding of interference and diffraction, the students move forward onto the production of holograms of eye models and later one of eye models fitted with contact lenses and even ophthalmic lenses.

We focus the learning process on the Denisyuk holography [6] by its simplicity and easier implementation. Students realize in practice how holography works, understanding the meaning and importance of coherence of the light employed and of an efficient vibration isolation. The students also realised the difficulties and limitations when working with transparent optical elements and alive structures with reduced consistency.

Keywords. Holography, Optometry, Eye, Denisyuk Holography, Ophtalmology.

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Use of Tracker to Study the Free Fall and Vertical Launch

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Abstract. Seven European schools (Agrupamento de Escolas da Maia - Portugal, Colegiul Tehnic Edmond Nicolau Focsani - Romania, Daugavpils 13. vidusskola - Latvia, IIS M. Filetico – Italy, 20th High School of Thessaloniki – Greece, Sercev Engelsiz Mesleki ve Teknik Anadolu Lisesi – Turkey and AGIFODENT - Asociacion Granadina para la informacion, formacion y desarrollo de las nuevas tecnologias – Spain) and three Universities (University of Porto – Portugal, Universitatea Dunarea De Jos Din Galati - Romania and Universita Degli Studi Di Roma La Sapienza -Italy) have developed an Erasmus + project, Science Connect, of a strategic partnership for innovation in order to: 1. use technology for supporting the learning process; 2. apply digital changes in education at organization level, especially the transferable ones; 3. establish effective partnerships for cooperation, that can solve common problems; 4. enable teachers to face the fears of using new technologies; 5. raise teachers skills, for modern and adequate teaching of students expectations and to make equitable and inclusive the digital education.

In the ambit of this project, students from the 11th grade developed a learning scenario to study the free fall and vertical lunch using Tracker as a computer-based learning tool. Their work was presented in a peer-to-peer system, in the first blended mobility for school learners that took place in Granada, Spain.

This activity allowed students to: 1. analyse the graph of position as a function of time through video analysis, obtain the acceleration of gravity using physical-mathematical modelling, and compare the value obtained with the theoretical standard value (9,81 m/s^2); 2. study the magnitude of the velocity in the vertical and horizontal directions; 3. classify the different types of rectilinear motion. It also contributed to the change of attitude of students for the study of science and increased student`s understanding and involvement in the study of Physics. Students acquired knowledge and skills for a scientific field based on the use of technology, strengthened cooperation skills, developed critical skills and abilities to explore and decide on issues related to their experience.

Keywords. Computer-Based Learning, Digital Education, Learning Scenario, Peer-to-Peer System, Tracker Application.

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Energy of Biomass Derived Coumpounds

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Abstract. In this project, it is intended to study the chemical behavior of molecules from biomass, which can be used in the synthesis of new chemicals and biofuels. Thus, it is necessary to know some physicochemical properties of these molecules, such as the combustion energy. These data are very useful in the chemical and biochemical industry, as they help to make better use of the resources coming from biomass for the production of compounds of high commercial value. The sustainable production of new products from biomass, instead of using raw materials from fossil fuels, will help to preserve the environment.

Thinking about this issue, the 12th grade students, in the scope of the Chemistry and Biology subjects, did an internship (one afternoon a week, for 8 weeks) at the Research Center in Chemistry of the University of Porto, CIQ-UP, where they followed the study of the compound 4-methoxy-1-indanone, integrated in a project under development, taking place under the supervision of Ana Luísa R. Silva, researcher at FCUP. The project in question is entitled “Energy and Structural Characterization of Biomass Key Components”, is funded by FCT and has the same investigator as the responsible investigator.

The study of the chemical species, 4-methoxy-1-indanone, was carried out, and will be used as a model molecule to predict the properties of related compounds, reducing the time of search for the molecules alone.

The sublimation technique under reduced pressure was used to purify the sample. The analysis of the degree of purity was performed by gas-liquid chromatography. The static bomb combustion calorimetry technique was used to determine the combustion energy of 4-methoxy-1-indanone.

The combustion energy of a compound is the energy that is released when a mole of fuel undergoes complete combustion within oxygen, under standard conditions.

In this work it was possible to follow a project on the energy study of biomass derivatives and obtain a provisional value for the combustion energy of 4-methoxy-1-indanone, -5046,97 kJ/mol.

