Hands-on Science

Celebrating Science and Science Education

Edited by:

Manuel Filipe P. C. Martins Costa
José Benito Vázquez Dorrío
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The Hand-on Science Network

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Foreword

Celebrating Science and Science Education

Reuniting a large and diverse membership of institutions from all over the EU, twenty years ago the Socrates/Comenius 3 Hands-on Science Network was established marking the beginning of a wonderful journey with an ever-increasing enthusiastic group of researchers, teachers, educators, students, parents, policy makers and many others all committed to the improvement of Science and Science Education. With a broad open understanding of the meaning and importance of Science to the development of our societies, each individual and of the humankind, the main goal of the Hands-on Science Network is the development improvement and generalization of science education and scientific literacy by an extended use of investigative hands-on experiments based active learning of Science and its applications, while fostering cooperation and mutual support understanding and respect among teachers, researchers, educators, students and all involved and committed to science education at all levels and contexts.

The focus of HSCI was not on the creation of new pedagogical or didactic theories or to remake, or simply rename, existing ones, well established or not... We do not need to *reinvent the wheel* but we do can improve it and give it a better use. Being aware of the evolution and changes in our societies, identifying and facing, in an open and critical mind way, the challenges, risks, new constraints but also opportunities, we welcome and give support to all positive contributions aiming a better effective science education.

At our 20th annual Hands-on Science conference in the beautiful city of Barcelona, that we are visiting for the second time after the HSCI2018 conference we fondly remember, we will celebrate *Science and Science Education* and the improvements and advances made along last twenty years. As always in a friendly and open-minded way we will discuss current trends challenges and opportunities respecting and integrating all different perspectives and diverse and innovative proposals of solution to the problems science education is facing.

Along these twenty years a large number of relevant and meaningful, pedagogically and scientifically, papers support materials and inspiring examples of good practices were presented at our conferences and published in the proceedings and books we edited, constituting a most valuable repositorium freely available to everyone.

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 the works presented at the 20th International Conference on Hands-on Science. Celebrating Science and Science Education, held in Barcelona, July 17 to 21, 2023.

Vila Verde, Portugal, July 15, 2023.

Manuel Filipe Pereira da Cunha Martins Costa
Editor in chief

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FOREWORD

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Creating of STEM – Equipment: Optical Workbench for Reflection and Diffraction Effects

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Abstract. The STEM (Science, Technology, Engineering, and Mathematics) field is crucial for the advancement of society, and hands-on experiments play a pivotal role in enhancing understanding and interest in these subjects. One key area of study within STEM is optics, which explores the behavior of light and its interaction with various materials. Reflection and diffraction are fundamental phenomena in optics that significantly impact how light behaves and can be manipulated. To facilitate hands-on learning and experimentation in these areas, we present the design and development of an innovative STEM Optical Workbench.

The STEM Optical Workbench is a versatile and interactive educational tool that allows students to explore and analyze the effects of reflection and diffraction. The workbench is designed to provide a comprehensive platform for conducting experiments, analyzing data, and gaining insights into the principles underlying these optical phenomena. By engaging with the workbench, students can deepen their understanding of light behavior and develop critical thinking skills through active experimentation.

The key components of the STEM Optical Workbench include a light source, mirrors, lenses, diffraction gratings, and various screens and detectors. The light source provides a controlled and consistent beam of light that serves as the primary input for the experiments. The mirrors allow for reflection and redirection of the light beam, enabling students to investigate the principles of reflection and understand concepts such as angle of incidence and angle of reflection. Mirrors are incorporated to demonstrate the principles of refraction, focusing, and image formation.

One of the most important features of the STEM Optical Workbench is the inclusion of diffraction gratings. These finely ruled surfaces enable students to observe and analyze the phenomenon of diffraction, where light waves bend and spread when passing through narrow slits or closely spaced lines. By manipulating the diffraction grating, students can investigate properties such as wavelength, intensity, and interference, providing a deeper understanding of the wave nature of light.

The workbench also includes a green laser, range of mirrors, holders and sound detector that allow students to visualize and measure the effects of reflection and diffraction. These screens help in observing interference patterns produced by diffraction gratings and analyzing the behavior of light waves. Detectors, such as photodiodes or cameras, capture and record the intensity and distribution of light, enabling students to quantitatively analyze the results of their experiments.

Keywords. Optical Phenomena, Reflection, Diffraction Effects, Workbench, Hands-on Experiments, Light Propagation, STEM Equipment.

1. Introducton

Inspired by research and progress in the field of science and technology, scientists and students of the National Technical University "Kharkiv Polytechnic Institute" (NTU "KhPI") have been working on the "Creating of STEM equipment" project for many years [1-5]. This project is designed to promote science, technology, engineering and mathematics (STEM) learning and development through the creation of new laboratory equipment.

This year, a team of scientists will present at the conference [6] their new achievement - simple laboratory equipment for demonstrating simple optical phenomena. This equipment is designed with the needs of education and research in the field of optics in mind. It will enable experiments and research that demonstrate the basic principles of optics, including light reflection, refraction and scattering.

New laboratory equipment includes a variety of optical components that allow visual illustration and investigation of these phenomena. With the help of this equipment, students and scientists will be able to experiment, make simple visual measurements,

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analyze data and gain practical skills in the field of optics.

The presentation of new laboratory equipment at the conference is an important event that will allow you to talk about the results of the team's long-term work and share knowledge and achievements with colleagues and other conference participants.

During the development of the STEM Optical Workbench, a comprehensive approach was implemented, which, provided that this Workbench is produced directly in the educational facility, allows students to be involved at all the main stages. At the same time, students have the opportunity to get acquainted with the initial elements of 3D printing, electronics, and mechanical processing of materials at various stages of production, and as a result, get a Workbench that allows you to visually observe the main optical effects.

We took into account that in recent years there has been a wide introduction of electronics into the educational process, and in particular 3D printers, which, thanks to the availability of various grant programs, are now available in many educational facilities, including schools. Therefore, the principle of using 3D printing was taken as a basis during the development of the STEM Optical Workbench. This approach makes it possible to significantly simplify the manufacture of Workbench components, increase the accuracy of their manufacture and prevent the formation of harmful wastes, in particular dust from the mechanical processing of plastic or wood.

In turn, a large number of various models for printing are now freely available through the Internet, which allows you to use this approach in study process without the need to master programs for creating 3D models.

2. Design conception

The developed STEM Optical Workbench was based on well-known optical circuits with mirrors, prisms and diffraction gratings. But unlike similar scientific level systems, we used the possibility of locating all parts on any flat surface without using specialized optical tables and rulers. For this purpose, it was planned to place all the main components of the STEM Optical Workbench on easy-to-move and adjustable stands made by 3D printing.

The STEM Optical Workbench includes 5 - 7 universal stands on which mirrors or elements with different surface characteristics can be placed to study the processes of light reflection and scattering. And special stand on which the diffraction grating is attached. It should be noted that modern 3D printers make it possible to make such gratings without any particular difficulties, thus making it easier to study such interesting effects as diffraction in schools. In addition, the plastic diffraction grating is an order of magnitude more resistant to mechanical influences during experiments conducted by children and can be printed in the required quantities without any problems.

Figure 1 shows the manufactured stands based on one of the models placed on the Thingiverse website

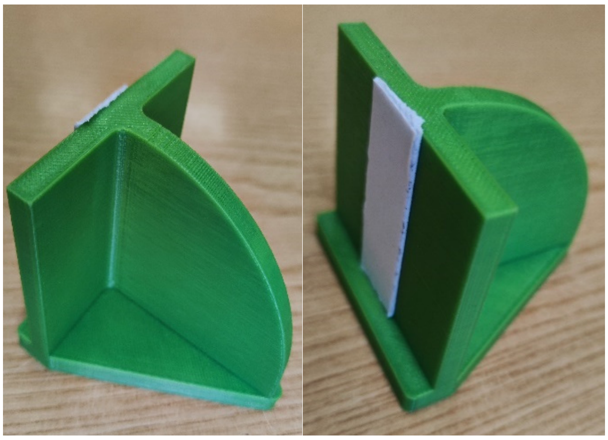

Figure 1. Stands for reflecting surfaces made by 3D printing

Figure 2 shows the general appearance of a diffraction grating made by 3D printing.

As a light source, a laser pointer available in any school was used, which, although it requires compliance with safety measures, is completely safe in contrast to powerful lasers. The laser was chosen due to the fact that a coherent beam of light provides the most visual demonstration of such basic optical effects as reflection, scattering, refraction and diffraction.

To ensure a convenient location on the table and the possibility of adjustment, the pointer is also placed in a special holder made by 3D printing. The general appearance of such a structure is shown in Figure 3.

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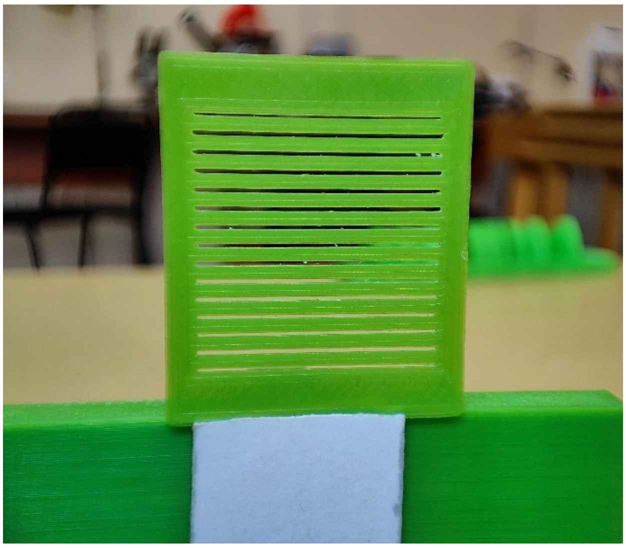

Figure 2. Plastic diffraction grating made by 3D printing

Figure 3. Laser pointer, installed into a holder made by 3D printing

During development the Workbench we take into account that when performing optical experiments, visualization of the light path is an important task, the solution of which ensures that experiment will be clarity and comprehensibility for the children. Typically, a so-called dark room with tightly curtained windows is used. But in the conditions of an ordinary educational facility, the implementation of such a room is a rather difficult task, which according to the budget can equal and exceed the actual cost of making an optical Workbench. Another approach is to visualize the rays using smoke or artificial fog. But again, using even compact smoke machines in the presence of children is quite risky. First of all, due to the possibility of various kinds of negative allergic reactions due to inhalation of such artificial smoke and in general the need to observe safety rules.

Therefore, to solve this problem, we propose to use a simple optical receiver circuit based on a photodiode connected to a buzzer. The principle of this device operation, the schematic diagram of which is present on the Figure 4, is that when a light beam hits the receiving surface of the photodiode, a current begins to flow through it, which can be used to activate the buzzer and thus signal the presence of light at a certain point. In the rest state, the light of the laser beam does not reach the photodiode VD1, so the current does not flow through the photodiode and the base-collector junction of the transistor Q1. Accordingly, transistor Q1 is in the closed state, no current flows through the emitter-collector junction. And, accordingly, the current does not flow through the serially connected boozer.

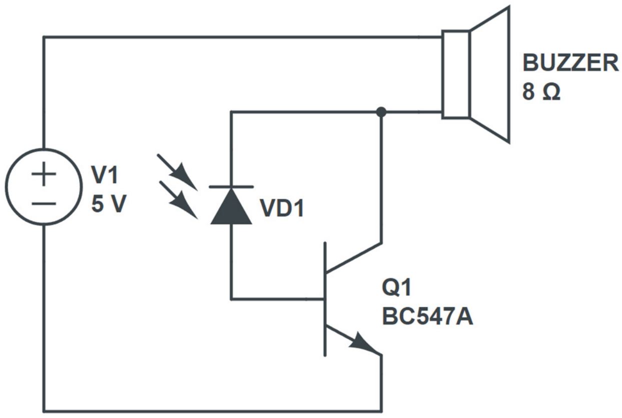

Figure 4. Schematic electrical diagram of the laser beam receiver

If the laser beam hits the VD1 LED, its transition resistance is significantly reduced. A small current appears through the photodiode and the base-collector junction of transistor Q1. The transistor opens and the emitter-collector junction and the boozer connected in series with it begin to flow. In this case, the boozer emits a sound indication of the presence of a laser beam.

Structurally, for the implementation of a portable receiver, it was made on the basis of a self-powered power bank housing.The overall view of the developed laser beam detector are shown in Figure 5.

The use of the proposed STEM Optical Workbench allows you to conduct basic optical experiments in a playful way like "catch the beam" and visually demonstrate to children of even the youngest age the difference between

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the reflectivity of different materials, as well as to see the weakening of light as a result of its repeated reflection from mirrors.

Figure 5. Overall view of the laser beam receiver

3. Demonstration

Examples of visualization of optical effects using the developed STEM Optical Workbench are shown in the series of photos on Figure 6.

As we can see using mirrors mounted on the plastic stands made it very easy to demonstrate the light beam trajectory. It should be noted that on the photo we can not demonstrate the sound reaction of developed laser beam receiver. So, for visualization of light pass in terms of this article we use a little bit of artificial fog from smoke machine and make photo in the dark room. When replacing one of the mirrors on the stand by a dark screen, you can clearly see the implementation of the diffraction effect, as shown in Figure 7.

As we can see, the capabilities of the 3D printer are more than sufficient for the production of a grid that allows you to see the formation of diffraction maxima under simple conditions.

The universal nature of developed holders allows you to attach prisms made of different materials to them and study the phenomena of light refraction in this way. Figure 8 shows the Workbench in the variant of studying the trajectory of rays through one and several prisms.

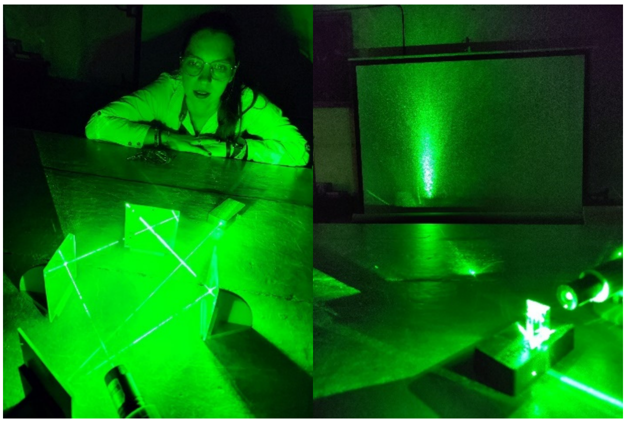

Figure 6. Visualizing of laser beam path through a system of 4 mirrors and light dispersion as a result of replacing one of the mirrors by material with a sharp surface

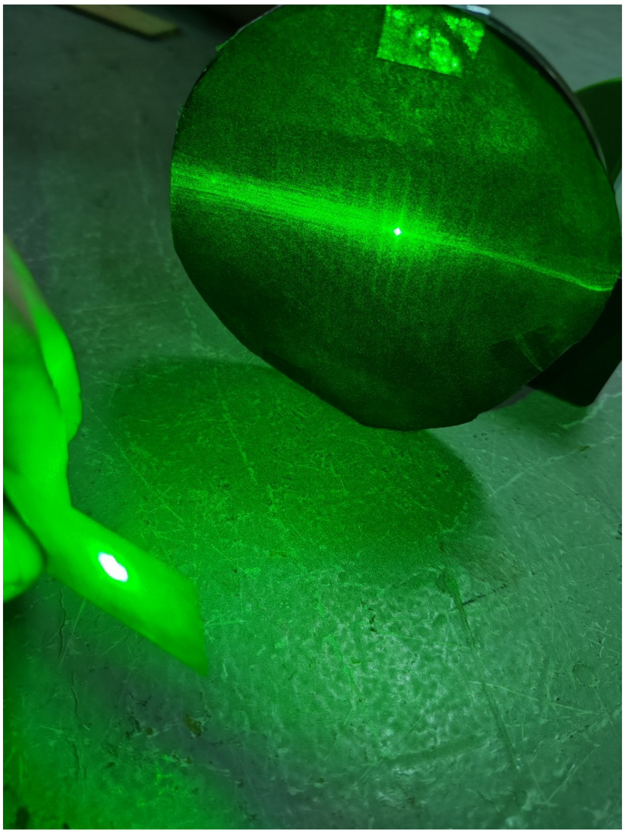

Figure 7. Visualization of light diffraction effect

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Figure 8. Visualisation of light rays' trajectory through one and several prisms

Using laser with clearly formed light beam allows you to create different optical patterns, depending on the composition of the glass and the geometric features of the prisms used.

Thus observing the effects of refraction, birefringence, total internal reflection and other visual demonstrations of the change in the trajectory of a light beam when passing through prisms.

Naturally, when conducting such experiments, safety rules should be observed in order to prevent even the laser beam reflected from the prisms from getting into the eyes of students.

4. Conclusions

In conclusion, the development of the STEM Optical Workbench provides a valuable tool for educators and students to explore and understand the fundamental principles of reflection and diffraction. By engaging with this interactive platform, students can actively experiment, analyze data, and deepen their knowledge of optics. This workbench promotes the development of critical thinking skills, encourages scientific inquiry, and fosters a passion for STEM subjects.

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Seeing Beyond the Stars: Unveiling the Principle of Reflective Telescopes for Deeper Comprehension

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Abstract. Telescopes and microscopes are taught in geometric optics textbooks, but many students struggle to understand their principles, which are actually quite simple. This suggests that the textbooks are not effective in conveying the information.

However, the truth is through well-designed experiments, students can intuitively grasp these principles. Regrettably, textbooks often suggest ineffective experiments and fail to provide a comprehensive conceptual framework.

Reflecting telescopes, like the astronomical telescopes, the Hubble Space Telescope and Webb Space Telescope, appear more complex compared to refractive telescopes. Reflecting telescopes are equipped with a primary concave mirror, along with a secondary mirror and support poles positioned in front of the main mirror, which may initially appear to obstruct its functionality. Some large reflective telescopes, such as the Webb Telescope, employ multiple smaller mirrors to form the main mirror. It may seem puzzling how these smaller mirrors can function as a concave mirror.

To comprehend how these telescopes function, it is crucial to have a deep understanding of how the structures in front of the main mirror, such as support poles, and the slots on the main mirrors influence the formation of the real image.

In response to these challenges, this study introduces an improved concept map and several teaching aids. The concept map addresses four key issues: (1) Objects in geometric optics are composed of numerous point sources of light that our eyes perceive; (2) The magic functions of concave mirrors; (3) A real image is equivalent to a real object in geometric optics, both being composed of point sources of light. The real image can be directly observed and magnified using a magnifier; (4) Reflective telescopes produce high-quality real images that can be recorded by electronic devices. These images can be treated as if they were real objects reconstructed at their location and magnified using an eyepiece.

Additionally, this study proposes several corresponding experiments and innovative teaching aids to demonstrate these principles visually, emphasizing the idea that seeing is believing.

By convincingly guiding learners to understand and accept these four key issues, they can intuitively and deeply grasp the principles of reflective telescopes. The aim is for learners to master the principles and even innovatively design reflective telescopes, enabling them to easily comprehend and explain their observations while conducting experiments related to reflective telescopes. Consequently, the quality of teaching the principles of reflective telescopes can be meaningfully enhanced.

Keywords. Concave Mirror, Point Source of Light, Real Image, Real Object.

1. Introduction

The author aims to address topics that are unreasonable, vague, possibly misleading, or inadequately described, which can mislead learners and overlook important aspects of the topic. The author strives to establish a teaching resource consisting of a new concept map, a series of teaching aids, and corresponding books and articles.

Firstly, the author recognizes the scope of the topic. The scope is defined as a field encompassing all the key knowledge necessary for learners to logically, comprehensively, and completely understand the topic. Acquiring all the key knowledge within the scope equips learners with the ability to solve real problems in the field. Each piece of knowledge within the scope is crucial for a genuine understanding of the topic. However, any unnecessary knowledge that doesn't contribute to the complete picture of the topic is omitted.

Secondly, the author develops a new concept map and reorganizes statements by clarifying ambiguities, generating new ideas, and identifying any missing parts of the topic. This process aims to present a clearer and more concise overall picture of the topics for learners.

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Additionally, a series of teaching aids, including hands-on materials, is created to illustrate each key piece of knowledge in the topic. This approach allows learners to successfully grasp topics that were previously challenging due to problems in textbooks or in public science education. It facilitates a more accessible, interesting, and effective learning process.

Finally, corresponding books, articles, and manuals are published to ensure people understand the teaching resource for a given topic and how to employ the teaching resource. This teaching resource is highly desired and can become part of the formal scientific education curriculum in schools, enhancing the efficiency and quality of scientific education.

One specific topic with inherent difficulties resulting from the textbook is the principle of the reflective telescope, along with related principles about concave mirrors.

In the chapter discussing real and virtual images, textbooks often use diagrams to illustrate the reflection and refraction of light rays, as well as how lenses and concave mirrors form images.

Unfortunately, many students find it challenging to comprehend the meaning of these diagrams and struggle to understand the nature of real and virtual images.

As a committee member of the 2023 University of Science and Technology Entrance Examination, the author posed a critical question regarding concave reflection in the examination. The question presented a fundamental figure commonly found in geometric optics textbooks (see Figure 1). Ideally, students should be familiar with this figure. However, the figure in the question in the entrance examination includes an additional light ray, and students are required to determine the point towards which the additional light ray after reflected will move (see Figure 2).

Absolutely, given the formal nature of the examination and its impact on determining which school students will enter based on their scores, students approach the question with utmost sincerity. Their answers provide valuable insights into their understanding of the topic. Furthermore, the officials consistently conduct thorough investigations into all the questions in the examination, analyzing the answers provided by students of different academic abilities using professional methods each year. Consequently, the evaluation of the examination's quality by officials is undeniably regarded as highly reliable and valid.

The answers to this fundamental question in the entrance examination reveal that both high-performing and low-performing students struggle to answer it correctly and confidently.

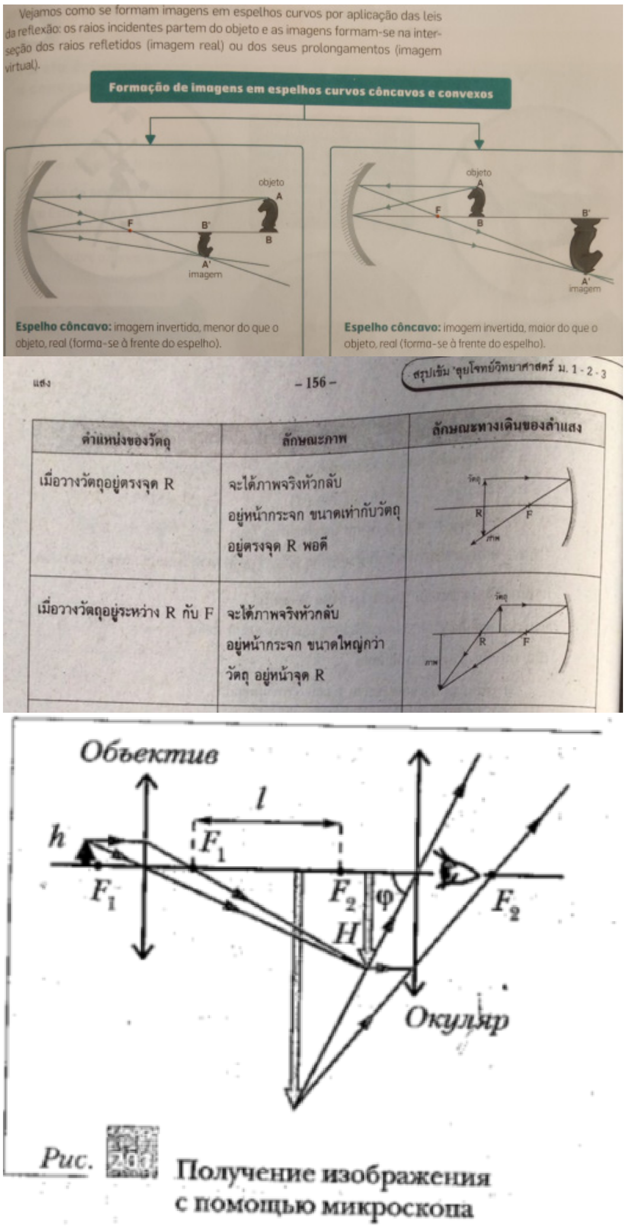

Figure 1. First of all, the magical function of a concave mirror should be introduced. Following that, the methods for determining the size and location of the real image will be discussed

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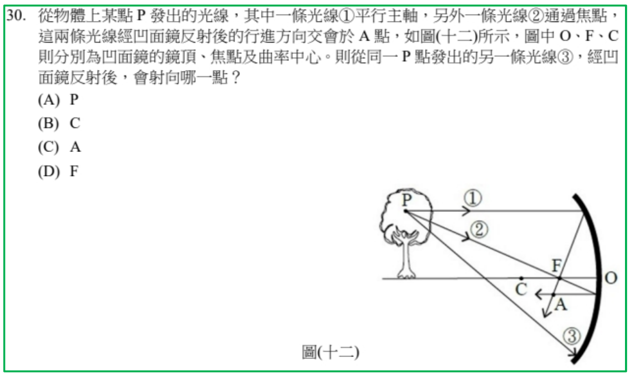
30. 從物體上某點 P 發出的光線，其中一條光線①平行主軸，另外一條光線②通過焦點，這兩條光線經凹面鏡反射後的行進方向交會於 A 點，如圖(十二)所示，圖中 O、F、C 則分別為凹面鏡的鏡頂、焦點及曲率中心。則從同一 P 點發出的另一條光線③，經凹面鏡反射後，會射向哪一點？

(A) P
(B) C
(C) A
(D) F

Figure 2. Which point does the light marked by number ○,3 reach after being reflected by the concave mirror?

This presents a pressing issue that science educators should address. If students with varying levels of performance cannot answer the question correctly—i.e., they are uncertain about the critical fact that all light rays emitted from a point of light source and reflected by a concave mirror converge at a corresponding point—then their understanding of real images is undoubtedly flawed or inadequate.

The subsequent question, deserving further exploration, is the cause behind the difficulties experienced by both high-performing and low-performing students in answering the question. It is evident that the primary reason is the failure of geometric optics textbooks.

According to the author's learning experience, the author has identified and declared this problem in textbooks and has been conducting extensive research on the matter for decades.

In general, most textbooks fail to emphasize the nature of an object or an image in geometric optics and do not highlight the fact that a concave mirror possesses a very unique property: all light rays emitted from a point source of light, after being reflected by a concave mirror, converge at a corresponding point. Textbooks should emphasize the importance of a point source of light in geometric optics. As a result, students struggle to understand the nature of an image, the relationship between the image and the lines depicted in the figure (see Figure 1) that represent the light rays, and the purpose of drawing multiple light rays whose directions can be easily determined after reflection by a concave mirror. Students mistakenly believe that the lines in the figure are solely used to determine the location of the real image.

However, the study of geometric optics can become much easier to comprehend and extremely interesting if a few key points are highlighted to refine the textbooks. It is truly regrettable that most existing textbooks separate the real experimental phenomena from the textbook content. In other words, after studying the textbooks, students find it challenging to explain what they observe in geometric optic experiments based on the knowledge they have acquired from the textbooks. This long-standing flaw is truly unfortunate and unacceptable.

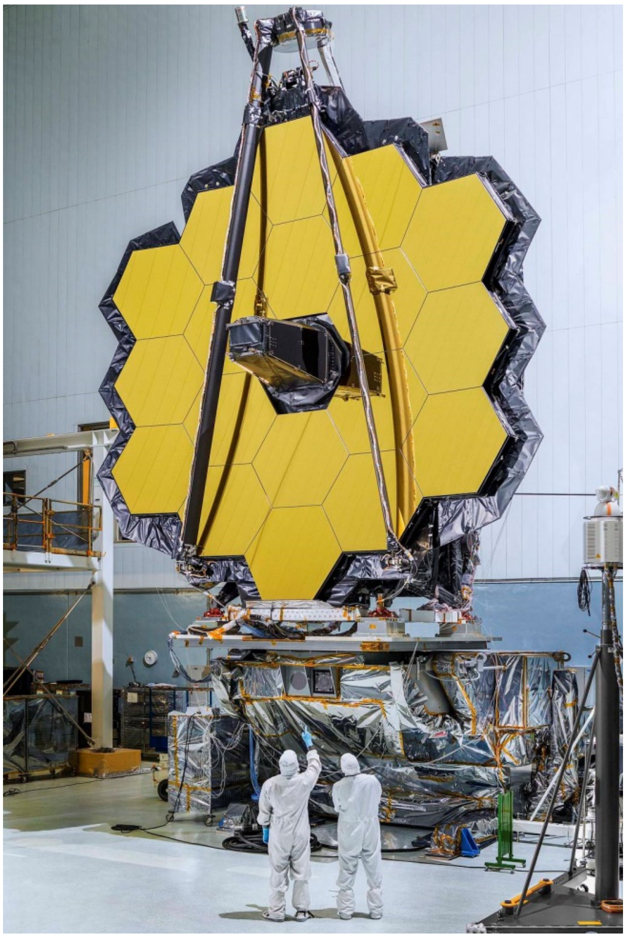

Figure 3. The James Webb Space Telescope. Image Credit: NASA/Chris Gunn

The James Webb telescope (see Fig.3) was launched during Christmas 2021 and is currently operating in its designated orbit, successfully unraveling the mysteries of the universe. While its appearance may not resemble that of a conventional telescope, understanding its intricate functionality can be challenging, despite the fact that the principles behind it are

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commonly covered in textbooks. It is unfortunate that our students lack a comprehensive understanding of the optical principles underlying this remarkable technological achievement, especially considering the breathtaking images it has captured and the plethora of previously unknown phenomena it has revealed. The existence of such an extraordinary instrument, which attracts significant attention from the public and media, should serve as a strong motivation to reassess the way we teach these topics in textbooks. This presents an opportune moment to reevaluate and enhance our instructional methods, ensuring that students can grasp the underlying concepts, which are actually easily understandable in reality, more effectively.

2. The scope of the principle of reflective telescope

Defining and optimizing the scope is crucial for understanding the principles of any given topic. Before teaching a topic, such as the principle of a reflective telescope, it is necessary to construct and define its scope. It is important to ensure that individuals have sufficient knowledge within this defined scope in order for them to master the topic. Organizing and establishing the relevant knowledge within the scope of reflective telescopes is essential. With this knowledge, individuals can effectively explain their observations while using a reflective telescope, comprehend new designs of reflective telescopes, and even innovate their own telescopes. However, it is also important to be prudent in eliminating unnecessary knowledge that may burden learners, allowing for a focused approach on the key issues. Within the scope of the principle of a reflective telescope, there are four key areas of knowledge: 1) understanding that a real object consists of numerous point sources of light, 2) recognizing the magical function of a concave mirror, 3) comprehending that a real image is similar to a real object because both consist of numerous point sources of light, and 4) smoothly grasping the principle of a reflective telescope.

2.1. A real object consisting of numerous point source of light

In mechanics, an object refers to a physical entity with mass. In thermodynamics, an object represents a system composed of numerous molecules and atoms. In geometric optics, an object is a collection of multiple point sources of light.

A point source of light is a location that emits light in all directions. In our everyday lives, most objects differ from light sources such as fire, light bulbs, stars, and the sun, as they do not emit light themselves. However, due to the phenomenon of diffuse reflection of light on each extremely small area of these objects, and considering the contribution of multiple light sources, including all visible elements like walls, windows, trees, clouds, and so on surrounding the objects, each extremely small area effectively emits light in all directions. Thus, an object in geometric optics can be considered as a collection of numerous point sources of light,, as depicted in Figure 4.

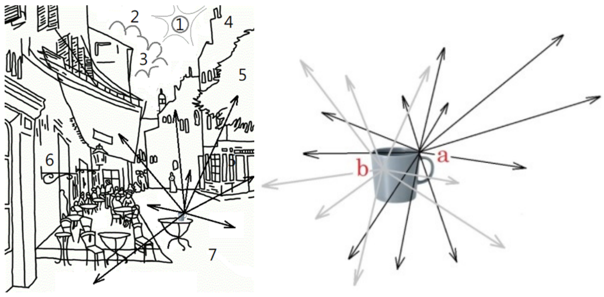

Figure 4. Any extremely small area on an object can be treated as a point of light in geometric optics

In the eyes of most animals on Earth, there exists a lens and a retina. The lens gathers light emitted from a point source of an object and focuses it onto a specific point on the retina. By receiving the optical signal from that illuminated point on the retina, an animal can perceive the point source of light

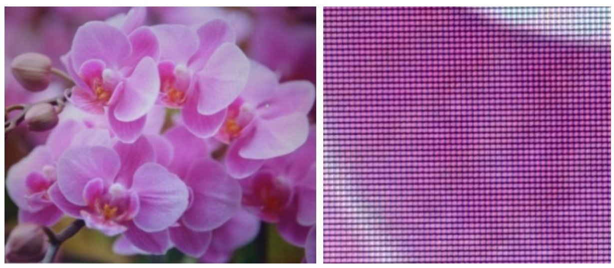

Figure 5. The image and the pixels forming the image on a screen

If all the point sources of light are visible, the animal sees the complete object. However, if only some of the point sources can be seen, the

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animal perceives only a portion of the object.

Similarly, on the display of a computer, mobile phone, or any device with an LCD panel, there are numerous pixels that simulate the point sources of light found on the surfaces of objects in our daily lives. This allows us to see images on the screen that closely resemble real-world objects, as shown in Figure 5.

2.2. A magic function of a concave mirror

We need to create a highly precise concave mirror to achieve its remarkable function as perfectly as possible. All lights emitted from each point source, located beyond the concave mirror's focal point, are reflected by the concave mirror, they converge through corresponding points located beyond the focal point as well.

In simpler terms, all the point sources of light from an object relate to specific intersection points.

While it may not be necessary to delve into the intricate details of how and why concave mirrors possess this special function, It is worth noting that scientists have developed various software tools and use very precise machines to perfect the shape of concave mirrors in order to optimize this particular capability. Although, in general, light emitted from a point source and reflected by a concave mirror will converge at a corresponding point, the function is not entirely perfect. Therefore, optimizing the shape of the concave mirror is essential to achieve the desired magical effect.

Furthermore, it is important to consider the wave nature of light when light from the same point source converges at a specific point. The phenomenon of diffraction becomes significant in determining the resolution of the real image formed by the concave mirror. This is because a point source of light in the real object may result in an extremely small diffraction pattern, which closely resembles a point source but is not precisely identical. The disparity between the real point source of light and the diffraction pattern ultimately determines the resolution of the concave mirror.

2.3. A real image assembles a real object

As we know, an object consists of numerous point sources of light, and it is through these point sources that we are able to see the object. When light from each point source on an object is reflected by a concave mirror, it converges at a specific point, similar to how numerous other lights do. It is important to emphasize that after converging at this point, the light continues to propagate in its original direction. Consequently, the result is that the light appears to originate from this converging point. It seems as though the converging point emits light in various directions, thus behaving like a real point source of light on the object. In other words, the converging point becomes a new point source of light.

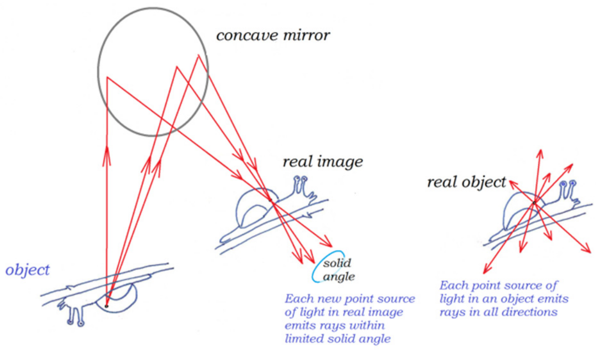

Figure 6. How is a real image formed? Exploring the differences and similarities between an object and a real image

Therefore, through the magical function of a concave mirror, each point source of light on a real object forms a new point source of light respectively somewhere. These new point sources of light closely resemble the original point sources on the real object, and the relations between these new point sources mirror the relations between their respective locations on the real object. In essence, all the point sources of light on the real object are reconstructed somewhere in front of the concave mirror, resulting in numerous new point sources of light. This phenomenon, facilitated by the concave mirror's magical function, gives rise to a collection of new point sources that closely resemble the real object. This collection is referred to as the real image, which bears a striking resemblance to the original object.

Since both the real image and the real object consist of point sources of light, there is no significant difference between them in optics. Consequently, we are able to directly observe an object at its original position, and similarly, we can naturally perceive the real image located at the position of the collection of converging points with our naked eyes. Furthermore, just as we can use a magnifier to enlarge a real object, we can also employ a magnifier to magnify a real image, as shown in Figure 6.

However, there is a slight difference between a real image and a real object. The point sources of light on a real object emit light in all directions, whereas the point sources of light on a real image emit light within a specific range of directions, limited by the boundary of the concave mirror and any obstacles in front of it. This phenomenon is illustrated in Figure 7.

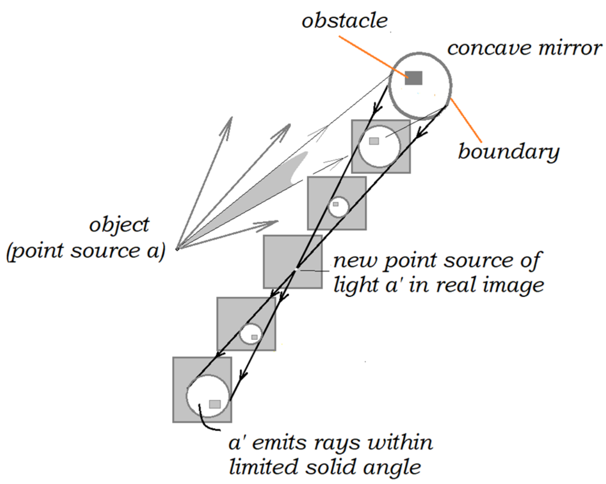

Figure 7. A point source of a real image emits light within a limited solid angle scope

This small difference accounts for the slight distinction between the real image and the real object. It also leads to unique phenomena when directly observing the real image or capturing it using devices such as CCD or film. Further consideration of these special phenomena aids in understanding the intricacies of the real image and reaffirms the principles of the concave mirror.

2.4. The principle of a reflective telescope

All the light emitted from each point source of an object is refracted through a lens and converges at a corresponding point. The collection of all these converging points forms the real image of the object. Similarly, when the light emitted from each point source of an object is reflected by a concave mirror, it also converges at corresponding points, just like other lights emitted from the same point source of light. These converging points act as new point sources of light, creating the real image of the object. The real image is almost identical to another real object located at the position of the real image.

Both concave mirrors and lenses are capable of forming a real image. This real image closely resembles another real object positioned at the location of the real image and reflects the original object by reconstructing all the point sources of light in accordance with the point sources of the original object. However, the process differs between concave mirrors and lenses.

However, making a concave mirror is easier compared to making a lens of the same size. This is because only a single surface on the concave mirror needs to be constructed with extreme precision, while a lens requires both surfaces to be constructed very precisely. Additionally, a concave mirror does not suffer from the dispersion problem.

When constructing a real image of a far-distance object, the negative factors that can influence the real image produced by a concave mirror are fewer compared to those affecting a lens.

Compared to a refractive telescope, a reflective telescope appears more complex due to the presence of a secondary mirror and support structures in front of the main concave mirror. Visualizing how these obstacles affect the function of the concave mirror can be challenging. Additionally, some large main concave mirrors in various telescopes, including the James Webb space telescope, consist of multiple smaller mirrors, and the gaps between these mirrors can also introduce concerns.

The key to understanding this puzzle lies in the fact that all light emitted from a point source on a distant object, after being reflected by any section of the concave mirror, will converge at a specific point. For example, when a point source emits light in all directions, the concave mirror with slots and obstacles on its surface will reflect the lights at various sections of the concave mirror. Despite the slots and areas of the concave mirror obstructed by obstacles, the light reflected by the remaining areas of the concave mirror still converge at a particular point. Therefore, the light emitted from each point source on the object, reflected by the unobstructed portions of the concave mirror, still converge at corresponding points. These

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corresponding points become new point sources of light, forming a real image.

The new point source, being converging point, can illuminate a tiny area on a film or a pixel on a CCD sensor. All these illuminated point-like areas or pixels together form the real image, which is not affected by the presence of slots and obstacles.

The real image created by a concave mirror with slots and obstacles in front of it can be observed with the naked eye. However, due to the limited directions in which the point sources of the real image emit light (constrained by the boundaries of the concave mirror and the obstacles), some or all of the light emitted by certain point sources of the real image may not enter the observer's eyes, allowing them to perceive the presence of the obstacles and slots.

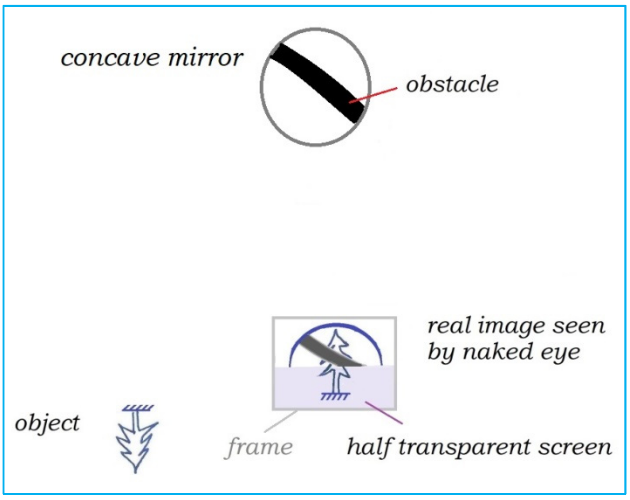

Figure 8. The influence of obstacles in front of a concave mirror is noticeable to the naked eye, whereas the real image formed on the screen remains unaffected due to diffuse reflection

Nevertheless, when viewed through an eyepiece, which acts as a precise magnifier, the light emitted from all point sources of the real image can enter the observer's eye. Therefore, the influence of the slots and obstacles cannot be perceived again when observing the image through the eyepiece.

3. Teaching aids for the principle of reflective telescope

Geometric optics is a profoundly experimental discipline that investigates the principles behind our ability to perceive optical phenomena. It is a vibrant and captivating scientific field that captures the interest of many students and leaves them deeply amazed. A primary objective is to provide logical and concise explanations for experimental optical phenomena as perceived by our eyes. Consequently, conducting relevant experiments holds immense significance. Rather than merely conducting a few experiments, we have meticulously designed a series of well-organized experiments that effectively illustrate the four key issues mentioned earlier within a carefully defined scope.

3.1. Experiment: Demonstrating the Composition of Real Objects as Collections of Point Sources of Light

Addressing this issue is relatively straightforward. In our everyday lives, we can find examples all around us. Take any object within our reach, for instance. Every small area of its surface is illuminated by light from various sources coming from different directions. By comparing this scenario to a perfect mirror, we can easily understand the concept of diffuse reflection. For example, let's imagine using a laser beam to illuminate a perfect mirror placed on a desk. When we position ourselves at a specific point, we can clearly see a strong reflected laser beam on the mirror (please be cautious and avoid direct viewing with naked eyes). However, if we move away from that specific point, we will barely see the reflected laser light and even the laser spot on the mirror. In contrast, if we replace the mirror with a regular white piece of paper, we can see the laser light spot on the paper from any position, regardless of our viewing angle.

Moreover, we can even use the pixels on a computer screen to emphasize the meaning of a so-called point source of light (see Figure 5). The image displayed on the screen is made up of numerous small pixels. Similarly, an object consists of numerous point sources of light.

3.2. Experiments Revealing the Magical Function of a Concave Mirror in Detail

Unlike textbooks that describe the concept of the focal point and highlight the fact that light parallel to the principal axis of a concave mirror will pass through the focal point after reflection, our primary focus is to emphasize the magical function of a concave mirror. Before presenting diagrams illustrating the behavior of four special lights and their clearly determined directions after reflection, we want to straightforwardly highlight the following fact about the magical function of a concave mirror:

All light emitted from each point source on the surface of an object beyond the focal point converges at the corresponding point after reflection by any portion of the concave mirror. This converging point acts as a new point source of light, effectively reconstructing all point sources of the object at specific positions through the mirror.

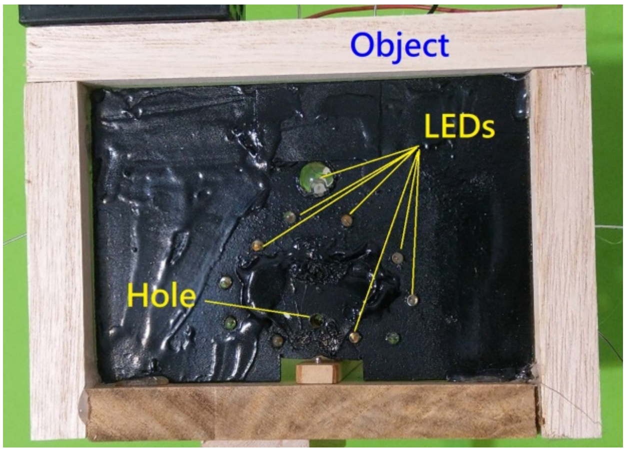

Figure 9. Formation of a heart-shaped object using several tiny LEDs as point sources of light

After captivating students with the enchanting capabilities of the concave mirror, we will also discuss the focal point and the related principles to determine the location and size of the real image.

Figure 9 demonstrates an experimental setup showcasing the remarkable function of a concave mirror. We utilize several tiny LEDs as point sources of light to form an object in the shape of a heart, shown as in Figure 4(a). One of these LEDs is replaced by a hole through which a small solid laser beam, capable of changing its direction using a smart design, consistently passes. Thus, the hole simulates a point source of light emitting light in various directions, shown as in Figure 10.

We position the object, comprised of the LEDs and the hole, in front of the concave mirror, shown as in Figure 11. By turning off all the LEDs and illuminating the tiny laser, which mimics the light emitted from any given point source of light, we can manipulate the direction of the laser beam. We observe that the laser beam hits different portions of the concave mirror but is consistently reflected to the same point, shown as in Figure. 12. This demonstrates that light emitted from a point source, when reflected by different portions of the concave mirror, converges at a corresponding point.

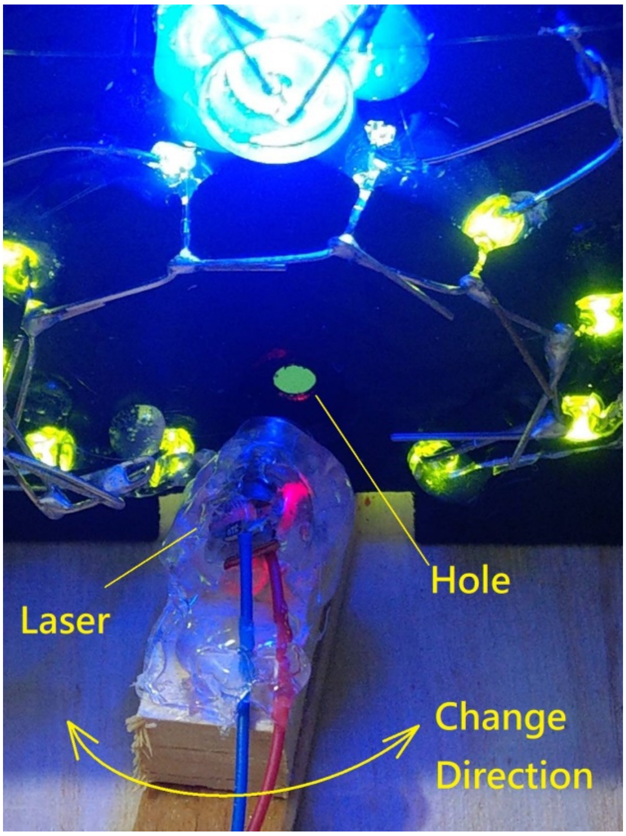

Figure 10. Laser beam passing through the hole in various directions, turning it into a point source of light

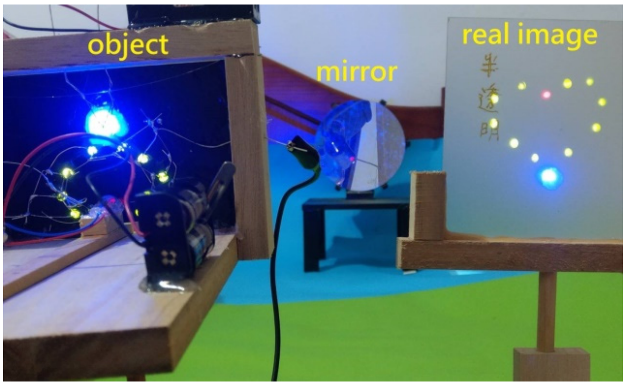

Figure 11. The object, a concave mirror, and the real image

The converging point illuminates a small area on the screen, enabling us to observe it and consider it as a new point source of light. Without

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a screen, the converging point directly functions as a new point source of light itself.

Figure 12. The laser beam hits different portions of the concave mirror but is consistently reflected to the same point

Figure 13. We sequentially light up the other LEDs to emphasize the object or a real image consists of numerous point source of light

Next, we sequentially light up the other LEDs, as shown in Figure 13, and note that each LED, acting as a point source of light on a real object, forms a new point source of light in space. These collective new point sources of light create a real image that closely resembles the original object.

3.3. Experiments reveal the fact that a real image closely resembles a real object

As we know, when light is emitted in various directions from a point source on an object and reflected by different portions of a concave mirror, it converges towards a corresponding point at a specific location. Due to the straight-line propagation of light, this converging point appears to emit light in various directions and acts as a new point source. Through the magical function of the concave mirror, all the point sources on the object can generate corresponding new point sources of light. The collective set of these new point sources forms the real image.

Since both the real image and the real object consist of numerous point sources of light, they are nearly identical in geometric optics. Therefore, we can directly observe the real image just as we would observe a real object, as shown in Figure 14. The left-hand side represents the real image, and the right-hand side represents the real object. Human eyes have difficulty distinguishing between them. We can even use a magnifier to enlarge both the real image and the real object, as shown in Figure 15, in order to further demonstrate their similarity.

Figure 14. The real image can be observed directly, just like a real object (left)

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Figure 15. The real image and the real object can both be magnified using a magnifier

Figure 16. Half of the real image appears on the screen while the other half seamlessly merges with it

Furthermore, it is intriguing to note that we can create the real image of the real image, just as we create the real image of an object. This further illustrates the equivalence between the real image and the real object in terms of geometric optics.

In Figure 16, we observe an interesting phenomenon when using a partially transparent screen. We can see half of the real image appearing on the screen, while the other half is visible directly. The two halves seamlessly merge together, demonstrating the continuity and coherence of the real image.

However, there are subtle differences between the real image and the actual object. Each point source of light in an object emits light in all directions. However, the point source of a real image only emits light within a limited solid angle range, which is determined by the boundaries of the concave mirror and the obstacles in front of it.

Figure 17 illustrates a concave mirror covered by a black paper with 18 hexagonal holes, mimicking the main mirror of Webb's telescope. The spaces between the 18 hexagonal holes can be considered as obstacles, similar to any objects in front of the concave mirror. In Figure 66, an experiment is conducted using a single point source of light emitting in various directions. It is evident that all the light emitted from a point source and reflected by the concave mirror still converges at a corresponding point and propagates within a limited solid angle range determined by the mirror's boundary and the obstacle in front of the mirror, as shown in Figure 18.

The real image formed by a concave mirror with slots as obstacles, when observed with the naked eye, clearly exhibits the influence of the obstacles. This phenomenon arises from the fact that point sources of light on a real image emit light within a constrained solid angle scope. Consequently, within certain solid angle scopes, no light is emitted from specific point sources on the real image. As a result, certain point sources of light on the real image may be invisible to the naked eye at a given position because the emitted light cannot enter the naked eye, while others may appear slightly darker as only a small portion of the emitted light reaches the naked eye. The scenario is highlighted in Figure 19.

However, the same real image formed by the concave mirror with the same obstacles can be observed on a screen and recorded by CCD (charge-coupled device) or similar devices without the influence of obstacles. This disparity can be explained by the characteristics of diffuse reflection. Although only a portion of the concave mirror's surface reflects light onto a point-like area of the screen or CCD-like electronic film, which is distributed within a constrained solid angle scope, the point-like area still becomes illuminated by the reflected light from the uncovered surface of the concave mirror. Consequently, it emits light in all directions due to diffuse reflection. As a result, all the new point sources of light on the

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screen become visible to an observer located at different positions, while there is no difference in brightness among them in theory, as illustrated in Figure 19.

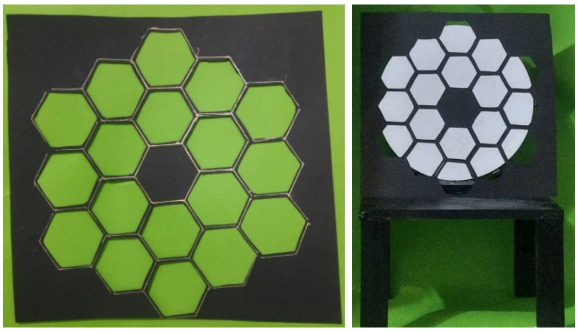

Figure 17. A black paper with 18 hexagonal holes covers the concave mirror to mimic the arrangement of 18 smaller hexagonal mirrors forming the main mirror of the Webb Telescope

As a result, the real image on the screen appears to be unaffected by the obstacles in front of the concave mirror. Similarly, CCDs and other recording electronic devices can accurately capture each point source of light in the real image, enabling a perfect recording of the entire real image of a distant object.

The current issue is: Many reflecting telescopes are observed through eyepieces using the naked eye, so why are they not affected by obstacles in front of the main mirror?

Therefore, following the experiment described below (refer to Figure 20), the semi-transparent screen is almost completely removed, leaving only a small portion for camera focusing, as shown in Figure 20 (left). It can be observed that the real image is disturbed by the obstruction of the slots between the hexagonal mirrors, especially the missing section at the center where the concave mirror is located, resulting in a blurry shadow.

However, when viewed through a magnifying glass, the disturbed real image formed by the concave mirror obstructed by the slots between the hexagonal mirrors surprisingly becomes a clear magnified image. This phenomenon can also be explained! It resolves the confusion surrounding reflecting telescopes when observed directly with the naked eye.

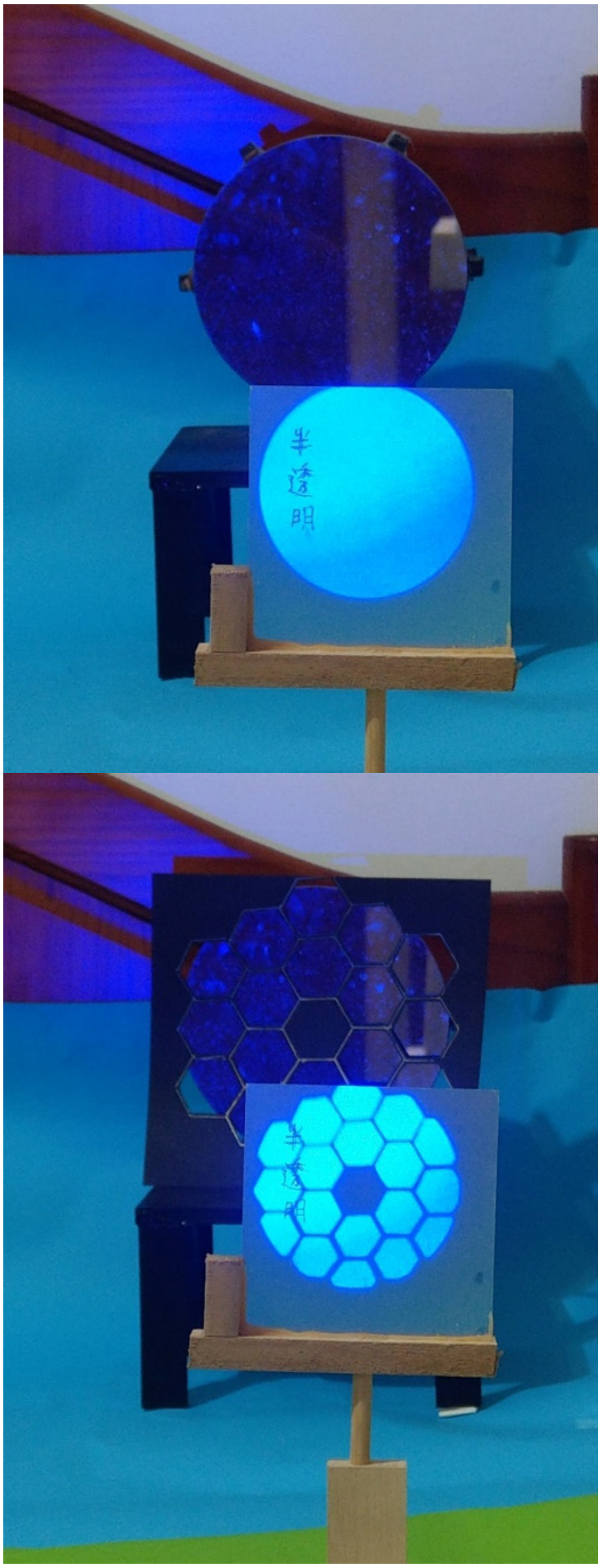

Figure 18. The light emitted from a point source and reflected by a concave mirror converges at a point and propagates along various straight lines within a limited solid angle range determined by the circular boundary of the mirror (top) and the obstacles in front of the mirror (bottom)

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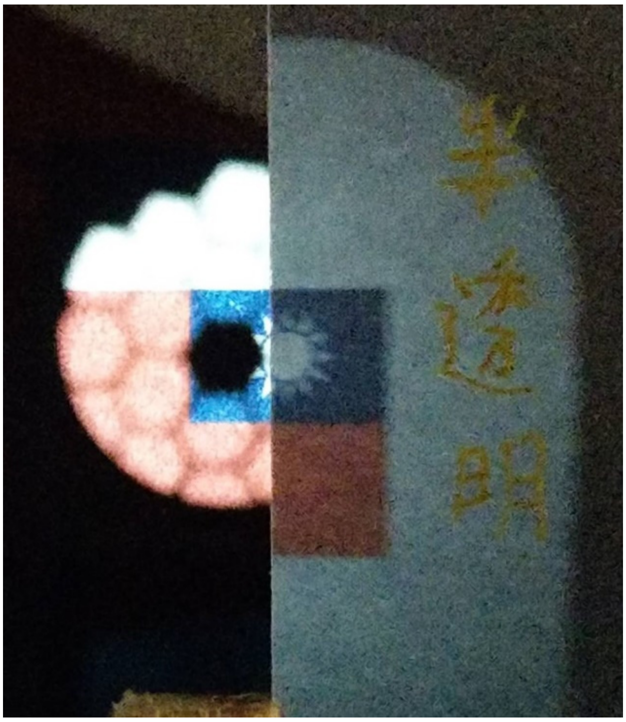

Figure 19. The real image formed by a concave mirror with slots as obstacles, observed with the naked eye, exhibits the influence of the obstacles (left). However, the same real image formed by the concave mirror with the same obstacles can be observed on a screen and recorded by CCD, etc., without the influence of obstacles (right)

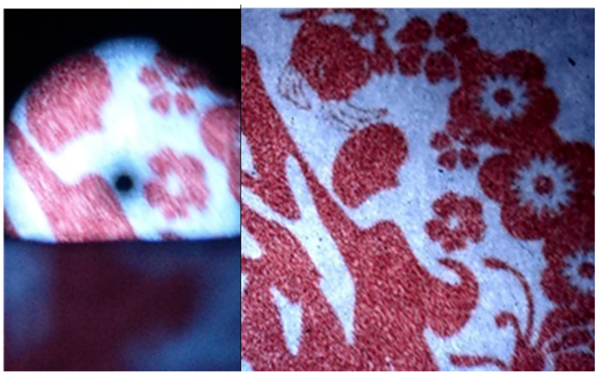

Figure 20. The real image formed by a concave mirror with slots equal to obstacles observed with the naked eye (left). The same real image observed through a magnifying glass (right)

3.4. A conclusive experiment illustrating the principle of a reflective telescope

Obviously, the specific boundary of the concave mirror and the presence of obstacles in front of it do not affect the convergence of light emitted from a point source on a distant object and reflected by different portions of the mirror. This convergence results in the formation of a new point source of light. Through this process, each point source on the object creates its corresponding converging point, ultimately forming a real image just in front of us.

In the case of a perfect mirror, each converging point accurately represents the details of the distant object. By recording the real image using film, a CCD, or other electronic devices, or by directly observing the real image on a screen, the object's details can be clearly observed. Regardless of the specific boundary of the concave mirror or the presence of obstacles, the convergence of light from the point source faithfully emulates a point-like pixel or area on the screen or film, enabling the observation of all the object's distant details. In essence, a telescope functions like a large camera.

However, it is not recommended to observe the real image formed by the main mirror of a reflective telescope with the naked eye, as it will be influenced by the obstacles in front of the mirror or the mirror's boundary. To overcome this, an eyepiece, which acts as a precise magnifier, can be used to view an enlarged real image. This enlarged image is actually the virtual image of the real image, free from the influence of the obstacles in front of the main mirror.

By conducting a simple experiment with a reflective telescope, it becomes easy to verify the knowledge we have discussed above.

4. Acknowledgements

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Chemistry and Science for Children (COQC)

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Abstract. When children open their eyes to the world, they show an incredible curiosity to interpret phenomena and to understand how the world around them works. If we want to achieve a better relationship between science and society, we must start from the very first opportunity which presents itself. If we don't want a scientifically illiterate society, we have to teach science from the first moment when young people ask us to. The Professional College of Catalan Chemists is developing an important scientific collaboration with primary schools in Barcelona. In this paper we present these collaborations, sharing experience and facilities and creating places or laboratories where children can engage in science.

Keywords. Early Education, Chemical Tools, Primary School, Teachers and Students.

1. Introduction

When children open their eyes to the world, they express an incredible curiosity to interpret phenomena and they try to understand how the world around them works. If we want to get a better relationship between science and children and society, we must start from the first symptom of children's curiosity.

On the other hand, If we don't want a scientifically ignorant society, we have to teach science from the first moment when young people ask us about science and chemistry.

Generally, teaching science to children does not have much impact at international conferences. Science in childhood education needs a good relationship between the world of research and the world of research in education and the world of educational practice in schools; unfortunately, this condition is far from reality.

The European project “communities for sciences” [1,2] aim to research the relationships between science and society. Science is a key component of modern societies. However, social stereotypes and discriminatory practices affecting specific communities (people with disability, minorities, immigrants, and women) also occur in science. An inclusive science education approach is necessary.

As promotes the European project "Communities for Sciences", the Professional College of Catalan Chemists (COQC) [3] is developing an important scientific collaboration with primary schools in Barcelona. The objective included in the United Nations 2030 Agenda is make science education more inclusive because working towards inclusion in science is also a way to contribute to the sustainable development of equality of chances for access to education.

The authors have shown [4,5] that the drawings about science and scientists make by children in primary school are still unaware of the role that gender plays in our society. There is no reason why a scientist a doctor or a driver have to be the father rather than the mother. Luckily the children do not think so. But the situation is different with teneegers, and they proposed a number of measures focussed to achieve gender equality [6].

Chemistry is everywhere. Still, the process of learning chemistry and science offers significant challenges to primary school students to explain the macroscopic world.

The COQC wants to make easier the dialogue between chemistry and science with primary school children. It is necessary to create spaces which can facilitate contact and exchanges between the professional college and primary schools. For this reason, the COQC has collaborations with several primary schools in Barcelona to carry out experiments that children can understand. In addition, the preparation of science teachers is also one of the priorities of these activities and collaborations.

Increasing these synergies will go on the benefit primary school students and teachers and chemists and scientists and by the way our society. It will be as an imaginative path to prevent misinformation, and future challenges

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faced by society.

Finally, in this paper, the reader can find these collaborations, sharing experience and facilities and creating classrooms or laboratories where children can engage in science, drawing scientists or using magnets, light and more. This activity has had a positive impact on educators (science teachers from primary schools).

2. Methodology

The COQC signed the conformity with the following primary schools in chronological order: during the 2021-2022 academic year, the La Pau school [7] in the Verneda neighborhood; during the 2022-2023 academic year, the Montseny school [8] in the Gràcia neighborhood, the Barrufet school [9] in the Sants neighborhood and the Virolai school [10] in the Gràcia neighborhood.

This collaboration, for each primary school, makes it possible to establish a schedule of meetings with primary school teachers to prepare:

- What to do in the classrooms?
- At which school levels?
- What material is needed?
- When to do the sessions with the children at school?

The COQC provides its own researchers for the meetings with the primary school teachers and these researchers will then carry out the scientific sessions with the students assisted by the school teachers.

In addition, and after having decided the activities to be carried out, the COQC provides material and chemical products to help schools with the scientific experiments and laboratory needs (facilities, laboratory tools, laboratory material and chemical products).

At the end of these scientific experiments the COQC gifted each group with some comics about "Little history of Catalan Chemistry", very suitable for “Young scientists”. Furthermore, these activities have been used to informally ask children and teachers about:

- Which of the following issues do you think are most important? (Young students)
- What do you believe is the biggest priority for the scientific community? (Teachers)

3. Primary schools

Figures show different activities developed in each primary school.

Figure 1. (top) School lab opening (bottom) children’ first day of lab work. Pictures from the Primary school “La Pau” https://agora.xtec.cat/ceiplapaubcn/

Firstly, as a result of our collaboration, in the La Pau School, during the 2021-2022 academic years, a useless room in the school was transformed into a science laboratory. The invaluable help of the primary school’ director and primary school teachers made this laboratory possible.

Now young students, 11-12 years old, can study and experimenting with chemistry, biology, physics, geology and more.

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Figure 1 shows students on their first day in the science laboratory the children enjoyed putting on their lab coat, gloves and working on some chemical reactions.

Figure 2. (top) At the beginning of the session, (bottom) photosynthesis experiment. Pictures from the Primary school "Montseny" https://agora.xtec.cat/ceipmontseny-barcelona/

Fig 2 shows, at the Montseny School with children, 7-9 year olds, students so young that they were very attentive sitting on the floor of the classroom. Then they experimented on photosynthesis by detecting starch from the green leaves of the trees in the school yard (not covered in tin foil).

In addition, they saw the decomposition of white light from the Sun, which entered through the windows, into the colors of the rainbow, using a pocket spectroscope.

These two groups with the youngest children are the ones that asked me the most challenging questions.

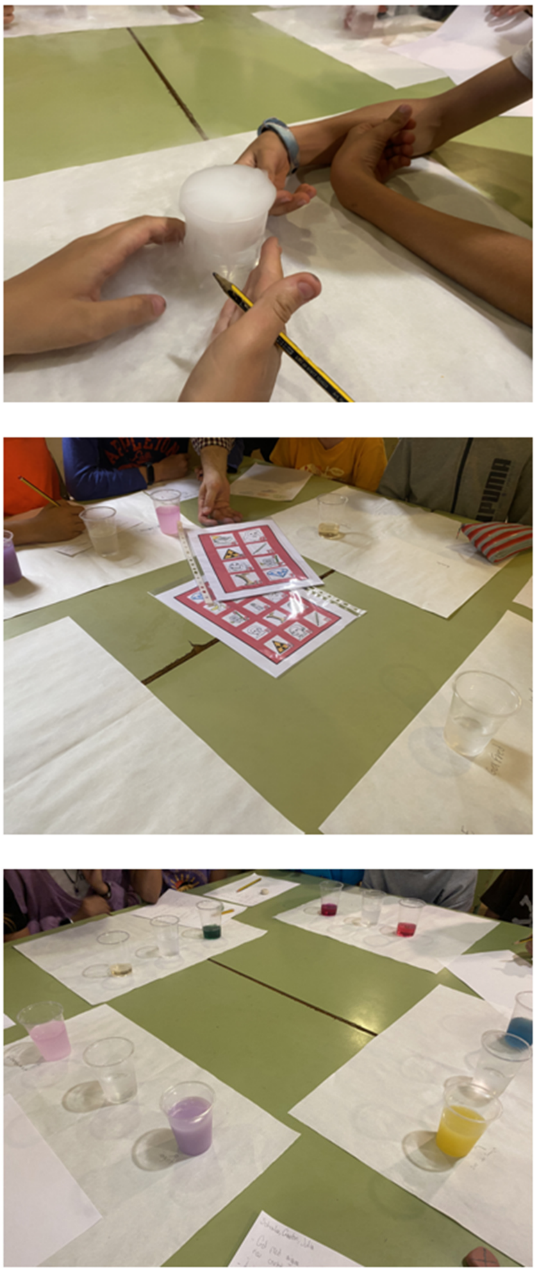

Figure 3. (top) Children playing with dry ice, (middle) playing with science cards (bottom) playing colour and pH. Pictures from the Primary school "Barrufet" https://escolabarrufet.cat/

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At the Barrufet School with children, 11-12 year olds, they experimented on changes in the state of matter (solid, liquid and gas) such as: fusion, evaporation, boiling, condensation and solidification. However, they discovered the sublimation of dry ice.

Children played with science/chemistry cards similar which autors presented in 2019 Hands on Science conference [11]. And finally primary school students worked on the acidity and basicity of some home products with the purple/red cabbage indicator. It was previously obtained by the school teachers by boiling leaves of this cabbage.

Figure 4. Informative poster of the activity "XIII Science Projects Exhibition" obtained from the Primary school "Virolai" website https://virolai.com

The afternoon of May 4, in Virolai School, the XIII Science Projects Exhibition was celebrated. Pupils from Infants, Primary and ESO have presented their projects. The dean of the COQC was part of the jury. Attendees at the Exhibition were able to learn from our little and big scientists about pH, fossils, planes, parables... and so much more!

4. Results

The figures have already shown part of the results and experiments did [12], so here we will focus on the answers of students and teachers to the questions asked. Together with the question they (children and teachers) were given all the possible answers and they had to choose.

Results are listed in order, from the most important to the least one, according to the opinions given by the students on the first one and by the teachers on the second.

4.1. Questions to young students

<u>Which of the following issues do you think are or will be the most important?</u>

- Artificial intelligence 45%
- Public and personal health 35%
- Climate change and environmental sustainability 15%
- Energy 5%

4.2. Questions to teachers

<u>Which of the following issues do you think are or will be the most important?</u>

- Energy 40%
- Climate change and environmental sustainability 30%
- Artificial intelligence 15%
- Public and personal health 15%

<u>What do you believe is the biggest priority for the scientific community?</u>

- Finding solutions to climate change 45%
- Improving diversity, equity, inclusion, and accessibility in STEMM fields 40%
- Advancing global science collaboration 15%

Comparing the answers of the children with those of the teachers we will observe great differences caused by age difference, family situation, different interest, or very distant circumstances between the primary school children and their teachers.

For instance, children (masters in Artificial Intelligence AI, mobile, tablet and Internet) want more AI in their future lives. However, their teachers think differently, they are more

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concerned about the energy problem.

Teacher-only questions indicate a strong interest in climate change while scientific collaboration in a global world is far from them. This is probably because most primary school teachers have only been taught minimal basic science concepts.

5. Conclusions

It will take passionate science advocates to advance and celebrate science's power to build a better world for all of us.

These passionate advocates are and will be today's primary school children. We (family, teachers, scientists and professional colleges) must do everything possible so they grow up loving science.

How do we do it?

We have to bring more scientists/chemists to classrooms and community centers.

We must foster relations with the primary school and its teachers with scientific institutions, such as the COQC, which increase their scientific knowledge.

Figure 5. The best conclusion is to observe children writing down and analyzing their results. Picture from the authors

And we have to create space for everyone – no matter whom or where they are- to contribute to scientific enterprise.

The COQC is committed to trying to fulfill these important points and has already started working on it.

Summer courses, the technical teaching section of the COQC has already designed summer courses on chemistry to bring primary teachers up to date.

Furthermore, increasing good relationship between COQC and primary schools will prevent misinformation, and future challenges faced by society.

Finally, in Figure 5 you can observe children experimenting, writing results, analyzing colors meaning. Considering the young students' attitude towars science leads us to the best conclusion:

"Children are the future and we can trust them".

6. Acknowledgements

We thank the teaching staff and directors from primary schools who have participated in this experience for their interest in the project. This activity was supported by the Professional College of Catalan Chemists (COQC).

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Use DIXIT Cards for a Dynamic of Networking

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Abstract. A networking dynamic based on a family game, DIXIT, it's presented. DIXIT permits dynamics where people who don't know each other can establish links and synergies. A DIXIT card comes from the DIXIT board game, it is a storytelling and fun family board game for all ages.

Keywords. Networking, DIXIT Cards.

1. Introduction

Networking is a dinamic developed which seeks to create and increase a network of contacts. Although it is not an action characterized by being novel, since traditionally, in commercial areas, it has always been very common, its importance has increased due to new dinamics.

Thus, in addition to the classic events in which networking took place -courses, conferences, congresses, presentations, etc.-, there have been.

When we apply some type of networking, what we are looking for is to create a relationship with our interlocutor, generate alliances, exchange information and perhaps cooperate in projects. If you want to learn how to create high-impact professional relationships, this blog is for you.

Exits different activities that helps us in dinamics of creativity but in the last years, nem activities have been introduced as for example, the use of games as DIXIT.

DIXIT is a French card game created by Jean-Louis Roubira, illustrated by Marie Cardouat, and published by Libellud. Using a deck of cards illustrated with dreamlike images, players select cards that match a title suggested by the designated storyteller player, and attempt to guess which card the storyteller selected. The game was introduced in 2008. DIXIT won the 2010 Spiel des Jahres award [1].

2. Objectives of networking

Among the most relevant purposes of this practice, we can find the next goals:

- Meet people and organizations
- Finding new projects or collaborators
- Make our work known
- Expand our portfolio or other interest groups
- Better understand the market
- Discovering business opportunities

2.1. Meet people and organizations

In networking spaces, regardless of whether they are physical or virtual, we can introduce ourselves to other people. These do not necessarily have to be within our expertise; It is also very enriching to know the experience, interests or hobbies of those who are dedicated to issues other than ours.

2.2. Finding new projects or collaborators

Whether we are doing a project or looking for new collaborators, networking helps us discover new people to collaborate.

Figure 1. Networking picture

2.3. Make our work known

It is a good opportunity to talk about our professional activity and those closed interests. Unlike other communications, which are addressed to large volumes of the population

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and can go unnoticed due to information saturation, thanks to networking, messages have a greater impact on recipients, since contact is closer and more personal.

2.4. Expand our portfolio or other interest groups

In relation to the previous point, achieving closer communication will allow us to better convey our mission, needs, value proposition, etc., getting different groups such as teachers, students, skateholders and investors know us and are interested.

2.5. Better understand the market

Knowing what our competitors are immersed in or what the latest trends are, among other things, translates into a greater knowledge of the market, which allows us to have more and better quality information, to make more rational decisions.

2.6. Better understand the market

Meeting and conversing with other people, from our sector or from a different one, makes it possible to share good practices and identify keys to collaboration. All of this translates, ultimately, into positive synergies.

3. Examples of networking activities

There are several types of networking that help you achieve skills, which are valuable in the current professional and work environment, such as knowing how to relate. If you've ever attended events or met interesting people, but wondered why you didn't get the most out of those encounters, maybe you didn't know of some types of networking that would have helped you with what you needed.

When we apply some type of networking, what we are looking for is to create a relationship with our interlocutor, generate alliances, exchange information and perhaps cooperate in projects. If you want to learn how to create high-impact professional relationships, this blog is for you. Let's see some examples.

3.1. Online networking

Currently, the use of social networks is common and they bring advantages if we learn to use them. Within the types of networking, this category is the one that has increased the most in recent years, due to the pandemic it is now possible to interact remotely with anyone.

The definition of networking in principle did not contemplate the possibility of virtuality, however with technological changes it is more than a necessity. But we must learn to use these media because not all social networks will help you create professional relationships. Here are some tips:

3.2. Networking Offline

Within the types of networking, offline corresponds to all those activities that are done in person. In this case, what networking is and how it is used can be very generic: any activity where we meet influential people in a field, leaders of a sector or enthusiasts of a particular area.

3.3. Personal Networking

We not only seek to relate to others because of the companies they represent or the projects they develop, an essential area that motivates humans to relate is the quality of people we can meet. Within the types of networking, this has to do with the intrinsic value of people.

Sometimes, we tend to think that it is difficult to connect with someone we do not know and we wonder how to network. We must understand that all people have a motivation and a purpose that moves them, in this case it is essential to want to know the other person in a genuine way.

3.4. Operational networking

Of the types of networking, this has the purpose of positioning ourselves for a position, finding alliances for our projects and generating human resources to grow professionally.

Thus, you can define your operational networking group according to your needs. But what is a networking group? In this context, they are all your contacts, be they commercial, organization, professional contacts and any relationship that aligns with your networking objectives.

Other examples would be Strategic Networking, Professional, Business Networking or Informal Networking.

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4. New examples of networking activities: Use of DIXIT Cards

DIXIT is an enchanting card game inviting you to let your imagination run wild. Discover 84 dreamlike illustrations on large text-free cards, and interpret those mysterious images.

Accessible and family-oriented, DIXIT is the ideal game to play with family or friends and to get to know your peers from another perspective.

Gameplay

Six cards have been dealt out and voted on, and the storyteller is indicating which story belonged to them. To the right, scores are tracked by rabbit-shaped tokens on a scoring track.

Figure 2. DIXIT Game

Each player is dealt six cards to start the game from a shuffled deck, which becomes the draw pile. For a three-player game, each player is dealt seven cards instead [2]. Each player takes a turn as the storyteller.

The storyteller looks at the six cards in their hand and selects one, composing a sentence or phrase that might describe it and says it out loud, without showing the card to the other players [3]. The storyteller's goal is to provide a description that is ambiguous enough that not all other players will recognize the card, yet relevant enough that some will [4].

Every other (non-storyteller) player then selects one card from their own hand which best matches the sentence given by the storyteller. In a three-player game, the two non-storyteller players each select two cards from their hand.[2] Then each non-storyteller player gives the selected card(s) to the storyteller face down, without showing it to the others. The storyteller shuffles the card they had described with the cards received from the other players, and all of the selected cards are then dealt face up. The minimum number of cards in the tableau for voting is five, from a three or four player game [2].

Thanks to this dynamic, we can use the cards to promote networking. As?

- We leave several letters within the reach of a group. We generate a question like Describe what you do?
- The participants select a card and based on the drawings of the selected card, through visual metaphors they answer the question
- We repeat the dynamic varying the people in each group.

By performing the dynamic several times, our storytelling is enriched and the explanation given to answer the question is increasingly powerful.

5. Conclusions

The creativity dynamics are very important to establish synergies between unknown groups. Done well, they can help groups get to know each other and establish potential collaborations in a short space of time.

Thanks to new tools and strategies, such as the DIXIT letters presented, networking activities are becoming more powerful.

Thus, DIXIT's creative drawings allow us to increase our creativity to allow us to improve our description in front of unknown groups of people. This explanation is enriched thanks to the effort of answering the question with the selected cards and also, the distinguished atmosphere favors the dynamics.

Without a doubt, DIXIT letters become powerful storytelling tools to favor group networking dynamics.

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Hands-on Cyanotype: Exploring the Intersection of STEAM Education and Inclusion

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Abstract. STEAM is an educational approach that embraces a wide variety of subjects: Science, Technology, Engineering, Arts, and Mathematics. The combination of these subjects aims to provide students with a well-rounded education that encourages critical thinking, problem-solving, and creative skills. By integrating the Arts into STEM subjects, students are challenged to think outside the box and approach problems in unique creative and innovative ways. The STEAM approach prepares students for a future that requires interdisciplinary skills and encourages them to pursue careers in fields that are essential to our society's growth and development. Hands-on activities are fundamental to the learning process allowing a more effective implementation of the STEAM educational approach.

Cyanotype, a photographic printing process that uses sunlight, presents an engaging and interdisciplinary approach to learning in school settings. This paper explores various cyanotype activities that can be integrated into educational curricula, highlighting their benefits for students' creativity, scientific understanding, and historical appreciation. By combining art, science, and history, cyanotype activities foster hands-on learning experiences, encourage critical thinking, promote a holistic approach to education and embrace inclusive education. This study was implemented in the Room 1 of the Learning support centre of the school, attended by eleven students (one girl and ten boys), six of those with Autism Spectrum Disorders (ASD), in which we apply hands-on structured teaching methodologies.

Keywords: Cyanotype, Photography, Interdisciplinary Learning, Creativity, Education, STEAM, Inclusive Education, Hands-on Activities.

1. Introduction

Cyanotype, discovered in the 19th century by Sir John Herschel [1], is a photographic printing process that utilizes sunlight to produce distinctive blue and white prints. While initially used for scientific purposes, cyanotype has evolved into a popular artistic medium due to its unique aesthetics and simplicity. This paper aims to demonstrate how cyanotype activities can be incorporated into school curricula, enhancing students' learning experiences across multiple subjects.

The 'traditional' recipe invented by Sir John Herschel in 1842 [1], has the merits of being relatively cheap, easy, and substantially non-toxic. It is suitable for newcomers to these alternative processes and can be placed in the hands of children. Herschel used the cyanotype process so that he could reproduce mathematical tables along with other notes and diagrams. Architects and engineers later picked up the process to produce copies of architectural drawings, which is also where the term “blueprint” comes from. Shortly after Herschel developed the cyanotype process, his friend, photographer Anna Atkins, started exploring the process for book illustration by making cyanotypes of plants. She used the method to produce the first book that included photographic images, titled “*Cyanotypes of British and Foreign Flowering Plants and Ferns”* [2].

2. The Potential of Cyanotype Activities in Schools

2.1. Creativity Enhancement

Cyanotype activities promote artistic expression and creativity [3] among students. The hands-on nature of the process allows students to experiment with composition, light exposure, and object placement, fostering their imagination and visual storytelling skills. Through cyanotype, students can explore the possibilities of alternative photographic techniques beyond digital photography, encouraging innovative thinking.

2.2. Scientific Understanding

Cyanotype activities offer an opportunity for students to engage with scientific concepts such as light, photosensitivity, and chemical

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reactions. They can learn about the principles of light absorption, UV radiation, and the photochemical process involved in producing cyanotype prints. Students can also explore the variables affecting the final outcome, such as exposure time and object placement, providing them with a practical understanding of scientific principles [4].

2.3. Historical Appreciation

Incorporating cyanotype activities into the curriculum provides a historical context for students to understand the development of photography and its applications. By exploring the origins of cyanotype and its use in scientific documentation and early photography, students can gain insight into the history of image-making and appreciate the evolution of photographic techniques [5].

2.4. Inclusive education

Teaching strategies are practices used by adults to help facilitate children's participation in everyday routines, learning experiences, and activities. Using these strategies engages children in activities, maintains their interest, and provides opportunities for them to learn concepts and thinking skills that support STEAM learning when using adaptations [6].

3. Integrating Cyanotype Activities into School Curricula

3.1. Art Classes

In art classes, cyanotype activities can be included as a module focusing on alternative photographic processes. Students can learn about the history of cyanotype, experiment with compositions, and create their own prints. They can explore the combination of cyanotype with other art mediums, such as painting or drawing, to produce mixed-media artworks [7].

3.2. History Classes

Cyanotype activities offer an opportunity for interdisciplinary learning in history classes. Students can research the historical context of cyanotype and its significance in scientific documentation and early photography. They can analyse the impact of cyanotype on the development of photography as an art form and discuss the contributions of notable photographers who utilized cyanotype [5].

3.3. Science Classes

Cyanotype activities can be integrated into science classes to explore concepts related to light, photosynthesis, and chemical reactions. Students can learn about the photochemical process of cyanotype printing, investigate the effects of varying exposure times and light conditions, and analyse the science behind the formation of cyanotype prints [4].

The blue colour of the cyanotype print is the result of the reaction of ferrous ions to the photo reduction of Ferric ammonium citrate in combination with Potassium ferricyanide.

Cyanotype is based on the sensitivity of ferrous salts to light. The sensitive layer contains iron ammonium citrate and potassium hexacyanoferrate (II). Daylight contains a certain portion of UV radiation and this reduces the iron (III) ions in these compounds to iron (II) ions. This produces compounds of blue – on the one hand Prussian blue – iron (III) hexacyanoferrate (II), and on the other Turnbull's blue – ferrous ferricyanide. Both these colours are bright blue and the picture is made up of their combination in the given ratio.

When iron (Fe, from the Latin "Ferrum") is chemically combined with other elements, its atoms acquire a positive charge by transferring two or three of their orbiting negative electrons onto atoms of other elements. As so each iron atom ends up in one of two states: "ferrous" iron - also called iron (II) or Fe^{2+} for short, "ferric" iron - also called iron (III) or Fe^{3+}. This number 2+ or 3+ is called the oxidation state of the iron, and signifies the positive electric charge that the iron atom has acquired in the reaction. Oxidation makes an atom or molecule more positive (or less negative) in the electrical sense. So, when iron forms compounds, it is oxidized.

Reduction is the converse: making an atom or molecule less positive (or more negative). e.g. oxygen gas, which consists of molecules containing two linked atoms of oxygen, O_2, is reduced to form oxides, which contain the O_2^- ion. Both processes involve the transfer of electrons. Oxidation is the removal of electrons while reduction is their addition.

Iron-salt processes basically work like this: All ferric (iron III) salts, when combined with organic substances, become sensitive to light. A

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commonly used mixture is ferric ammonium citrate and potassium ferricyanide. Exposure to ultraviolet light breaks down the iron compound by oxidation, thereby releasing carbon in the form of carbonic acid. The exposed print is then immersed in water, causing a reaction between the new compound (peroxide iron salt) and the potassium ferricyanide. A deep-blue compound, ferric ferrocyanide or Iron (III) Hexacyanoferrate (II), is formed. The Potassium ferricyanide and Ferric ammonium citrate have each been mixed with water [4].

4. Practical Considerations

4.1. Safety Measures

When conducting cyanotype activities, it is essential to follow safety guidelines, including proper handling of chemicals and ensuring students' protection from UV radiation. Teachers should provide appropriate personal protective equipment and establish protocols to ensure a safe working environment.

4.2. Material and Equipment Requirements

Cyanotype activities require specific materials and equipment, such as cyanotype paper, sensitizer chemicals, brushes, and rinse water.

4.3. Experimental Procedure

The cyanotype is made up of two simple solutions:

- Solution A: 25 grams Ferric ammonium citrate (green) water to make up 100 ml solution.
- Solution B: 10 grams Potassium ferricyanide and water to make up 100 ml solution.

In order to prepare the cyanotype dissolve the chemicals in water (start with a little less than 100 ml in each) to make two separate solutions (Fig.1). Add Ammonium ferric citrate to water into one container and Potassium ferricyanide to water in another. Stir with a plastic spoon until the chemicals dissolve. Add water to make up 100 ml of solution. The chemicals will also have volume, so do not add 100 ml of water – the final solution should be 100 ml. Mix equal quantities of each solution together in a third container. Unused solutions can be stored separately in brown bottles away from light, but will not last very long once they have been mixed. Dispose of any unused chemicals in a sensible and environmentally friendly way [11].

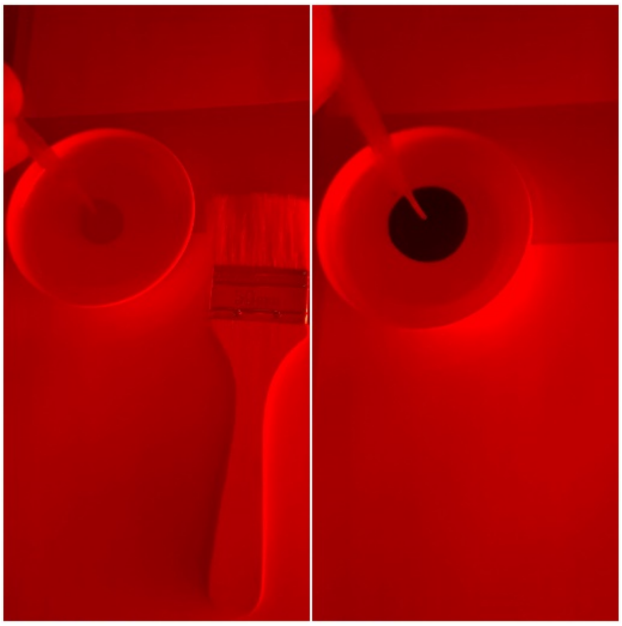

Figure 1. Mixing solutions A and B

Floors, carpets, walls, work surfaces, clothes and skin can be stained by the chemicals. Cover all possible areas, use rubber gloves and an apron or an old shirt to work in. If you have the space, choose an area where you can spread out. Ordinary light bulbs or tungsten light is safe to use, but UV light will affect your prints. Some fluorescent lighting may also affect your prints.