Other properties must be determined to better understand this molecule from a chemical point of view. The development of this study, for the universal database, allowed the use of these molecules in the production of new products and fuels, contributing to the reduction of the impact that man has caused in the environment.

Keywords. Biofuels, Biomass, Combustion Energy, Physico-Chemical Properties.

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Procedures for Removal Sulfur Content from Diesel and Jet Fuel

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Abstract. Project-based learning (PBL) allows students to work independently to build their own knowledge in a dynamic and active learning process.

The growing concern about environmental pollution and its side effects on human health has attracted the attention of the scientific and industrial communities. The development of methods capable of eliminating pollutants can be a step forward in improving human and environmental well-being. This class of methods includes liquid-liquid extractions, production of nanomaterials and infrared.

Acid rain is a major environmental pollution problem, mainly caused by the sulfuric acid produced in the atmosphere by Sox emitted with industrial and automobile waste gases. The requirement to produce fuels with very low levels of sulfur (S < 10 ppm) has stimulated much work in the area of sulfur removal, i.e. desulfurization, to create technologies more environmental friendly. Desulfurization by extraction, using two immiscible solvents presents several advantages such as mild reaction conditions and no use of a high expensive chemicals. On the other hand, desulfurization method using materials with high sulfur absorptive capacity is also an economic strategy.

This project proposes the development of efficient desulfurization methods using liquid-liquid extraction and materials with high capacity of sulfur compounds absorption. These materials are based in high surface silica nanoparticles and high porous size coordination polymers. These materials were also prepared during the project and their characterization was performed by infrared spectroscopy. Untreated real fuels as jet fuel and diesel will be treated. Real fuel samples will be supplied by Galp.

Therefore, the 12th grade Chemistry students, working in partnership with the Balula´s group from REQUIMTE-LAQB, Department of Chemistry and Biochemsitry department of Faculty of Science of University of Porto-perfoming desulfurization of real fuels by liquid-liquid extraction and also desulfurization by absorption using two diferente absorptive materials. The students started bye preparing the absorptive materials: i) silica nanoparticles were prepared by dilution of Tetraethyl orthosilicate in ethanol, adding ammonia, using centrifugation to obtain nanoparticles. The pools polymer was prepared by preparing two solutions in methanol, a zinc nitrate and another with 2-Methylimidazole. Both solutions were homogenized using an ultrasonic bath. The solution precursor of metallic component added to the solution precursor of the organic component. The reaction mixture left on magnetic stirrer during 2 hours and 30 minutes. In the end, the resulting material was recovered by centrifugation and washed with methanol 4 times. The material was isolated by centrifugation and dried at 60ºC and 175mbar.

By carrying out this project, students have developed personal skills and their ability to deal with the unknown as well as facing a challenge, always based on problem solving methodology. They have also developed social skills thanks to Balula's teamwork and contact with the entrepreneurial world.

Contacting with a research environment leads to the development of their ability to structure and analyse complex problems that require multidisciplinary skills as well as executing all tasks relating to each stage of the project in a lab environment.

Keywords. Desulfurization, Porous Coordination Polymers, Project-Based Learning, Silica Nanoparticles.

Acknowledgements.

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In-Depth Study of Physics Phenomena by Connex Approaches

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Abstract. One of the main problems facing current education is that students get bored very quickly and do not give enough time, for the most part, to study a given topic. For this reason, we must find ways to make up for their lack of appetite for repetition, so that the Latin saying "repetitio est mater studiorum" becomes a common way of working students.

Our experience of over 30 years in education has led us to consider that the same subject can be approached in different ways, contributing on the one hand, each of them, to the creation or consolidation of different skills, and on the other hand to contribute together to the understanding of a physical phenomenon in connection and interdependence with the daily reality and the theoretical-scientific approach.

In this article, we present a combined approach that combats students' boredom and lack of motivation to learn. We named it the three-steps learning method. Starting from the creation of a device model according to what students know it or which can be introduced through a video presentation, asking them to make an interactive simulation for the same device, students finally get to study the same phenomena through specialized software. leading them to the scientific laws that apply to both practical construction and interactive simulation. Going through all three stages, students learn the same thing in a non-boring way.