Using a brush, simply paint the chemicals onto the material (Fig.2). Paper, card, textiles or any natural material can be used to print on. Decide how big your print is going to be, and cut your material to size. Make sure your working area is dimly lit, or lit with a low-level tungsten bulb. Once the material is coated, leave it to dry in the dark.

Print a cyanotype by placing a negative (to reproduce a photograph) or object (to make a photogram) in contact with your coated paper or fabric (Fig.3). Sandwich it with a piece of glass. Expose the sandwich to UV light. Natural sunlight is the traditional light source, but UV lamps can also be used. A photogram can also be made by placing items on the surface. Plants, decorative items or other objects can be used to create silhouettes or interesting shapes.

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Figure 2. Preparing the canvas

Figure 3. Printing the cyanotype

Exposure times can vary from a few minutes to several hours, depending on how strong your light source is or the season where you are printing. When the print has been exposed, process your print by rinsing it in cold water (Fig.4).

The wash also removes any unexposed chemicals. Wash for at least 5 minutes, until all chemicals are removed and the water runs clear. Oxidation is also hastened this way – bringing out the blue colour. The final print can now be hung to dry and be admired (Fig.5).

Figure 4. Rinsing the cyanotype in cold water

Fig.5 Drying the cyanotype

5. Characterization of the class

The school, located in Lousada, in northern Portugal, is a public educational institution covering preschool and basic school up to the ninth grade; The Portuguese education system is divided in pre-school education (from the age of three until the start of basic education), basic education (six to fifty years old). The Room 1 of the Learning support centre with structured teaching has students aged between eleven to

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fifty years old. It is wide with perfectly identified functional areas endowed with suitable materials, and we use a method called Structured Teaching [8],[9],[10]. This is based on the unique learning needs of people with ASD, including strengths in visual information processing and difficulties with social communication, attention and executive function. Eleven students participated during the work group area. Only three autistic students are verbal (one boy of fifth grade, one of the ninth grade and one boy of the eighth grade). The others (one of the fifth grade and two of the ninth grade are non-verbal).

6. Cyanotype activities (Blue Print) made by students

Figure 6. Printing some students' cyanotype

Students choose plants and day-to-day school material to make the blue prints. Printed a cyanotype by placing an object (to make a photogram) in contact with your coated paper (Fig.6). Sandwich it with a piece of glass. Exposed the sandwich to UV light. Natural sunlight is the traditional light source. A photogram can also be made by placing items on the surface. Plants and school material were used to create silhouettes or interesting shapes. Then they exposure to sunlight about 15 minutes. After that, students processed prints by rinsing it in cold water (Fig.7) and waited the final prints to dry (Fig.9 and Fig.10).

Figure 7. Washing the cyanotype

Figure 8. Student observing cyanotype rinsed with water

7. Summary and conclusions

In conclusion, a cyanotype activity is a fantastic way to explore the world of photography and experiment with a unique and historic process. This activity enables individuals to create beautiful, blue and white images on paper by using a photosensitive solution and sunlight. Cyanotype is a relatively simple process that can be done with minimal equipment, making it a great activity. Not only is it a fun and creative activity, but it also teaches valuable lessons about light, chemistry, and the history of photography. Overall, a cyanotype activity is a wonderful experience that can be enjoyed by anyone looking to explore photography in a new and exciting way.

Figure 9. Drying the botanical cyanotype

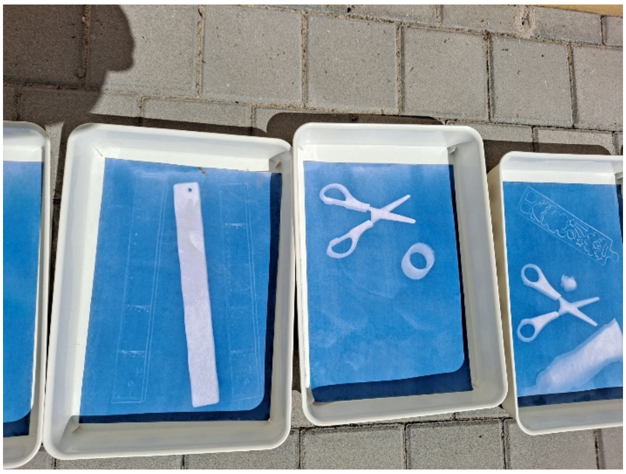

Figure 10. Drying the cyanotype printed with school material in the school playground

The proposed activities showed creativity through student's agency, curiosity, engagement and enthusiasm. Rich motivating contexts for play and exploration were fostered, by the utilization of day-to-day materials and school plants. Collaboration, promoted by use of group work in group work area, played important role in involving children specially in children with autism spectrum disorders.

The children showed enthusiasm and joy during the blue print activities being much more focus and committed than usual.

One fact to take into account is that there was a student with ASD who did not like splashes of water, so he was helped by teacher in the part of washing the cyanotype, for prevent a prevent a crisis, as the student cannot stand splashes of water.

The teacher emphasised the need to foster motivation and collaboration and provide a rich environment with space and time for exploration.

The above-mentioned activities contributed to engage students on STEAM education.

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Chemistry at Sight

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Abstract. The present communication introduces a blog in progress named "Química a la vista" ("Chemistry in Sight"), whose aim is to help to observe different aspects of chemistry that can be seen on the street or on the road.

Keywords. Chemical Industry in Catalonia, Industrial Heritage, Sites, Businessmen.

1. Introduction

Like other sciences, the academic courses of chemistry are based on three main items: the first point is the description of the structure of matter at different levels, reaching molecules, ionic networks, and atoms and subatomic particles; the second point is the relationship between the structure and the properties of the macroscopic substances; and the third point is, the influence that different forms of energy have on structures and properties. But the relationship between these scientific aspects and everyday life is rarely explored. Rarely the academics describe the materials and substances that chemical industries provide to the user, or the ways of obtaining products and materials..

In order to make it easier for teachers and the interested public to find the everyday aspects of chemistry related to the production industries, the author started to develop the blog "*Química a la vista*" (*Chemistry at Sight*) [1], with different stages and of which the first is presented here . It is an open project without a deadline. For the moment we limit the blog to sites and places of Catalonia.

This project of divulgation is the creation of a blog what describes weekly an element of the territory related to chemistry or chemical engineering and, by extension, to the production and distribution of energy, the distribution, purification and treatment of water and wastewater, and other related topics . The conditions to be included in the project are that it must be artificial equipment or installation, that is to say, created by man, and that it must be visible from the street or the road. We could name the project as the *Observatory of the Catalan Chemistry*. But I don't like this kind of denominations very much for its ambiguity and pretentiousness... So the project is named "*Química a la vista*" ("*Chemistry at Sight*") [1] It is written in Catalan but easily translated to other languages with the app *Translation* included in the blog.

A technical description is given for each of the elements, as well as historical notes, anecdotes and personal memories, if necessary, with details of how to get there. All the elements can be seen from the outside: there are no visits to the interior of buildings, although they are mentioned when necessary. Everything should be in plain sight, as the blog title says. The *GoogleMaps* and *GoogleEarth* applications can be useful tools to locate and have an updated and unpublished perspective of the places and sites.

There are few precedents for works with this approach, albeit somewhat different. The closest is the work done by Josep Duran a few years ago: "*Passeig per l'invisible. Itinerari químic per la ciutat de Girona*" ("*Walk through the invisible. Chemical route through the city of Girona*"), published by Girona City Council in 2010 [2]. The book describes a complete itinerary through the city, referring to industrial and artisan facilities related to chemistry, and various aspects of products and processes, such as soap, the chromating process, certain medicines, metals, minerals ... It also contains didactic proposals, worksheets and experiments to be carried out by pupils.

Another interesting general reference is the book "*Passejades per la Barcelona científica*" ("*Walks through the Scientific Barcelona*") [3] by Xavier Duran and Mercè Piqueras. It is a general book, quite exhaustive and with a historical perspective. There are seven thematic chapters on health, transport, water, street names... and eight scientific itineraries: on the Rambla, Montjuïc, the botanical gardens, museums, clocks...

As for Catalonia, the book by Daniel Romaní "*Catalunya industrial*" ("*Industrial Catalonia*") [4] is very useful and up-to-date, focusing especially on museums that can be visited.

Industrial heritage is increasingly valued in today's societies, and there are various initiatives to learn about it, inventory it and

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preserve it. The "*White Book of the Industrial Heritage of Catalonia*" is in the process of being written by the participants of the *Interdisciplinary Heritage and Industrial Landscape Group* (GIPPI), coordinated by Eusebi Casanellas, former director of the *Museum of Science and Technology of Catalonia*. Many of the entries in this blog will be the basis for some parts of this White Book, especially regarding the chemical section.

2. The state of the art

The first stage of the project consists of observing and describing the different sites and vestiges that the chemical industry, in a general sense, shows us in our urban and industrial environment. This includes current industries, and remnants of old industries that have some elements of interest. The main objective is didactic, in addition to the obvious objective of presenting the industrial heritage. It's about observing what you see from the street, with the naked eye, and relating it to scientific or technological aspects that the reader can understand with their elementary education and knowledges. Equipment names will appear in the description, such as chimneys, reactors or boilers; names of products of all kinds, such as cement, sulfuric acid or petroleum; names of facilities, such as refinery or steel mill; and names of the promoters or owners of the different facilities, booth current or old. It will not include those industries or facilities that, even if they have chemical processes or manufacture chemical products, do not show from the street any technological signs that can be used for the purpose of the blog. It would be the case, for example, of certain pharmaceutical industries, which have all the processes - undoubtedly chemical - inside closed buildings.

The second stage, not yet started, will consist of the observation and description of chemical aspects of the street not related to installations or productions. For example, the air pollution measurement devices; or manhole covers made of ductile iron.

At the date of writing the present text, the following posts have been uploaded, with a weekly frequency, beginning on September 2022:

1. The Badalona Oil Bridge
2. The three chimneys of Sant Adrià de Besòs
3. The natural gas tanks in the port of Barcelona
4. Oxygen tank of a hospital
5. The gasometer and the water tower of the Barceloneta
6. Butane deposits in Montornès del Vallès
7. Fuel tanks in the Zona Franca
8. The Granollers atomizer
9. The Bages salt ruins
10. The Besòs Incinerator
11. The three chimneys of the Parallel
12. The former Solvay in Martorell, now INEOS-INOVYN
13. Distillation of liquid air in Baix Llobregat
14. The Montcada i Reixac cement factory
15. The domestic butane truck
16. The combined cycle power plants in Sant Adrià de Besòs
17. The Tarragona refinery
18. The Damm brewery in Barcelona and Prat de Llobregat
19. The chemistry of the gas station
20. Ciments Molins in S.Vicenç dels Horts
21. The racks of the Camp de Tarragona South Polygon
22. The old Procter&Gamble factory in Mataró
23. The Vandellós power stations
24. The drinking water plant of Sant Joan Despí
25. The Ascó nuclear power plant
26. The electrochemical industry of Flix
27. The Vallcarca cement plant in Garraf
28. The CELSA steel plant in Baix Llobregat
29. ASESA: the first refinery in Tarragona
30. La Llagosta plant of waste water treatment
31. La Rajoleta d'Esplugues de Llobregat
32. IQOXE, formerly IQA in Tarragona
33. La Sanson, the old Sant Just Desvern cement plant.
34. The old thermal power plant of Cercs
35. The first Asland de Castellar de n'Hug
36. The salt pans of Trinidad

Each post contains the history of the installation, the technological basis of its design, the description of what can we see from the outside, and several pictures. Some are our own, others are taken from *GoogleMaps* or *GoogleEarth*, and, if no other material is available, from pictures of the company publications.

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3. An example of a post

The figure 1 [1] is the header of the blog. Below is a facsimile of one of the posts (the number 20) in three figures [2], [3] and [4], which describes a cement industry currently in operation. You can initially see a current picture, the description of the process, the history of the factory, and a current GoogleMaps picture of the facilities.

.

Figure 1. The blog header

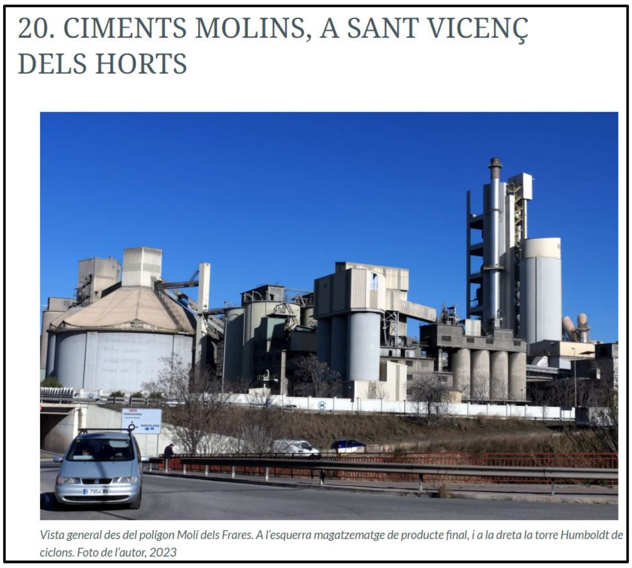

Figure 2. Header of post number 20

4. Indexes

The blog has also 5 thematic indexes with references and links to the different posts: They are actualized with every post. At the moment the number of links is as follows:

- names of firms and entities: 166 references
- proper names of engineers, scientists and businessmen: 68 references
- products, substances and abbreviations: 222 references
- technical equipment devices: 117 references
- geographical locations: 49 references.

The main aim of those indexes is to have a list of the scientific and technical terms related to the chemical industries, as well as the list of scientists, engineers and businessmen who made possible the development of the chemical industry in Catalonia.

L'abundor de pedra calissa a les muntanyes de l'entorn de Barcelona explica la presència de les diverses cimenteres. El producte que fabriquen, el ciment en les seves diferents variants, s'usa en la construcció urbana, industrial i l'obra pública, i es pot exportar a països llunyans per via marítima. A l'entrada 14 [+] varem veure la fàbrica de ciment de Montcada i Reixac. A aquesta entrada descriurem la fàbrica dels *ciments Molins*, de Sant Vicenç dels Horts. I encara quedaran per futures entrades la fàbrica Sanson, a les altures de Collserola, la planta de Vallcarca a les costes del Garraf, i la planta de Santa Margarida i els Monjos al Penedès. I, molt més lluny, la planta de ciment de les Cases d'Alcanar, al Montsià.

L'empresa *Ciments Molins* (oficialment *Cementos Molins*) [+] va ser fundada el 1928 per **Joan Molins Parera**, i ha estat sempre una empresa familiar. Els anys 80 els germans **Joan** i **Casimir Molins Ribot** van impulsar la projecció internacional amb filials a Sudamèrica, Àfrica i Índia. L'empresa va canviar la seu corporativa de Sant Vicenç dels Horts a Madrid després de l'1 d'octubre de 2017 [+], però amb una forta divisió dels accionistes, que molt majoritàriament són de les diverses branques de la família **Molins**.

Com totes aquestes empreses que fabriquen un producte barat, de primeres matèries locals, i amb molta incidència del preu de l'energia, ha anat canviant amb el temps, i sempre estan en mans dels dissenyadors dels equipaments. Passa el mateix amb les empreses de ceràmica i siderúrgiques: els dissenyadors dels forns són els que determinen com evolucionaran les empreses. *Molins*, com altres empreses del sector, van començar amb forns verticals, però aviat van passar als típics forns rotatoris. En va tenir fins a tres simultàniament, a més d'un forn per a ciment aluminós, que treballa en condicions diferents dels altres.

Vista de GoogleEarth (2022) de la unió entre el forn rotatori i la torre de ciclons.

Molins van començar fabricant *ciment aluminós* el 1929. Aquest ciment té una alta proporció d'aluminat de calci, pren amb rapidesa i és resistent als sulfats.però la calor i la humitat fa que es degradi generant la patologia denominada *aluminosi*. A partir de 1943 *Molins* va fabricar també ciment portland. El procés de fabricació del ciment portland ja es va comentar a la citada entrada 14 [+], i no es repetirà aquí perquè, excepte en petites diferències, el procés és el mateix. Com a diferència amb *Asland*, l'actual forn de *Molins* evacua el material del forn mitjançant un sistema de *satèlits* o sortides laterals que refreden el producte abans de molturar-lo, barrejar-lo amb els additius i magatzemar-lo. Les fonts energètiques poden ser molt variades, depenent dels preus del moment: han usat hulla tèrmica, coc, derivats del petroli, residus industrials combustibles com neumàtics, i altres, a més de l'electricitat per moure els motors dels molins i altres màquines..

Figure 3. Center of post number 20

Figure 4. Bottom of post number 20

5. Acknowledgements

This work would not bé possible without the collaborations of most industries who accepted to be visited by the pupils of the assignatures or Industrial Chemistry and Petrochemical

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Processes corresponding to the courses of Chemical Engineering at the University of Barcelona, along the years between 1995 to 2008.

6. References

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[2] Duran, J. Passeig per l'invisible. Itinerari químic per la ciutat de Girona. Ajuntament de Girona: Girona, 2010.

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SETISAT: A Mini Satellite Designed to Search for Signs of Life

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Abstract. This article describes the work carried out by the students of the professional training courses of the IES Escolas Proval High School to participate in the CanSat challenge organized by Esero, the delegation in Spain of the Educational Resources Office of the European Space Agency (ESA). The challenge is to build a satellite the size of a soda can to accomplish a specific mission. Students must invent the prototype so that the mission can be possible.

Keywords. Vocational Training, Satellite Design, Electronics and Programming, Project Based Learning.

1. Introduction

All the work of this challenge is oriented to the achievement of a specific goal. Students must be able to integrate multiple electronic devices of which they must know their characteristics in order to connect them with each other. In addition, it is intended to achieve the development of values such as responsibility, leadership, teamwork and communication with the different social agents related to the environment of the institute.

The satellite mission has two parts. A first one that must measure the pressure and temperature values of the atmosphere and a secondary one in which the satellite, which from now on we will call CanSat [1], is equipped with systems capable of measuring other atmospheric parameters compatible with life, such as level of contamination, concentration of oxygen, intensity of light, existence of a magnetic field,... Additionally, the ability to emit a recorded audio when required from the nearby radio station has been added to our prototype. In this way we have turned the satellite into a probe that is capable of finding out if life can exist on other worlds and if it were intelligent, it could hear a welcome message announcing our arrival indicating that our mission is peaceful. In honor of NASA's SETI [2] project we decided to call our prototype SETISAT.

All electronic devices that enable the mission to be accomplished must be mounted inside the can's casing. Normally the mission consists of sending the data by radio to a computer where it will be represented in graphics that will allow its subsequent analysis. Students must interpret this data and decide if the mission has been a success.

The CanSat must ascend to an approximate altitude of one kilometer in a clear area for its landing to be safe and for its search and recovery to be possible. Once the desired altitude is reached, he releases himself and parachutes down to land. During the descent, the mission carries out environmental measurements with the sensors or by controlling an onboard device.

Every year the students of the higher course of Electronic Maintenance of the IES Escolas Proval [3], at the end of the course, must develop an electronic prototype and present it to their teachers at the end of the course. This served as an incentive to enroll in this adventure. The SETISAT team is made up of six students in electronics from different courses and two professors who have been their tutors (Figure 1). The students are organized by assigning roles in order to specialize each one in tasks such as hardware design, device programming, mechanical design of the envelope, construction of the parachute, search for financing and dissemination of the work through different media.

Figure 1. SETISAT team work meeting

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Working in this way instils in the students the acquisition of technical skills in which the search for effective solutions is prioritized by iterating with the prototypes that are being built. It is intended that students delve into fields such as 3D design, device programming or electronic design that allow the objectives of the mission to be achieved.

2. CanSat challenge

The CanSat, Satellite in a Can Challenge, is an educational competition in which participants must design, build and launch a miniature satellite which should be the size of a soda can, known as a CanSat. The main objective of this competition is to simulate a complete space mission on a reduced scale, allowing participants to experience different aspects of space engineering and promoting hands-on learning.

Below is a general description of what the CanSat challenge consists of, describing the work stages:

- Design: The participating teams must design the prototype, which consists of an electronic device equipped with sensors and communication systems. The design should consider aspects such as the physical structure, power systems, sensor electronics, and control systems.

- Construction: Once the design is complete, teams must build it using commercially available materials and components. This implies the manufacture of the structure, the integration of the electronic components, the programming of the necessary software and the performance of functional tests.

- Launch: A real launch of the CanSat is carried out using a rocket or an equivalent means, such as a balloon, drone, paraglider,..., which allows the device to be raised to an approximate height of one kilometer.

- Missions: During the flight, the CanSat must carry out a specific mission, which may vary in each edition of the challenge. For example, the mission might involve collecting atmospheric data, monitoring radiation, making temperature measurements, or capturing images. The CanSat must carry out the mission autonomously and collect the corresponding data.

- Data recovery and analysis: After the flight, the CanSat must be recovered and the data collected during the mission must be analyzed and presented. This includes processing the data, interpreting the results, and preparing technical reports and presentations.

The CanSat Challenge provides participants with the opportunity to apply knowledge in various disciplines, work in a team, solve technical problems and experience the full cycle of a space mission in an educational environment.

3. Educational objectives

During the development of this challenge, several disciplines are involved, among which are:

- Electronic Engineering: Participants must design and build the electronic hardware of the Cansat, which includes communication systems, sensors, actuators and control systems.

- Mechanical Engineering: It is necessary to design and manufacture a physical structure that protects the internal components during the launch and allows the proper deployment of the systems. The calculation of a parachute must be carried out so that the speed of descent is within established limits.

- Programming and Software Development: It is required to program the software that controls functions, such as data collection and processing, communication with the base station, and execution of control algorithms.

- Physics and Mathematics: Participants must understand the physical principles and the relevant mathematical equations in order to understand the measured parameters and the conversion into different units.

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- Telecommunications: Knowledge of radio communication systems is applied to establish data links between the Cansat and the base station that allow information to be transmitted and received during the flight.

- Earth and Space Sciences: Participants must understand concepts related to the atmosphere, climate, meteorology, and other aspects related to space exploration.

In addition to these disciplines related to the academic field, it is also important to develop other skills that allow the prototype to

- Project Management: To complete the challenge successfully, it is essential to have project management skills, such as planning, resource allocation, monitoring and coordination of tasks. Collaboration between team members and taking responsibility for assigned tasks is essential.

- Patronage: Students must address the social agents, companies and institutions that are related to the institute and convince them of the viability of their idea and get them to support them in the construction of their prototype through material donations or a small monetary contribution. In the case of our students, it is important to make themselves known to the companies where they will later end up doing their internship. In this sense, this project is a very interesting part of their curriculum vitae for them, since it has managed to arouse interest in companies around the institute.

- Communication and dissemination: It is important that the mission be made known to the educational community and society. For this reason, it is necessary to develop informative actions that help their classmates and teachers understand what the project consists of. Informative actions are also carried out using the traditional media, the press, and social networks. In addition, during the competition phases, the teams have to present their work in front of a jury who asks them technical questions about the development of the prototype.

These are some of the disciplines that students learn to use during the project. Teamwork, problem solving, and interdisciplinary learning are encouraged, giving students hands-on experience in the field of space technology.

4. SETISAT primary and secondary missions

In the primary mission, the Cansat must measure the air temperature and atmospheric pressure. These measurements will be stored on a memory card housed inside the probe. The data will also be sent every second to the main radio station which will store it in a database. Then, from a web browser, the data will be consulted using SQL statements and a Linux-based server will graph them based on the flight altitude.

On the other hand, a parachute will be installed to slow the fall so that the flight lasts approximately two minutes descending from an altitude of one kilometer.

The measurement of the altitude will be carried out by two methods. The first using a barometric sensor that allows to measure the pressure and indirectly obtain the altitude. In the second method, a GPS is used that will measure the altitude more precisely and that will allow the measurement of the first method to be contrasted.

Once the students understood what the objective to pursue consisted of, work sessions were held to develop the secondary mission. In some of these sessions, the SETI project was discussed, in which data from radio telescopes was analyzed to search for signals of unnatural origin. The SETI@home project harnessed the processing power of thousands of personal computers around the world to analyze the SETI project data through software applications that each user installed to collaborate. This increased the interest of the students and it was decided to build something related to the search for life on other planets and to use the CanSat as a space probe to send welcome messages upon the arrival of a hypothetical habitable world. Work began on this idea and it was decided to choose as a secondary mission a device that would take measurements related to life indicators such as the presence of light, humidity (presence of water), breathable or harmful gases present in the atmosphere.

On the other hand, we were attracted by the idea that from the main station we could send control signals that could activate an actuator inside the CanSat. It was then thought that the CanSat could emit an audio related to a welcome message or some melody that would fit this purpose and that the message could be selected from the ground station.

Another important aspect for the existence of life is the presence of a gravity that is not excessive or too low. Values close to 9.8m/s2 would allow us to point out that it would be a good world to live in. The gravity will be measured by the dynamics of the flight in free fall before the deployment of the parachute.

However, there are other important magnitudes that must be taken into account. The magnetic field is known to be important as it prevents high-energy particles from outer space from entering the planet's atmosphere and negatively influencing existing life forms. The chosen GPS incorporates a compass based on the QMC5883L, capable of measuring the magnetic field in all three axes [4].

The launch of the CanSat in our atmosphere will then serve to calibrate all the instruments on board. Once the probe is launched, it will be checked if the evolution of all these parameters are as expected. If this is not the case, it should be considered whether the chosen instruments are appropriate or if the measurement conditions are not the best or if some design or programming error has been made. In any case, the challenge of integrating such a number of instruments in a reduced space is a great challenge.

The presence of light is essential for plants to carry out photosynthesis. In the case of people, it is key to the release of serotonin that affects mood. According to some sources, the level of light necessary for an indoor plant to photosynthesize should be at least 50 lux. Therefore, it was decided that, if the measurement were higher than this, it would mean that the planet is suitable for vegetable life. To measure this parameter, a phototransistor-based sensor capable of measuring light energy in the entire visible spectrum has been used, TEMT6000 [5]. Another parameter that had to be measured had to be the concentration of oxygen present in the atmosphere. We know that 21% concentration is enough for our type of life. Therefore, it must be verified that the concentration value is similar, anyway, at higher altitudes less oxygen must be found. To measure this parameter we have used the DFRobot Gravity I2C oxygen sensor [6].

It was decided to use a gyroscope to measure atmospheric dynamics and use it to measure the tilt of the falling can. For this, it was assumed that if the can did not present inclinations of the can with respect to the vertical while it was descending, it would mean that there would be no movement of the atmospheric mass. Atmospheric movements are very important on a planet since they define the climate of the area. To measure this parameter, a gyroscope based on the MPU6050 [7] was used. On the other hand, humidity would also be measured with the BME680 multiple barometric sensor [8] that will be used in the main mission. The measurement of the humidity of the atmosphere will indicate the existence of precipitations. With this sensor we will also record the presence of polluting particles. Although we wanted to measure the presence of CO2 and this sensor allows us to measure it, there was a problem, the measurement time is longer than the flight time, so this measurement was discarded.

In addition to these sensors, an acoustic warning system has also been installed to announce the arrival of the probe in this new world. The can has been equipped with an audio system capable of outputting any pre-recorded audio on an SD card. For this, the DFPlayer module has been used, which allows playing multiple audio files. From the base station you can select the audio you want the probe to emit. This will allow you to test the radio return channel to the CanSat and check how it depends on the distance.

In order to determine the autonomy, the detailed consumption of each device is indicated in table 1. It can be seen that the device that consumes the most is the amplifier. It must be taken into account that the audio message will not be continuous, but will only work when the playback of one of the audio files is requested. However, considering a continuous average consumption of about 700mA and that a 3000mAh battery is used, then it can be said that the autonomy is about 4.6h. Taking into account

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that the audio tracks were played continuously, then the autonomy would be reduced to about 3.5 h.

Table 1. Power consumption of CanSat devices

Electronic device	mA	mA
ESP32 dev kit	50	200
Compass QMC5883L GY-273	2,6	2,6
Pressure sensor, temperature, humidity and gas BME680	5	12
Accelerometer and gyroscope	5,6	5,6
Light sensor TEMT6000	5	5
Transmision module APC220	28	40
Oxygen sensor Gravity I2C	5	5
GPS GLONASS Dual BN-880	50	50
DF Player mp3	40	50
PAM8403 Stereo Amplifier	500	500
Total	696	862

Figure 2 shows the connection of each of the system elements in detail.

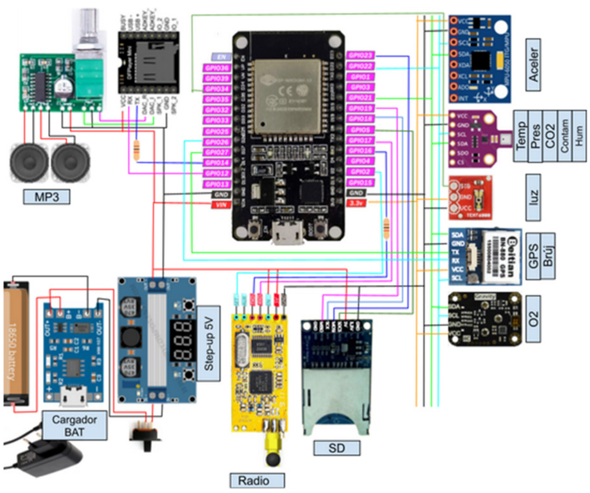

Figure 2. Complete block diagram of the CanSat system

In the case of the base station (Figure 3) another ESP32 is used, a device capable of accessing a WiFi network that allows it to be a gateway with the data server. The microcontroller allows you to query MySQL using a php script that will be interpreted by the Apache server.

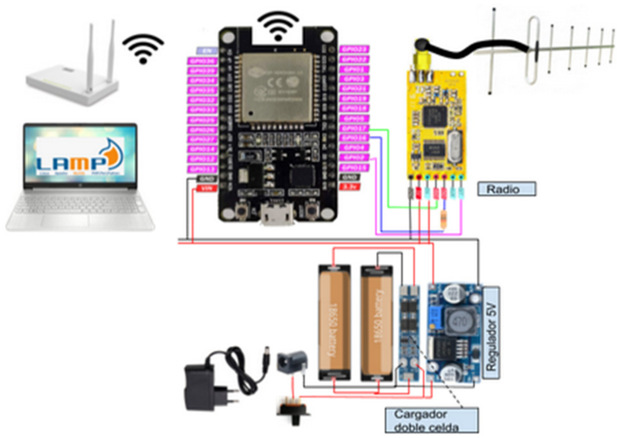

Figure 3. Block diagram of the radio base station

5. System design

The electronic design consists of the integration of independent device boards that provide data to a main microcontroller through its serial communication ports. The chosen control system is an ESP32 microcontroller [9]. Before choosing this processor, other alternatives based on Atmel microcontrollers from the Arduino family (Nano, Micro, Nano Every or UNO) were studied. They were all valid devices, but the ESP32 microcontroller was clearly better. Its program memory is larger, 4 MB flash, it runs at 240 MHz, it has two cores, and it has a large number of ports, including SPI and I2C, which were important for communicating with some of the devices. The price was also a good reason to end up opting for this option. In addition, its size was small, which made it a good fit for the size of the casing.

For the measurement of temperature and pressure, the BME680 multisensor was chosen because it also included measurement of humidity and polluting gases. With the same sensor, the requirements of the primary mission and part of those of the secondary mission are covered.

For radio communications, an APC220 module was used that allows reaching up to 1000m transmitting at 9600 bauds.

Several of the devices used in the tests are shown in Figure 4.

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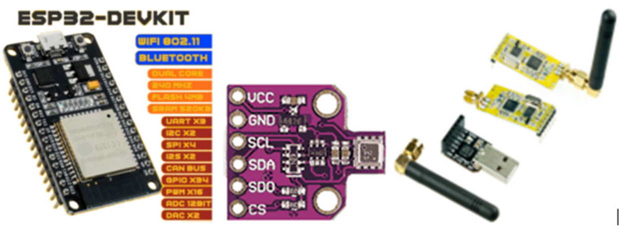

Figure 4. Devices for primary mission tests: ESP32, BME680 and APC220 radio

The first tests were made using prototype boards (Figure 5). Good results were obtained even with obstacles (communication through brick walls). In order to further distance the transmitter from the receiver, the transmitter was powered with lithium ion batteries, thus making the transmitter portable.

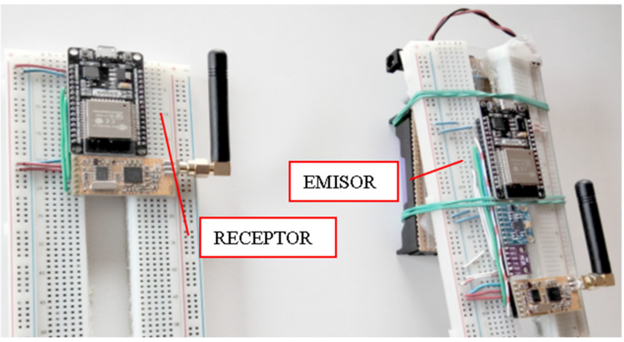

Figure 5. First tests of the primary mission: portable transmitter and receiver

These first tests served as an incentive, since a basic assembly had been achieved with which the data was stored in the database. An interesting feature of our prototype is that the data arriving at the receiver is sent via a WiFi connection to the server where the data is stored. This allowed the receiver antenna to be portable, thereby improving pointing capability without limiting the distance to the server to the length of the USB cable (Figure 6).

To send the data, a time loop has been programmed in the transmitter and every second the data of temperature, pressure and a station indicator (SETISAT) are sent to avoid interference with other data frames from other CanSats.

In the first test with the factory antennas of the transmitters, it was verified that the transmission distance that was covered was tens of meters and was greatly influenced by the presence of large obstacles such as buildings or trees. Then it was decided to solder a coaxial cable to the antenna. From the other end, an F-type connector was connected to a 14dB UHF antenna with a resonant frequency of about 600MHz. Although the frequency of the antenna was not in the range of 433MHz, the results obtained (Figure 7) were very satisfactory.

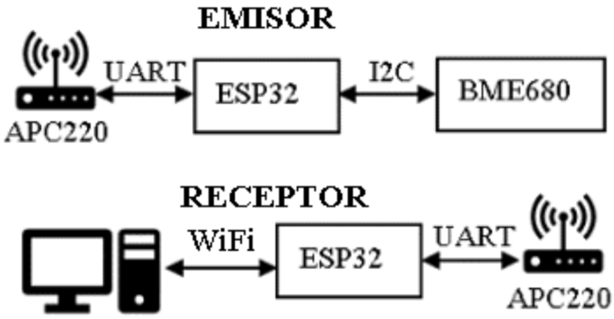

Figure 6. Initial prototype wiring diagram

Figure 7. Transmission distance tests at 1.2km between IES Escolas Proval High School and the San Sebastián Chapel

In parallel with the preliminary design of the electronic devices, work was being done on the design of the parachute. To carry out the calculations that would allow obtaining the diameter of the parachute, the design guide provided by Esero has been used. In our case it was decided to build a flat parachute. The reason for choosing this geometry was its simplicity of design and ease of construction. We also found it more showy than other types. The first prototype was made using plastic bags. Taking into account the maximum weight, 350g, the result of the calculations was a parachute of about 30cm in diameter. The free fall tests were done by launching the parachute from a third

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floor, about 10m of altitude, and a fall speed of 10m/s was obtained. This confirmed that the parachute diameter matched the rate of descent requirement. Once the pre-launch tests were carried out with the plastic parachute prototype, it was rebuilt, this time using umbrella cloth.

On the other hand, it remained to be resolved how to graph the data so that the students could carry out their interpretation. In the Voice and Data Equipment Maintenance subject, we study how to connect nodes based on the Arduino family to a web server. It also studies how to mount a LAMP server in a virtual machine and how to program a web-based HMI (Human Machine Interface). Taking advantage of these contents, it was decided to visualize the data using these tools.

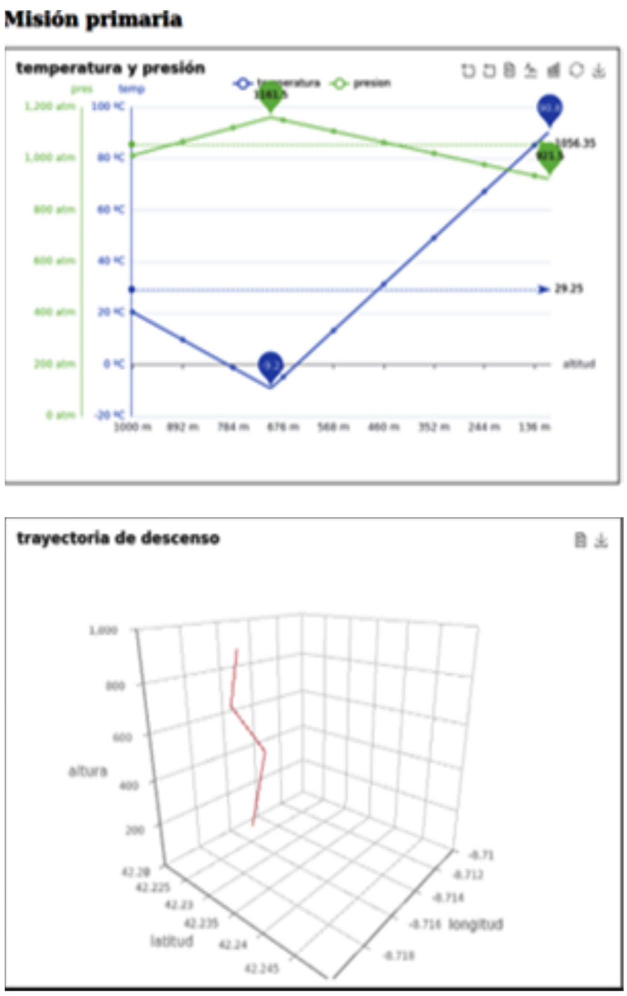

Figure 8. Example of graphs using the Echarts Apache library

The received data is graphed using a web server where the received data is stored in a database. The data is plotted in real time as the CanSat descends. The base station microcontroller uploads the data to tables within a MySQL database. Each table generates a temporary footprint as the data is stored. The measurements are represented by comparing them with the altitude. Web pages have been written on the server using the Echarts Apache library [10]. Thanks to this library we can represent linear or three-axis graphs. This allows to represent the descent of the CanSat and visualize the location using the coordinates provided by the GPS (Figure 8). It must be said that the library facilitates the calculation of averages in addition to indicating the maximum and minimum of the measured variables.

In addition, the interface has been programmed on the website that allows choosing the audio track that will be heard during the descent (Figure 9). The audios are recorded in the SD memory card of the DFPlayer module [11] that has been installed in the CanSat.

Figure 9. Web form for the selection of the welcome message

The data can be viewed through the phpMyAdmin web manager (Figure 10) which also allows editing the structure of the tables.

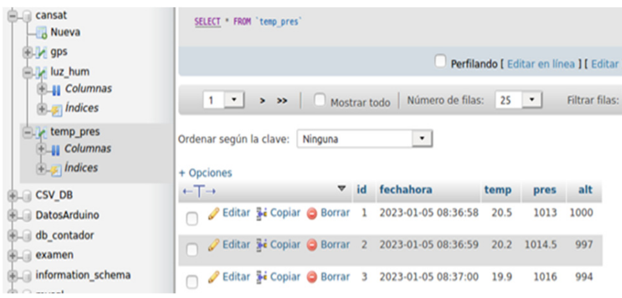

Figure 10. phpMyAdmin operating environment for MySQL

In the design of the casing, it has been considered that there are sensors that must be placed outside so that they can carry out a correct measurement of the atmospheric parameters. This is the case of the light sensor, the GPS or the barometer, as well as the oxygen sensor. On the other hand, the loudspeaker also needed to be located somewhere that would allow the sound front to be emitted and make it

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easier to hear it from as far away as possible. In this case we have placed it behind our team logo that has been extruded into the cylinder of the casing.

It has been manufactured using our own 3D printer. TinkerCAD has been used for its design. With this web application, you can quickly learn how to achieve the required format in the contest rules. In addition, we have been able to place the different electronic elements using the electronic component libraries that are available in this software tool. The components that we have not found in the TinkerCAD library have been downloaded from pages that have a large number of designs (grabcad, thingiverse). To identify our design and distinguish it from the rest, the name of the team has been embedded in the casing (Figure 11).

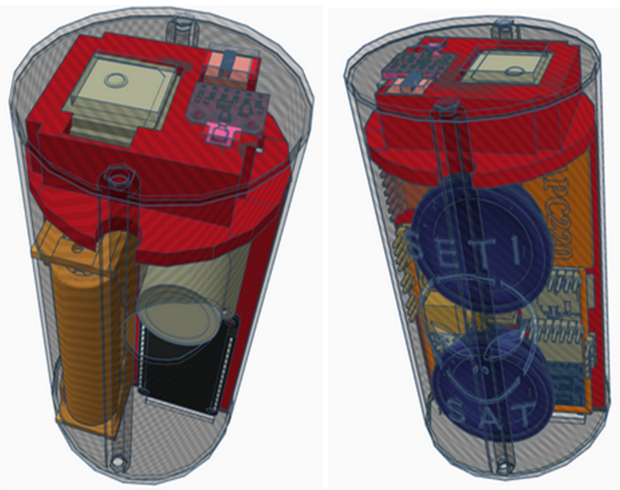

Figure 11. Detail of accommodation of devices inside and extrusion of the logo in the cylinder of the casing

In Figure 12 you can see how the distribution of components has been inside the CanSat. As can be seen, only one speaker has been installed because the wiring between devices took up a lot of space. Difficulties have also been found with the strips of pins soldered on them, because the 90º arrangement made them occupy a volume that would have served to locate other devices.

Likewise, a housing for the receiver was also designed (Figure 13). This box contains the power system using two lipo batteries and a 5V regulator as well as an APC220 [12] radio module and the ESP32 microcontroller. With these devices a link has been built via WiFi with the data server that allows freedom of movement with the antenna without the need to use cables. Some logo details were extruded directly into the 3D design. For other graphic details, a vinyl printer was used to create the logo, which was then glued to both the CanSat and receiver lids.

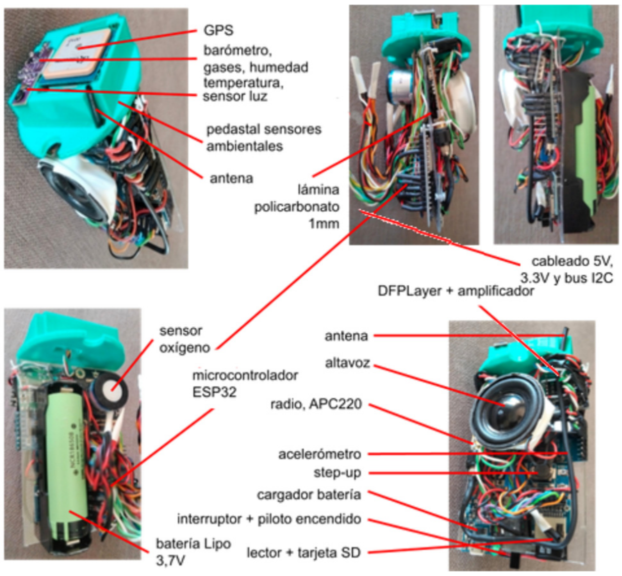

Figure 12. SETISAT CanSat electronics assembled in a single block

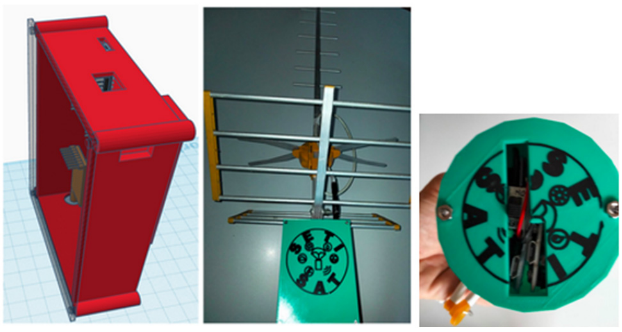

Figure 13. Design of the receiver enclosure, receiver housing mounted on a Yagi antenna, and detail of the cover with access to the main connectors

Modifications had to be made in the distribution of the elements within the transmitter enclosure in the final assembly due to the space occupied by the wiring between the elements. Specifically, one of the loudspeakers was removed and the location of the radio module was changed, as this was how the antenna was better housed. Once the CanSat was assembled, its weight was 270g. For the launch, a weight of 50 grams is added to meet the challenge requirements. The parachute (Figure 14) has been fixed to the casing with rubber bands that will cushion the descent braking of the CanSat when the parachute opens.