The three steps method includes the making of a functional model of a practical device, and whose working can be explained by the theoretical knowledge provided by the school curriculum. The second step was to use a physics-based 2D freeware sandbox, Algodoo, to create an interactive simulation of the same device. Changing the parameters that determine the operation of the simulation is an additional feature, which can only be used at a high cost of time and not only in the case of the functional model. That is why we used the study of parameters only with this software.

The last step was the video analysis of the operation of the model, using the Tracker application. The obtained graphs can be compared with those in Algodoo, the students reviewing in this way the mathematical expressions of the physical laws that apply to the studied phenomena, on which the functional model work is based.

The results we obtained by applying the method of the three steps lead us to consider that it can be useful, especially in the study of physics. It can be extended to various other fields that are related to physics, mechanics and mathematics. The role of the method in the development of imagination and artistic skills should not be neglected. For this reason, we consider that it is fully subsumed to STEAM studies.

Keywords. Algodoo, Connex Approach for Physics Phenomena, Tracker Application, STEAM.

Microplastic Filter - EcoTap

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Abstract. Researches about the microplastics problem, microparticles with dimensions less than or equal to 5 mm, are incresingly present in the scientific community. A clear example of that is a study by WWF, World Wide Fund for Nature, which proved that we ingest an amount of plastic that corresponds to one credit card per week. With this in mind, the educational project of 12^{th} grade students aim at sustainability through the production of a filter to install on taps, capable of retaining these particles that are harmful to the human health and to the environment. In the first phase of the project, some analyses were carried to assess which are the most frequent dimensions of microplastics present in tap water and, consequently, select the most suitable materials for the production. These analyses were performed on water samples from different parts of the country. Consequently, we found out microplastics with dimensions up to 5 mm, some sticks and particles from sewer pipes. On the other hand, the filtering mechanism will be composed by two devices: a metal alloy capable of retaining the larger particles and a ceramic membrane responsible for the filtration of microparticles, without compromising the viability and the flow rate of the filtrate. Finally, after implementing the filter inside a tap in a public establishment, it will be essential to test certain parameters (filter cleaning, efficiency, clogging of pores, etc.)

Keywords. Ceramic Membrane, Filtration, Metal Alloy, Sustainability.

Acknowledgements

We would like to thank “Centro Interdisciplinar de Investigação Marinha e Ambiental” for their orientation and “Faculdade de Engenharia da Universidade do Porto” for their support by allowing that major part of the experiences was performed in their premises.

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Production of Compressed Earth Blocks Using Cigarette Butts and Recycled Paper

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Abstract. The Rebrick Project has as main concern the production of compressed earth blocks (BTC) for construction application allowing waste recovery and the possibility of contributing to the imperative reduction of environmental impacts.

Thus, the incorporation of sustainable materials in the BTCs allows the minimization of cement use, binder responsible for the emission of 8% of the total CO_2 expelled into the atmosphere, and the drain of pollutant residues.

Therefore, the necessary materials (soil, cigarette butts and recycled paper) were characterized, the ways of producing them were evaluated, the mixture was optimized and the physical and mechanical characteristics were verified.

Keywords. Blocks, Cigarette Butts, Recycled Paper, Sustainability.

Acknowledgements

We would like to formally thank professor Aires Camões and engineer Carlos Jesus, both from the Department of Civil Engineering of University of Minho, for all the advice and assistance provided throughout the entire process. Without them it would not have been possible to give life to our idea. In addition, we would also like to thank ESM's Chemistry teacher Isabel Allen and ESM's Biology teacher Luísa Santos regarding the inconditional support they have given us and their belief in, not only our project's potential but also our one. If it were not for them, we would not have the opportunity to develop such project and adquire knowledges for life.

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"Encontro com o Cientista": Informal Talks to Engage Students

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Abstract. "Encontro com o Cientista" is an activity within the weekly program of Escola Ciência Viva – Aveiro, an educational project by the University of Aveiro, Ciência Viva, and the Municipality of Aveiro, dedicated to Education in Science, Technology, Engineering, Art and Mathematics (STEAM).

The activity consists of informal talks between students and researchers from different areas of knowledge. The objective is to promote dialogue in order to show researchers' daily activities, and the importance of their work. Additionally, it seeks to demystify stereotypes associated with the figure of a scientist, as well as to motivate students to pursue careers in science and research.