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Figure 14. Final appearance of the transmitter with parachute.

6. Conclusions

This work has allowed the development of multiple activities related to skills that allow students to design, build and test a fully functional prototype. On the other hand, communication and spreading skills are developed [13] in such a way that the ability of students to explain what they have built allows members of their educational community to resolve doubts and also solve the questions of a jury that values the effort done.

It is an opportunity to check knowledge in the subjects of the Electronic Maintenance training cycle and also allows students put themselves forward professionally. Many of these companies have taken an interest in the project and as a result of this news some students will do internships in some of them.

This project has been verified in real conditions through the launch carried out at the Rozas Aerospace Research Center (Lugo, Spain) on April 24, 2023. Subsequently, on April 27, the public defense of the project has been carried out (Figure 15) in the Xosé Neira Vilas Auditorium (Santiago de Compostela, Spain) in front of a jury made up of experts from Galician Universities and the European Space Agency, obtaining first prize in the Galician regional final of the CanSat 2023 Challenge [14]. It was a great surprise for everyone and an experience that the SETISAT team will never forget.

Figure 15. Divulgation of the project at the "Ciudad de la Cultura" – Santiago de Compostela.

7. Acknowledgements

To the students participating in the project, whose enthusiasm and work have made it possible to obtain first prize in the regional final.

The training received by Esero [15] has allowed us to learn about other experiences of other High Schools and has made it easier for us to finish our prototype. Therefore, the support provided by the organization has made it possible for the mentors to guide the work of the students and resolve many doubts about aspects of the competition and the development of the CanSat.

Finally, the effort made by the Department of Education of Xunta de Galicia that has allowed the launch of our CanSat despite the many difficulties they have had to overcome.

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STEAM and Inclusive Education: Hands-on Science Experiments Using Static Electricity

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Abstract. Education policies progressively reflect the need for an improved and generalised scientific literacy. STEAM (Science, Technology, Engineering, Arts and Mathematics) education embraces this goal and many programs have been implement to target the need for an active and effective STEAM education at all school levels from kindergarten through high school.

This study was implemented in the Room 1 of the Learning support centre of the school, attended by eleven students (one girl and ten boys), six of those with Autism Spectrum Disorders (ASD), in which we apply structured teaching methodologies. The results of this study aim to reveal the potential for creativity and the role of inclusion and STEAM education. Experiments using static are fun. When most people consider experiments using static electricity, then visualise the one involving hair and a balloon. Though, many further experiments will amaze people of any age and can effectually also exemplify how physics and chemistry are used in creating illusions.

The present paper presents the analysis of data that involved one teacher and students working in Learning support centre context, during work group. The paper reported simple science hands-on activities on static electricity, through the lens of creativity. Most students showed enthusiasm and joy during the experimental activities being much more focus and committed than usual. The activities herein reported are the extension and follow up of an experiment developed in the 2021-2022 academic year with another set of ASD students that was previous reported at the HSCI2022 conference. A comparative analysis of the results will be provided and discussed.

Keywords. Inclusive Education, Autism Spectrum Disorders (ASD), Static Electricity Experiments, STEAM, Creativity.

1. Introduction

Electricity is present in a large part of our daily lives. Without it we would not be able to engage in any important daily activities. We often don’t know exactly how precious it is until we experience a power outage. In the work herein we explore static electricity through a series of simple and diverse experiments that illustrate this natural phenomenon at a level adequate to the age level and the particular characteristics of the students involved.

Most of us agree that experiments using static electricity can be fun. When thinking about static electricity most of us envision experiments involving hair and, or, a balloon. However, many more different experiments can amaze children, of any age, and can effectively illustrate the science involved including while creating illusions [1].

In Portuguese basic schools the “Static Electricity” topic is introduced to students in grade 4. The first approach is often to show that static electricity is the energy that can make hair literally stand up! It is said static electricity to be a phenomenon where charged particles are interact from one object to the other. When two objects are rubbed against each other, in a dry surrounding, the objects acquire equal & opposite charges thereby developing a “static electricity” force between them [2].

Inclusive education is the most effective way to give all children a fair chance to go to school, learn and develop the skills they need to acquire in order to be able to prosper and be active members of the society.

Inclusive systems value the unique contributions students of all backgrounds bring to the classroom and allow diverse groups to grow side by side, to the benefit of all [3].

Incorporating science experiments into learning in inclusive education is a great way to involve children and make lessons more hands-on, actively participated and fun. While autistic students may have different and particular needs in the classroom, they also enjoy science experiments. However, there can be some sensory needs that need to be taken into consideration when planning science experiments, to ensure that autistic children are as comfortable as every other student.

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Many children on the autism spectrum have sensory processing disorder or struggle with certain sensory issues. A very oversimplified definition of this is just that their brain processes sensory inputs (touch, taste, sight, smell, sounds) from the environment around them differently than most children. For some children this can mean they crave extra sensory input and for others it can cause an aversion to certain stimuli all together [4].

This paper contains seven activities, documenting examples of exploring science through the lens of creativity. In this study, the activities will be complemented by photography that will illustrate the advantages of using creativity in science and, or, arts in inclusive education. The activities, its design and planning, were drawn from selected observations and supported by information gathered through several types of data, non-verbal communication, and communication tables.

This study was developed in a learning' support centre with structured teaching, enrolling six students with autism spectrum disorders (ASD). The findings of this qualitative study aim to reveal the potential for creativity of science education in the classroom of students with ASD.

This study is the follow up of a study reported [10] at the HSCI2022 conference. Based on our previous experience we have designed seven "clean" science experiments that are "quiet" not requiring students to get their hands messy, since these can be typical triggers for autistic children.

2. Instruments and methodology

2.1. Instruments

The instruments used to record and to analyse the data were: the field notes [5] and photographs [6] taken by the teacher; reflections of the teacher [7]; and, inputs collected from the children [8].

2.2. Methodology

The objective of the observation during the activity of this pedagogic experiment is to spot and to characterize students' creativity [9], interest and interaction while exploring science.

The notes taken include the students' interventions, observation facial expressions, the emotions, the actions the events occurred. The pictures taken, enable to better identify and to characterize the quested creativity.

3. Characterization of the class

The school, located in Lousada, a small village in northern Portugal, is a public educational institution covering preschool and basic school levels up to the ninth grade; The Portuguese education system is divided into pre-school education (from the age of three until the start of basic education), basic education (six to fifty years old).

The activities were developed at the Room 1 of the Learning support centre, with students aged eleven to fifty years old. This room is a wide one with well identified functional areas endowed with suitable materials, and we follow a Structured Teaching method. This is based on the unique learning needs of students with ASD, including those with difficulties in visual information processing and with social communication, attention and executive function.

Eleven students participated during the so-called work group area. Only three of the autistic students are verbal (one boy of the fifth grade, one of the ninth grade and one boy of the eighth grade). The others (one of the fifth grade and two of the ninth grade) are non-verbal.

4. STEAM activities

The main underlying goal of the STEAM activities implemented is: to introduce and foster to recognize that objects are made of different materials and the materials differ in surface, shape, colour, size, etc.; to develop science investigation skills, mainly observation and categorization skills in simple inquiry activities; to develop the ability to construct simple tasks, to be able to draw basic conclusions from the inquiry activity; to develop basic knowledge, to serve as correct preconceptions, about static electricity.

The used materials were balloons; confetti; pieces of wool; plastic spoon; ruler, tissue paper; plastic bag; stone; plastic cup; glass cup; eraser; metal spoon; pencil; ice cream stick; wooden comb; plastic pen; coloured Styrofoam; salt;

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pepper; PVC tube; dish; plastic tray; straw and dishwashing soap.

4.1. Static electricity hands-on activity #1 – Snake

Static electricity experiments are fun to do. It incorporates both the principles of physics and chemistry into something very simple. It is an interesting way to initially engage any child in STEAM education while teaching them that learning can indeed be fun.

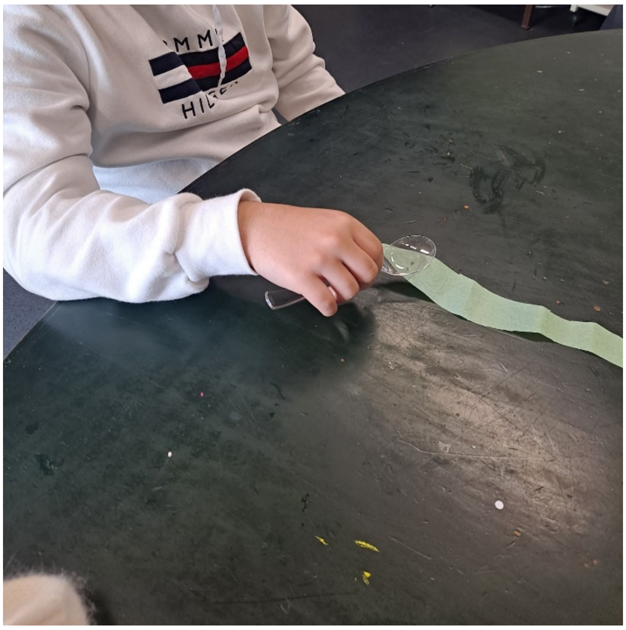

Figure 1.1. Student Z "whispering" the snake with static electricity

This first activity (also applied last year – and reported at HSCI 2022 [10]) is mainly focus on teacher scaffolding. The intention is to captivate students' attention, introduce materials and workspaces, and engage them for the following activities.

Teacher has the ability to guide the group through the "static electricity" concept. Two students have already previous knowledge about this theme, others haven't.

In this activity creativity was present when teacher encourages children to make connections between previous ideas and cross curriculum concepts. For instance, one of the students recognized one situation from out of the school learning when he says: *"The car's door sometimes gives a shock in my hand."*

The teacher asks the students to cut a snake in paper tissue. Then asks the students to rub the plastic spoon with a piece of wool and "whisper" the snake...

Figure 1.2. Student Z "whispering" again the snake with static electricity, through new friction

Figure 1.3. Student M "whispering" the snake with static electricity

4.2. Static electricity hands-on activity #2 - Balloon

The teacher induces the pupils to think like an inquiring person which is looking for an answer to the identified question (what kind of objects can cause static electricity; in what kind of case we can experience the effect of static electricity?). The teacher asks the non-verbal

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pupils to point the pictogram √ (yes) or X (no) to an object, considering what they think about the behaviour of the balloon when it will be rubbed against a piece of wool (making a prediction). The verbal ones said it orally. Teacher gave to the students a worksheet to write down their predictions and verifications about the several materials besides the balloon.

Further the teacher offered the pupils balloons and other material for verification of their predictions. She explained that it is important to rub all the tested material against the piece of wool in the same direction and the same number of times, to get comparable results.

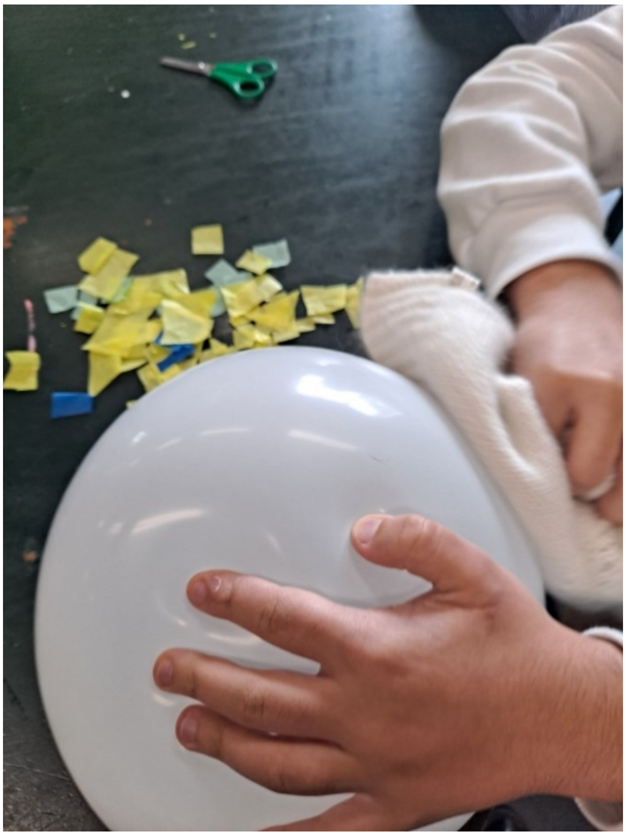

Figure 2.1. Rubbing a balloon with a piece of wool

Figure 2.2. Student Z rubbed balloon attracting small pieces of paper

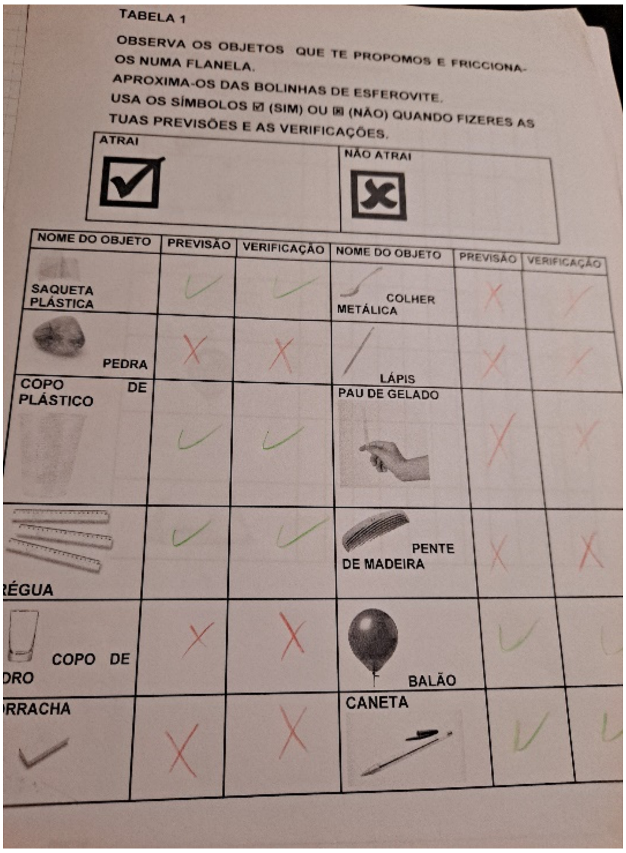

TABELA 1

OBSERVA OS OBJETOS QUE TE PROPOMOS E FRICCIONA-OS NUMA FLANELA.
APROXIMA-OS DAS BOLINHAS DE ESFEROVITE.
USA OS SÍMBOLOS ☑ (SIM) OU ☒ (NÃO) QUANDO FIZERES AS TUAS PREVISÕES E AS VERIFICAÇÕES.

ATRAI	NÃO ATRAI
☑	☒

NOME DO OBJETO	PREVISÃO	VERIFICAÇÃO	NOME DO OBJETO	PREVISÃO	VERIFICAÇÃO
SAQUETA PLÁSTICA	✓	✓	COLHER METÁLICA	X	X
PEDRA	X	X	LÁPIS	X	X
COPO DE PLÁSTICO	✓	✓	PAU DE GELADO	X	X
ÉGUA	✓	✓	PENTE DE MADEIRA	X	X
COPO DE DRO	X	X	BALÃO	✓	✓
RRACHA	X	X	CANETA	✓	✓

Figure 2.3. Worksheet of predictions and verifications of several materials

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4.3. Static electricity hands-on activity #3 – plastic spoon and styrofoam

The purpose of this activity is to measure the "attracting power" between a plastic spoon and tiny pieces of Styrofoam. To achieve this goal, pupils should rub a plastic spoon in a piece of wool and put it near to the small pieces of coloured Styrofoam.

The more functional students counted how many pieces of Styrofoam were "attracted by the spoon" and then, in the worksheet, painted the equivalent number of squares, as many balls of coloured Styrofoam that were attracted to the spoon (figure 3.3). In this way, in this activity the students worked maths, numbers and quantities as well as arts while painting.

Figure 3.1. Student Z with a rubbed plastic spoon attracting Styrofoam

The activities presented in the following chapters, were implemented this year in order to compare with the same activities developed in the previous year and reported at the HSCI2022 conference [10], because this year students are older and some of them are more functional.

Figure 3.2. Child H with a rubbed plastic spoon attracting styrofoam

Figure 3.3. Worksheet with as many squares coloured in the table as many pieces of paper the rubbed object attracted

4.4. Static electricity hands-on activity #4 – plastic spoon or balloon and salt and pepper

Students made a mixture of pepper and salt. Then they rubbed a plastic teaspoon and a balloon on the piece of wool for about 40 seconds. They placed the plastic teaspoon over the salt and pepper mixture and observe. All of the students observed that the pepper was attracted by the teaspoon and by the balloon. Student H said: "Pepper jumped and sticks to the teaspoon and to the balloon."

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Figure 4.1. Plastic teaspoon attracting pepper, separating pepper and salt

Figure 4.2. Balloon attracting pepper, separating pepper and salt

4.5. Static Electricity hands-on activity #5 – butterfly

After the snake activity described in 4.1., the teacher continued to explore the static electricity concept in order to verify if students could apply previous knowledge to a new situation.

This new experiment intended to demonstrate how static electricity can move the wings on a tissue paper butterfly. The used materials were glue stick, balloon, scissor, pencil, tissue paper and cardboard. The student drew butterfly wings on a piece of tissue paper with a pencil, cut the butterfly, and then glued it by the middle of the cardboard. The wings needed to be loose, in order to have motion, to demonstrate the effects of static electricity.

Teacher showed the students the balloon, a piece of wool and the cardboard with tissue paper butterfly shape. Teacher asked students to make predictions, if they rub the balloon and get it near to the butterfly. Referring to this new situation, student E. answered: “The wings of the butterfly will raise when we approach the rubbed balloon.” This points out that this child carried out significant learning as he transferred knowledge into a new situation.

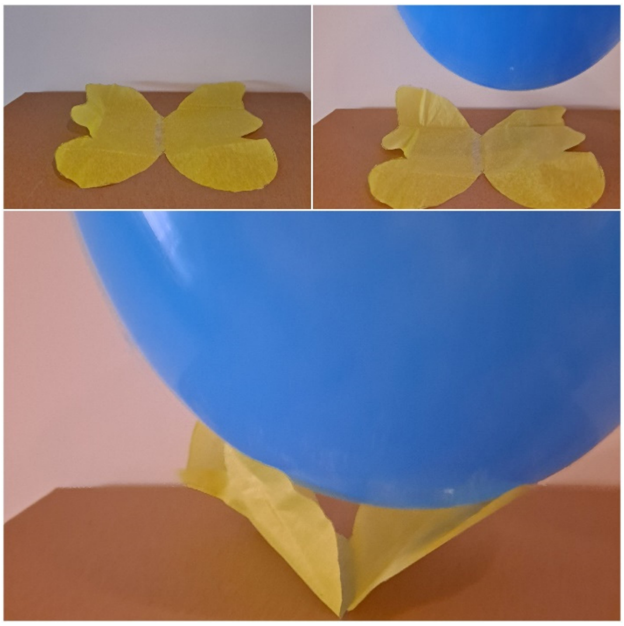

Figure 5. Photo sequence Static electricity butterfly

The balloon should be close but shouldn’t touch the butterfly. They saw the wings lower and raise as the balloon is moved closer and further in distance. The pull of the charged attraction enables the paper to move towards the balloon.

4.6. Static electricity hands-on activity #6 - bending water using static elect ricity

In nature, water can bend due to the moon exerting tidal forces [1]. The same bending effect can be accomplished by using static electricity.

The materials used in this activity were running water, piece of wool, balloon and PVC tube. Students used the wool to rub the surface of the PVC tube for 40 seconds. They created a stream of water by turning the tap on slightly and placed the PVC tube close to the water and watched with amazement as the stream bends.

Figure 6.1. Bending Water Using a rubbed PVC tube

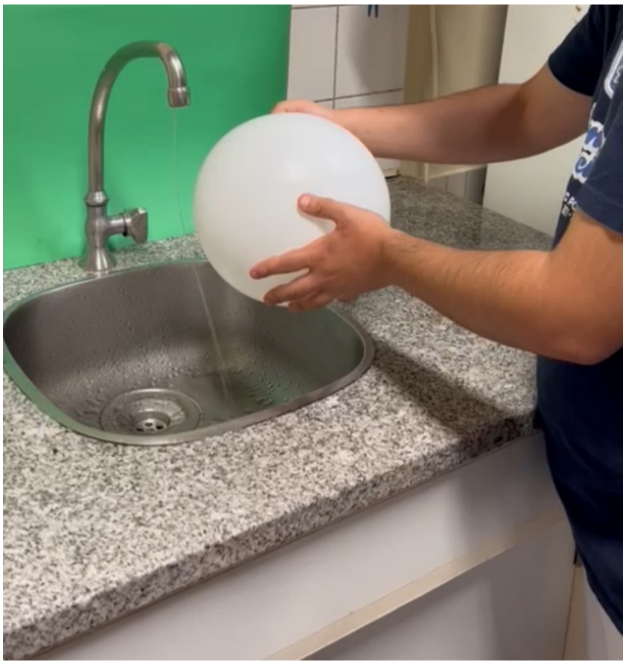

Figure 6.2. Bending Water Using a rubbed balloon

Rubbing the material on the PVC tube generates negatively charged ions. This repels the electrons found in the water. The water closest to the positioning of the rod receives positive charges from it. The attraction between positive and negative charges creates a force on the water, allowing it to appear as if it were bending [1].

In order to verify if students made significant learning, teacher asked: “And if you rub the balloon and bring it closer to the water, what will happen?" Two students answered: “The water would approach the balloon.” The students’ answers showed that they made connections and transferred knowledge.

4.7. Static electricity hands-on activity #7 – bubble moving tube

Static electricity may also be used to move soap bubbles in another rather appealing experiment.

The materials used were plastic tray, dishwashing soap, PVC tube and a piece of wool. Students spread the bubble solution on a plastic tray. Blowed larger bubbles on the tray with the straw. Charged a PVC tube by rubbing it. Students placed the object near the bubble and observed [1].

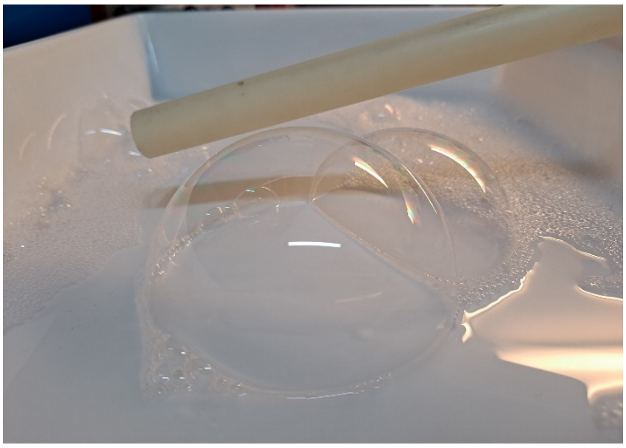

Figure 7.1. Bubble near a PVC tube

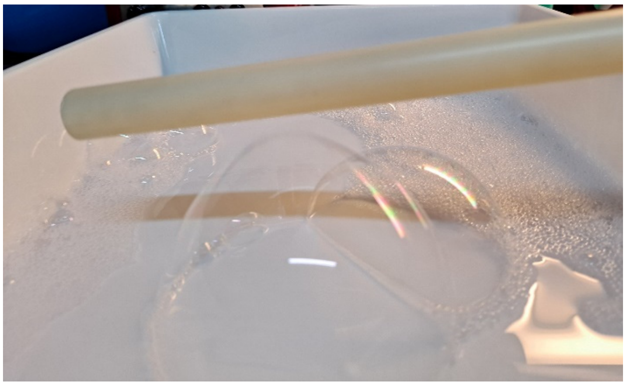

Figure 7.2. Bubble attracted by a rubbed PVC tube

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Students observed that the soap bubbles followed the charged PVC tube.

At this point, teacher asked if they reached any conclusion of what they observed. The most functional verbal students answered: "When we rub plastic objects, they gain the power to attract."

In all of these experiments, we are manually moving electrons from one material to another [11].

All matter is composed of three types of particles: negatively charged electrons, positively charged protons, and neutrally charged neutrons.

Normally, the electrons and protons present in an atom are balanced, which is why most matter is neutral. But electrons are tiny and very light. That's why friction manages to give mobile electrons enough energy to bond their atoms and cling to others, migrating between different surfaces.

When this happens, the first object has more protons than electrons and has a positive charge, while the second object has more electrons than protons and has a negative charge.

And when one of these new bodies comes into contact with another material, the mobile electrons take the first opportunity to leave the material with a negative charge and incorporate the material with a positive charge. It is this movement of electrons that makes us feel small shocks, hear clicks or even see little lights when we come into contact with some people or objects [11].

5. Summary and conclusions

Incorporating science experiments into learning is a great way to engage children and make lessons more hands-on and fun. The teacher initiated the activities explaining and making demonstrations to the students. Encouraging observation by the students in simple science activities was fostered.

The proposed activities showed creativity through student's action, curiosity, engagement and enthusiasm. Rich motivating contexts for play and exploration were fostered, by the utilization of everyday materials, besides the whole classroom organization and the knowledge of student's functional profile. Collaboration was promoted by the use of group work in a group work area, and played an important role in involving students, specially, the ones with autism spectrum disorders.

The students showed enthusiasm and joy during the experimental activities, being much more focus and committed than usual, except two of the students due to their severe autism.

The above-mentioned activities contributed to engage students on STEAM education.

Across the episodes there were stated many examples of students participating, observing, and making connections.

The teacher emphasised the need to foster motivation and collaboration and to provide a rich environment with space and time for exploration, especially in what concerns a group of ASD students.

Comparing these results with the ones reported previously [10], these students were able to make more predictions and verifications and their predictions and verifications were mainly correct. This means that significant learning was achieved. These students being older and verbal, know how to ask questions, make connections, prove results and know how to communicate them.

In addition to the three activities on static electricity carried out by primary school students (ages between 6 and 9 years), in the past year [10], this year' older students carried out four activities more and have more autonomy, also because they are older and three of these students are more functional and verbal.

6. Acknowledgements

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A Dichotomy. School Science: Everyday Science?

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Abstract. Science and engineering in action is all around us in our everyday. We are all practitioners of STEM but rarely realise that such is what we are doing in our everyday such as irreversibly changing ingredients through cooking, using forces to pick up and move things, mixing solutions, washing clothes.

School science is but one genre of science but it is that which adults who were able to attend school recall. In many instances the science taught was abstract and not explained as relevant to everyday life. Hence adults who learnt that way do not identify and recognise the science, engineering, technology and maths in action around them and in their activities and actions. Such and understanding is important in raising the scientific (STEM) literacy of a populations, literacy is not just facts but the ability to apply the facts, understanding them in action and apply them using what are referred toa s 21st Century skills.They are simply listed as Crtical thinking, Communication skills: Creativity. Problem solving; Perseverance: Collaboration; Information literacy; Technology skills and digital literacy.

Adults who did not receive schooling, or if they did had no science and maths beyond numeracy, are effective practitioners of STEM in action but are unaware that this is what they are plasticising. Two exemplars of Everyday science awareness in action are described in this paper; one of adults of children about to start formal school in England and the other of women who never received schooling in rural Bangladesh and their introduction to Everyday science in Action. Facilitating these everyday practitioners to realise they use STEM in action these practitioners also receive the encouragement to explain what they see to their children whom may nor only develops their own everyday STEM in action awarenss ikt develops children's vocabulary, observational skills and social skills together with communication, literacy in action in terms of STEM and of language.

Keywords. Bangladesh, England, Skills, STEM, STEM-Everyday.

1. Introduction

Many adults who attended school in primary and secondary stages learnt some science such information they may remember in adulthood. However, School science is but one genre of science but it is that which adults who were able to attend school recall. In many instances the science taught was abstract and not explained as relevant to everyday life. Hence adults who learnt that way do not identify and recognise the science, engineering, technology and maths in action around them and in their activities and actions. Such and understanding is important in raising the scientific (STEM) literacy of a populations, literacy is not just facts but the ability to apply the facts, understanding them in action and apply them using what are referred to as 21st Century skills. They are simply listed as Critical thinking, Communication skills: Creativity. Problem solving; Perseverance: Collaboration; Information literacy, technology skills and digital literacy [1].

2. STEM in Action Everyday

Driver [2] recognised that secondary pupils in English schools did not come to their science classes without any knowledge and that these pupils were scientist. She pointed out that children in the early teenage years of secondary school came with their ideas and explanations as well as recognising that such pupils sometimes struggled to make sense and understand the t more abstract ideas of science.It was a challenge to their teachers. Osborne, Bell and Gilbert [3] recognised that primary years) were also scientists explaining phenomena and experiences within the confine s of their knowledge and understanding and their culture. They named this Children's science. Gopnik through publishing her research in a form accessible to practitioners through her books for a a general readership which reorganise that youngest of children are through their activities show the attributes of science investigations [4]. School science is but one aspect of science in the world. Conversely adults particularly parents often don't identify the STEM in action that their children are experiencing in the pre school years of interacting with objects and phenomena,adult designed toys and everyday items. These

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crucial adults in a child's early life often have the tendency to tell children how to use an item and not let them explore for themselves. We recognise now that the skills of STEM together with those of reading, writing and numeracy are some of the essential 21st century skills.

Science and engineering in action is all around us in our everyday. We are all practitioners of STEM but rarely realise this. In our homes for example, we may cook rice to eat, bake bread from flour and other ingredient, or cook raw eggs and notice that the flour, the rice we bought or the egg which we obtained from breaking the egg's shell, have changed., Moreover, these changes are irreversible. The process of cooking, a chemical process requiring energy, has changed the ingredients. In everyday life we do not need to know the science of the irreversible changes, but it is so important for these children's adults, and the adults themselves, is to point out such science in action to the youngest of children so they start learning about the science in action, or the mathematics, engineering and technology which is used. Such ability to recognise the actions as STEM in working, is a fundamental. This irreversibility of some cooking actions is a very important science concept, irreversibility of some actions. However, equally important is recognising and seeing in actions that some items can be reversed. Melting an ice cube, results in water reappearing, this water can be changed back to the hard ice cube if the water is in a container which provided the template for the water's frozen state.

Home and the everyday, their communities, the everyday environment are the classrooms and 'laboratories' for young children developing an emerging awareness of STEM in action through observations, experiences and having STEM in Action in their everyday pointed out to them by their adults and wider community. However, research has shown that such an understanding is lacking in many adults and communities [5]. Formal school laboratories and workshops are but one aspect of these subjects and not always accessible to learners.

This recognition of STEM in Action in our every day is so important to know that the impact of humans on our planet and the effects of climate change, brought about by human activity as pointed out in the Intergovernmental report on climate change [6] has been recognised. Thus it is more important t than ever in this race against time to save our planet that children from their earliest years become aware of these issues. Therefore the importance for STEM in helping learners understand and combat against such is vital. It is now crucially important for such to be part of developing children's.The UNESCO Development goals. The UNESCO Target 4.2 of Sustainable Development Goal 4 aspires that 'By 2030, all girls and boys will have access to quality early childhood development, care and pre-primary education so that they are ready for primary education.' Quality is not defined. These are similar to the Commonwealth Development Goals. However, STEM, learning and education do in fact appear in all seventeen goals, education is much wider than basic literacy and numeracy. Education is life long, beginning at birth with the critical foundation years up to statutory school age up to eight years of age. In order to develop such it is necessary to assist the children's adults in also understanding this Everyday 'STEM in ACTION', that such is an integral part of our everyday lives and science (STEM) is not a subject confined to school. It is an essential part of our lives and how we work.

3. Recognising a Wider Understanding of Essential Science understanding. Community workshops

As teachers of science we were trained and have practised in either further education higher education or straight into the workplace or apprenticeships but is our understanding of science in our world narrow? School science, particularly in the primary and earlier phases embraces maths, engineering and technology under the science superordinate heading. The STEM components are integral in the learning and practice of 'science'. Many years of teaching at all stages of formal education have shown me that school science is a very narrow part of the spectrum that is science in the everyday world very often the curricula have been designed from the top down which has led to a simplifying of major scientific ideas and discoveries and is has been remote from real life science in action.

Children spend more time out of school than they do in school. They acquire a lot of their understanding of the everyday world t- he living world, and the physical world from their own observations and experiences living in it and from the cultural interpretations of certain phenomena, as well as folklore and everyday

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interpretations. My contention is that we should be looking very carefully at everyday science and the experiences that children and their adults have.

Working with parents in south- east England of young children we found that their understanding of science was very much what they remembered from school and were quite amazed when we started explaining about everyday things such as cooking, whether it be rice or vegetables, asking could you change the cooked item back to the uncooked item or were the somethings that we use such as ice cubes which they agreed could be changed back to the water by submitting the ice cube to some heating.

The workshops were organised in school halls at the request of the headteachers who invited parents and carers of the children who had just started school(4 years old). The sessions began half an hour before the end of school when the relevant children joined. Everyday items put out were a range such as cardboard boxes, a slope with toy cars and different surfaces, sieves and pasta and small grained material such as sugar, beamer scales and items to see weighing items in action as electronic scales are the norm the children had no idea about balancing.

Parents commented

“Thank you so much it was good to hear science is not about test tubes and things, but everyday”
“Thank you, good, very useful”
“Great, I had a brilliant time, I got ideas I can do at home”
“She is going to make a mess at home now!”
“We’ve done a lot of this at home but never thought of it as science”
“Thank you so much it was good to hear science is not about test tubes and things, but everyday”
“Thank you, good, very useful”
“Very good”
“Great, I had a brilliant time, I got ideas I can do at home”
“Really good”
“Really good ideas on each table”
“Very useful”

We asked parents not to tell children but ask scaffolding questions, such as, “What have you noticed,? “What could you do next?”. And very importantly to not tell them what to do nor that the children were ‘doing it wrong’.

A Different approach was taken with mothers at Sreepur Village Bangladesh [6] which did not involve children in the formal sessions. The women at Sreepur at the time of this work in 2023 were there because they had lost everything and suffered great hardships struggling to support their children. Many of the beneficiaries s had not received any schooling. They did not ‘know’ the science or uses of numeracy or the convention of time using clocks but were extremely able in problem solving and in critical thinking and had no idea that what they were doing was science in its widest self sense in action their understanding of science was very low but their understanding of everyday phenomena which were essential for their lives.Their 21st Century skills were more apparent in their responses to situation provided in ‘class’ then the English adults confronted with challenges in everyday science. was much higher then people who had received school science classes but they had been taught facts remote from the facts in action.

Figure 1. Participants involved in everyday Science actions at Sreepur

Examples of activities and responses of participants are given bellow: The dialogues were contemporaneously translated and written by the facilitator. The sessions were conducted in Bangla.

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A session was held f waste and local pollution followed by practical action in the village. (Figure 1) The responses of mothers: *"After discussion, all the participants said, we realized humans are solely responsible for air pollution. We throw waste everywhere, drive excessively, and use numerous types of chemical farming methods, all of which cause pollution in the atmosphere. We learnt how air pollution affected in our health and for this many health problem developed the human body. We also learnt different alternative methods like avoid smoking, throwing waste in dustbin, avoid pesticides while farming to prevent pollution.*

Figures 2. Practical actions about extinguishing fire

A subsequent session was organised about fire. Fire is a great present danger for village dwellers because of the materials used in building their dwellings. Actions are shown in Figure 2. The mothers commented, **"**We learned about the basic methods of fire extinguishment after the lesson. We came specifically to learn the various causes and sorts, of fire ignition. Before the lesson, we only understood that in the case of a fire, water must be poured. But today we know that we can use dry sand, soapy foam, and a variety of other things to smother the flames and deprive the fire of oxygen in the case of a sudden fire." We aim to identify STEM in action which is relevant to the lived and well being fo the mothers and their families. The following activity was about local made remedies for diarrhoea. Diarrhoea is a frequent aliment and these mothers knew that a home made treatment can be made. One session talked about when to make such and the class members learnt which ingredients were best to use and in what quantities and hence how to make a mixture.

Figure 3. Understanding Time

Understanding Time and Data collection is an important skills (Figure 3). The mothers learnt the way the day and night re divided into 24 equal parts and how such is shown on a cloak. They then worked out the times of the major events of the day, such as waking up, going to bed, eating, doing their jobs.

The lady above commented, "I kept telling our teacher from the beginning of the session that I don't understand and can't tell the time on the clock. And I am quite keen to study it. Then,

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when she taught me thoroughly, I picked up the skill quickly. Now I can determine what time it is just by looking at the clock. I am delighted."-

4. Discussion

It is my contention that we should be paying a lot more attention to the understanding that children bring to their school classes and the first years of life from birth two when they enter a formal school situation should be valued and we should be working with parents and other adults such as carers to help them understand that the stem that is inherent in children's play and in everyday activities of living. The Mothers of Sreepur have tremendous problem solving and critical thinking ability but lack formal STEM understanding whereas the parents at the English schools had factual particularly science knowledge but were less secure in recognising STEM in Action in their everyday lives as well as in the free choice play or even in facilitated play of their children using constructed toys with which to play. Remarkably even practicing scientists fail to recognise science in action in their lives considering it to be that which is restricted to laboratories or field research.

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Introducing Science on Stage Europe STEM Festivals, Science on Stage Türkiye & a Sample Delegate Project:"Ecco Homo!"

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Abstract. In this paper, in addition to introducing Science on Stage Europe STEM festivals along with Science on Stage Türkiye to education climates worldwide, it is also aimed to present "Ecco Homo! First People on Earth" which is an example of a STEAM plan that took place as a delegate project in one of these festivals. Science on Stage Europe is the largest non-governmental organization in Europe with its headquarters in Berlin, including 35 countries and spreading STEM education sharing with the motto "From Teachers to Teachers".

Keywords. STEM, Science on Stage Europe, Science on Stage Türkiye, Ecco Homo.

1. Introduction

Science on Stage is the European Network for Science Teachers. It aims to improve STEM education in Europe by supporting and encouraging teachers in their professional development and growth. As an umbrella organisation, it supports 35 member countries in realising their activities. The ultimate goal is to promote a more scientifically literate population, to ensure quality education and to encourage students to consider a career in science, IT and engineering; true to the motto "teachers make the difference".

Many teachers have great ideas how to excite students for STEM. The activities of Science on Stage focus on identifying, sharing and scaling up good practices. So they find their way into classrooms all over Europe. Therefore, Science on Stage Europe organises Europe's biggest educational festival from and for STEM teachers. The participants are selected through selective national events in the member countries. The Science on Stage festivals are the core of the network since they are the starting points for a wide range of national and international follow-up activities.

At the European Science on Stage festival each country is represented by its own STEM teacher delegation. Therefore each National Steering Committee organises its national pre-selection the year before the festival. Each country organises their national pre-selection in another way for example; some national events last four days, some only one, some other national events include students in on-stage presentation, some include actual research and some are open only for teachers, some are held virtually or through a written application.

A national jury selects the STEM teachers with the most innovative projects to be a part of their delegations.

Although all the national pre-selections are quite unique and have a selective character they have one thing in common: They are a great way to meet enthusiastic teachers and to exchange ideas and activities!

2. Historical background of Science on Stage Europe

Science on Stage evolved out of Physics on Stage [1], which was initiated in 1999. Representatives of CERN, ESA and ESO Outreach Departments responded with Physics on Stage to the European Commission's Call for Proposals for the European Science and Technology Week 2000. This period lasted between the years 1999-2000 and could be titled as "Initiation Period".

In 2002 ESA (European Space Agency) organised and funded Physics on Stage 2 festival with support from CERN, ESRF, EMBL, EFDA and ESO. Along with the EIRO forum and with funding of the European Commission, Physics on Stage 3 was organised in 2003. This period lasted between the years 2001-2003 and could be titled as "Continuation Period".

Science on Stage was established in 2004. It followed the model of Physics on Stage with national activities leading to international festivals. The main difference was that from now on teachers of all-natural sciences could take part.

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The first Science on Stage festival took place at CERN, Geneva, in November 2005. The second took place in April 2007 at ESRF/ILL in Grenoble. After funding of the European Commission ended in 2008, Science on Stage Germany as National Steering Committee (NSC) continued the series with the Science on Stage festival 2008 in Berlin. It was mainly supported by think ING, an initiative of the Federation of German Employers' Associations in the Metal and Electrical Engineering Industries. Up to this, it was the largest science education initiative ever undertaken in Europe and, in fact, unique in the world. This period lasted between the years 2004-2008 and in this period, Physics on Stage became Science on Stage**.**

In 2009, Science on Stage Europe was re-organised as a bottom-up initiative out of the 27 National Steering Committees (NSCs) with alternative funding. After the Science on Stage festival 2008 in Berlin, the festival took place in Copenhagen in 2011, supported by the Danish Ministry of Education. This period lasted between the years 2009-2011 and could be titled as re-organisation of Science on Stage Europe.

Non-profit association Science on Stage Europe was founded by the representatives of the participating countries in November 2011, recognized by German Law with headquarters in Berlin. In this sense, the year 2011 could be titled as “Foundation Year”.

The tradition of organising the Science on Stage festivals via National Steering Committees have been carried on from the year 2012 onwards. This is why this period starting from 2012 can be titled as “Science on Stage Festivals Period”. The 13th European Science on Stage festival will take place between 12-15 August 2024 inTurku, Finland. In the past, the festival took place in various European Cities such as; Prague, Czech Republic (2022), Cascais, Portugal (2019), Debrecen, Hungary (2017), London, England (2015), Słubice, Poland/Frankfurt an der Oder, Germany (2013).

2.1. Science on Stage Europe Festivals

Since the year 2000, eleven festivals have been held in various places in Europe. Starting with 'Physics on Stage', it was soon clear that all sciences should benefit from the exchange among teachers. Meanwhile, the Science on Stage festivals are Europe's biggest STEM teaching events.

The European festival ‘Physics on Stage’ was held for the first time in 2000. The target group included physics teachers who came together at the European Organisation for Nuclear Research (CERN) in Geneva. The event was organised by CERN, ESA and ESO.

From 2005 onwards, the initiative was continued under the name of ‘Science on Stage’. From then on, all-natural sciences were included. The organisational responsibility was laid into the hands of the seven research institutes on EU level that have formed the EIRO forum.

In 2007 it was decided to carry on the initiative by all member states. The continuation was enabled by the funding of the employers’ association Gesamtmetall and its initiative think ING. Since then, nationally organised Science on Stage festivals took place every two years.

Delegate teachers, who are determined through national auditions held in each member country of this organization, participate in Science on Stage Europe Science Festivals which are being organized in one of the member countries every two years and exhibit their STEM projects at an international level. The project guide themes are open to pre-school, primary, secondary, high school and education faculties teacher candidates. These guides are; STEM for the Youngest, STEM Education for Sustainable Development, Digital Technologies in STEM Education, Diversity in STEM Teaching, STEAM in Education, Low Cost Experiments in STEM Education, Joint Projects, STEM for Teachers in Education.

Each Science on Stage Europe Festival is followed by international teacher exchanges and the possibility of submitting a joint project for a future festival.

Besides festivals, Science on Stage Europe networking offers teaching STEM materials developed by European STEM teachers. In international teams of 15-20 teachers have meetings and by working together they develop teaching concepts and ideas to be published as teaching STEM materials in several languages.

Science on Stage Europe also organises

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regular practical teacher trainings across Europe each based on festival projects, festival follow up activities and international teacher trainings.

2.2. Science on Stage Türkiye Festivals

Türkiye joined Science on Stage Europe Network Organisation as a member country in 2014 and has been carrying out the national representation of Science on Stage Europe Festivals through the Science on Stage Türkiye [2] organization.

Figure 1. SonS Türkiye Poster, National Festival 2016

From the year 2014 onwards, Science on Stage Türkiye organised four national festivals. The first festival was held at METU Ankara on 30 November 2014. Five delegate projects were selected by the academic jury and the delegation represented our country at the Science on Stage Europe Festival held at Queen Mary University in London, England.

The second national festival took place on 7 May 2016, in Ankara. Nazım Hikmet Cultural and Congress Centre hosted 1200 participants including academicians, teachers, parents, students, school groups from many cities of Türkiye at this festival. One educator from Finland and one academician from Hungary were invited to the festival. They presented sample projects from their countries and performed scientific workshops at the festival. Many oral presentations, hands on activities and exhibitions took place at this festival. This national Science on Stage Festival was realized in collaboration with International Hands on Science Network and International Children Summit.

Figure 2. SonS Türkiye 2018 Festival, National Council Hall, Ankara

Third Science on Stage Türkiye Festival was held on 30 September 2018 in National Council Hall again in Ankara. The other partners of this festival were International Hands on Science Network, LUMA Center Finland and International Children Summit Coordination. Two educators from the Board of Education Council in China, two educators from Switzerland and the StarT Project Manager from LUMA Center, Finland were invited to this festival. Their participation with their oral presentations and science workshops highlighted the festival. Besides the teacher exhibition stands, student project exhibitions and presentations, many science shows took place at the festival. Türkiye was represented by eleven selected national delegates at Science on Stage Europe 2019 Festival.

The quota for Türkiye had been risen to eleven by Science on Stage Europe due to Türkiye's very active organizations and agenda of educational events, teacher trainings and projects that had been carried out all across the country.

In 2021, Science on Stage Türkiye initiated National Ambassadors Program. Teachers across the country were recruited. Selected teachers by Science on Stage Türkiye Board were assigned to become volunteer Science on

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Stage Türkiye Ambassadors. Since then, teacher training webinars, workshops have been held and many educational projects have been carried out by Science on Stage Türkiye with volunteer supports of SonS Türkiye Ambassadors.

Figure 3. Türkiye Delegation, SonS Europe 2019 Festival, Cascais, Portugal

Due to the world pandemic on 25-26 September, Fourth Science on Stage Türkiye festival was held online. The festival lasted for two days. Many educators, academicians and students from Kazakhstan, Spain, Hungary, Portugal, Switzerland, Norway were guest participants of Science on Stage Türkiye. The event was realised with the collaboration of International Hands on Science Network.

The Fifth Science on Stage Türkiye Festival will be held at National History Museum and Park in Ankara on 7 October, 2023. It will be realised with the collaboration of International Hands on Science Network, International Children Summit Coordination and Global Save Our Species Project Coordination.

3. A Sample Delegate Project from Türkiye: Ecco Homo

Ecco Homo, was a Science on Stage Türkiye delegate project in Czech Republic in 2022. It was an educational study realised in the Pandemic Period. It started its work as an eTwinning project in 2020. It was constructed by the collaboration of different types of schools and teachers from different branches from Spain, Croatia, Jordan and Türkiye at their first sections of archaeological museums.

Ecco Homo was awarded with the Quality Label by the Croatian National Agency in 2021. It was also awarded with the Quality Label by National Agency of Türkiye in 2022 and the European Quality Label in 2023. During the dissemination efforts of the project, it was participated in the competition held for Science on Stage Türkiye National Delegate Project Selections 2022 and was among the 11 projects selected from Türkiye and opened a booth as a STE(A)M project at Prague Clarion Congress Hotel on March 23-27. In 2022-2023, project was accepted into the Global Save Our Species Project Coordination together with the students.

3.1. Background of the Project

Paleolithic humans made tools of stone, bone (primarily deer), and wood.[3] The early paleolithic hominins, Australopithecus, were the first users of stone tools. Excavations in Ghana, Ethiopia have produced thousands of artifacts, and through radioisotopic dating and magnetostratigraphy, the sites can be firmly dated to 2.6 million years ago. Evidence shows these early hominins intentionally selected raw stone with good flaking qualities and chose appropriate sized stones for their needs to produce sharp-edged tools for cutting.[4]

Ecco Homo studied the unrecognized Paleolithic Period artifacts, each of which was a STEM piece in the first sections of archaeological museums abroad and in Türkiye listed below [5-14]:

Abroad,

- Archaeological Museum of Murcia in Spain
- Archaeological Museum in Barcelona
- Krapina Museum in Croatia
- Amman Archaeological Museum in Jordan

Türkiye,

- Archeology Museum, in Adana
- Archeology Museum in Antalya
- "Eti Archeology Museum"in Eskişehir
- Rıdvan Çelikel and Istanbul Archeology Museums, University of İstanbul in İstanbul
- Ahmet Urkay Carpet Museum in Denizli
- Archeology Museum in Adıyaman
- Anatolian Civilizations Museum in Ankara

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Figure 4. Students of Eryaman Şehit Ertan Akgül Anatolian High School at the Museum of Anatolian Civilizations

3.2. Project Objectives

Ecco Homo, which prioritizes the use of museums for teaching, focuses on the "first people" on a thematic level. All partners, conduct research on the Paleolithic period sections in the archaeological museums. An examination of the concrete assets of a common human life in different geographies in Anatolia and the world helps us to find answers to the questions that can be asked about "First People". Ecco Homo studied the unrecognized Paleolithic Period artifacts, each of which was a STEM piece, in the first sections of the archaeological museums.

Teachers from Istanbul, Antalya, Denizli, Adıyaman, Ankara, which shed light on this period of Anatolian archaeology, together with the teachers from Spain, Jordan and Croatia, which attract attention the nations, have researched these settlements and artifacts that they observed.

“Ecco Homo/Here's Human!” is actually a museum education project. However, it also leaves its traces in nature and natural assets with “green environment” motto. Moreover, it is "right-based" as its material is human and works with different disciplines as a STE(A)M project.

Educational studies, which included the first cultural phase of world history, were carried out before museum visits, and these studies contributed our understanding in virtual or real tours in the museums.

In addition to the surveys we applied before the training, 'Leave your code to the time! The coding work that we made with our handprints, came to the fore in the project works.

Our Codeweek code is cw20-OY9Fr. Our coding activities continue for this year as well. Upload the events you have done on behalf of your schools. Let's get our Perfectionism Certificates together...

The rights-based works we did throughout the project helped us to look at museum education activities from a different perspective.

Figure 5. A STE(A)M Project, Poster Work, Praque Clarion Hotel,2022

We attended the Gender Equality Workshop with the support of ICHILD. With the support of ICHILD, we trained Child Rights Ambassadors. We attended trainings, with Erdal Eser, Art History Department of Faculty of Literature, Sivas Cumhuriyet University. Final webinar called "Partnership in Life - Partnership in Art" emphasized "Here is the Human".

And the table we prepared for the closing became the name of our project as a result of the survey. Each of us is a part of nature. Nature contains a great balance, mathematical order and rhythm. Our handprints, our body are STEM parts.

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Below is a list of goals in Ecco Homo project,

- First of all, to highlight the importance of working with ICT through eTwinning.
- To recognize the importance of virtual teaching and collaborative work with other students from different countries.
- Adaptation oft heteaching-learning process, through adequacy and flexibility of teaching programming.

Priority to continue paying special attention to students with specific educational support needs.

3.3. Project Working Process

Teachers trained in different disciplines from different school types involving a special education school and students aged 14-18 came together for «Ecco Homo/Here is Human!», as an international eTwinning project. The student selection process started as soon as our partner schools were chosen, which coincided with the opening of our schools [15-23]. The project took remote executables into consideration regarding Covid-19's actions. Workschedule was rearranged in accordance with the new process shaped by Pandemic. Our project received support as a result of its coordinator's application to the EU Think Civil Program in the 2021-2022 academic year. This financial support led us to produce our project visibility materials with the students. With the support we received, we made two professional video shoots in the Paleolithic Period sections of the Museum of Anatolian Civilizations and in the Ankara hall where the fossil findings were exhibited. And we completed the production work.

We were invited to Ankara University DTCF for the 9th National Anthropology Student Congress on May 9-10. This time, our students made the presentation on the stage. We, with our students and teachers, watched the presentations of University and Master's students who came for the festival from various parts of Türkiye for two days.

The Pandemic Period urged us to initiate our academic studies. Ecco Homo was carried out as an eTwinning project in 2020. It was awarded with the Quality label by the Croatian National Agency in 2021.

During the dissemination efforts, the project participated in the competition held for SonS2022. It was among the eleven projects selected from Türkiye, and opened a stand as a STE(A)M project at the Prague Clarion Congress Hotel on March 23-27.

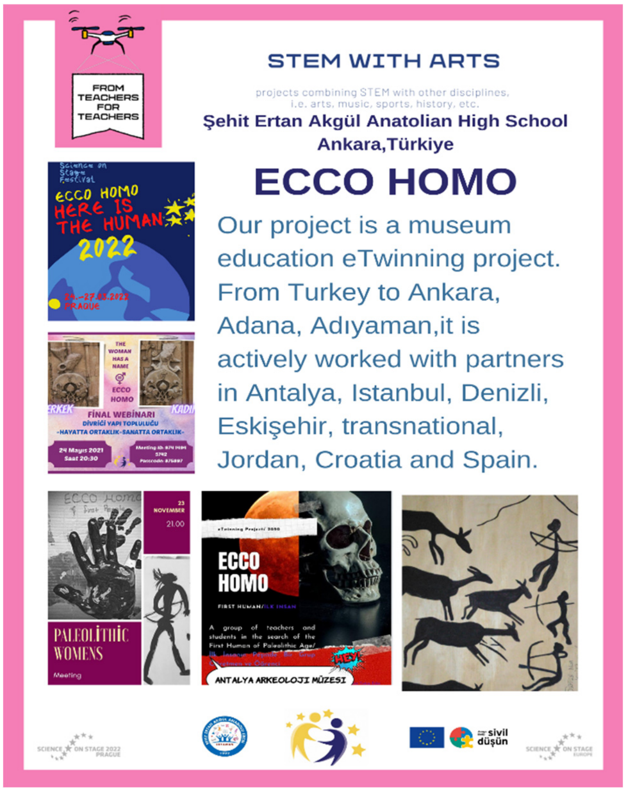

Figure 6. A STE(A)M Project, Poster Work, Praque Clarion Hotel,2022

At the same time, in Necmettin Erbakan University, project took part in UPUES Congress in 2022, organized by Konya Metropolitan Municipality and Konya Provincial Directorate of National Education. This presentation was made online in English by our Spanish partner teacher Pedro Antonio Galindo Valero. It was a pleasure to watch the presentation from «Science Stage on Europe».

In 2022, we participated in the Solvo of Tomorrow competition organized by the Habitat Association. We participated in the "Nature Pioneers" activities with the Ministry of National Education and the Wildlife Conservation Foundation with the "Plastic Warriors" project. In addition to being a STE(A)M project, Ecco Homo also took on the task of being a Nature Education project in terms of using nature's first assets. TEMA Foundation shared the activities carried out as a high school representative with the 10th grade students in our school.

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In 2022-2023, our project with our students was accepted to the Global Save Our Species Project Coordination.

Ecco Homo has a sister project. The Woman Has a Name! With the «Drop Your Code to Time» Codeweek events, both projects have reached countless schools. We repeated this event with our European colleagues at the Prague Clarion Congress Hotel, where we turned it into a workshop. The most impressive coding work of 2021-2022 was the coding work we did with the students of Boztekke Village, a village school in Giresun province.

Figure 7. Ecco Homo stand work at SonS Europe 2022 in Prague

3.4. Conclusions

While the project was working, it was realized that every piece of art in the museum was a STEM item. Our recommendation is the conversion of museums into the school environment, ensuring that different disciplines work in museums. Ecco Homo has also completed its environmental rights, children's rights and gender equality studies.

3.5. Acknowledgements

The authors would like to thank to Professor Dr. Erdal Eser, Art History Department of Faculty of Literature, Sivas Cumhuriyet University, for his valuable contribution to the delegate project.

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Ayşe Çetinalp, English teacher from Türkiye. Goda Kovalenkienė, delegate from Lithuania.

And finally special thanks to eTwinning partners, schools, teachers, intern scientists and students and EU Think Civic Program.

From Finland to Sirius, Zagreb to EIn Europa training centers, ICHILD and its experts, Women Have a Name!

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Crazy about Biochemistry: Gateway to Biochemistry for Teenagers

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Abstract. Crazy about biochemistry is on of the courses included in the program lead by La Pedrera Science Academy. This course in particular aims to shown to 16 and 17 years students some of the basic concepts in which biochemistry is involved. In this course 24 students come to the Faculty of Biology from Universitat de Barcelona during 10 Saturdays to perform a variety of experiments going from the most basic techniques, like SDS-PAGE or bacterial transformation, to the most advanced and up to date techniques such as CRISPR-Cas9. Thus, in each of the sessions the students learn about a completely different topic in the field of biochemistry, from its most basic aspects like protein structure to the neurosiences. Aside from this a huge range of techniques are introduced to the students ranging from conventional PCRs to multidimensional microscopy. Hence, making this project the perfect gateway for young future scientists to learn about STEM.

Keywords: Crazy about Science, Biochemistry, Teaching, Young Scientists.

1. Introduction

Crazy about Science is a program organized by *Fundació Catalunya La Pedrera*, especially by their science section called La Pedrera Science Academy. This program consists of a series of curses for teenagers between 16 and 17 (in their first *batxillerat* year). These courses have extremely different topics ranging from Economy or Sustainability to Physics or Maths. Nonetheless, each of the courses is organized by a prestigious science entity, like the IRB (*Institut de Recerca Biomèdica de Barcelona*) in the case of Crazy about Biomedicine, the Institut Català d'Investigació Química (ICIQ) in the case of Crazy about Chemisty, or the Universitat de Barcelona (UB) in the case of Crazy about Biochemistry.

These programs where oroginally designed to introduce teenagers to science and STEM. This comes from a need to engage young population in these career paths because, in high schools youngster with scientific inclinations are often the focus of jokes or left out. However, in these programs teenagers with the same motivations meet up and feel comforted and not alone.

These programs have a strict selection process starting with a preselection based on the students' academic background, their motivations and their teachers' recommendations. After this preselection, an individual interview is done to each student to assess their scientific knowledge and their interest on the programme. [1]

2. Crazy about Biochemistry (Bojos per la Bioquímica)

Crazy about Biochemistry is the program that settles in the Faculty of Biology of the University of Barcelona and its heart is Dr. Josep Maria Fernandez Novell. He organizes members that have already done the curse and are studying their last years of the degree to work as teachers for this course.

Crazy about Biochemistry is a program designed to teach teenager about a great variety of topics of vital importance in this field. The teaching process is complex in the sense that the concepts that are taught are usually difficult to understand with their current knowledge. However, each year their capacity to assimilate difficult concepts astonishes me, and all being said all teachers make a huge effort to simplify and distil as much as possible all the theory needed. Even though theory is important for our students to learn the key educational point of this program it to make them learn by doing, this means that the sessions are mainly practical, aside from the minimum required theorical ones.

The structure of the program is of two theoricopractical lessons followed by four sessions of completely practical experiments. This is repeated for another round of 6 sessions with some other sessions in the middle where practical concepts like how to do a presentation or a poster are tought. Each session is of four hours with a small break in the middle so that students have breakfast and relax a bit from the intensive sessions.

This program contains a total of 8 different topics of extremely different natures going from the most basic aspects of biochemistry, like protein chemistry, to others of applied nature like fermentations and their use in alimentary industry.

3. Sessions

This program contains a total of 8 different topics explored using 2 hours of theory lessons and 4h of practical experiments. These topics range from the most basic aspects of biochemistry like protein chemistry, to other s of a more applied nature like fermentation in the alimentary industry.

During the sessions a wide range of techniques are used to ensure that students have enough knowledge on them to have a solid base for their future studies. It is important to note that not only wet lab is tought as nowadays scientist must have knowledge of bioinformatics.

Through this section, how each section is organised, and the concepts taught will be explained. [2]

4.1. A computational Approach to Biological questions

Science and technology advance in very rapidly, thus everyday there exist tons of published data that need to be analysed. This is why this session is designed to make students realise of this issue and teach them some ways of how it is done. This session is focused on modelling systems that can analyse and/or predict real experimental conditions.

4.2. Biochemistry through the internet

This session is focused on giving the students up to date tools, easily accessible using the net. These tools are constantly in use by scientists, which include structural analysis with the online program from the NCBI, the icn3D, and other of its tools like BLAST.

These techniques are introduced through an evolutive analysis between similar proteins. At the beginning of the session the students are given a question to answer: What is more conserved sequence or structure?

Then, the tools are showed to the students little by little so that they can understand and use the resources for their personal projects.

4.3. Electrophoresis (SDS-PAGE)

This technique is of great use in all fields of biochemistry, thus, it is essential that the teenagers know how and why it is performed. This technique is taught in a way that students can realise it use, for example, to know if a protein is pure or its approximated size.

During this session they also learn basic aspects of electrophoretic techniques and of protein chemistry, such as how are proteins synthesized, the importance of each residue and the structure types there exist.

4.4. Multidimensional microscopy

During this session the students learn how microscopy is important across all biochemistry fields. They learn about the different types of microscopies and their uses across different fields. During the practical sessions students learn about the most common staining techniques of mammalian cells and bacteria, as well as immunostaining to observe them in a confocal microscopy.

4.5. Microorganisms

Microorganisms are key to biochemistry as their metabolism is rich and is often altered in both academia and industry to acquire desired products with ease, like insulin or aminoacids for pharmaceutical industries.

During this session our young scientists learn about some of the most common uses of microorganisms as well as one of the most common techniques used with them, bacterial transformation.

Aside from learning and performing this technique, students also learn a bit of their metabolism like fermentation. Past editions of the program, this was the main topic and the experiments, and they resided in making beer. A very common procedure done by alimentary industries and a very common work offer for biochemists.

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4.6. Spectrophotometry

Another of the most important techniques that is of main importance in biochemistry is spectrophotometry. This technique is used everyday in every biochemistry laboratory. This type of spectrometry is extremely useful to calculate concentration of many substances, this is what the practical aspect of this session resides in.

During this session, direct and indirect concentration measurements are done. Protein (BSA) using the Bradford reagent as well as glucose using an commercial kit based on enzymatic activity. During this session very important concepts are also taught, like the importance of having a standard in many techniques as well as controls. In addition, the importance of replicating the measurements is also taught as always some wrong measurements occur.

4.7. Genetic Engineering: CRISPR-Cas9

Even though this seems an extremely complicated technique is important to explain it and assess the ethical questions that it may raise. It turns out to be a simple system to understand if taught properly, and with this information, youth has an up to date overview of genetic engineering.

Practical session for this practice resides in designing an experiment using this system as well as performing a small and easy experiment designed by Bio-Rad. This experiment resides in recovering the function of LacZ using this system. This means that after the required transformation and culture procedures, bacterial colonies with successful mutations by CRISPR-Cas9 will turn blue (as the media will contain X-gal). [3]

4.8. Neurosciences and Wester Blotting

One of the fields of biochemistry that is rapidly expanding are neurosciences. The most used technique probably not only in this field but also for other biochemical applications, are Wester Blots. This technique is introduced in this theorical session.

However, the main focus of this session is to teach them about other ways to explore science. This mainly is the analysis of behavior of mice through some video tapes. This is very important to teach them about working with animals ethics and other ways to explore scientific research.

5. Conclusions

This program has helped many teenagers, myself included, to peruse a scientific career. Furthermore, this program helped to have an easier entry to university studies as many of the techniques explained during the first year of the degree were already performed during this program.

A picture of the 9th participants of the program the day they received their diplomas from completing the course. This year these teenagers will chose their career paths and this course has helped them in this regard, either by reassuring their choices or by discarding this as a future option.

Figure 1. 9th edition of Crazy about Biochemistry students, with Dr. Josep Maria Fernandez and the teachers from the program (Maria Saez and Roger Martínez)

For this reason, this curse has helped and will help lots of young scientists to decide on this career. As I have been both an student and a teacher of this program I can say that it has been one of the most rewarding experiences of my life. And I think that in time great scientist will blossom that started from this program. Thus, for all the crazy scientists: keep researching and keep making the world a better place.

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6. Acknowledgements

This year crazy about Biochemistry is in celebration, as of 2023 it is its tenth birthday. This could not have been possible without one person, Dr. Josep Maria Fernandez Novell. As I have already said, he is the heart of the program and has always been. For this reason, in name of all students that have participated in this program I thank him for all this years of encouraging young scientists to pursue their careers aside from their mentoring works.

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The Scientific Content of the KidWind Challenge

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Abstract. Wind power generation is a system, and the gear box plays a vital role within this system. However, the gear box's function extends beyond simply increasing rotational speed. Similar devices with gear box functionality are also extremely crucial in other power generation systems.

The KidWind competition may appear to be a student activity, but it actually revolves around real wind power generation systems, albeit on a smaller scale. In other words, participating in the KidWind Challenge encourages students and their advisors to explore key principles of wind power systems.

In the competition, students are required to design and construct an entire wind power system in advance. Subsequently, the wind power system is tested, and it generates electricity within a miniature wind tunnel. The score of the wind power system is determined by the electricity consumption of an external resistor, with its resistance being adjusted by the participating team. The higher the power consumption of the external resistor is, the higher the score is. This implies that participating teams must create a wind power system capable of providing more usable electricity for the end-users.

When designing and building various electricity-providing systems, including the wind power system in reality, engineers and scientists share a common goal: providing as much electricity as possible for users.

To achieve the goal of constructing a wind power system, the first step is to design a professional wind turbine that can efficiently capture the maximum amount of wind energy when operated under the design conditions.

Secondly, only the magnetic damping of the electrical generator can be utilized through the gear box to control the wind turbine's rotation at the optimal rotational speed. This optimal rotational speed, determined by the best tip speed ratio established during the design phase and varying with the wind speed, should be achieved via the torque generated by the magnetic damping. By doing so, the wind turbine can effectively capture the maximum amount of wind energy.

Finally, to minimize electricity consumption resulting from the resistance of the induction coil inside the generator, it is necessary to adjust the resistance of the external resistor connected in series with the induction coil to its highest possible value.

Therefore, the wind turbine, rotating at the optimal rotational speed, harnesses the possible largest amount of kinetic energy from the wind, which is subsequently converted into electricity in the generator. Notably, a significant portion of this electricity is consumed by an external resistor, which possesses a much higher resistance compared to the induction coil and represents the end-users.

As the vast wind power systems in extensive wind farms demonstrate, even small-scale wind power systems designed for competitions signify the successful conversion of a significant portion of wind energy into usable electricity.

As the chair of the judges for the KidWind Challenge competition in Taiwan, the author hopes that this article will assist students in comprehending the scientific aspects of the competition and further exploring these principles in a comprehensive manner.

Keywords: Wind Turbine, Electric Generator, Magnetic Damping, Gear Box, Energy Transfer, Available Electricity, Energy Work Theorem.

1. Introduction

Wind power is one of the most mature and fastest-growing green energy technologies of the past few decades. The utilization of wind energy by humans has a long history, with traditional windmills adapted to local conditions found all over the world.

Due to their superficial similarities, people often mistakenly assume that wind power technology is simple. However, modern wind turbines used for power generation are fundamentally different from traditional or toy paper windmills in both design and function. Professional wind turbines for power generation

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are significant applications of modern aerospace engineering, with performance that cannot be compared to traditional windmills. Moreover, modern wind turbines are primarily used for electricity generation and also involve the field of electrical engineering, encompassing various interdisciplinary subjects.

With the abundance of nuclear power plants and increasing international pressure for carbon taxes and zero emissions, Taiwan, a country with a growing electricity demand, is in need of a larger share of green energy. Fortunately, Taiwan is blessed with abundant wind resources in the Taiwan Strait, making it an ideal location for offshore wind power generation. Consequently, Taiwan is currently undergoing an unprecedented scale of energy transformation centered around offshore wind power.

This monumental wind power project is rapidly unfolding, bringing vitality and influencing Taiwan's future development. It has become a matter of great importance for the country's overall progress and is closely intertwined with people's lives.

The scientific education of wind power has gained significant momentum and has become one of the most widespread science outreach activities worldwide. However, most wind power education activities, both domestically and internationally, are limited to creating spinning windmills to drive generators, without a deep understanding of the underlying principles of modern wind power generation.

There are numerous wind power education activities, so common and prevalent that it is often difficult for the general public to differentiate between them. In particular, the KidWind Challenge and a few other competitions that involve quantitative measurement of the power generated by wind power systems using precision instruments highlight the true principles of modern professional wind power generation. These competitions emphasize the specialized knowledge and content of practical wind energy systems, distinguishing them from the more popular wind power science education activities

It is true that wind turbines are becoming increasingly common, but the complexity of wind power technology is often underestimated by the general public. On the hand, in Taiwan we can not establish the related industry ability quickly simply due to the country's limited mastery of the technology. This can be attributed, in part, to the insufficient availability of wind power education materials, as certain aspects of the technology are kept as proprietary information.

However, Taiwan has embarked on a significant wind power project, recognizing the importance of developing expertise in this field. The greater the number of individuals who can master the technology, the greater the benefits for the country will be in the future.

2. KidWind Challenge completition

The KidWind Challenge competition was initiated by the KidWind Project, a nonprofit organization dedicated to promoting renewable energy education and hands-on learning opportunities for students. The organization was founded by Michael Arquin in 2003. Michael Arquin, an educator and engineer, recognized the need for engaging and interactive activities to teach students about renewable energy, particularly wind power. Thus, he developed the KidWind Project, which includes the KidWind Challenge as one of its flagship programs. Participants are tasked with designing, building, and testing their own wind turbines using a provided kit or materials.

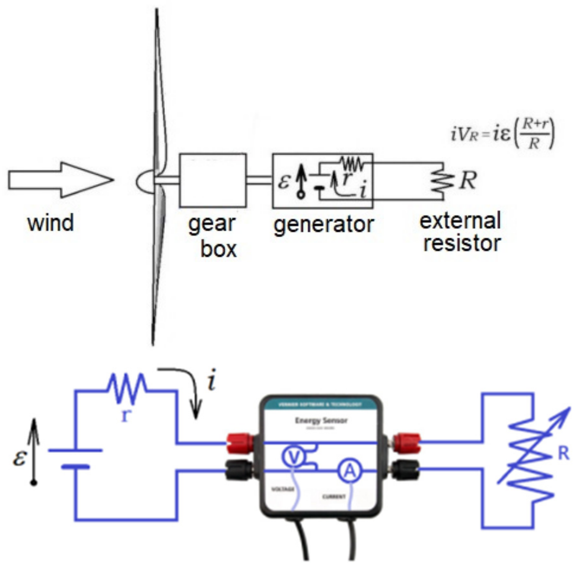

Figure 1. Comprehensive understanding of the key aspects of a real wind power system is crucial for participants

During the competition, students work individually or in teams to construct their wind turbines, applying engineering principles and problem-solving skills. They have the opportunity to experiment with different blade designs, materials, and configurations to optimize the performance and efficiency of their turbines. Once the wind turbines are built, participants undergo rigorous testing and evaluation. The turbines are subjected to various performance metrics, such as measuring power output, rotor speed, and overall functionality. Students may also present their design process, data analysis, and findings to a panel of judges.

Furthermore, this competition serves as an educational platform that exposes the fundamental principles behind professional wind turbines, gearboxes that optimize the ratio of rotational speed, and generators that efficiently provide maximum electricity to users. It's important to note that the competitive score of the wind power system is determined by the electricity consumption of an external resistor (refer to Figure 1), which can be adjusted to minimize electricity usage for the induction coil.

As the power consumption of the external resistor increases, reflecting the electricity used by the end-user, the score also rises. This scoring method encourages students to consider all the main issues of a mature and commercially viable wind power system by working with a homemade, small, and simplified prototype, making the competition highly valuable and distinctive. Throughout the competition, participants must address core issues and handle key components of practical wind power systems that generate electricity under real wind conditions. By fully engaging in this competition, students have the potential to become future researchers, managers, and advocates of wind power.

The KidWind Challenge competition not only promotes hands-on learning and critical thinking but also fosters teamwork, creativity, and a deeper understanding of renewable energy concepts. It provides students with a platform to showcase their technical skills and innovative ideas while promoting sustainability and environmental awareness.

3. Wind power system

Many people mistakenly believe that the primary task in wind power competitions is to create a well-functioning wind turbine. However, this is not the case. Commercialized wind power systems, which supply electricity to the public, consist of several key components, including a professional wind turbine, a gearbox, a well-designed generator, and specifically adjusted loads for the generator. It is the collective performance of these components that enables the system to effectively convert wind energy into electricity for end-users. The homemade wind power system is also subject to the same principles. Each part of the wind power system must be carefully designed and implemented. Any major mistakes in any of these components can negatively impact the performance of the wind turbine and result in the system's failure to provide electricity to users.

In the following paragraphs, we illustrate the process of constructing and operating a wind turbine to harness the maximum possible amount of wind energy. Additionally, a mathematical model will be established to reasonably and realistically describe the behavior of the quasi-direct current generator used in the competition. This model will allow for quantitative analysis of magnetic damping, electricity generation, and related phenomena.

Most importantly, we investigate how to effectively utilize the well-designed gearbox and magnetic damping, exerted on the induction coil, to control the wind turbine's rotation at the optimal speed and extract the highest percentage of wind energy, particularly when the resistance of the external resistor is significantly larger than that of the induction coil. This ensures that the maximum possible portion of wind energy is converted into available electricity for users

3.1. Modern wind turbine

We have previously discussed the principles of modern wind turbines in several other articles. In the following paragraphs, we will focus on several key points regarding how lift is effectively exerted on the blades and the process and considerations involved in designing a professional wind turbine.

3.1.1. The wind turbine blade is subject to lift

When lift is generated on the wing of an airplane flying straight and level, a distinct layer of air above and below the wing is directed to

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flow downward (see Figure 2). This downward flow is caused by the decrease in air pressure above the wing and the increase in air pressure below the wing. The acceleration of air within this layer during a brief interval of time is a contributing factor to this phenomenon of lift, as governed by Newton's laws.

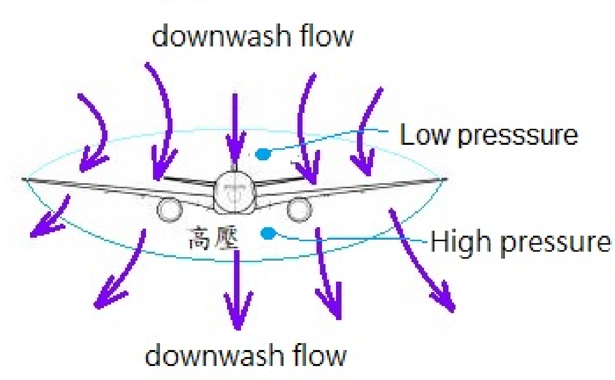

Figure 2. Downwash current accompanying the lift phenomenon

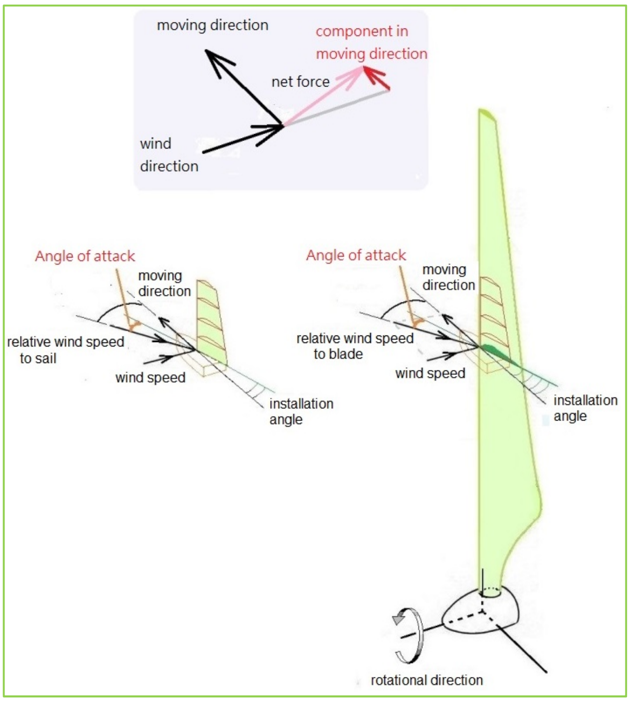

Figure 3. The net force from lift and drag propels sailboats and wind turbines in a similar manner

When an airplane wing generates lift, it occurs at an appropriate angle of attack (AOA) relative to the wind, which is considerably smaller than the critical angle. Both the lift and drag forces act on the wing simultaneously, and they are both dependent on the angle of attack. However, if the angle of attack approaches or exceeds the critical angle, the drag force increases significantly while the lift force decreases dramatically. Simply put, to achieve an optimal lift-to-drag ratio and prevent stalling, it is crucial to maintain the angle of attack well below the critical angle, within a suitable small range.

Interestingly, the wing of an airplane, the sail of a sailboat moving across the wind, and the blades of a wind turbine cutting through the wind perpendicularly all experience lift under similar conditions. However, they utilize lift in distinct ways. The combined force of lift and drag exerted on a sail propels the sailboat forward as it crosses the wind. Similarly, the combined force of lift and drag exerted on the turbine blades enables the wind turbine to rotate, as shown in Figure 3.

3.1.2. How to design modern wind turbine

When a lift force is generated on the wing of an airplane, it leads to the creation of a downward airflow known as the downwash flow. This downwash flow is a significant characteristic associated with lift phenomena. As the lift force performs positive work on the blade, transferring its kinetic energy to the blade, the downwash flow is also observed in the blade's coordinate system. In this coordinate system, the downwash flow occurs because the blade slows down distinct layers of flowing air. This decelerated air then continues to flow downstream. Essentially, the blade harnesses a portion of the wind's energy, causing a specific layer of air to lose some of its kinetic energy and decelerate.

The situation is noteworthy. A leading blade creates a layer of slower-moving air with a certain thickness. The slower-moving air flows backward. And the the subsequent blade aims to partially harness the kinetic energy within this same thickness of air. However, if the slower-moving air is still within the region targeted by the following blade, the following blade can not extract sufficient wind energy. Instead, the following blade may unintentionally increase the energy of the slower-moving air, leading to a decrease in the efficiency of energy transfer from the wind to the blade. Consequently, when the wind turbine blade rotates too quickly, it ends up losing its kinetic energy

On the other hand, if the wind turbine rotates too slowly, it cannot effectively capture and

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harness the kinetic energy present in a significant amount of wind, causing it to simply flow away without being fully utilized.

Clearly, the optimal rotational speed of a wind turbine depends on the wind speed. As the wind speed increases, the ideal rotational speed also increases. Scientists utilize the tip speed ratio, which is independent of the wind speed, to estimate the optimal rotational speed that corresponds to a specific wind speed. The tip speed ratio is defined as the ratio between the speed of the blade tip and the wind speed.

When a wind turbine rotates at the inferred optimal rotational speed, based on the best tip speed ratio, each blade operates without interference from the others, allowing it to capture the maximum possible amount of wind energy. This optimal speed ensures that the blades harness the available wind energy efficiently (see Figure 4).

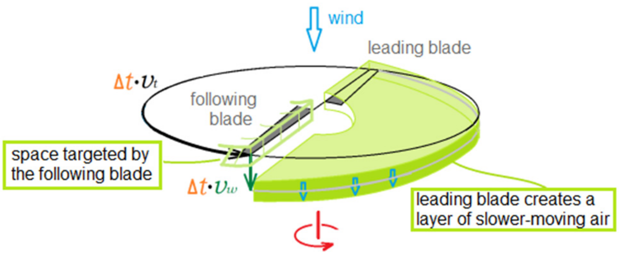

Figure 4. At the inferred optimal rotational speed, the wind turbine's blades operate independently without interfering with each other, while also minimizing the loss of wind energy

Blades with larger aspect ratios (AR) offer the advantage of experiencing higher lift-to-drag ratios, which are crucial for achieving an ideal blade design. This is why modern wind turbines often utilize blades with large aspect ratios, giving them a long and narrow appearance.

Depending on the practical purposes, the number of blades is determined. Therefore, the number of blades, the tip speed ratio, and the installation angle of the tip section of the blades are artificially determined together.

To achieve a wind turbine with high torque output, it is necessary to design a turbine with a higher number of blades. Conversely, if a wind turbine is designed with fewer blades, the torque output will be lower. In order to optimize energy capture and minimize interference between blades, a higher tip speed ratio is preferred when using fewer blades, while a lower tip speed ratio is more suitable for turbines with more blades.

When the wind turbine rotates at the optimal rotational speed determined by the best tip speed ratio, the direction of the wind relative to the rotating blade's tip is established. Consequently, the installation angle of the tip section needs to be coordinated with the direction of the wind relative to the tip section. This coordination ensures that the angle of attack remains within a suitable range, allowing the tip section to generate an optimal lift and drag.

Once the installation angle of the tip section, the number of blades, and the best tip speed ratio are established, the installation angle of each blade section is directly and simultaneously determined.

The best tip speed ratio determines the desired ratio between the tip speed and wind speed, as well as the speed ratio of each blade section, considering the direction of the relative wind for each section. As a section of the blade gets closer to the rotational axis, the speed of that section gradually decreases, while the wind speed in front of the wind turbine remains constant. Consequently, the direction of the relative wind for each section gradually changes. Thus, the installation angle of each section needs to increase as it approaches the axis. This adjustment ensures that the angle of attack for each section is suitable, allowing for an optimal lift-to-drag ratio in each section of the blades.

Due to the varying installation angle of each blade section, the overall blade appears as a peculiar curved wing.

According to aviation techniques, it is crucial to optimize the airfoil of each blade section, even when the angle of attack is optimal. This optimization significantly improves the overall performance of the wind turbine. However, since the root section of the blade only captures a small portion of wind energy within a limited area, the airfoil (cross-section) of the root section is designed as a circular shape to ensure robustness and stability.

To minimize the surface friction drag of each blade section, the chord line of the faster-moving tip section is made smaller. Following the same principle, the chord line of the section closer to the root is larger. This design helps reduce the loss of kinetic energy caused by turbulent flow triggered by surface friction. As a result, the blade takes on the appearance of a long rectangle, with a narrower tip section and a wider root section. These considerations discussed above are illustrated in Figure 5, highlighting the design features mentioned.

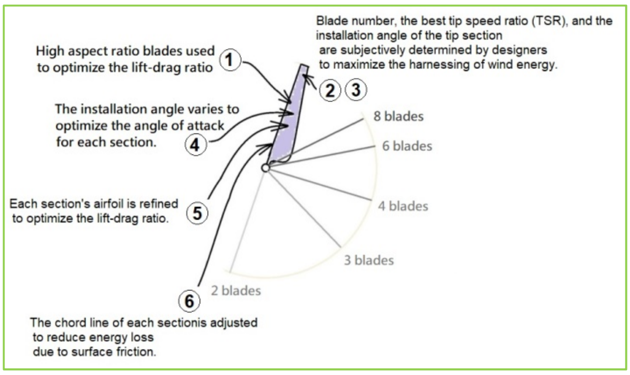

Figure 5. Key considerations for designing a modern wind turbine

Additionally, certain minor improvements can be made, such as incorporating winglets at the blade tip and spoilers near the leading edge of the blade to suppress boundary layer separation. It's worth noting that all the intricate details regarding the blade's shape have been thoroughly investigated using various modern methods and drawing upon extensive knowledge of fluid mechanics.

3.2. Load of electric generator

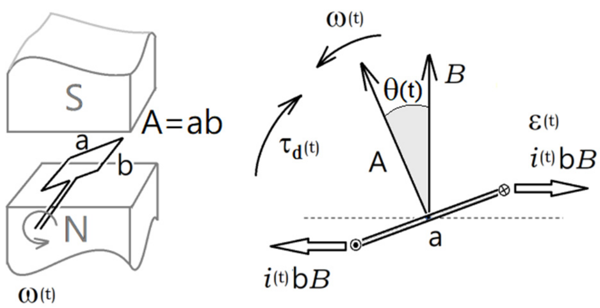

Figure 6. Schematic diagram of an electric generator

Figure 6 depicts the schematic of the electric generator utilized in the competition. The generator comprises a rotating tangential induction coil with dimensions of width "a" and length "b." The coil rotates at a variable rotational speed denoted as ω(t). At any given time "t," the angle between the area vector of the induction coil and the magnetic field generated by a magnet is denoted as θ(t).

According to Faraday's law, we can express the electromotive force (emf) using the following equation:

$$\varepsilon(t) = -\frac{d\Phi}{dt} = -\frac{d(\vec{B}\cdot\vec{A})}{dt} = -\frac{d}{dt}\left[BAcos\big(\theta(t)\big)\right] = AB\cdot\sin\big(\theta(t)\big)\cdot\omega(t) \tag{1}$$

Since the induction coil is connected in series with an external resistor of resistance R, the expression for the induced current can be written as follows:

$$i(t) = \frac{\varepsilon(t)}{r+R} = \frac{AB\cdot\sin\big(\theta(t)\big)\cdot\omega(t)}{r+R} \tag{2}$$

The power of producing electricity, which is equal to the product of the induced current and electromotive force, can be expressed as:

$$\varepsilon(t)i(t) = \frac{\big(AB\sin(\theta(t))\omega(t)\big)^2}{r+R} \tag{3}$$

As we are aware, the electric current flowing through a magnetic field (as shown in Figure 6) experiences the Lorentz force. By performing relevant calculations, we can determine the force exerted on the induction coil and obtain the total torque. This torque, as expressed in equation 3, is exerted on the induction coil by the magnetic field.

$$\begin{aligned}\tau_d(t) &= 2\frac{a}{2}i(t)bB\sin\theta(t) \\ &= i(t)AB\sin\big(\theta(t)\big) \\ &= \frac{\big(AB\sin(\theta(t))\big)^2}{r+R}\omega(t)\end{aligned} \tag{4}$$

Therefore, at a given time "t," where the angle between the area vector of induction coil and the magnetic field is θ(t) and the rotational speed of the induction coil is ω(t), the magnetic damping exerts negative work on the mechanical system. The power associated with this negative work, which is equal to the power of electricity production, can be expressed as follows:

$$\tau_d(t)\omega(t) = \frac{\left(AB\sin(\theta(t))\omega(t)\right)^2}{r+R} \tag{5}$$

By employing Equations 1 and 2, we can verify the fact that the power $\tau_d(t)\omega(t)$ of negative work exerted on the mechanical system by magnetic damping torque is equal to the power of production, which is equal to $\varepsilon(t)i(t)$. This fact can be expressed as follows:

$$\tau_d(t)\omega(t) = \varepsilon(t)i(t) = \frac{\left(AB\,sin\big(\theta(t)\big)\,\omega(t)\right)^2}{r+R} \tag{6}$$

Due to the inertia of the wind turbine and other rotating components, the angular velocity $\omega(t)$ tends to remain nearly constant over a significantly longer time period than the interval T. During the time interval T, the induction coil completes one full rotation. This implies that $\omega(t)$can be represented as ω_d, which is equal to$2\pi/T$. Thus, we can express it as $\omega(t) = \omega_d$, as shown in Equation (7).

$$\omega(t) = \omega_d \tag{7}$$

The angle between the area vector and the magnetic field is denoted as

$$\theta(t) = \omega_d t \tag{8}$$

Therefore, the electromotive force, the induced current, and the magnetic damping torque mentioned above can be rewritten as the following three equations, respectively:

$$\varepsilon(t) = AB \cdot \sin(\omega_d t) \cdot \omega_d \tag{9}$$

$$i(t) = \frac{\varepsilon(t)}{r+R} = \frac{AB\cdot\sin(\omega_d t)\cdot\omega_d}{r+R} \tag{10}$$

$$\tau_d(t) = \frac{(AB\sin(\omega_d t))^2}{r+R}\cdot\omega_d \tag{11}$$

Again, we can verify the fact that the magnetic damping torque is doing negative work on the mechanical system, and the absolute value of this negative power is equal to the power of electricity production. This fact can be described by the following equation:

$$\tau_d(t)\omega_d = \frac{(AB\sin(\omega_d t)\,\omega_d)^2}{r+R} = \varepsilon(t)i(t) \tag{12}$$

In the competition, a miniature motor is used instead of a generator, so the electrical current has been rectified to nearly direct current through brush rectification. Therefore, $\varepsilon(t) > 0$and $i(t) > 0$, and ideally, $\varepsilon(t) \approx \varepsilon$ and $i(t) \approx i$. Since the rotational speed of the generator is linked to the rotational speed of the wind turbine, the rotational inertia of the wind turbine is relatively large. Even though $\tau_d(t)$ may vary periodically over time, ω remains nearly constant. Therefore, $\omega(t)$ is denoted as ω_d.During the competition, ω_d, τ_d, ε, and i are all approximately constant values.