"Encontro com o Cientista" was held from October 2019 to March 2020, every Friday afternoon.

Several topics were addressed in this program, such as the environment, mathematics, holography, oceans, biodiversity, civil engineering, immunology, circular economy, urban planning, among others.

This presentation will address the collaboration model used between the scientific community (i.e. researchers), the science communicators, and the students. Furthermore, it will be presented the methodology for selecting topics, speakers, and venue. Some quantitative data concerning this activity will also be provided.

Keywords. Informal Talks, Students, STEAM.

The Trend towards Physics and its Relation to Some Variables in Students of the Faculty of Science in Palestinian Universities

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Abstract. The study aimed to identify the attitudes of the students of the Faculty of Science in the the Palestinian universities toward physics and its relation to some variables such as sex, cumulative average, university level. The study sample consisted of 134 students of the Faculty of Science at the Islamic University, Al-Aqsa University and Al-Azhar University. The trends are composed of the variables of the demographic study, and then the trends in its three dimensions (cognitive, emotional, behavioral) and then open questions about the strengths and weaknesses and proposals to increase the trend toward physics. After verifying honesty and consistency according to scientific research steps, the study for the following results: The total score of the students of the Faculty of Science in the Palestinian universities was 70%. In terms of dimensions, the degree of cognitive dimension is 72%, emotional dimension is 68% and behavioral dimension is 69%. The trend of the sample towards physics is attributed to the gender variable, while differences in the sample were found to be in favor of the GPA variable in favor of the excellent, and there were statistically significant differences in the degree of trend among the sample members. Support the University for Al-Aqsa University, k the most prominent points of weakness were the lack of diversity in teaching methods and evaluation, the non-use of modern technology in teaching, and the existence of physical courses in the field of physics. The most important proposals to increase the attitudes of the students of the Faculty of Science towards physics were the need to pay attention to the practical aspects, activate the academic guidance and follow up textbooks by specialized committees, and consider the needs of students and their wishes.

Keywords. Physics Education, Science Students, Physics Courses, Palestinian Universities.

FÁBRICA and CIÊNCIA VIVA School Clubs - *Innovative Partnerships*

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Abstract. Ciência Viva School Clubs is an initiative of the *Ministry of Education* and *"Ciência Viva"* - *National Agency for Scientific and Technological Culture*. These Science Clubs aim to be open science spaces to the whole educational community, whose main objectives are to promote access to innovative scientific practices and to stimulate enthusiasm for science, in Public Schools, Professional Schools and Private or Cooperative Educational Schools. On the other hand, this initiative aims to promote partnerships between Schools and Scientific Institutions, Universities, City Hall, Science Centres, Science Museums, and others entities.

Several school communities, from north to south of Portugal and including Azores and Madeira islands, have accepted the challenge to be part of this network, which counts a total of 237 School Clubs, so far.

University of Aveiro, through Fábrica Centro Ciência Viva de Aveiro, is involved in this nationwide program, organising and promoting several projects and activities in different locations of Portugal. Our goal is the promotion of knowledge and scientific literacy and to build resources and contexts to implement innovative practices at schools. Fábrica has undertaken to support and cooperate in the development of scientific projects, based on tailor made programs and hands-on strategies. These programs include STEAM activities, lectures, workshops, meetings with teachers, field trips, science shows, teacher training, among others. Fábrica is partner with 34 School Clubs from different regions of Portugal, reinforcing national coverage of this initiative.

This communication aims to explore, in detail, the science communication program developed for that program and the established partnership model. The results obtained will be presented, focusing on students engagement in science and technology and the involvement of schools, and their members of the educational community.

Keywords. Science Centres, Schools.

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Electric(e) – Plant Microbial Fuel Cell

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Abstract. Rhizosphere is the soil´s region under the influence of roots, where deposits of photosynthetic material are oxidized by bacteria, resulting in the release of electrons, particles used to generate electric current.

Considering this, 12th grade students will attempt to corroborate this theory by developing their own adaption of a Plant Microbial Fuel Cell (PMFC), using *Oryza Sativa*, a species of rice, two graphite electrodes and a salt bridge, throughout three circuits, aiming to produce electricity.