Here, we need to define the values of ω_d, τ_d, ε, and i in a reasonable manner. To do so, we start by taking the time average of the absolute values of the power associated with the negative work exerted on the induction coil by the magnetic damping torque and of the power of electricity production. According to Equation 12, we can derive the following expression:

$$\frac{1}{T}\int_0^T \tau_d\,(t)\omega_d dt \;= \frac{1}{T}\int_0^T i\,(t)\varepsilon(t)dt$$
$$= \frac{1}{T}\int_0^T \frac{(AB\,sin(\omega_d t)\,\omega_d)^2}{r+R}dt$$
$$= \frac{A^2B^2\cdot\omega_d{}^2}{2(r+R)} \tag{13}$$

If we assume the ω_d, τ_d, ε, and i are all approximately constant values, we can rewritten Equation (13) as .

$$\frac{1}{T}\int_0^T \tau_d\,(t)\omega_d dt \;= \frac{1}{T}\int_0^T i\,(t)\varepsilon(t)dt$$
$$= \tau_d\omega_d = \varepsilon\, i = \frac{A^2B^2\cdot\omega_d{}^2}{2(r+R)} \tag{14}$$

Given the relation

$$\tau_d\omega_d = \frac{A^2B^2\cdot\omega_d{}^2}{2(r+R)} \tag{15}$$

we can determine the value of τ_d as

$$\tau_d = \frac{A^2B^2\cdot\omega_d}{2(r+R)} \tag{16}$$

To find the values of ε and i, we refer to Equation 22 and Ohm's Law which implies that

$$i = \frac{\varepsilon}{r+R} \tag{17}$$

We have

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$$\varepsilon i = \frac{\varepsilon^2}{r+R} = \frac{A^2B^2 \cdot \omega_d{}^2}{2(r+R)} \quad (18)$$

Consequently, we conclude that

$$\varepsilon^2 = \frac{A^2B^2 \cdot \omega_d{}^2}{2} \quad (19)$$

leading to

$$\varepsilon = \frac{A\,B\ \omega_d}{\sqrt{2}} \quad (20)$$

Additionally, we find that

$$i = \frac{\varepsilon}{r+R} = \frac{A\,B \cdot \omega_d}{\sqrt{2}(r+R)} \quad (21)$$

The conclusion is as follows: When the generator is rotating at a rotational speed $\boldsymbol{\omega_d}$, the time-varying DC electromotive force $\boldsymbol{\varepsilon}$and current $\boldsymbol{i}$ can be simplified as equivalent DC electromotive force and DC induced current, respectively:

$$\boldsymbol{\varepsilon} = \frac{\boldsymbol{A\,B \cdot \omega_d}}{\sqrt{\boldsymbol{2}}}\ ;\ \boldsymbol{i} = \frac{\boldsymbol{A\,B \cdot \omega_d}}{\sqrt{\boldsymbol{2}}(\boldsymbol{r+R})} \quad (22\ )$$

The time-varying magnetic damping torque $\boldsymbol{\tau_d(t)}$ can be simplified as a torque that only varies with the rotationlal speed of the induction coil:

$$\boldsymbol{\tau_d} = \frac{\boldsymbol{A^2B^2 \cdot \omega_d}}{\boldsymbol{2(r+R)}}. \quad (23\ )$$

3.2.1 Circuits

According to circuit principles, as shown in Figure 7, the electrical potential energy caused by the induced electromotive force is respectively consumed in the internal resistance of the generator, denoted as r, and the external variable resistance, denoted as R:

$$\varepsilon = ir + iR \quad (24)$$

$$\varepsilon i = i^2r + i(iR) = i^2r + iV_R = iV_R(1 + \frac{r}{R}) \quad (25)$$

When the same power εi is generated, if $R \gg r$, then $iV_R \approx i\varepsilon$. If, by mistake, $R \ll r$ is chosen, then the measured iV_R is much smaller than $i\varepsilon$. A significantly smaller iV_R compared to $i\varepsilon$ clearly disadvantages performance in competitions and can lead to the burning out of the generator during practical operation, wasting the generated electrical power. Therefore, when the data is taken in competitions, the variable resistance R should be set to a value much larger than the internal resistance $r$of the generator, approximately $\mathrm{R} \approx R_{max} \gg r$.

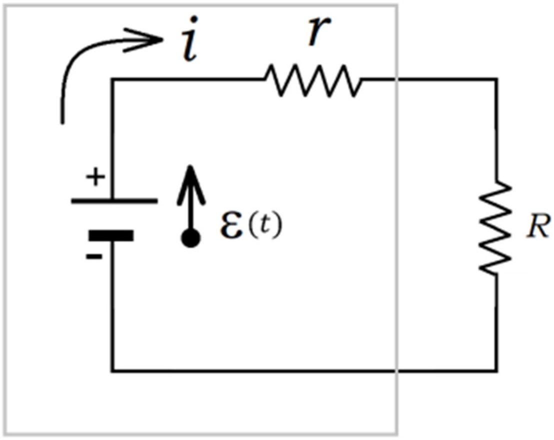

Figure 7. Power distribution of the generated electricity ε*i*

3.3. Gear box

Many people believe that the function of a gearbox is simply to adjust rotational speeds of different axes, either increasing or decreasing them. While this notion is partially correct, the actual function of a gearbox is more complex. In essence, a gearbox enables the driving machine and the driven machine to rotate at their optimal relative speeds. This allows both machines to operate under their respective best conditions. The same principle applies in the context of wind power systems, where the gearbox plays a crucial role.

It is essential for a wind turbine to rotate at its optimal speed in order to capture the maximum amount of wind energy available. This is a key consideration. Moreover, a gearbox is necessary to employ magnetic damping, which helps control the turbine's rotation at the optimal speed determined by the best tip speed ratio.

Therefore, by rotating at the optimal speed, the wind turbine can effectively capture a significant amount of wind energy. This captured energy can be efficiently converted into electricity through an electric generator.

To ensure optimal utilization, it is important to arrange the load (users) of the generator in a suitable manner, allowing for the consumption of the majority of the electricity produced.

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The author repeatedly emphasizes the significance of the energy work theorem in comparison to the law of energy conservation. This theorem provides detailed insights into the transfer of energy.

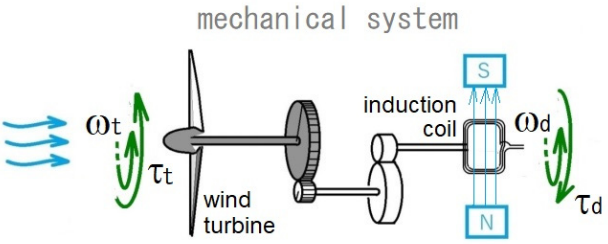

Figure 8. The singled out mechanical system within the wind power system

Referring to Figure 8, we can consider the wind turbine, multiple axes, different-sized gear wheels, and the induction coil in the generator as a mechanical system. In this system, the driving torque τ_t generated by the lift on the blades and the magnetic damping torque τ_d resulting from the induced current are the only two external torques acting on the system. All frictional forces are neglected. According to the energy work theorem, the sum of all external torques applied to the mechanical system must be equal to the change in total kinetic energy K_{total} of the system. This relationship is expressed as Equation (26).

$$\omega_t\tau_t + (-\omega_d\tau_d) = \frac{dK_{total}}{dt} \qquad (26)$$

Here, ω_t represents the rotational speed of the wind turbine, and ω_d represents the rotational speed of the induction coil. τ_d is the magnetic damping torque exerted on the induction coil, and it is clearly a function of ω_d. This relationship can be expressed as follows:

$$\tau_d = \frac{A^2B^2\cdot\omega_d}{2(r+R)} \qquad (27)$$

K_{total} represents the total kinetic energy of the mechanical system, and its mathematical expression is given by:

$$K_{total} = \frac{1}{2}I_{eff}{\omega_t}^2 \qquad (28)$$

Here, I_{eff} is the effective moment of inertia, and ω_t is the rotational speed of the wind turbine.

According to the energy work theorem, we have the following equations:

$$-\frac{dK_W}{dt} = \omega_t\tau_t \qquad (29)$$

$$-\frac{dE_e}{dt} = -\frac{E_{e,f} - E_{e,i}}{dt} = -\omega_d\tau_d \qquad (30)$$

These equations can be rewritten as:

$$\frac{E_{e,f} - E_{e,i}}{dt} = \omega_d\tau_d = \frac{dQ\varepsilon}{dt} = i\varepsilon \qquad (31)$$

We can further rewrite Equation 27 as:

$$-\frac{dK_W}{dt} + (-i\varepsilon) = \frac{dK_{total}}{dt} \qquad (32)$$

$$-\frac{dK_W}{dt} = i\varepsilon + \frac{dK_{total}}{dt} \qquad (33)$$

Equation 33 reveals that the rate of wind energy consumption per second is equal to the power of electricity generated plus the rate of change of kinetic energy of the mechanics system per second.

The function of the gear box ensures that

$$\omega_d = N\,\omega_t \qquad (34)$$

By substituting Equation (34) into Equation (26), we obtain:

$$\omega_t\tau_t = N\omega_t\tau_d + \frac{dK_{total}}{dt} = i\varepsilon + \frac{dK_{total}}{dt}$$
$$= iV_R(1+\frac{r}{R}) + \frac{dK_{total}}{dt} \qquad (35)$$

It is worth noting that we apply circuit theory to the circuit consisting of the induction coil and the external resistor, and we obtain:

$$i\varepsilon = iV_R(1+\frac{r}{R}) \qquad (36)$$

Equation 35 provides insights into the distribution of wind energy within the wind power system. When $\omega_t\tau_t = N\omega_t\tau_d$, , wind energy is transferred into the system at a rate of $\omega_t\tau_t$, which is then converted into electrical power $i\varepsilon$ through the generator. The electricity is consumed by the external resistor at a power of iV_R. This process can be summarized by the following equation:

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$$\omega_t\tau_t = N\omega_t\tau_d = i\varepsilon = iV_R(1+\frac{r}{R}) \quad (37)$$

If $\omega_t\tau_t$is not equal to $N\omega_t\tau_d$, we can rewrite Equation 35 as:

$$\omega_t\tau_t = \omega_t N\tau_d + \frac{dK_{total}}{dt} \quad (38)$$

By conducting further calculations, as shown in Equations 39 and 41:

$$\omega_t\tau_t = \omega_t N\tau_d + \frac{d}{dt}(\frac{1}{2}I_{eff}\omega_t{}^2) \quad (39)$$

$$\omega_t\tau_t = \omega_t N\tau_d + I_{eff}\omega_t\,\frac{d\omega_t}{dt} \quad (40)$$

Finally, we arrive at:

$$\tau_t = N\tau_d + I_{eff}\,\frac{d\omega_t}{dt} \quad (41)$$

Ifτ_t is greater than $N\tau_d$, $\frac{d\omega_t}{dt}$ is positive, and ω_t increases. If τ_t is smaller than $N\tau_d$, $\frac{d\omega_t}{dt}$ is negative, and $\omega_t$decreases.

It is evident that both τ_t and $N\tau_d$ are functions of ω_t. Mathematically, if we possess knowledge of $N\,\tau_d$, a function of ω_t, and τ_t, a function of ω_t, we can solve the differential equation to understand how ω_t changes over time and determine the final value of ω_t as time progresses.

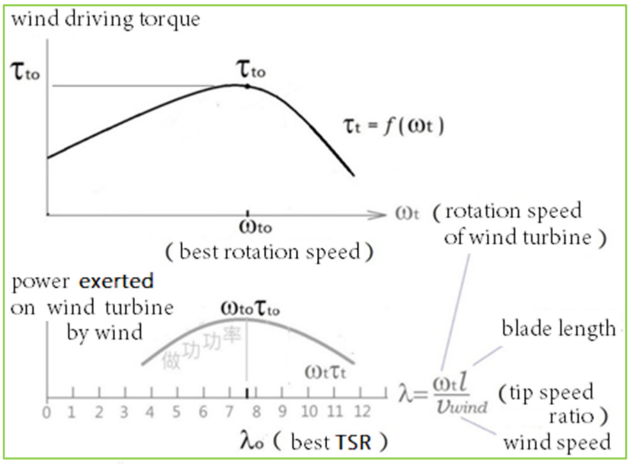

Figure 9. Plot of the τ_t vs. ω_t curve based on the widely recognized function $\omega_t\tau_t$, where ω_t is a variable determining the shape of the curve

However, accurately determining these two functions presents a significant challenge.

Fortunately, reliable references indicate that$\boldsymbol{\omega_t\tau_t}$, a function of $\boldsymbol{\omega_t}$, exhibits a mountain-like curve with a single maximum point in the xy coordinate system. The x-axis represents $\boldsymbol{\omega_t}$, while the y-axis represents $\boldsymbol{\omega_t\tau_t}$.. By observing the curve of $\boldsymbol{\omega_t\tau_t}$, we can gain insights into the curve of the function $\boldsymbol{\tau_t}$ in the coordinate system where $\boldsymbol{\omega_t}$ is plotted on the x-axis and $\boldsymbol{\tau_t}$ on the y-axis, as depicted in Figure 9.

It is notabe that the curve of $\boldsymbol{\omega_t\tau_t}$ reaches its highest point when $\boldsymbol{\omega_t}$ is equal to the best rotational speed$\boldsymbol{\omega_{to}}$ which is determined by the best tip speed ratio. The curve of $\boldsymbol{\tau_t}$ also reachs its biggest value when $\boldsymbol{\omega_t}$ is near to the best rotational speed denoted as $\boldsymbol{\omega_{to}}$ in Figure 9. Although we do not exactly know the function $\boldsymbol{\tau_t}$ of $\boldsymbol{\omega_t}$, we have an approximate understanding of how the $\boldsymbol{\tau_t}$ vary with $\boldsymbol{\omega_t}$, as shown in Figure 9 (bottom),

Since we already know $N\tau_d$, it is evident that $N\tau_d$ is directly proportional to $\boldsymbol{\omega_t}$.

$$\boldsymbol{N\,\tau_d} = \frac{\boldsymbol{A^2B^2}\cdot\mathbf{N}\cdot\boldsymbol{\omega_d}}{\mathbf{2}(\boldsymbol{r}+\boldsymbol{R})} = \frac{\boldsymbol{A^2B^2}\cdot\mathbf{N}\cdot\mathbf{N}\cdot\boldsymbol{\omega_t}}{\mathbf{2}(\boldsymbol{r}+\boldsymbol{R})} \quad (42)$$

In other words, the curve of the function $N\tau_d$ in the coordinate system is a declining straight line, depicted in Figure 10. The slope of this straight line is:

$$\frac{A^2B^2\cdot\mathrm{N}\cdot\mathrm{N}}{2(r+R)} = C\,\frac{\mathrm{N}^2}{(r+R)} \quad (43)$$

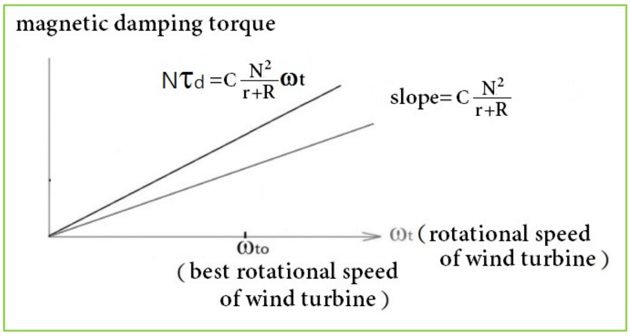

Figure 10. Declining straight line representing $\boldsymbol{N\tau_d}$

Now, let's plot the two functions in the same coordinate system and utilize their curves to solve the differential equation. As depicted in Figure 11, if ω_t is greater than the crossing point's ω_{ti}, $N\tau_d$ will be larger than τ_t, and ω_t will decrease and approach ω_{ti}. On the other hand, if ω_t is smaller than the crossing point's ω_{ti}, $N\,\tau_d$ will be smaller than τ_t, and ω_t will increase and also approach ω_{ti}.

In simpler terms, this means that the wind turbine eventually reaches a stable rotational

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speed, $\boldsymbol{\omega_{ti}}$. In this situation, the wind energy is converted into electricity as described by Equation 37.

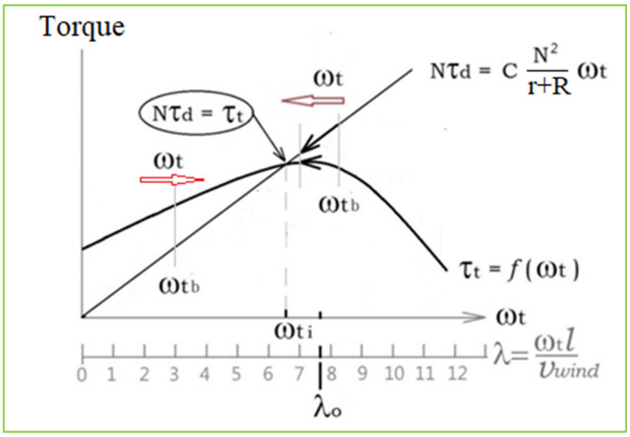

Figure 11. The wind turbine reaches continuous rotation at the rotational speed $\boldsymbol{\omega_{ti}}$, which corresponds to the intersection of the curve $\boldsymbol{\tau_t}$ and the declining straight line $\boldsymbol{N\tau_d}$

The most critical issue here is that the rotational speed ω_{ti}, which represents the x-axis value of the crossing point between the two functions $N\,\tau_d$ and τ_t, is not equivalent to the optimal rotational speed ω_{to}. Consequently, the wind turbine is unable to harness the maximum potential of wind energy in this scenario.

By adjusting the gear ratio of the gear wheels, while ensuring that the external resistor's resistance R remains at its maximum value, we therefore modify the value of N. This alteration allows us to change the slope of the $N\,\tau_d$ function, making the straight line intersect the τ_t curve at the point $(\omega_{to},\ \tau_{to})$. Consequently, referring to the discussion in Figure A, we can deduce that the wind turbine will rotate at its optimal rotational speed ω_{to}, enabling it to harness the maximum available wind energy. The obtained wind energy is then converted into electricity using a generator.

It is important to note that due to the external resistor's significant resistance R, which is much larger than that of the induction coil, most of the generated electricity is consumed in the external resistor.

It is evident that adjusting N precisely to ensure the $N\tau_d$ line intersects the $\boldsymbol{\tau_t}$ curve exactly at the point $(\boldsymbol{\omega_{to}}, \boldsymbol{\tau_{to}})$ is an extremely challenging task. Additionally, when the wind speed changes, the $\boldsymbol{\tau_t}$ curve will also change, causing the new $(\boldsymbol{\omega_{to}}, \boldsymbol{\tau_{to}})$ point of the new $\boldsymbol{\tau_t}$ curve to shift in an upward-right direction in Fig.12 and Figure 9(upper), indicating a new position. Due to this reason, the crossing point between the line and the new curve no longer coincides with the new point $(\boldsymbol{\omega_{to}}, \boldsymbol{\tau_{to}})$. As a result, the wind turbine is unable to harness the maximum possible portion of wind energy. In such a situation, it becomes necessary to adjust the resistance of the external resistor in order to modify the slope of $N\,\tau_d$ appropriately. This adjustment ensures that the straight line $N\,\tau_d$ intersects the $\boldsymbol{\tau_t}$ curve at the point $(\boldsymbol{\omega_{to}}, \boldsymbol{\tau_{to}})$ in the case of ineact N or in the case that the original point $(\boldsymbol{\omega_{to}}, \boldsymbol{\tau_{to}})$ is moving to a new point $(\boldsymbol{\omega_{to}}, \boldsymbol{\tau_{to}})$ due to the variation of the wind speed, allowing the wind turbine to effectively harness the maximum available wind energy.

Returning to the competition, in the wind tunnel, the wind speed is maintained at a constant rate of approximately 3.6 m/sec. Under the given windy conditions, participants install different sets of teeth wheels in the wind power system with varying values of N, determining the slope of the straight line $N\tau_d$. Simultaneously the resistance of the external resistor is carefully kept close to its maximum value. The primary objective is to measure the output electricity and determine the optimal N, denoted as N_α that leads to the highest output, as shown in Figure 12.

Once the optimal N, denoted as N_α, is determined as the closest value that can be obtained through experimentation, even though N_α may not precisely represent the exact best speed ratio of the set of teeth wheels in reality, participants can further adjust the resistance of the external resistor to maximize the output electricity of the wind power system. During this process, the percentage of electricity consumed by the external resistor may change slightly, but it significantly enhances the performance of the wind turbine in harnessing much more wind energy. As a result, the system is capable of harnessing a substantial portion of wind energy, with the majority being consumed by the external resistor.

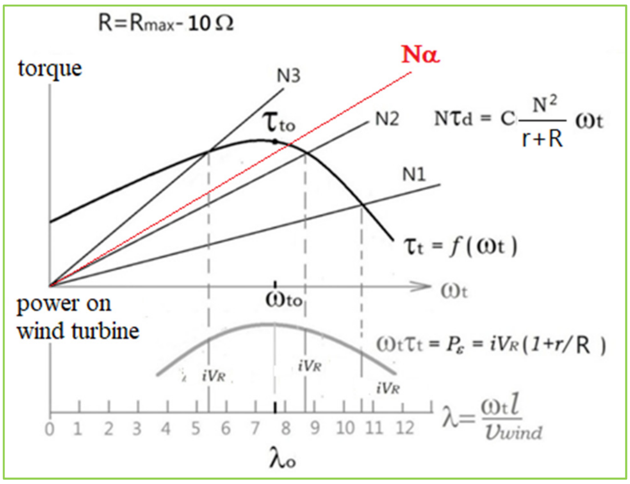

Figure 12. Experimental identification of N_α, the closest achievable best speed ratio of the set of teeth wheels in practice

In this competition, the wind power system that produces the most available electricity will emerge as the winner.

4. Home made wind turbines

In the KidWind Challenge competition, participants are required to handcraft their wind turbines. Here, two feasible and simpler methods for developing competitive modern wind turbines are suggested to enable more students to participate smoothly in the competition.

The first method involves directly creating the wooden modern blades. This process includes planing, carving, cutting, and sanding rectangular wood pieces to meet the specific requirements of modern wind turbine blades. The method aims to achieve the following key characteristics:

1. A proper length-to-width ratio (aspect ratio) of the blade, typically around 5:1 to 7:1.
2. An installation angle of the tip section of the blade that does not exceed 2 degrees for a three-blade wind turbine.
3. Sequentially increasing installation angles in each section of the blade.
4. Appropriate airfoil shape of each section of the blade.
5. Slightly narrower tip section compared to the root section.

Wooden wind turbines, approaching professional turbines, often demonstrate optimal performance and spark curiosity and interest (as shown in Figure 13).

Paulownia wood (available at B&Q stores in Taiwan) is a suitable choice for this method due to its hardness and workability. Careful selection is necessary to ensure that the wood does not have any holes or voids.

It is worth noting that, in the case of a three-blade wooden wind turbine, an innovative approach involves using AB glue to bond additional pieces of Paulownia wood only to the root section of the original blade. This increases the thickness at the root, allowing for a larger variation in the installation angle. Consequently, the desired maximum installation angle for the root section can be achieved appropriately

Figure 13. Carving, planing, and sanding wooden blades for assembly into a three-blade wind turbine. Increasing the root section thickness before machining enables a significantly larger installation angle in that area

The second method involves using composite materials with balsa wood. To create competitive wind turbines, this method utilizes multiple layers of balsa wood with sequentially varying shapes (see Fig.14). These wood pieces are bonded together inside a mold using specialized AB glue for composite materials. Once bonded, the wood pieces are clamped and shaped within the mold to achieve the desired form of a modern wind turbine blade. After the AB glue cures and solidifies well, the turbine blade made from the balsa wood composite material is produced. The advantages of this method are as follows:

1. Only one wooden mold is required. The mold has a single curved surface, making it easy to make. With this simple mold, 3-

4 blade pieces can be produced effortlessly.

2. By stacking balsa wood pieces with sequentially varying shapes in the mold, the blade takes form. This approach not only improves the airfoil shape to some extent but also allows for precise installation angles as per the design requirements. The sequential variation in the layers of balsa wood creates an airfoil shape similar to thin CLARK Y, which is suitable for higher speeds near tip section.

Figure 14. Simplified composite material technology used in blade manufacturing. Sequentially adhered and overlapped balsa wood pieces in a mold (left) ensure reasonable installation angles and airfoil shapes for each section of the blade (middle). The resulting wind turbine with these blades is depicted on the right

5. Summary

In this presentation, we have discussed the design and operation of a complete wind power system, which includes a professional wind turbine, a gear box, and an electric generator with an appropriate load. The primary objective of this system is to maximize the capture of wind energy and convert it into usable electricity.

For simplicity, we treat the wind turbine, the gear box's axis and teeth wheels, and the generator's induction coils as a mechanical system. This system experiences external torque from magnetic damping and driving torque from the lift of the turbine blades. According to the energy-work theorem, magnetic damping converts the mechanical system's kinetic energy into electricity. Additionally, the wind transfers a portion of its energy to the mechanical system while the lift exerted on the blades by the wind performs positive work on the wind turbine.

Professional wind turbines are designed based on relevant principles and operate at the optimal tip speed ratio specified in their design. The ideal rotational speed of the wind turbine is determined by this tip speed ratio, which allows for the maximum harnessing of wind energy. The number of blades, tip speed ratio, and the installation angle of the blade tip section are collectively determined based on practical and engineering requirements.

The gear box utilizes magnetic damping in the electrical generator to balance the driving torque from the lift on the turbine blades. As a result, the wind turbine rotates constantly at a certain rotational speed. However, this rotational speed may not be optimal for capturing the largest portion of wind energy.

By adjusting the gear box speed ratio and the generator's load (i.e., adjusting the resistance of the external resistor), the effect of magnetic damping through the gear box can be balanced with the driving torque when the wind turbine rotates at the optimal rotational speed. This equilibrium ensures that the wind turbine rotates at the ideal speed, maximizing the capture of energy from the wind.

To minimize electricity consumption caused by the resistance of the induction coil, it is crucial to connect an external resistor in series with the induction coil, ensuring it has the highest possible resistance value. As a result, the rotational speed of the wind turbine is carefully adjusted to capture the maximum amount of wind energy.

This captured wind energy is efficiently converted into electricity. The majority of this electricity is consumed by the external resistor, which symbolizes the end-users. Throughout this entire process, the wind power system effectively transforms a significant portion of wind energy into practical and usable electrical power.

6. Acknowledgements

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STEM in Play - the Vital Start: Hands-on STEM. Learning Starts in Play in the Earliest Years

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Abstract. Early years Science is in reality STEM (Science, Technology, Engineering and Maths) in action in play. Hands on science starts with play. Play is what children do from their earliest years. It is children's work. Play is a crucial stage in a child's learning journey and is an apprenticeship for adulthood. Play in children is not 'Just playing'. Play is where a child choses to interact with an activity which is Hands-on, hence science, STEM. Understanding begins from earliest days and is Minds- On. Beginning with observation identifying that with which they will interact, and then with interaction is also Hands-on, hence a STEM experience, STEM-E, which follow the sequence of actions summarised in the STEM Play Cycle Play is on-going. It is progressive, developing with practice and age and occurs wherever the child's interest is' caught'.

Keywords: Hands-on, Minds-on Play, Skills, STEM.

1. Introduction

Early years are defined by Unesco [3] as the stage from birth to eight years. There are sub sections, particularly of the stage from birth to 6 months when the child can sit up by themselves, 6 months to about 2 years old or so when the chid begins to communicate, work with others and start saying words,

Science experiences of the youngest children is in reality STEM (Science, Technology, Engineering and Maths) in action in play. Hitherto this non verbal group has largely been ignored with reference to Science, which embraces the basics of the other STEM areas.This umbrella use of 'science as STEM encompasses many variations such as STEAM, STREAM, STEMD. Hands on science starts with play. Play is what children do from their earliest years. It is children's work [1,2]. Play in these early critical learning years, before formal school instruction begins, is a crucial stage in a child's learning journey. Their play is an apprenticeship for adult hood, as occurs particular in other mammalian species in particular. Indeed some animals such as the Corvus species of the *Corvidae*, the Crow family of birds play.

Play in children is not recreational as many adults regard such, and understand the word, "play``. because their recreational activities are a change from their everyday essential work [2] Children's play in our communities is instinctive and an essential apprenticeship for adulthood whatever community in which they are living. play in the youngest children should not be ignored nor dismissed by STEM educators as trivial and ', Just playing' [3]. Play is where a freely chosen activity occurs and is also Minds-On. an artefact (which is what toys are, a biofact or other. Play, an interaction instigated by the child, proceeds with a sequenced interface. Free choice is the optimum learning condition but mediated and even facilitated play which is what occurs when the child being given the item also follows the same sequence of interaction and skills development and use.

The interaction is individual in the early years. The child as an active constructor of their own learning and development of both skills and understanding. The actions involved in play in these earliest years are physical as well as cognitive often extremely hands-on and minds-on. The interactions illustrate science, maths, engineering concepts in action, often employing a technology, or tool. The sequence of interactions from interest being caught follows a definite sequence in the STEM Play Cycle [4], validated by researchers in Canada.

Play is an apprenticeship for adult tasks which are relevant to the community in which the child lives, such are relevant to the environment the habitat and the culture of their lives. A whole genre have been identified by western educators identifying categories of play [5]. However, STEM, based play is of an entirely different category. it is identifiable in these various play genre as an inherent part. The science actions within play preschool, in play grounds have been observed [5]. These types of play happen in parallel with STEM experiences. Children apply their knowledge skills and understanding to new situations based on their experiences.

The starting point of STEM learning is for the children to experience involvement with items or

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phenomena which will develop as the children develop and build on their experiences and discoveries to more formal learning experiences into a sound experiential ‘science or STEM capital’. Very young preschool children are experiencing STEM actions in their chosen activities, hence STEM-E. Such are foundation experiences and skills development, essential for future learning and understanding STEM- E and STEM itself. It is imperative that all educators understand the child’s STEM experience hands-on minds-on. Such has been hitherto neglected. STEM play occurs in parallel with the either genre of play. Likewise, the emergence of socialisation develops starting with solitary play, the baby notices and interacts physically touching a mobile hung over their cot for example, moving to playing as the child gets older alongside another child to modelling what another child does to integrated socialisation play. Play is on going, it is progressive, developing with practice and age and occurs wherever the child’s interest is caught. This paper outlines the progression of STEM play in the first years of a child’s life where the foundations of problem solving critical thinking on the skills of integrating with objects or observing natural phenomena are developed such skills are the soft skills needed for 21st century development which no longer can be reliant on just facts

2. Observing Play in Action

From first hand non participatory observations of children playing in free choice from the early years I identified STEM actions. I realised that in the first two years of live interactions are foundation experiences mastering physically and mental skills of playing. Hence we have STEM-E, ‘E’ standing for experiences at this stage. Such merges in to STEM once the skills, physical and mental, are mastered. Researchers and practitioners have identified various categories of play, for example [5] has an extensive annotated table of types of play. She identifies object play and exploratory play for example, which I encompass in STEM play. STEM play as a category is not identified.

Re-enactment of activities observed by children of their adults play a major part of a child’s play. It has been recognised [7] by researchers that epigenetic influences in ancestral I humans appears in children’s play in the instinctive need to build shelters, or ‘dens’ and is believed to be inherited from our earlier ancestors when the need for shelter, as is in particularly other mammals is an imperative. However, these spontaneous responses re those of any animal with the need for protection, a safe shelter, food, and defence for instance. These are manifest in human societies and emerge in any child.

Table 1. The science (STEM) Actions of 3 Children (first encounter, a subsequent encounter by a 1 and 2 year old and a 4 year old) An Observational Study

Action sequence	Action	Experience	Science Idea
Initial encounter Materials basic properties	Child1. Hit water surface	Exploring an unknown material	Force, properties of material
Exploring material	Child 2. dropped items near the water bowl into the water, bath duck, metal spoon, wooden play block, pebble, bath sponge.ping pong ball	Experience of properties	Floating and sinking, absorption in case of the sponge which gave out water when squeezed, Force,
Changing-control over material	Child 3 collected things he probably thought would float or sink and a small bottle with a lid.	Experimenting with items available, indicates some understanding of the properties of the material	Push, floating and sinking
Making something Using previous knowledge	Child 3 used a lid (like from toothpaste dispenser) to float as a boat, then filled with water and it sank.	Using previous experiential knowledge to fulfil child's planned objective	Forces, knowledge of properties of boats experimenting with sinking hollow open objects.

Such is recognised more and more by practitioners, parents and others, including policy makers, that play in children is of a very different nature from play in adults where play is synonymous with recreational activities for enjoyment or perhaps play in around is used as a derogatory term for people wasting time when they should be focusing on a particular job.

However children play is not a waste of time it is what children do children are little mammals and little mammals in particular are very inquisitive and curious and through being curious items and phenomena among which they come across in their daily lives are of interest to them and they explore such needed a animal references and so on.

There is a school of thought that some of the instinctive play of human children particularly those who live in the so-called more advanced societies all a reflection on behaviours which in ancestors who were subsistence living having to make shelters I'm so the play of children say making hide hideaways 's is a throwback to that vital survival behaviour reference.

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3. Interest as the Entry to Interaction-Play

People in adult life show interest in some items and not in others. we walk along a pavements lined with shops and we don't stop and look in every window usually but we only stop in those which catch our interest. Similarly visitors to museums Botanic Gardens zoos and science centres from art gallery's stop and interact with the exhibits which interest them crap reference put forward his theory of interest which is very relevant to all these museum studies but it is also exactly what happens with children playing.

The very youngest children who as soon as they are born start interacting with their environment are collecting experiences and these I refer to as stem E the very basics and these experiences will consolidate and the children will begin to see patterns which is the stem in action such as when they push an item and lesser is something obstructing it the item will move forward if they push from behind or if they pull it towards them unless something is in the way and serves as a barrier or there is a rough surface producing friction which the pool cannot overcome but either way they are experiencing in these cases forces in action and they gradually learn that this happens each time. Hence, children are little scientists they are collecting data all the time just as scientists do and see patterns [8]. Moreover the use of tools in children's lives in the toys they use or the implements to assist grown-ups in tasks such as sweeping brooms or of vessels for carrying water are but tools in everyday procedures.

4. The Sequence of Play Interaction - the STEM Play Cycle

Watching children at play it becomes apparent that the first thing that has to happen is that they have to express an interest in the item with which they go on to play with and they then investigate it see what it will do what I can do to it ask the huts suggested reference and they may lose interest very quickly whereupon they go and start playing with another item or they may persevere and in fact go through a whole cycle of interactions which I have named the stem play cycle.

Hence, a sequence of interactions emerged, named the Play cycle [9]. An identifiable, predictable sequence is observable in children's activities, play, and can be given the emphasis which depends on the particular topic of interests of the external observers, such as ab interaction with a biological organisms, such as a green plant with eye catching leaves or a behaviour interaction between two different organisms, such as a flower and a pollinator. Likewise earth science observations, interactions and thus experiences can be recorded after observation. For example, walking along a substrate which activities the attention of the child, a silt/sandy path. The child drops down, touches the substrate, picks up a handful, runs the silt through her fingers back to the floor and repeats.

Figure 1. The STEM play cycle

Moreover, using tools is a particular aspect of play and there is an identifiable Tool Cycle. This can be adapted to solely use of digital tools such as tablets.

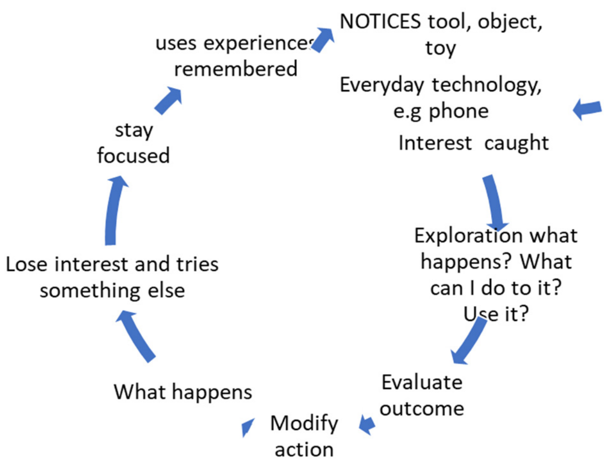

Figure 2. The STEM in Play Tool Cycle

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When the adult working with a child focusing on the same item of interest it is an opportunity it is recordable. A child is aware of he STEM actions which can be identified the experiences, skills aquation and progress can be monitored and recorded if required. Thus a given child's progress can be recorded and monitored over a period of time. This is particularly effective if the child returns again and again to the same item or phenomenon where he will employ a STEM actions illustrating concepts in action.

Figure 3. A child investigating a path cover

5. Discussion

Following the identification of play beginning with the interest of the player being 'caught' the sequence of interactions is identifiable. Such has proved useful for early years practitioners in identifying the actions of children whilst involved in the genre of work. The observation sequentially recorded by whatever means preferred, such as listing the stages in a tabular form, taking photographs and inserting them around the relevant cycle(et al. 2023) [4] provides assessment and reporting opportunities.

Moreover, the recognition of the activities of chdlren as essential foundation experience leafing to the development of particularly problem solving, critical thinking, the ability to apply their skills and understanding to new situations is an excellent and required ability to develop the 21st century skills so needed whilst communities seek methods of mitigating climate change and designing an implementing sustainable actions.

Play is most often and easily recognised as physical science with activities easily facilitated In play groups, preschool and early years formal settings. However, biological aspects and those of earth science are also aspects of children's experiences and through observation and actions. They require any observer to understand the everyday biology and earth Science which children encounter. It is time that the Policy makers, Teacher educators, researchers and implementers recognised the importance of a sound start in children's STEM journey from the earliest of years.

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"Dream Garden in Flora Preschool": As Titled by Little Scientists for STEM Laboratory Activities

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Abstract. This paper presents the importance of creativity, play, organizing accordingly settings at school and collaboration between school and family in STEM activities for early childhood by exposing some sample activities realized in Flora Preschool in İstanbul during 2022-2023 academic year.

Keywords. STEM, Early Childhood Learning Environments, Learning by Doing.

1. Introduction

Starting from the birth onwards, children are enthusiastic discoverers about their immediate environment and they are very curious about everything around them. We know that early years are the most crucial years and the children have utmost curiosity to discover their surroundings.

They enter into the science discipline through environmental learning from the very first years of life. It is extremely crucial to evoke, support & develop their sense of curiosity, creativity, research desire, questioning & answering skills in organized settings where they can feel free to address the questions.

In addition, children can be highly influenced by home and the cultural values that construct their environments. At this point, providing learning environments and experiences collaboratively with school that thrive curiosity & discovery is suggested.

Whether it be in school or at home in early childhood learning environments, STEM teaching approach can be included as a natural part of the games children play. Play creates an environment where children experience many concepts and skills related to science, technology, engineering and mathematics.

STEM can be implemented in a number of materials & ways. It can be integrated into early childhood learning environments, both with "technology products such as robots" and "low cost current materials" that already exist in most of early childhood settings.

Similarly, in addition to the STEM studies that teachers plan and share with children, teachers can also create possibilities for spontaneous STEM experiences by providing children with various materials that they can design in free time activities.

It is actually the Little Scientists in Flora Preschool who wrote the title of this paper by spontaneously & naturally naming the STEM activities that they were doing there as "*Dream Garden Activities*". Dreams are

colorful, unique and have the power to open oneself to new discoveries. So are the plays for children!. Gardens are also the natural media in which the children feel themselves free to reconnect with their natures outwardly & inwardly. When combined these metaphors together, the abovementioned title *Dream Garden* draws attention towards the importance of creativity in the process of learning through STEM for a preschooler.

For a child in preschool stage, play is not only a solid ground for creativity and discovery but also a home for communication, adaptation and innovation those of which are going to be shaping the 21st Century individuals. While staying individual, achieving the whole at the same time so to define; *integration*… While learning from each other, teaching others at the same time so to define; *learning together*… As far as the 21st Century skills are concerned, the motto "*Learning is sharing!"* is going to be a gate to new era in education. Thus, involving preschoolers in STEM activities through play is crucial in order to develop their abilities they will need to to meet 21st century skills.

Through plays, children also actively and easily connect science (S), technology (T), engineering (E), mathematics (M), literacy, the arts, while interacting with each other in their learning process [1].

We, as their teachers and parents, have the responsibility so as to prepare play-based hands on and minds on activities that motivate children

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to learn naturally all the necessary skills which will prepare them for the future [2].

This paper's objective is to present some creative, playful and spontaneous learning experience samples that could form grounds on which further STEM applications could be constructed.

2. Play based sample activities

The target group of this paper was early learners in Flora Preschool. The 1st author carried out a learning project with this group throughout the academic year 2022-2023 in the school settings.

At the beginning of the term, a number of meetings were held in Flora Preschool with parents and they were informed about the STEM curricula of which they would act as a crucial collaborator. Organization of the activity settings both at school and at home was a preparatory step for the project.

The facts that the children could find a similar constructive environment at home as well as in their school in which they could feel free access to discovery, asking questions & being motivated for further research was extremely important were shared with parents. Parents were obtained current educational literature and motivated to organize Little Scientist's home as a STEM setting environment with natural every day materials such as glasses, funnels, bottles etc. and were assigned to do weekly homework projects together with their children by using their rooms, kitchens, balconies, gardens in their homes.

Students, in addition to getting introduced to the new science laboratory at school as an organized science setting for them, they were also introduced concepts such as air, water, soil from their immediate surroundings. Concepts such as space & rockets, magnets, sounds, light followed the previous ones.

Real lab tools were placed in their shelves and questions such as: "*Who the scientist was, what he/she would do, what he/she would use in order to achieve their discoveries, what we would do if we had been a scientist*…" were the very first motivator questions rising their curiosity and discovering links from their daily lives. The first couple of their activities were dedicated to get to know the lab tools, to observe their similarities and the differences with the tools we use in our daily lives at home.

At the core of the first activities, the students made connections between the functions of lab tools and the functions of some kitchen tools of which they had observed while their parents were using at home. Creativity of the preschooler mindset came on to the stage with these observation

Figure 1. Using everyday materials for STEM activities

They defined a new terminology in naming the tools. For example; beaker was a glass with bird's beak, graduated cylinder was a water cup for a stork, erlenmayer was a carafe for magical liquids, a funnel was a facilitator for pouring the oil from one bottle to another. In here, it was fascinating for the first author to observe how capable the early learners to tie the knots between school and their homes in terms of the usage of the tools.

Below are presented some of the Little Scientists' experimental play samples that can be included in STEM learning. The samples reflect the students' discoveries and definitions mostly by their own sentences during the activities.

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2.1. Our amazing air toys: Parachutes and air rockets

2.1.1. What do we know about the subject?

We can not see air. We can not taste it. We can not reach out it or touch it. So, how can we tell that it is real? Actually, one of the few times air was noticeable was when it was in the form of wind as the Little Scientists in Flora Preschool marked.

In our learning project, so as to demonstrate the concept that air occupies space, we created a number of science plays and toys together.

2.1.2. Discussing the topic "air"

"Can we see air?"… "Can we touch it or smell it?",.. "How do we know that it is there?"… "How do we feel it?"… "As living beings, can we live without breathing?"… "What happens when we breath?"… One way to prove that air exists is by observing some of the things it does.

2.1.3. Seeking the answers through experiments

We seeked the answer with an experiment to the question "what happens when two pieces of paper, one crumbled like a little ball and the other flat, are dropped from the same height in the air?" and "which one falls sooner?" Students formed their predictions beforehand and they were not surprised when they saw in their experiment that their hyphothesis pointing out the crumbled paper like a ball would drop first were confirmed since they had much experience from their plays with balls.

Little scientists, on the other hand, resembled the landing of the flat paper on the ground smoothly & slowly to the landing of a bird with it's wings opened. It was because of these open wings like flat paper that made the bird land slowly on the ground.

2.1.4. Creating their own toy parachutes

Little Scientists created their toy parachutes out of plastic bags, strings and the small objects as their loads. Then they searched for the answers to such questions as " what happens when parachutes start to fall to the ground? Will it matter if we drop it from a high height or a low one? Will it matter if we attach different materials as loads? Will any of these things affect the speed the parachute falls or the path it takes?"

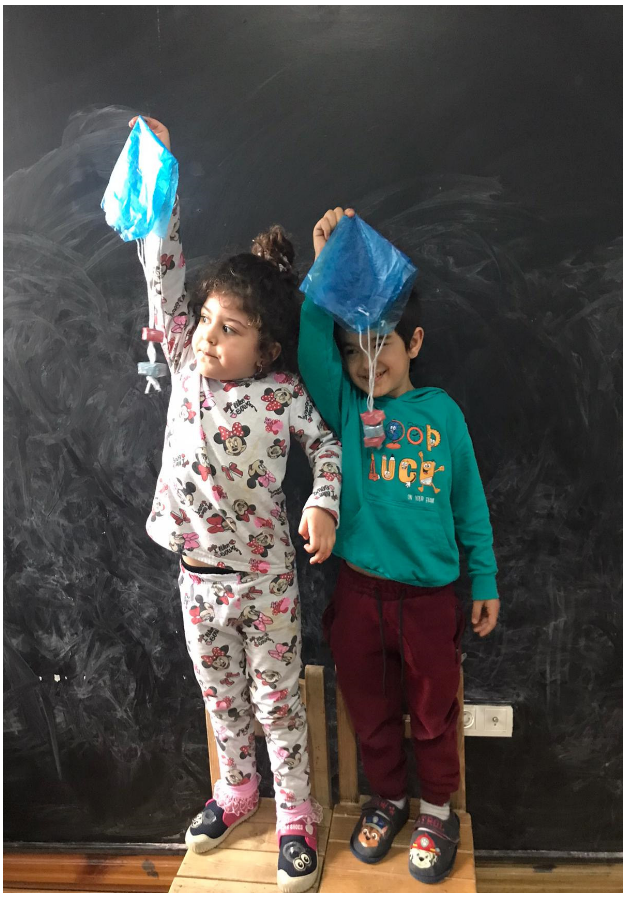

Figure 2. Experimenting with toy parachutes

2.1.5. Playing with "Air Powered Rocket"

Air powered rocket consisted of plastic water bottle of 2.5 Liter, a plastic tubing and a paper rocket at the end of the tubing. Little Scientists, in groups, repeated performing the experiment many times with great joy.

When they hit the bottle with their feet, they observed the pushing effect of air in the bottle to fly the paper rocket at the end of the tube. When asked them what was pushing the paper rocket from the end of the tubing, "it was of course, the air that was running in the bottle towards the end of the tube when hitted the bottle by their feet".

2.1.6. Designing an another air rocket and flying their heads

At the final step, Little Scientists designed some other "Air Rockets" out of plastic water bottles, lids, aluminium folio and craft papers. Then, hitting to the bottless with their two hands from each side at the same time, they all

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launched their rocket heads. This experience was was very easy for the Little Scientists to answer the question "*what makes the rocket head fly up?*"

2.1.7. What did we end up with?

It can be a difficult task for children to learn about the air since air is relatively invisible. This, however, does not mean that air should not be a viable topic in the classroom or home; it simply means that the activities should be a bit more inventive. During these plays, students discovered that although we couldn't see, touch or smell the air directly, we could still observe it's effects. In this air workshops, we mainly observed pushing and pulling effects of the air. Since they were so amused with the experimental procedures, they called the learning as "playing with air".

2.2. Air detectives: Discovering and playing with the clues

2.2.1. What do we know about the subject?

Although we are not aware of air all the time, it is always around us. Air is the gas that floats all around us. It is made up of colorless gases and although we usually can't feel it, air is always touching us. Actually, air is pushing against us but we don't feel it because our body presses back against the air.

2.2.2. Why did Little Scientists decide to be an air detective?

In their learning project, they decided to be air detectives and to make discoveries about it. They wanted to make the air visible, audible and tangible through their experiments. For a scientist, this was possible. They loved making experiments since they were Little Scientists. They also loved playing games just because they were children. So, they wanted their project to be experimental games.

We made a plan together. We thought and searched for several materials in order to use in their experiments. Just simple things that we could find around us. For example; pom poms, pipettes, plastic bags, plastic water bottles, balloons, papers, glasses… They were easy to find and easy to make experiments. We designed our experiments and conducted them together. In the end, we were very proud.of our discoveries.

2.2.3. First experiments with air

In their first experiment, Little Scientists blew air onto their hands. Then, they discovered using pipettes. They decided to use pipettes in their experiments and they blew air to their hands through pipettes. When they were blowing air through the pipettes onto their hands, they observed that their palms were being tickled. It was almost as if "*groups of little ants had been wandering about in their palms*".

Figure 3. Time to swim together with fish underwater

Then a Little Scientist put a pom pom on the table. She put one end of the pipette onto the pompom and pulled it by sucking the air into her mouth strongly. She showed us how to perform her experiment and we also did it altogether. It was fun to lift the pom poms up without ever touching them with our hands. When we asked her how she did it, she said "*only by sucking the air inside the pipette as if I was drinking milk by using pipette from the bottle*".

Soon they created another experiment. This time, by blowing the air through the pipette, they

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pushed the pom poms forward on the table. It was then did they discover that it had been the air blowing through the pipettes who pushed their pom poms on the table further.

Some of them remembered how they blew their balloons when they were playing. They told that they could blow a balloon with air as an experiment. But they also wanted to see the air inside the balloon so they decided to take a transparent plastic bag and blew the air into it then tied it a knot.

Now, they could see the air in the blown plastic bag. The air also was transparent. Whenever they touched it, it's shape changed. Teacher told them that this was normal because air was a mixture of gases and gases were flexible. Air also did not have a shape itself. This was why it took the shape of balloon when inflated.

There came another experiment with again pipettes! They pushed the air through the pipettes into a glass of water. There it was!. There were many air bubbles inside water! At the same time, they heard the sound of air inside water… "*It was as if they had been swimming together with many fish underwater. It was so magical!"*

2.2.4. What did we end up with?

Through their experimental plays, they proved that they could see air, they could hear the sound of it and they could even touch it.

They also discovered that there were many materials around them they could reach easily in order to make experiments like real scientists. They were very proud of becoming a large team of Little Scientists and their teacher. Being an air detective was not difficult and it was such a fun!

2.3. Playing with force: Balloon rackets and pom pom launching machines

2.3.1. What do we know about the subject?

Although they may give examples for "push" and "pull" forces, they are not very familiar with the term "force and it's effects" in this level. But playing with push and pull forces made it easier to understand that they were the main forces that we keep using in our daily lives.

2.3.2. Experimenting the pulling effect

For our first play, our question was "*Which group can pull the other one to the line in between*?" In order to perform this play, we were splitted into two groups holding our hands tightly. Each group tried very hard to pull the other group and we forced the other group to cross the line between groups. The magic term for this play was "pulling force".

Figure 4. Pulling force can construct a play

2.3.3. Experimenting the pushing effect

Their second play was experimenting with balloon rackets. In this play, paper plates were their rackets and their tennis balls were balloons filled with air. They discovered the pushing effect of rackets with this play.

2.3.4. First steps towards toy engineering

Their third play was actually creating a pompom machine out of only paper cups, balloons & pompoms. With these toys, they were able to experiment with both forces at the same time. By pulling tied end of balloons at one end of paper cups & immediately after loosening our hand, the pompoms inside the paper cups were thrown at very far distances. This play was so exciting and it made them ask questions such as; "*How can I throw my pompom to the further distance? How can I push my pompom more strongly?...etc.*"

2.3.5. A new term "gravity" and toy parachutes

They, once again used their toy parachutes to observe the pulling force of planet Earth. The

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term that a scientist was using for this pulling force was "Gravity". "*It looked as if it had been a magic of the Earth!*"

2.4. Dreaming and building: Gleaming stars and high powered rockets

2.4.1. What do we know about the subject?

Space is a wonderous medium in which many clusters of stars, planets, meteors take place. We are not able to take a close look and observe them unless we use specialized scientific tools. It is a colorful and magical medium to be observed. But we can always research about them in science and of course we can dream about our magic planets. We are also dreaming to reach our planet when we become an astronaut. Here comes the art together with our dreams. We can create models of shining stars and also planets with erupting volcanos. Art makes our dreams visible.

2.4.2. Creating dream planets and shining stars

In this step of their learning project, Little Scientists used art in order to create their dream planets. Some of them preferred to create their shining stars. With this work, they also learned the difference between a star and a planet, the difference between a meteor and a comet.

2.4.3. Designing a rocket model needs numbers & shapes

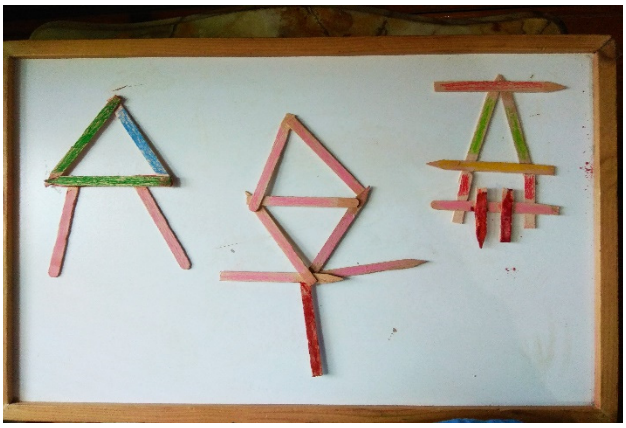

Figure 5. Rockets are ready to be launched

Little Scientists, in this step, designed their own rocket models by using ice cream sticks. It was a difficult work at the beginning. In order to give it's shape by arranging the sticks demanded their some time & energy. They were very happy when they reached the conclusion and even happier when they fired their rockets and sent them into space by using the red dyed mixtures and droppers.

2.4.4. Life inside a rocket in the space

Little Scientists had some questions to be answered in this adventurous space play such as, "*how does an astronaut inside the rocket move or how does he/she eat food?"They learnt, by examples, of storing their food in the bags with taking out of the air inside them. They even made their space puddings out of powders in the bags and learned how to water them in order to eat as a pudding in space.*

Figure 6. Making space pudding

2.4.5. Is it possible to build a train-rocket?

Building a train-rocket is a self product of collective work after many discussions made by Little Scientists in order to seek the answer to their own questions. Going to space is a long travel. It may last weeks, months even years. This is why, an astronaut may need so many things to take with him/her. If there will be so many belongings, then how is it possible to carry all of them only inside a little cabin? When they become rocket engineers, they will build rockets from a train of many successive cabins in order for astronauts to take their families and their belongings with them.

Figure 7. Building train-rockets

3. Conclusion

STEM-based program teaches children even more than science, technology, engineering and mathematics concepts. Learning by doing with real-world applications, questioning and seeking the answers to the questions by getting inspired by their dreams help develop a variety of skill sets, including creativity and 21st-century skills. There are many strategies to apply in STEM programs extending from an organized curriculum plan to a spontaneous free time activity and many materials to use from a wide spectrum of technological products to current everyday materials.

However, the goal of this paper was based on exposing the importance of play in STEM education in preschool level. The first author thinks when the program is more flexible, it becomes more creative. As it can be seen from the content exposed here, program may vary depending on the spontaneous questions arised by the Little Scientists may lead us to seek for their answers in a number of creative ways.

It is an undeniable fact that STEM programs may need qualified and scientifically well trained teachers so as to accomplish their goals. Besides, mostly for preschool level, we would like to emphasize here the importance of one more teacher qualification. It is by all means "To be able to dream with children spontaneously and be able to accompany them in their colorful journeys!" Because be it both scientifically and intuitively, we also know that each strive is bound to start it's journey, once upon a time sparkled by a dream!

Although STEM applications have recently been increased in education systems, they are still lower than expected at preschool level. Providing STEM experiences for preschool children will help them better prepared for future educational steps. It is hoped that the activities implemented in Flora Preschool and presented in this paper will provide inspirations for education communities in preschool level and support teachings at early childhood settings.

4. Acknowledgements

We extend heartfelt thanks to Little Scientists and their dear parents acting as dedicating partners of the whole educational journey during the academic year 2022-2023 in Flora Preschool in İstanbul. Without their active participation, this colorful educational journey would not have been achieved.

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Introducing Secondary School Students to Spectrophotometric Techniques

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Abstract. Electrophoresis is a widely used technique in contemporary biochemistry for determining the concentration of an unknown sample, be it protein-based, sugar-based, etc. This assay describes a laboratory practice conducted at the University of Barcelona, targeting students in the secondary school (16-17 years old). The primary objective is to familiarize students with laboratory procedures and introduce them to various techniques employed in the field of biosciences, including spectrophotometry.

Keywords. Electrophoresis, Spectrophotometric Techniques, Secondary School.

1. Introduction

The knowledge of laboratory techniques that a student may have before reaching university, beyond what they can acquire on their own, is very limited. For this reason, the center promotes programs to bring science and laboratory work within the reach of secondary school students.

In this context, the principles proposed in these workshops are based on the relationship between a brief theoretical introduction and the participant's experience, involving close communication and seeking to create incentives to awaken the scientific interest of young people. Furthermore, conducting didactic activities beyond the traditional academic framework, utilizing specialized equipment and appropriate technical resources, proves to be highly beneficial for the comprehensive education of students.

Based on this philosophy, the activities carried out in these small courses consist of a welcome session with a talk on biochemistry and essential biomolecules, a short break for the students to have breakfast, and then the practical sessions. During these sessions, pupils perform a spectrophotometry [1], which is an integrative technique that combines aspects of biology, chemistry, physics, and mathematics. Through this technique, and with the help of a few guided questions, it is possible to bring out the potential of each one of the adolescents and develop their reasoning skills and common sense.

All these activities are part of different projects such as "Bioquímica en Viu" or "Endinsa't a la Bioquímica", promoted by the University of Barcelona for students of 1st and 2nd year of baccalaureate, and carried out at the university during the months of January and February.

2. The activity

From a teacher's perspective, the goals of the activity are focused on teaching and explaining laboratory rules, as well as introducing and familiarizing students with the lab equipment which they will be using, such as micropipettes, Pasteur pipettes, centrifuges, etc.

When the students entered the laboratory for the practical session, each one found a lab coat at their place and then we made a reminder of the laboratory rules, and why they are important. For example, the ponytail in case of long hair people to avoid contamination of the sample and avoiding burns when working with a heat source. From my personal experience, I was amazed at the number of rules and safety pictograms they knew and their usefulness.

Finished this introduction to break the ice, we began with the topic of the practical session, spectrophotometry. It was funny to see the pupil's faces when we asked if they knew something about this technique, and their reactions was understandable because they had never heard of it before. However, if we asked word by word, "spectro" and "photo", they concluded that the practice was related to light or the emission of photons to determinate the concentration of a sample, a reasoning that is not far from reality.

To explain how the technique works, we made a schematic drawing (Figure 1) of the functioning of the spectrophotometer, the path that light follows, and how it is displayed as absorbance.

Once they understood the fundamental principle of the technique, the only thing left was to explain what absorbance was, an unknown

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magnitude for them. For this purpose, last year a workmate showed me a theatrical representation with student's participation that I consider to be very effective because most of the time, if something is taught through interpretation, the message is better understood.

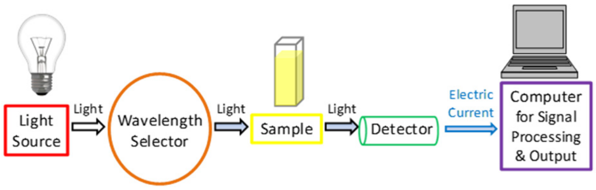

Figure 1. Drawing of the functioning of the spectrophotometer

We used markers for the purpose to simulate the photons emitted by the spectrophotometer. Two teachers would stand in, one simulating the light source, and the other one simulating the detector. In this setup, we could explain the maximum absorbance, corresponding to an empty sample. Then, we would call students one by one to stand between us, acting as the sample. In this way, each student would capture two markers (representing the photons), and thus, the detector would detect the difference. As more students joined the representation, meaning an increase in the concentration of the sample, the number of photons detected by the detector decreases and the absorbance increases.

2.1. The practice

The practical aspect of this exercise involves identifying, from two sample cases, which person may have diabetes, and which one does not. To achieve this, students will employ spectrophotometric techniques to determine the concentration of glucose present in the samples and compare them with the standard values.

To begin the process, we start with a brief introduction and demonstration on how to handle the micropipette, as most children have never used them, and they are fragile instruments. To familiarize them with the technique, we distribute small beakers containing water and guide them to pipette the water four or five times. Once this stem is completed, they are prepared to commence the practical session.

Each group of approximately three people (depending on the class size) receives a sample of glucose at known concentration (5, 10, 20 or 50 mM), as well as a problem sample for which the concentration needs to be determined, and a mix of enzymes which react with the glucose [2]. Additionally, Eppendorf tubes are provided for them to prepare the solution.

The procedure is as follows:

1st label the Eppendorf tubes with a marker to identify the content of each one.

2nd pipette 10 μL of the corresponding glucose solution into each Eppendorf tube.

3rd, add 990 μL of the enzyme mix to each Eppendorf and let it react for 5-10 minutes.

At this stage of the experiment, the most curious students ask why we add the enzyme kit if our goal is to determine the concentration of glucose. To answer this, we take advantage of the 10-minute reaction to explain that glucose cannot be directly detected using the spectrophotometer, so we need specific reactions to generate a measurable product, NADPH. This compound has a molecular structure that allows it to be detected at a wavelength of 340 nm. For this reason, the kit is a mixture of a buffer and all the compounds needed to take the reaction place ($NADP^+$, ATP, hexokinase, glucose 6-phosphate dehydrogenase, $MgSO_4$ and NaN_3).

$$Glucose + ATP \xrightarrow{HK} Glucose - 6P + ADP$$

$$Glucose - 6P + NADP^{+} \xrightarrow{GDH} 6 - phosphogluconate + NADPH + H^{+}$$

Figure 2. Glucose reaction with the enzyme kit to obtain NADPH

Once the reaction has finished, we distribute spectrophotometric cuvettes to each Student. They pour the content of an Eppendorf (of known or unknown concentration) into the cuvette and then they measure the absorbance using a spectrophotometer that has been calibrated with a cuvette filled with distilled water. The results are recorded in a table which includes the four concentrations of the standard curve as well as the two problem samples.

Finally, we collaborate with the students to construct the standard curve using known concentrations of glucose. This curve will enable us to determine the concentration of the problem

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samples. Then we encourage the students to brainstorm and come up with ways to calculate the concentration of the problem samples based on the curve and specific absorbance values. Furthermore, we provide an explanation of the Lambert-Beer law and allow them to calculate the concentration using this equation. At this point, with the obtained concentrations of the problem samples, we can draw conclusions regarding which patient is the diabetic and which one is healthy, considering that the standard concentration of glucose in the blood of a fasting healthy individual is between 3.9 and 5.9 mM. [3]

3. Conclusions

Based on personal experience, it is common for students to initially struggle with expressing themselves or discussing concepts that may not make immediate sense to them. However, as the practice progresses, it becomes evident that they become more engaged and eager to determine which patient is diabetic. It is also notable that during the final part of the practice, where students work in their own to determine the concentration of the problem samples, they encounter more difficulties because they are accustomed to working with equations rather than interpreting known information on a graph. Finally, I consider that this practice, along with other activities in similar programs, plays a vital role in developing critical thinking skills in students and awakening their scientific curiosity, which many of them harbour within themselves.

4. Acknowledgements

I would like to thank all the schools that have trusted in the project and have com to do these practices with us, as well as the Universitat de Barcelona for provide us with all the scientific materials and the laboratories too. I would also like to thank Josep Maria Fernandez for trusting me to tutor the practices and be part of this, and all the other professional colleagues who have taught me and helped me to take away my fear from the beginning.

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Bringing Science Closer to Society

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Abstract. Science students should learn the key concepts, how science arises, and how concepts connected with the history of science. Teaching science through history has the potential to show the progress of scientific knowledge over time. Some museums bring science closer to society; they based on the popularization of science for everyone, specially, for students of Primary and Secondary schools. Museums such as the Archimedes Museum and those of the Faculty of Physics, and Faculty of Chemistry, and Faculty of Biology at the University of Barcelona bring these fields to everybody. Finally, in this article, some Pharmacy stores such as those in Carcassonne and Québec are showed to give importance to the places that are close to us and they explain part of the history of science in a simpler and more understandable way.

Keywords. History of Science, Science Museums, Scientific Places, Pharmacy Store, Teacher Education.

1. Introduction

Science students, chemistry students for us, should learn the key concepts of this subject, instead of science or chemistry arise and how they connected with the history of science.

In Spanish Elementary Schools, there is no science in their curricula. In addition, in Spanish High Schools, scientific subjects such as chemistry, physics, or biology are not treated from the vision of its history.

The teaching of science through history has the potential of showing the progress of scientific knowledge over time. In addition, it can give students an image of scientific ideas that evolve starting from simple to ones that are more sophisticated [1].

Most museums bring science and its history closer to society [2], they are based on the popularization of science for everyone. Some of them are specially prepared for students of Primary and Secondary school levels.

Science and history of science is "in the air" young students can visit a science museum or some "special in science" places or Pharmacy, stores loaded with science [3]. All of this, in one's own city or town, it will lead to increase interest in science among students and brings science closer to society.

It is important for The Professional College of Catalan Chemists (COQC) [4] to convey an important message about chemistry as a natural and safe science that studies the composition, structure and properties of matter. The COQC collaborate with the history of Chemistry in many activities and presentations. It is also important to understand the relationship of chemistry with its own history [5] to increase interest in science in general.

From the teacher education point of view, the history of science allows teachers to develop a more affluent and more real understanding of science. Knowing history of science affects what and how they teach, as well as the message they suggest to students about sience.

Furthermore, the history of science helps teachers to anticipate their students' aristotelic ideas or ideas presented by past scientists and correct students' misconceptions [6]. Teachers can find "analogies" in science museums which help pupils to move from the macroscopic world to the sub-microscopic and non-observable world [7]. However, analogies included in science texbooks often show limitations or even incorrectness [8].

Museums such as the Archimedes Museum [9], and those of the Physics, Chemistry and Biology Faculties at the University of Barcelona [10], and Pharmacy stores such as those in Carcassonne or Québec, both were explained in this article. These examples are close to people and they explain part of the history of science and increase people understands science and chemistry for us.

The authors have not intention to examine in deeper into the museums and pharmacies on display, but to present them as a possible way out, everywhere, to relate science and the

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history of science.All these places can increase society's interest in science and perceive science better and related with the history of its location.

2. Museums

We will start with some science museums, less known in different regions.

2.1. Archimedes museum

Archimedes of Syracuse was born in Syracuse, Sicily in 287 BC and also died in Syracuse in 212 BC. He was an Ancient Greek mathematician, physicist, engineer, astronomer and inventor. He is the founder of statics and hydrostatics.

"Eureka! Eureka!" after Archimedes had stepped into a bath and noticed that the water level rose, whereupon he suddenly understood that the volume of water displaced must be equal to the volume of the part of his body he had submerged. The most important contribution to the hydrostatic field is his principle that allows the buoyancy of any floating object partially or fully immersed in a fluid to be calculated.

Archimedes suggested that any object, totally or partially immersed in a fluid or liquid, is buoyed up by a force equal to the weight of the fluid displaced by the object.

The Archimedes museum is for all ages, and also for children, with a special section, a sort of creative gym, dedicated to acquaint oneself to the experience of a cultural location and the objects held there. The goal is to make the little ones feel great pleasure in finding answers to their questions and in seeing various ways of stimulating their curiosity. In a nutshell: a museum where you explore with all your senses, including touch.

This interactive museum facilities tactile and sensory exploration, teaching you to “touch” all the working mechanisms: *Shaduf, Lighthouse of Alexandria, Scale, Astrolabio, Inclined plane, Archimede’s Screw, Pulleys, Polyhedron, Mechanical paradox, Icosaeder, Water clock, Mirage of parabolas, Helicoidal Gear, Scythed ship, Self-locking mechanism, 3 Sphere ball bearing with vertical axis, Flat ball bearing, Herodotus machine, and* more.

Figure 1. (left) Lighthouse of Alexandria, (right) Astrolabio and (bottom) Inclined plane. Three pictures from The Archimedes museum

All explanations are a conversation between Archimedes and you that embraces history, science, mechanics and physics. Two examples of these explanations taken from the museum are the Helicoidal Gear and the water clock.

Helicoidal Gear. “My colleague’s approach to mechanics is truly incredible. Leonardo considers the “machine” almost as a living organism, the result of the assembly of different devices; he understands that from the several possible combinations of different components it is possible to design an infinity of machines. In his studies and drawings, Leonardo proposed to break down machines into their fundamental “organs”, observing variations in performance and characteristics, a bit, as he would do in the field of anatomy. That is why they are “explanted” from the machines and represented individually, detached from the rest of the devices to which they were connected. In the case of the helical gear, created to optimize the transmission of motion in a machine, the

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mechanism features an infinite screw that sets a toothed wheel in motion”.

Water clock. “Measuring time! What a revolution. When you can accurately measure time, then the opportunity arises to apply mathematics to time as well as space, and a new world opens up to science. In Alexandria, I saw Closiblus ingenious clock. They are much better than the previous ones, because he finally thought of keeping the height of the water column constant –hydrostatic pressure, following my well-known principle. In fact, it is the only way to make the water flow with regularity from the bottom of the vessel, and hence give it a reliable measure of time”.

2.2. Science museums at University of Barcelona

The raison to keep these resources is to make available to the entire university community and the public in general, the rich scientific and cultural heritage of a historic institution such as the University of Barcelona, in its multiple expressions, in a comprehensive look at the collections as a whole.

Figure 2. (left) Physical material and (right) Balance with its pharaohs time history. Pictures from the Faculty of Physics UB

All the devices on display belong to the Scientific Instruments collection of the Faculty of Physics.

It is one of the most relevant and well-documented patrimonial collections of the UB, made up of more than five hundred scientific instruments accumulated over more than 180 years of academic and research life. The devices embrace various fields of physics, such as astronomy, optics, electricity, magnetism, mechanics or hydrodynamics.

Figure 3. (top) Chemical material and (bottom) Periodic Table of chemical elements. Pictures from the Faculty of Chemistry UB

The instruments belong the Faculty of Chemistry were used mainly for teaching and research. Some instruments have an associated QR code that, once scanned, leads to the device's file, which can be found in the Virtual Museum of the UB and which includes detailed information on its cataloging.

Furthermore, on the occasion of the International Year of the Periodic Table of Chemical Elements in 2019, the Faculty of Chemistry at the University of Barcelona launched showing the collection of periodic

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tables it has in different sites of the Faculty, with the aim of consolidating it as part of its heritage.

Professor Mercè Durfort was one of those teachers who left a lasting mark on the way we see the biological world. She was the person in charge of making the small but very important museum of huistorical material from the Faculty of Biology at University of Barcelona as you can see in Figure 4.

Figure 4. (top) Different shells organized by Mercè Durfort professor (RIP) and (bottom) Microscopes. Pictures from The Faculty of Biology UB

3. Pharmacies

Many pharmacy stores everywhere are true temples where you can grasp their history. These stores need to be highlighted because society doesn't seem to.

In the shop windows and inside of many pharmacies, everywhere, you can discover materials used in pharmacy laboratories and how they have evolved over time. For example, there are generally mortars, all types of them and from different periods that allow us to understand how they have evolved.

Figure 5 shows mortars and bottles filled with chemical compounds used in pharmacy in the Quebec pharmacy.

Figure 5. Picture of one Pharmacy store in Quebec, Canada

Figure 6. Three pictures of the same Pharmacy store in Carcassone, France

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In addition, Figure 6 shows syringes, scalpels, forceps, old drawings and schematics and products like Drainochol with magnesium salts for liver disease, and more. Everything is in the window of this Pharmacy store in the middle of Carcassonne. In Barcelona, a city with an important legacy of pharmacies and pharmacists, there is the Catalan Royal Pharmacy Academy "*Reial Acadèmia de Farmàcia de Catalunya*" [11] with an important heritage that is available to everyone. In addition, in the city of Barcelona there are still some very old pharmacy stores that you can buy some drugs, and you can also visit as shown in Figure 7.

Figure 7. (top) Headquarters of Catalan Royal Pharmacy Academy Different and (bottom) Oldest Nadal pharmacy in the city

4. Discussion

Becoming aware of the importance of the dissemination of science carried out by museums and other organizations close to home, among young people and the whole of society, is absolutely necessary.

The study of the history of science and the historical difficulties of scientific development alert teachers to the resistance of their students' alternative ideas to the teaching of science or chemistry [5, 12] and could give them insight into strategies they need to promote the development of these ideas.

On the other hand, students can critically analyze their alternative ideas (probably bad ideas) and understand historical models more easily [13]. This analysis can encourage students to discover their conceptual weaknesses [6], and visiting science museums will be the first step.

The final objective is that our society and, specially, young students can establish a connection between science and museums and pharmacies which are surround them in their daily life. Advancing in scientific excellence drives discovery and innovation and, more important, prepares future scientists, and prevents misinformation.

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Introducing a Holistic Scientific Inquiry-Supported Classroom Observation Protocol

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Abstract. This study is aimed to introduce the main topics and theoretical framework of holistic Scientific Inquiry-Supported Classroom Observation Protocol (SISCOP). A group of researchers who are worked under a Scientific Technological Research Project Support Program developed the protocol. The purpose of the observation protocol is to identify a teacher's familiarity with the nature of scientific inquiry, reveal their strengths and provide evidence for attributes that need development. In this context, the Protocol determines the connection between the lesson conducted by teachers in their classrooms with the nature of scientific inquiry, primarily through the themes of classroom environment, supporting investigation and classroom communication.

Keywords. Observation Protocol, Scientific Inquiry, Theoretical Framework, Classroom Observation.

1. Introduction

In this age with the increasing world population, labour force trained in different fields is much needed. This situation bolsters the establishment of a high-quality education/training process. Previous studies have shown that scientific inquiry is an effective method in raising scientifically literate individuals in science education (e.g. [1-2-3]) and that many countries include it in their curricula (e.g. [4-5-6]).

Activities in scientific inquiry form a whole with their planning, implementation and implications on students. It would be a rational approach to focus on the teachers who produce the activity and design the process of scientific inquiry to evaluate the effectiveness of activities in scientific inquiry considering that international studies indicate teachers to be crucial determinants of students' learning [7-8-9-10-11]. Teachers, who create a positive environment wherein students feel supported while learning, can have long-lasting and positive effects on the academic success of students [12-13-14-15-16-17]. For one to characterise scientific inquiry as effective, the activity and the implementing teacher must follow certain standards. The standards that teachers should follow according to the NRC National Science Education Standards (NSES) are selecting and applying the subjects according to the interests, understanding and abilities of the students, adopting teaching, and assessment strategies that support the development of students and interdisciplinary work [1]. Additionally, a successful and innovative teacher takes on the roles of being a motivating, diagnostic, innovative and experimental individual, as well as being a guide, researcher, model, collaborator, and learner [18].

In Turkey, the current science curriculum is based on research and inquiry [5]. As teachers are the practitioners of the science-teaching programme in the field, determining teachers' needs towards scientific, inquiry would aid in determining their levels in field activities, which are the practical equivalent of theoretical teaching. Additionally, the success of in-service programmes intended for teachers' developmental fields and are suitable for the curriculum will also increase based on these data [19].

2. Classroom Observation Protocols

Making inferences about the classroom performance process based on motivation or student success alone reduces the depth of observation and validity of the results achieved. In the literature, researchers have developed many observation protocols to examine the characteristics of different teaching methods and learning environments. Some of these observation protocols include the following: The Reformed Teaching Observation Protocol (RTOP) [20], UTeach Observation Protocol (UTOP) [21], Oregon Teacher Observation Protocol [22], Four Dimensions of Classroom Practice [23], and European Union's 7th Framework Program Fibonacci Project [24].

Researchers develop some observation protocols within the framework of educational approaches and aim to observe the effectiveness of these approaches in the classroom. For example, the evaluation team of the Arizona Collaborative for Excellence of Teachers (ACEPT) at Arizona State University developed the RTOP to measure and define constructivist approach-based teaching [20]. Further examples are the observation tool Dimensions of Success developed for the evaluation of out-of-school STEM programmes [25], and the classroom observation protocol developed for socio-scientific subject-based teaching [26]. These observation protocols examine an effective classroom lesson only within the framework of the mentioned approach.

In addition to these protocols, there are context-based observation protocols prepared specifically for science and mathematics education. For example, the UTOP comprises four parts: classroom environment, lesson structure, practice, and mathematics/science content [21]. The UTOP also includes 12 open-ended questions that allow the examination of a teacher's opinions after the observation, along with spaces where observers can take notes about the background of the lesson.

The Korean Teaching Observation Protocol [27], which aims to improve science teaching and learning in Korea, is an observation tool that includes science-specific features such as 'promoting scientific thinking skills' or 'teaching various types of scientific inquiry'. Finally, the scientific inquiry-observation protocol developed by the European Union's 7th Framework Program Fibonacci Project aims to evaluate classroom practices at primary and middle schools and kindergarten level [24].

In addition to the diagnostic items evaluating teacher–student interaction in classroom practices, researchers organised the observation form in the following three stages as: (1) forming students' ideas, (2) supporting the research process, and (3) supporting the analysis and result within the framework of scientific inquiry.

Upon examining all these protocols, one can observe that the boundaries of observation are clearly drawn and the observer can evaluate the target behaviour. However, in practice, there are limitations regarding making generalisations: that there are multiple observation items, the protocol is not observer-friendly and evaluation of an effective lesson holistically within the framework of different variables is not feasible.

3. Classroom Observation in Scientific Inquiry Lessons

It is necessary that views on scientific inquiry-based lessons go beyond what teachers and students do and focus more on how and why they do it [28]. That way, the continuous communication between researchers and teachers can maximise the benefit for both parties while reducing the gap between research and practice. This is also critical in understanding teachers' perception and teaching, as well as the impact of scientific inquiry on students' learning.

During an observation in a classroom performing scientific inquiry practices, one should consider several factors, such as teachers' material selection, activity organisation, and students' perceptions of their learning. Additionally, in classrooms that use scientific inquiry, an observation tool is needed to distinguish inquiry from other types of learning, identify students' learning progress and characterise teacher–student interactions in the inquiry classrooms. Yet, there are only a limited number of theoretical or analytical tools available for observing the inquiry process in classrooms [29]. Establishing the Main Topics and Theoretical Framework of the Observation Protocol.

3.1. An Overview of the Observation Protocol

This study took the definition of inquiry presented in the NSES [6] as reference. According to NSES, inquiry is a multifaceted activity that involves authentic science research pursued by students. In education, the concept of inquiry is not limited to teaching strategies; it also refers to the scientific intellectual habits and cognitive skills that students must acquire to conduct research. In line with this definition, this study also considered the standards stipulated by the Ministry of National Education, observation protocol items available in the literature and researchers' experiences. This study developed the first draft of this protocol by determining the theoretical framework of scientific inquiry. Further, the items describing the features in the determined framework were considered. For example, this study included the item 'it helps students understand the nature of science' in the protocol within the scope of the theoretical framework developed for the

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observation protocol. This study also adapted some items from other articles, such as ‘it reinforces students’ sense of curiosity and/or discovery about the subject of the lesson’ from the RTOP [20]. In this context, the Scientific Inquiry Supported Classroom Observation Protocol (SISCOP) [30] determines the connection between the lesson conducted by teachers in their classrooms with the nature of scientific inquiry, primarily through the themes of classroom environment, supporting investigation and classroom communication. The observation protocol’s focus is teacher behaviour.

The first part of the observation protocol is the DESCRIPTIVE INFORMATION section, which determines the descriptive features of the lesson video you will analyse. The second part includes the COURSE STRUCTURE section, which contains the main themes of the observation protocol of the course. The adopted scoring criteria for this stage are as follows [25]:

- (4) Consistent evidence: There is convincing and consistent evidence to support the existence of the qualities defined by the clause. The teacher shows behavioural patterns that consciously support the relevant quality.
- (3) Acceptable evidence: There is clear evidence to support the existence of the quality defined by the clause. However, this evidence is not consistent enough to be defined as 4 (consistent evidence). There are characteristics that must be developed regarding the qualities in the relevant clause.
- (2) Inconsistent evidence: There is weak evidence to support the existence of the qualities defined by the clause. The teacher does not show consistent behavioural patterns that consciously support the relevant quality.
- (1) No evidence: There is little or no evidence to support the existence of the qualities defined by the clause.

The COURSE OVERVIEW section is in the third part of the observation form. Mark the items in this section, considering the entire lesson, focusing more on how teacher behaviour for the specified quality occurs. In the fourth and final part of the observation form there is the TEACHER–STUDENT COMMUNICATION section. During the observation, you directly analysed, evaluate how the teacher performs the teacher–student communication holistically and indicate the kind of communicative approach that the teacher exhibits. In the following, each section of the observation protocol will be presented together with the theoretical framework it contains.

II. Course Structure Section

Course Structure Section is the main themes of the observation protocol. The section primarily consist of three themes that are classroom environment, supporting investigation and classroom communication. Each theme’s theoretical inquiry framework is as follow:

A. Classroom Environment:

A reformed lesson begins by acknowledging and respecting ideas that students bring to the classroom. Students are envisioned as a community of inquirers and, as such, engage in exploration before attempting explication or definition. Therefore, this part of the protocol is translated with the concepts of revealing preliminary information in scientific inquiry and reinforcing the feelings of curiosity and discovery.

Classroom environment comprises three subsections: classroom arrangement (interaction), establishing the theoretical framework (propositional knowledge/scientific concept) and developing students’ ideas (curiosity and prior knowledge). Classroom arrangement includes the seating arrangement, students’ interaction with each other and the materials and precautions to prevent time loss and chaotic situations.

Establishing the theoretical framework refers to explaining the foundational phenomena or events of scientific inquiry through viable scientific concepts. These concepts, defined as propositional knowledge, cover scientific knowledge related to a wide variety of subjects, including scientific, geographical, and mathematical knowledge. Developing students’ ideas aims to add to the students’ sense of curiosity and discovery and to reveal the students’ prior knowledge and experiences to help build the lesson on students’ ideas.

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B. Supporting Investigation:

Supporting investigation comprises two subsections: supporting students to conduct their own research within the framework of scientific inquiry (procedural knowledge/ hands-on and minds-on science), and guiding analysis and results (evidence-based thinking).

Supporting students to conduct their own research is one of the most significant features of scientific inquiry by reviewing the procedural knowledge and processes used in a research or experiment. 'Students made predictions, estimations and/or hypotheses and devised means for testing them' or 'students were reflective about their learning' are some items of the procedural knowledge. Accordingly, the supporting investigation section within the scope of scientific process skills and the framework of the concepts of hands-on and minds-on science, which focus on the skill of scientific inquiry in practice and evidence-based thinking, respectively, were developed.

C. Classroom Communication

Classroom Communication comprises three subsections: supporting students working together (working with others), supporting students' communicative interactions (communicative interactions), and student–teacher relationships (support classroom discussion).

In a reformed classroom, communicative interactions are very diverse and decentralized. These mean, student/teacher relationships are more egalitarian with teachers supporting initiatives coming from students. As a result, the communication concept is an integral part of scientific inquiry.

III. Course Overview Section

To strengthen the content validity and consistency of the observation protocol, which was conducted according to the theoretical framework explained in detail above, the researchers added two separate but supportive sections, course overview and teacher–student communication. The goal is to reach a practical and inclusive proposition in the evaluation of an effective lesson, even if there is a hypothetical theory.

Course Overview, which is in the third section of the observation protocol that performs a general review of the observed lesson, comprises eight pairs of items that describe the traditional classroom and scientific inquiry-based classroom environment. As an example, one can present 'Setting students in interactive groups' as a scientific inquiry-based classroom arrangement item opposed to 'Sitting students in a sequential (traditional) layout' in a traditional classroom arrangement. The observer evaluates whether the teacher performs the attributes in these items according to a 5-point scale to observe the connection between the quality of the lesson and scientific inquiry through the teacher. This study adapted these items from the conclusion section of the Inquiry in Science Education bulletin developed as an output of the European Union's 7th Framework Program Fibonacci Project [31].

Scientific inquiry practices are relatively complex, and, in their nature, scientific inquiry classes are dynamic, interactive and diverse. Therefore, tools developed for traditional classroom observations are not always suitable for inquiry lessons. Moreover, science education practices based on scientific inquiry involve teachers displaying various aspects of their pedagogy, from the organisation of the learning environment to the questions they ask and the feedback they give to the students. One should acknowledge that a course based on scientific inquiry could occasionally include traditional teaching methods. In a classroom environment comprising students with limited scientific process skills and field knowledge, as in the swing of a pendulum that moves depending on the mass attached to its tip, the transition to teaching based on scientific inquiry begins to oscillate according to the skills of the teacher. One should spread this transition period over time according to the capacity of the class. Scientific inquiry supporting effective and lasting learning is related to this oscillation. Therefore, the observation of a lesson should not be based on the strict evaluation of the required qualities being present or absent, but on determining in which side of the oscillation the teacher behaviour occurs with a more flexible perspective based on the nature of education. This way, one can reveal the strengths of a teacher and aspects that they need assistance with more clearly. In this context, Course Overview section of the observation protocol

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serves as the verification of Course Structure section.

IV. Teacher–Student Communication

The fourth section Teacher–Student Communication, which is based on a holistic evaluation, comprises a single item and determines which characteristic pair the lesson corresponds to, such as interactive or non-interactive, dialogic or authoritative [32-33].

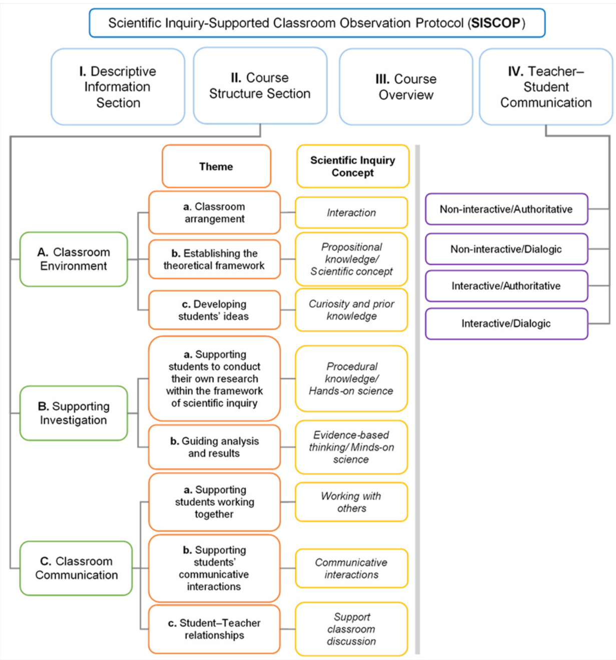

Figure 1. Theoretical Framework of Scientific Inquiry-Supported Classroom Observation Protocol

Dialogue is not only an exchange of ideas and agreement on a particular subject, but also a process of students gaining knowledge that they could not have acquired on their own before. In this context, the term Dialogic emphasises the inclusion of different perspectives in the learning process. The term Authoritative, however, focuses on a particular thought or perspective. The term Interactive refers to the participation of students in the learning process, apart from the teacher. The term Non-interactive is associated with ignoring students' participation in the learning process. In summary, including or excluding different perspectives in the learning process relates to the terms dialogic–authoritative and supporting or ignoring student participation, especially through discourse, relates to the terms interactive–non-interactive. Interactive/Dialogic refers to many voices and ideas while Non-interactive/Dialogic refers to one voice but many ideas. And Interactive/Authoritative refers to many voices but one idea while Non-interactive/Authoritative refers to one voice and one opinion.