Sustainability is the foundation of this multidisplinary project, which, if successful at such a small scale, may broaden horizons concerning the world of renewable energies.

Keywords. Electrons, Plant microbial fuel cell, Rhizosphere, Sustainability.

Acknowledgements

Advice and assistance provided by FCUP´s Biology professor Paula Melo concerning the choices of the species and respective growth medium, by ESM´s Chemistry teacher Isabel Allen regarding the comprehension and execution of the chemical component intrinsic to the experience, by ESM´s Biology teacher Luísa Santos in the coordenation of the team and by engineer Paulo Serra from Lusosem respecting the supply of seeds were undeniably crucial and of preeminent value and thus highly appreciated.

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APPLASTIC: an APP that May Save the World

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Abstract. Our project is based on a serious problem that has been affecting the planet. The issue is the large amount of plastic that ends up in the sea as a result of human waste. For every person on the planet, there is one tonne of plastic and nearly 80 percent has become plastic waste wreaking havoc on the oceans around the world. To prevent waste from increasing, this project aims to develop an application that would reach users and raise their awareness. The purpose of this app is to persuade its users to share their own consumption values, so that others can access them, making it an opportunity to “see and improve”, ending up calculating the users' individual ecological footprint.

Applastic is a remarkably simple and interactive app, where users insert their personal data (weight per amount of wasted plastic) and learn how to decrease their own ecological footprint and in this way help the nature and the future generations. It also has some features like personal information, global/national ranking and advice. This advice is provided for us from an information centre where users can ask questions and learn more about this environmental problem and the solutions that are presented to solve it. The app shows us the need to preserve the animal life that is affected by our mistakes.

This platform offers us “scores”, that are earned by doing sustainable actions, which are compared to other users’ score and then presented in a ranking. This competitive way of dealing with this problem ends up attracting more people and making it addictive. Therefore, the users are reducing their ecological footprint in an unconscious way, improving their lifestyle.

This application is for everyone, especially for young people who are still growing and developing their opinions and beliefs. They are the future. They want and they will change the world. Applastic is just another way of helping them with that difficult mission.

Keywords. Application, Ecological Footprint, Social Media, Awareness.

Acknowledgements

We would like to thank professor Nuno Flores, from Faculty of Engineering of the University of Porto (FEUP), for his orientation and support by helping us to know more about informatics and giving us some advice.

WateReuse: an Environment Toilet Flush

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Abstract. Water is not a never ending source, but most humans have still insisted on making use of water in an uncontrolled way, often do not even use it, just waste it. Studies show that if there is continued growth of waste there will be an unsustainable situation in the near future, where there will be water insufficiency in the whole world. From this perspective, this project aims to achieve the savings of drinking water, as it is increasingly necessary and urgent. In this project we are developing a toilet that uses drinking water, previously spent on the washbasin in order to save it. In this context, we are producing a single piece that will consist of an "L" format. In this, you can find a washbasin, in the top, and a toilet, at the base. In addition, inside the model, there will be the entire usual toilet, however, in place of a floating buoy, we will put a water sensor. This water sensor will be connected to an arduino, correctly programmed for our purpose in this project. The arduino will also be connected to an electrovalve that will make the separation between two pipes, one that will lead the water to the tank and the other that will drive it directly into the sewer; and another that will guide the water from the tank to the toilet basin. We will also use a button/motion sensor to flush. The latter case will only happen when the water sensor transmits the information that the tank is full. WateReuse brings together a set of technologies that have been programmed for our objective. The joint use of these techniques leads to the development of an environmentally sustainable product. The excessive use of water used in the flush toilets usually found, results in an exacerbated and unnecessary waste of drinking water. From a constructive (mechanical) point of view, the set of materials that will result in a final product, it will enable a reduction in drinking water expenses, at the level of restroom. In addition, it does not require additional energy outflow. In Portugal, the production of a product equivalent to what we are doing is not a common practice. Using an arduino connected to its constituents, previously mentioned (water sensor, solenoid valve), is an innovation, which aims to replace the regular floating buoy used in normal cisterns, guaranteeing, in the same way, a functioning system.

Keywords. Arduino, Sustainability, Drinking Water, Water Saving.

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AUTHOR INDEX

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