As a result, the theoretical framework followed in the development of the observation protocol described so far is summarized in Figure 1. In the figure, the sections of the protocol, its sub-themes and the concept of scientific inquiry corresponding to the sub-themes are explained (Figure 1).

4. Potential Use of the Observation Protocol

The scientific inquiry-supported classroom observation protocol determines a teacher's closeness to the nature of scientific inquiry. The protocol evaluates the teacher's connection to scientific inquiry through variables such as the activities they implement in the classroom, planning and implementation, effects of these practices on students and classroom communication skills. The current observation protocol is an observation tool that one can be implemented in crowded classrooms and nonhomogeneous groups in lessons that revolve around the teacher.

Furthermore, the protocol is suitable for observing face-to-face and video-recorded lectures. This study developed the protocol in a way that enables teachers, in addition to observers, to evaluate themselves individually and observe their peers while watching their videos. The theoretical framework of the observation protocol provides guidance for the adaptation of the protocol for different teaching branches. Finally, one can use the observation protocol for teacher education programmes and teacher candidates, as well as for the professional development of in-service teachers.

5. Acknowledgements

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Making Nanorobots Mocks: Creativity at Primary School

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Abstract. Thanks to creativity tools, primary schools students create a nanorobot mock based on nanotechnology to solve a challenge relate to Sustainability Development Goals (SDG). The creation is part of a project called Nanoinventum.

Nanoinventum is a scientific co-creation project, based on disciplines in Science, Technology, Engineering, Arts and Mathematics – STE(A)M – aiming to introduce nanotechnology and sustainability 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.

Keywords. Comic, Creativity, Primary School, Nanoinventum, Nanorobots, Nanotechnology.

1. Introduction

Creativity is an inherent part of learning. Whenever we try something new, there is an element of creativity involved. There are different levels of creativity, and creativity develops with both time and experience.

Creativity is valuable in education because it builds cognitive complexity. Creativity relies on having deep knowledge and being able to use it effectively. Being creative involves using an existing set of knowledge or skills in a particular subject or context to experiment with new possibilities in the pursuit of valued outcomes, thus increasing both knowledge and skills. It develops over time and is more successful if the creative process begins at a point where people have at least some knowledge and skills. [1]

Everybody presented a curious mind when they were younger. Children are constantly experimenting and asking questions about everything that surrounds them. But, as they get older, all these questions tend to fade away. Why does this happen? Why do kids lose interest in how the universe works? How is it possible that most of them turn away from science instead of approaching it and try to find the answers to their questions? [2]

The teaching and spreading of new technologies are not an easy task [3] and Nanoscience and Nanotechnology (N&N) are, by no means, no exception; N&N deals with extraordinarily complex phenomena, in an abstract interpretation. It is necessary the use of visual metaphor to understand this complex nanoworld, promoting 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.

Nanoscience is the part of science that studies the phenomena observed in extremely small structures, working between 1 and 100 nanometers (a nanometer is a billionth of a meter). The organization in nanometric structures gives substances and materials a different behavior and unexpected properties.

On the other hand, a nanorobot is a nanoscale machine with Any mobile machine involve some level of control, whether the control unit is exogenous or integrated within the platform. A small-scale device must incorporate components for controlling both its trajectory and speed to be considered a micro- or nanorobotic device. As such, swimmers driven purely by chemical reactions should not be categorized as robots. [4]

As a proposal to understand nanotechnology and to introduce nano to primary school, the nanoinventum project is presented. 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

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their competences through reasoning, deduction, play and key roles. [5,6]

Observing the different behavior of two apparently identical surfaces, the change in the reaction time of two effervescent tablets or the variety of colours of gold nanoparticle solutions, allow students to ask themselves questions that help them understand the phenomena. This is the first step in the learning process. Often the initial question is difficult to answer, it is at this moment that the teacher will have to help the child to look at the phenomenon from another perspective and ask researchable questions.

Before working and understanding Science, students need to make reasoned predictions. The process of looking for the answer in the questions asked can vary a lot, from an experimental work, a search in books or the internet, a conversation, an interview with an expert, reading articles... Children must be able to give an answer to the question reasoned, based on contrasting the initial predictions, the results of the research and the theoretical model. At the end, they will have to consider different situations in which the students have to apply the knowledge obtained.

2. Creativity at Nanoinventum project

Nanoinventum [7], an STEAM projects to introduce nanotechnology at primary school 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. The first edition of the NANOINVENTUM project was developed and deployed in springtime 2017. From that, more than 5000 students have created more than 700 mocks of nanorobots [8] to solve one of the Sustainivility Development Goals.

The process of creation of the nanorobot mocks are based on different steps

- Team roles
- Sheet for first approach to the idea, drawing and 3D mock.
- Creation of a comic with the idea
- Upload the final proposal in the quantumbot app [9]

Figure 1. Students nanorobots creations

Figure 2. Example of student draw

2.1. Multidisciplinary Teams

Multidisciplinary teams of 1four 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.

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- 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.

2.2. Sheet for first approach to final idea, drawing and 3D mock

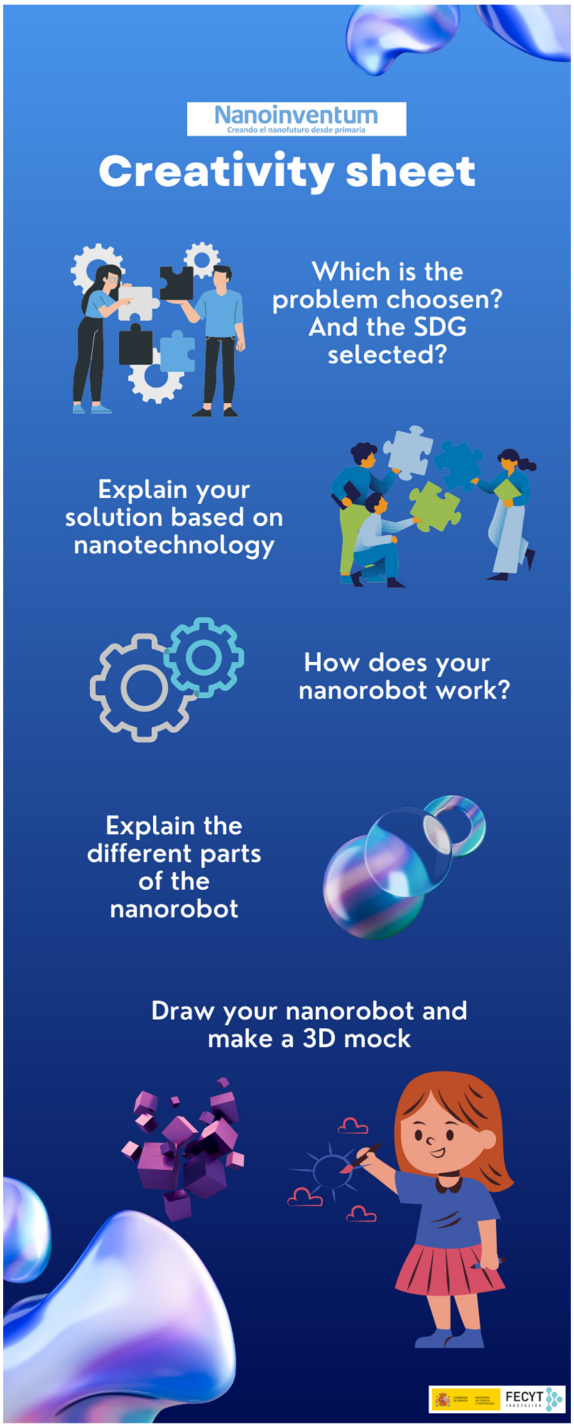

Figure 3. Infography Sheet

2.3. Creation of a comic with the idea

One of the final stages of the Project is the creation of a comic with the final idea. For its realization, the expertise Miriam Rivera (biomics) [10], trains teachers and shares resources and templates for its creation.

- With the comic students are able to:
- Work on Nanoscience and present it in an attractive way
- Having the ability to synthesize
- Write narrative and dialogues
- Having planning and methodology of creative work
- Having artistic skills

Figure 4. Example of a nanoinventum comic

The student will follow the following steps:

1. **Synopsis:** Summary of the story with which the students will explain what problem their nanorobot solves and how they will solve it.
2. **Script:** Document that explains in detail, for each bullet (4-6), that will be drawn and the text that will be written, whether

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it be the one that the narrator or the characters will say.

3. **Comic:** Final product. It will be between 4 and 6 bullets.

2.4. Quantumbot app

Students upload their creations to the quantumbot app. The app is designed so that, first of all, the student has to select the SDG corresponding to his idea and therefore, is aware of the subject. Then, the students fill in their idea and post their mockup photos. The information from the app automatically goes to the Project's blog [7], where after a review, it is posted to be analyzed.

Figure 5. Screenhot of quantumbot APP

3. Conclusions

Primary school students are very open to exploring ideas and concepts, so teaching with creativity in the primary school classroom following the proper steps permits to them learning all type of concepts, even nanotechnology.

Creativity is like any other element of schooling: it requires knowledge, skills, application and practice. Nanoinventum offers different creativity tools, from comic to digital tolls as app to create, in an orderly way, the model of a nanorobot, a complex concept that the students transform into something simple, attractive and beautiful.

Experience in schools has shown that short explicit instruction in elements of creativity, integrated into the current classroom subject, is the most effective method of introducing creativity to students. Creativity is not a separate subject, and teaching creativity is more effective if the elements are incorporated throughout the learning process.

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The Scientific and the Pseudoscientific: a Journey through Epistemological Anarchism

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Abstract. Fighting against pseudosciences is a challenging task. In fact, one might have to answer first the most basic question: what makes a theory scientific? Although it is possible to counterargue pseudosciences, even when disguised in science clothes, sometimes it may be difficult to draw the line. This may eventually lead to cognitive biases that exist even among scientists.

This apparently easy-to-resolve ever-lasting wrangling between science and pseudoscience is known as the Demarcation Problem, a debate that has been going on especially since the last century. A problem bursting with solutions determined to find the ultimate scientific trait, today, it is narrowed to multiple criteria. Through Popper's falsifiability and "the Scientific Method" that try to solve the issue, this article also covers an intriguing and rather obscure episode in the philosophy of science: Feyerabend's epistemological anarchism.

Keywords. Pseudosciences, Science, Theory, Biases, Demarcation Problem, Popper, Feyerabend, Epistemological Anarchism.

1. Introduction

Sciences are not the only and exclusive source of knowledge available to humankind. There are other tools and processes at our disposal with which we can gain understanding. Philosophy and other fields driven by logics or even morals and intuition may allow us to raise ideas about different aspects of the world and our societies. However, sciences are the best tool we dispose of to understand our reality and its mechanisms.

Being aware of this fact, why should we look for "alternative" views? Antiscience –those approaches that reject or oppose current scientific knowledge– and pseudoscience –those views that, lacking evidence and scientific methodologies, present themselves through scientific rhetorics and terminologies– are up to date nowadays [1]. Refusing evolution along with intelligent design or creationism, flat Earth conspiracies, denying climate change, homeopathy, psychoanalysis… are just a few widespread examples.

These *theories* are debunked under the light of reason, logics, and scientific knowledge. Still, they constitute a social problem to deal with [1]. The reasons behind the acceptance and adoption of false beliefs are multifactorial, with the influence of social, economic, and political phenomena to be considered. In addition, cognitive biases play a leading role in false belief formation, something that even scientists cannot escape.

Despite apparently being easy and simple to solve, pseudosciences ponder other questions regarding how we consider scientific knowledge. Drawing a line that allows us to tell the difference between scientific knowledge and non-scientific statements is not trivial. Defining *science* and *pseudoscience* precisely in absolute terms is difficult if we want to avoid family resemblance, and looking for the features that say what makes a theory scientific is a tricky path. In fact, this challenge, which goes back to ancient times, has been baptised in the philosophy of science as the Demarcation Problem [2]. Especially prolific during the 20th century, important figures in the field, such as the renowned Karl Popper, made their contributions. With the scientific method itself involved in the debate, some controversial and extreme proposals lead us to its rejection: this is Paul Feyerabend's epistemological anarchism.

2. Why do people believe false things?

There is a tendency to assume that the behaviors that lead to antiscientific and pseudoscientific beliefs are irrational. However, people who accept them usually do it from a logical point of view, following internal consistencies. Thus, assuming the contrary may bring us to a confirmation bias, where everyone adopting these beliefs is irrational, and to *demonization*, where people defending these positions are seen as bad simply for believing

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them. Blame, of course, will not help to tackle this issue [1].

An interesting proposal to face this question comes from Dr. John S. Wilkins in the book *Philosophy of Pseudoscience: Reconsidering the Demarcation Problem*. In his chapter, Wilkins suggests that antiscientific and pseudoscientific approaches result from suboptimal rational processes [1]. Exposure to certain stimuli, influences, experiences, and information may conduct us to draw non-scientific conclusions without wrong reasoning. In the end, our capacity and circumstances to reason about the world are bounded by limited resources, poor management of information, and uncertainty.

This interpretation is one of many. There is also a psychological dimension to it, where pseudosciences seem to provide definitive answers to unsolved problems and peace of mind during periods of crisis [3], as experienced during the COVID-19 pandemic. Furthermore, the influence of opinion manipulation and failed education is undeniable. But these factors alone are not enough to account for all false beliefs, since educated people can also adopt them.

Other contributions come from social psychology, where the beliefs derived from social influences are a particular highlight. For instance, situations where an individual seeks to improve social status by adhering to a mainstream opinion –even when it turns out to be false. Persuasion and other kind of manipulations can also lead to biases. Other suggestions imply that we are also subjected to previous heuristic or logical limitations –acquired throughout life– that induce us to invalid inferences. For example, ways of reasoning in a social situation or a technological field may not be valid when we seeking information about the world: nature does not follow a human pattern. Finally, we can also mention developmental dispositions, such as cognitive illusions –with fields such as neurotheology, that look for explanations of mystique and religious experiences– or other rather pathological conditions, such as delusion and confabulation.

False belief formation and cognitive biases are intriguing topics. As pointed out above, it is not possible to reduce these matters to a single factor, but rather we must account for multiple dimensions, constraints, and contexts in this complex puzzle.

3. A matter of mindsets: the Salem region

It cannot go without considering another peculiar contribution, yet again by Wilkins, concerning scientific mindsets [1]. Why are there people that, hinging on the veracity and reliability of sciences in their professional area, end up accepting antiscientific theses?

Ironically, this idea originated in American Internet forums to discuss creationism and intelligent design. Apparently, engineers arguing in favor of intelligent design from a “scientific perspective” abunded. A user, Bruce Salem, put this observation into words. Thus, the *Salem hypothesis* was born. Initially stating that engineers tended to defend creationism, it then evolved in time into a softer general version that may be summarized as follows:

> *It is probable that the apparent “scientific” defense of antiscientific and pseudoscientific theses is advocated by people coming from certain areas of applied science and technology fields.*

Data on the matter should be available to test the legitimacy of the hypothesis and check if statistics back it. Unfortunately, limited studies address the issue [4, 5, 6, 7]. Still, the author uses the concept to illustrate how different mindsets may influence in our scientific understanding and reasoning.

Wilkins suggests an axis through which we can explain how our thoughts and beliefs arise (Figure 1). As in a balance, some elements will affect our position in this axis and, thus, our way of thinking. Two poles are found in the edges: the deductive region –which Wilkins names the Salem Region– and the inductive region. On the one hand, the deductive region bears a deductive mindset. In that sense, problems are questions to be solved from established and well-known theories and principles. This, in the extreme, leads to a deductive bias –i.e., science is only done through established knowledge– and even to an authority bias. In turn, essentialism may follow –i.e., a definition of

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reference is used to guide discoveries. Altogether, these factors may generate resistance to accepting new or ground-breaking theories. That is to say, it is a conservative region. On the contrary, the inductive region solves problems by discovery. In the extreme, theories are just a result of scientific activity but are not determinant. This mindset rely more on evidence and, hence, less on authorities or dogmas, and tends to exemplificate –i.e., taking particular similar cases to relate them. As a whole, the indictuvie region predisposes to a major acceptance of innovative proposals, meaning it is more liberal.

Therefore, a person in the Salem Region, according to Wilkins, tends to trust previous knowledge and probably accepts science only during the formation of its mindset, e.g., study period. This way, it will rely on authorities (inside and outside science) and will deny those innovations contradicting already accepted truths –being these either social, religious, political or scientific. In line with Wilkins, this would explain why certain people with a scientific background in applied fields would tend to accept antiscience: a rather deductive mindset predisposing them to reject not established facts.

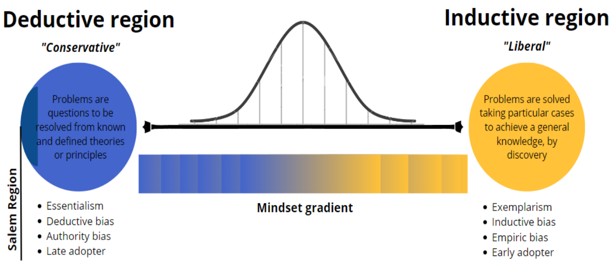

Figure 1. Wilkins' edge summarizing the two mindsets about science

It is true that some fields are more deductive. Some engineering areas use knowledge from physics and chemistry to design new technologies. Medicine employs molecular biology for diagnostics and treatments. As it happens, people are not stuck in a single point of this edge, but our mindset adapts to stimuli and needs. Neither the deductive region is *bad* nor the inductive region is *good*. They are different mindsets adapted to the tools we have. Of course, an engineer will not accept pseudoscience only because of engineering. Science needs different modes of thinking and reasoning to advance. Here, we must consider that there is no unique feature to characterize sciences and their methodologies, something that adds levels of complexity to the Demarcation Problem.

4. The Demarcation Problem and the Scientific Method

In modern times, the philosopher who brought the Demarcation Problem to the main page was Karl Popper through falsifiability [8]. This framework provided a very direct solution in assuming that science cannot prove theories albeit accumulating favorable data, but it can rather eliminate bad theories upon one single false notion. Therefore, scientific hypotheses are falsable, while pseudoscience is left out due to the impossibility of being subjected to test.

As simple as it seems, many after Popper pointed out that some pseudoscientific claims are, in fact, falsifiable (e.g., astrology) and that some current scientific trends are, at the moment, unfalsifiable (e.g., string theory). Furthermore, there are situations in which anomalies or objections to theories have not been used to reject hypotheses but rather to propose *ad hoc* solutions to be further examined (e.g., Neptune discovery). Falsificationism cannot explain that, and further criticism driven by important figures such as Thomas Kuhn, Imre Lakatos, and Paul Feyerabend lead to questioning the Demarcation Problem itself [2].

In 1983, philosopher Larry Laudan published *The Demise of the Demarcation Problem* [9] with the intention to kill the debate and dismiss the need for demarcation through a series of arguments. In the end, he brought down the idea, among many others, that no demarcation criteria proposed so far could provide a set of necessary and sufficient conditions to define scientific activity, due to its heterogeneity. Although Laudan achieved his goal, pseudoscience continued to be a social problem and philosophers of science felt the need to resume the debate. It is here where the publication in 2013 of Chicago Press volume *The Philosophy of Pseudoscience: Reconsidering the Demarcation Problem* [10] marked a turning point in the debate, making progress in response to Laudan's views and beyond, establishing a precedent for the field in the last decade. Since then, proposals have flourished to address the debate, to name a few interesting examples: Victor Moberger's pseudoscience as BS (from *bullshit*) [11], virtue epistemology as a tool to implement ethics in the debate, or scientific skepticisim.

One crucial conceptual contribution comes from Dr. Greg Dawes [12]. He agrees with Laudan that there is not a single criterion for demarcation. But he uses that to maintain that a multifactorial account of demarcation can arise, considering different kinds of sciences and pseudosciences in a continuum. Conceiving science as a social process, a theory may be scientific when being part of a research tradition and methodology in the scientific community. From Dawes' perspective, science can be defined as a cluster concept gathering related but differentiated, activities; while pseudosciences is another cluster concept clustering related, varied activities attempting to mimic science but resulting epistemically inert. If a theory is either refused its admission or excluded from research traditions and communities that are relevantly tackling the concerning problem, we can regard it as pseudoscientific. Criticism of Dawes proposal also exists, and many other demarcation systems have raised in the last decade. Unfortunately, it is out of the scope of this work to cover them all.

All things considered, it remains clear that the Demarcation Problem is not a trivial issue but a field bursting with debate and progress regarding how we conceive science and knowledge. At this point, one might ask: *what about the Scientific Method*? If we think of it, is it not a criterion to demarcate science from pseudoscience? The truth is that the classic Scientific Method that comes to mind –i.e., observation, research, hypothesis, empirical testing, data analysis, and conclusion drawing– is not absolute. Non-scientific processes may also follow these steps, and many fields considered scientific do not follow them –or not in this order. As expressed, science employs multiple mindsets and follows diverse methodologies that can be totally differ across disciplines. Thus, "the (unique) Scientific Method" does not exist as classically taught and cannot be used as a single criterion to define science.

Does this mean, then, that *anything goes* in sciences? In this line, a polemical figure brought us a hardcore and critical proposal that shapes an obscure chapter in the history of philosophy of science.

5. Anything goes: epistemological anarchism

Sciences and their methodologies are based on philosophical and logical principles that define frameworks to progress within. In this picture, a robust philosophy of science stands as a necessary tool for science, as seen in previous sections, but Paul Feyerabend is probably considered an exception as a philosopher of science. Declared *the worst enemy of science* by Science journal in 1987 [13], he used his humor and sharp tongue to raise criticism among the scientific community.

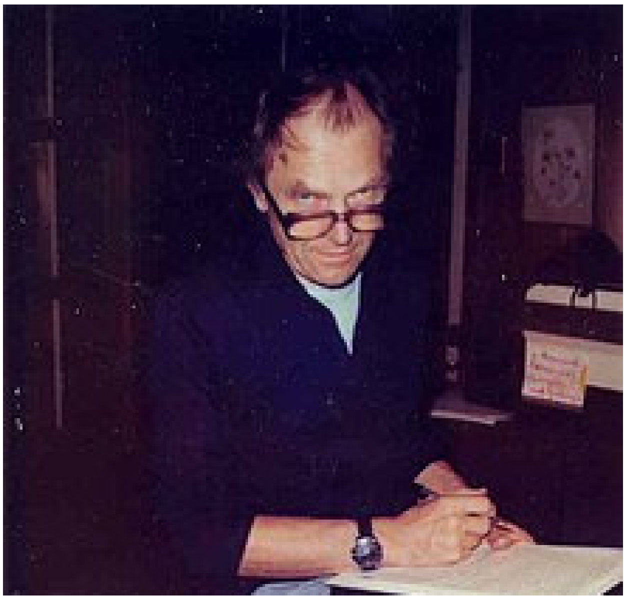

Figure 2. Paul Karl Feyerabend (January 13, 1924 – February 11, 1994)

Paul Karl Feyerabend (Figure 2) was born in Viena in 1924. After the Second World War, where he was injured for life, he studied sociology, history, physics, and philosophy. In 1951, thanks to a scholarship, he was accepted in the *London School of Economics and Political*

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Science under the supervision of Karl Popper, from whom he learned.

His most important (and controversial) work, *Against Method* [14], was urged by his friend and renowned philosopher himself Imre Lakatos to leave his “crazy ideas” registered. In the end, and after Lakatos’ death, the book *Against Method* was published in 1975 with a provocative intention, causing a major stir. His goal was to defend a total and radical *freedom* in science. And here appears the term *anarchism* to refer to his philosophy. Feyerabend accepted this concept, which Lakatos initially brought up, but he later pointed out *dadaism* as a more accurate description. Throughout his lifetime, and upon critics, Feyerabend reinforced his ideas and included answers in new editions of his book.

“The only principle that does not inhibit progress is: anything goes.”

Feyerabend’s epistemological anarchism can be summarized, as he puts it, in one single motto: *anything goes*. The aim is to advocate for honesty and flexibility in scientific research. This implies an open attitude towards any proposal intending to explain a given phenomenon. This brings Feyerabend to criticize research practices that reject hypotheses and theories without a previous scientific analysis. This way, he pretends to bring to light his problem with scientific methodology: the *dogmatic* use of a few established methods limit and hinder scientific progress. The *anything goes* would promote the coexistence of diverse contradictory theories or the reexamination of some already discarded. Thus, he strongly defends a very wide methodological pluralism opposed to dogmatic attitudes and set epistemological rules [15].

Upon criticism of his approach and in a provocative register, he claimed that misunderstood practices such as *voodoo* or astrology might be considered in science given an open attitude to review them. On the contrary, they were called out without a deep insight. With a literal *anything goes*, it seemed that general relativity and shamanism could be on the same level. Allegedly, he admitted using these examples simply to provoke, without explicitly supporting them. These literal and radical interpretations have sometimes undermined his message [15].

Feyerabend attempted to add historical evidence to defend his *anything goes* and highlight scientific dogmatic tendencies. He did that through Galileo Galilei, who, between the 16th and the 17th centuries, established the basics of modern mechanics, made observations with the telescope, and promoted Copernicus’ heliocentric theory, overcoming geocentrism. For Feyerabend, Galileo’s theories did not enjoy yet enough solid evidence to dismiss geocentrism. He maintained that the historical figure turned to propaganda and ignored unfitting data in a clear example of scientific dogmatism. Although we might want to agree up to a point, Feyerabend ignored the success and the actual evidence provided. A theory may contain errors and still be more valid than a previous system, either including more predictions or a wider view. Galileo did not act by dogmatic impulses.

6. Anything goes? Debunking epistemological anarchism

Feyerabend did not propose any specific instruction regarding a better *praxis* to do science derived from his epistemological anarchism. Defending an absolute freedom is meaningless without constraints and responsibilities. And the same goes for the plurality of methods: it lacks sense if it means that there are no rules. We can rely on criteria and tools to discern between two possible theories: cohesion, congruence, predictions, fecundity, etc.

Feyerabend also argued that we could never know if a theory is right just because we have not proven it yet. However, he does not take into consideration that new theories expand knowledge regarding previous ones and foster new research, or that reckoning a pseudoscience would require it to enter the scientific dynamic (with evidence and within the scientific community). Furthermore, one valued factor in science is coherence; without it, debate remains sterile.

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Feyerabend sought support in Kuhn's incommensurability. According to it, two theories are incomparable, *grosso modo*, because they are incompatible. Nonetheless, one of Feyerabend's points in freedom is the coexistence of conflictive theories, which contradicts incommensurability because they would be irreconcilable. In the end, we accept a theory because we consider it better represents or approaches truths. Considering Feyerabend's contributions in a literal sense would bring us to an extreme relativism. How can we know anything at all if all theories are to be considered? How can we progress if anything goes? How can we affirm this relativism if anything goes (even rejecting this relativism)? An absurd dead end [16].

7. Conclusion

Feyerabend's ideas also contain some valuable thoughts. It is true that some methodologies and theories contain contextualized *ad hoc* hypotheses that challenge their defense. In particular cases, the scientific community may have presented dogmatic behaviors, but it is not a major problem. On the other hand, science must be plural and falsifiable: there is not *the* scientific method, but many of them. Scientific theories may raise mistakes for which we have to seek solutions. But this makes it neither dogmatic nor situates them at the pseudosciences level. We can discard Feyerabend's epistemological anarchism as a philosophical system and maybe leave the *Nothing is true, everything is permitted* meditation to the *Assassin's Creed* saga. In our society, the literal interpretation of his ideas might end up being dangerous with antiscientific, pseudoscientific, and negationist movements out there in the first line. The reality is that these theses are neither acceptable nor defensible from a scientific point of view. And as seen in this article, there is an increasing need to create a demarcation.

6. Acknowledgments

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Collaborative Development of a Database of Green Practices

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Abstract. A database is a well structured collection of data stored in a computer system and it is usually controlled by a Database Management System. All Information Systems have databases as a basic component which provide information to their users. The creation of a database is carried out by following a number of steps starting from requirements analysis, database design and implementation in a specific Database Management System. The purpose of the current paper is to present the collaborative development of a Database. We have chosen a topic relevant, interesting for students that creates opportunities for teamwork. Green strategies, which are an integral part of the concept of sustainable development, are among the most important challenges of today's world. Students from two universities - The University of Athens (Greece) and the University of Information Technology and Management (Poland) - jointly defined the requirements of the Database, designed the Database by creating the appropriate Entity Relationship Diagram and created the relational database in the Oracle Apex Server DBMS. The purpose of the project was to create a database for saving/presenting data about green practices of the two universities. Tools for content replenishment are provided. The collaborative project allowed the students to learn about the partner's practices, exchange experience of their implementation and discuss new ideas about green initiatives.

Keywords. Relational Database, Sustainable Development, Green Practice, Entity-Relation Diagram, Teamwork.

1. Introduction

A database is a well structured collection of data stored in a computer system and it is usually controlled by a Database Management System. The basic component of any Information System (IS) is a database, which holds the data and provides information to the users. Several steps are followed to create a database starting from requirements analysis, database design and implementation in a specific Database Management System.

The current paper presents the collaborative development of a Database about a topic which is relevant and interesting for students and creates opportunities for teamwork. Green strategies [3], which are an integral part of the concept of sustainable development [2], are among the most important challenges of today's world.

Students from two universities - the National and Kapodistrian University of Athens, Greece (NKUA) and the University of Information Technology and Management, Poland (UITM)) – worked together to define the requirements of the Database, designed the Database by creating the appropriate Entity Relationship Diagram (ERD) and created the relational database [1,4,5] in the Oracle Apex Server DBMS [9].

The purpose of the project was to create a database for saving/presenting data about green practices of the two universities. Tools for content replenishment are provided.

The collaborative project allowed the students to learn about the partner's practices [7,8,12], exchange experience of their implementation and discuss new ideas about green initiatives.

2. Green policies at the universities

The green policies of the NKUA and the UITM are developed and implemented within the framework of the 2030 Agenda for Sustainable Development declared by the United Nations [10] and the 17 Sustainable Development Goals indicated in the Agenda [11].

2.1. Implementation of Sustainable Development Strategy at the universities

Both universities follow similar strategies focused on four key areas:

Education: including the subject of sustainable development at all levels of education; developing new on-line courses and trainings to qualify properly educated staff,

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application of technologies to increase student involvement, implementation of blended learning, virtual group classes and interactive learning;

Research and development: using information systems/technologies in research that will ensure more efficient use and allocation of existing resources, improve data and information management/sharing, supporting the activities of scientific and student clubs, promoting the principles of sustainable development in lectures, seminars and conferences through environmentally friendly organizational solutions (e.g. electronic conference materials, recycled materials for bags, notebooks, water dispenser, collective transport for conference participants), open-access publications;

Infrastructure and organization: effective water management on university campuses, the use of alternative, renewable energy sources, biodiversity activities, reducing the amount of paper/plastic waste and increasing the recycling rate to at least 50% on campus, transformation of research and teaching laboratories towards the so-called green laboratories, consolidation of data centers and data migration to cloud-based systems to reduce energy consumption;

Partnerships: developing an integrated environment (in the form of a system / platform) to support open cooperation, exchange and access to relevant data and information; international cooperation to promote institutional and management decisions and models; intergenerational communicationat at various levels of education, collaboration with national and international institutions working in the field of sustainable development, including PRME, RESPONSIBLE BUSINESS FORUM and UI GREEN METRIC.

2.2. UI Green Metrics

In the digital era all facets of our life tend to be measured in figures. The same is true for the green status of a university. Every year the University of Indonesia (UI) publishes the UI GreenMetric World University Rankings on sustainability by Region, Country, Category, and Campus Setting [6].

It may be helpful to have a closer look at how this ranking is calculated. Universities are estimated by 5 categories of indicators, with 6 to 11 criteria in each. There are a few examples below:

Setting and Infrastructure: the ratio of open space area towards total area, area on campus covered in planted vegetation, university budget for sustainability effort, campus facilities for disabled, special needs and or maternity care etc.;

Energy and Climate Change: energy efficient appliances usage, smart building program implementation, number of renewable energy source in campus, greenhouse gas emission reduction program etc.;

Waste: recycling program for university waste, rganic/inorganic/toxic waste treatment, sewerage disposal etc.;

Water: conservation/recycling programs, the use of water efficient appliances, pollution control in campus area etc.;

Transportation: the ratio of total vehicles (cars and motorcycles) divided by total campus population, shuttle services, Zero Emission Vehicles (ZEV) policy on campus, initiatives to decrease private vehicles on campus, pedestrian policy on campus etc.;

Education: the ratio of sustainability courses towards total courses/modules, numbers of sustainability publications / events /student organizations / web sites / reports/ sustainability related startups etc.

3. Designing and developing the Database

A Database is a collection of well-organized records on publicly available mass storage media. It serves one or more applications in an optimal way and allows common and controlled handling of data input, modification, and retrieval.

A Database captures a view of the real world and is created to be used by a specific group of users and to serve specific purposes.

The design of a Database is carried out in four consecutive stages. Each of these stages receives information from the previous one and feeds into the next one.

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These stages are:

• Requirement Analysis

• Conceptual Design

• Logical Design

• Physical design

For each of the above phases of database design, the corresponding level of abstraction is used, i.e. the hiding of information, which is not necessary to be presented at each stage. In each of the above stages of designing a Database, the appropriate model is adopted: the conceptual, the logical and the physical model.

The concept "model" is used in many scientific disciplines and can be rendered differently depending on the design stage of a Database. A data model is a set of conceptual tools used to describe the real-world entities captured in the database and the relationships between them [5]. Many data models have been proposed for designing a database, such as hierarchical, network, object-oriented, relational, etc. The appropriate model for the database of current work is the relational model and an Entity-Relationship Diagram was used to design the database.

The relational model was proposed by Codd in a publication [1] which presented that information stored in large databases can be accessed without the need to know how that information is structured within the database.

This approach does not require the database user to be an expert and to know details about the structure of the database, while all the "elements" of the database are available for access and processing. The relational model is founded on mathematical foundations but has its own terminology.

3.1. Database Design

The requirement analysis for the database was carried out in collaboration after a previous study and research of the actions that are held in both universities. Students were actively involved in this stage to identify the requirements.

The database design was created using the Entity Relationship Diagram which depicts all the requirements set by the members of both universities (Figure 1).

The core entity set of the database is the "*Event*". Each event is described by a unique ID, a description, a start date, and an end date. Each event is held from one "*Institution*", in a specific "*Location*", it has an "*Event Type*" and "*Participants*" who organize or participate in the event with different roles.

Each participant can participate in one or more different events and each event may have one or more participants. The Conceptual Schema created using the above ERD Diagram (Figure 1) clearly defines the structure of the database. It also allows the database expansion with possible future new requirements.

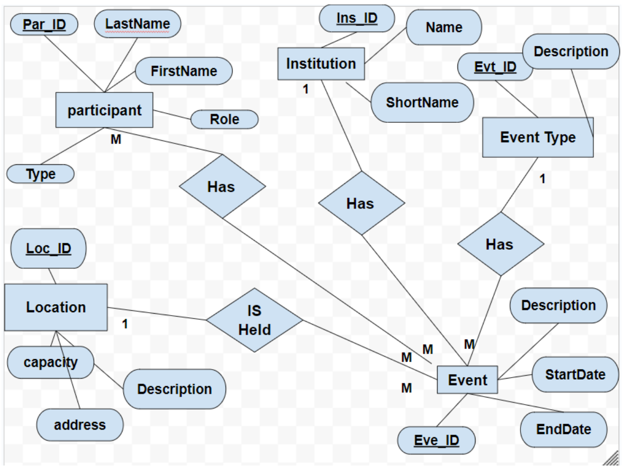

Figure 1. ERD Diagram: Conceptual Schema of the Database of Green Practices [13]

3.2. Logical Schema of the Database

The ERD diagram was used to construct the logical schema of the database in the Oracle APEX cloud-based development platform [9] using the appropriate SQL commands to create the database tables and relationships.

The Oracle Application Express (APEX) platform allows the design and development of systems based on a database in a simple way using only a web browser. The environment is online and provides the Oracle Database as well as simple management tools. The SQL code used to create the database can be seen in Figure 2. Sequences (Figure 3) and Triggers (Figure 4) were created for each database table to automatically identify the next Primary Key value of each database table during data entry.

```
CREATE TABLE PARTICIPANTS
 (Par_ID        INTEGER,
 FirstName      VARCHAR2(30) NOT NULL,
 LastName       VARCHAR2(50) NOT NULL,
 Role           VARCHAR2(30),
 Type           VARCHAR(30),
 PRIMARY KEY (par_id) );

CREATE TABLE Event_Types
 (Evt_id        INTEGER,
 Description    VARCHAR2(200) NOT NULL,
 PRIMARY KEY (Evt_id) );

CREATE TABLE Institutions
 (Ins_id        INTEGER,
 Name VARCHAR2(200) NOT NULL,
 ShortName      VARCHAR2(50),
 PRIMARY KEY (Ins_id) );

CREATE TABLE Locations
 (Loc_ID        INTEGER,
 Description    VARCHAR2(200) NOT NULL,
 Capacity       INTEGER,
 Address        VARCHAR2(400),
 PRIMARY KEY (Loc_ID) );

CREATE TABLE Events
(Eve_ID         INTEGER,
 Description    VARCHAR2(200),
 StartDate      DATE,
 EndDate        DATE,
 Loc_ID         INTEGER,
 Ins_ID         INTEGER,
 Evt_ID         INTEGER,
 PRIMARY KEY (Eve_ID),
 FOREIGN KEY (Loc_ID) REFERENCES
Locations(Loc_ID),
 FOREIGN KEY (Ins_ID) REFERENCES
Institutions(Ins_ID),
 FOREIGN KEY (Evt_ID) REFERENCES
Event_Types(Evt_ID)
);
```

Figure 2. SQL Commads for Database creation

```
CREATE SEQUENCE seq_locations
INCREMENT BY 1 START WITH 1;

CREATE SEQUENCE seq_participants
INCREMENT BY 1 START WITH 1;

CREATE SEQUENCE seq_event_types
INCREMENT BY 1 START WITH 1;

CREATE SEQUENCE seq_institutions
INCREMENT BY 1 START WITH 1;

CREATE SEQUENCE seq_events
INCREMENT BY 1 START WITH 1;
```

Figure 3. SQL Commads for Sequence creation

Save & Compile | Download Source | Drop

```
create or replace trigger "EVENTS_T1"
BEFORE
insert on "EVENTS"
for each row
begin
IF :NEW.EVE_ID IS NULL THEN
  SELECT seq_EVENTS.NEXTVAL INTO :NEW.EVE_ID
    FROM dual;
END IF;

end;
```

Figure 4. Trigger created for identifying the next primary key value of any Event

The next section briefly presents the web application that was created which enabled project participants of both Universities to enter data into the database.

3.3. Application Development

For the application development, the App Builder Tool of the Oracle APEX platform was used. The App Builder Tool is a low code, high productivity integrated development environment where we can develop applications on top of our data [14]. Different kinds of pages were used to create our application. Figure 5 presents the Login Form of the application and Figure 6 the menu of the application.

Participants from both universities were entered data to the database. This data entry process is still taking place and our goal is to include as many events as possible from both universities. Figure 7 presents the Events Form of our application.

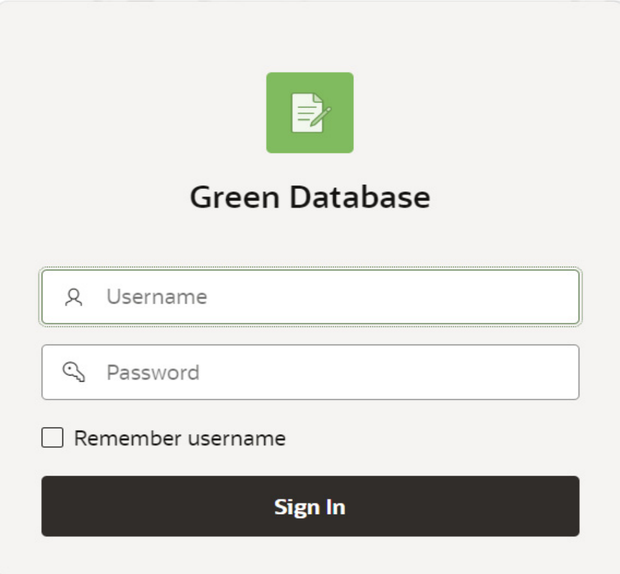

Figure 5. Login Form of the application

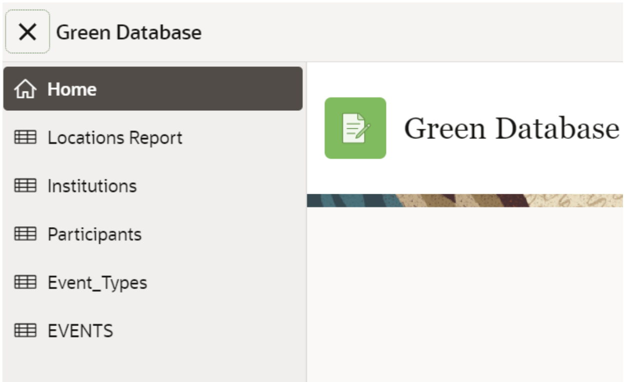

Figure 6. Menu of the application

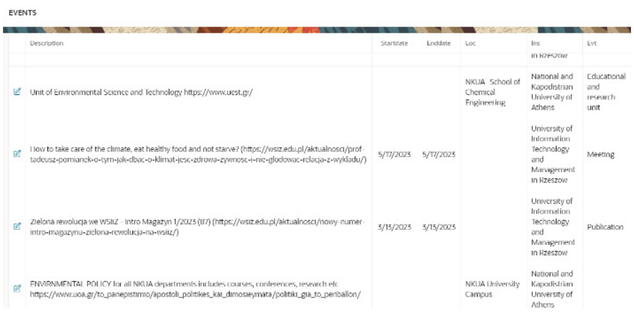

Figure 7. Events Form of the application

An additional future goal for our team is to suggest improvements for the database and whole application.

3.4. Overview of the event types represented in the Database

Event data is entered into the Database via the Events Form (Figure 7). A variety of event types can be represented:

- lectures delivered by experts on sustainable development and green practices,
- establishment of new majors related to sustainable development,
- workshops to train skills and to see green practices in action,
- conferences to discuss contemporary issues, develop solutions and exchange experiences,
- publications, both printed and electronic,
- sport activities to promote green practices,
- contests (posters, computer graphics, installations, traditional forms of arts etc.) to publisize the concept of sustainable development,
- activities at student clubs to engage more people in green practices.

A new type of events can be created through Event_Types section in the Menu (Figure 6). Also new institutions, locations and participants can be added with the same Menu.

4. Conclusions

Selecting events to be presented at the database was an important step of the project for a few reasons. First, events of different types with different attributes should be entered. Second, while making choices students became more awared about the green practices and their value that would encourage them for more active engagement.

We make every effort to equip the students and graduates with competences related to the principles of sustainable development which they would be able to use both in their professional career and in private life. As universities we also strive to minimize the negative impact on our natural environment. As an academic community, we promote diversity and an inclusive culture. We are convinced that students and faculty, through their bottom-up initiatives can contribute to protecting the natural environment.

The collaborative development of the database of green practices is only one of examples. This is a project in progress to be continued. However already now we can conclude that it has both an educational value as an opportunity of field practice in database design and a social value as a tool shaping

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students' attitude and proactive approach to the implementation of the Sustainable Development Goals.

5. Acknowledgements

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Science but not as We science Teachers Know it. The Two Sciences in Children's Lives

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Abstract. Science and engineering in action is all around us in our everyday wherever we live. We are all practitioners of STEM but rarely realise that such is what we are doing in our everyday. Such as irreversibly changing ingredients through cooking, using forces to pick up and move things, mixing solutions, washing clothes. This everyday science is one aspect of science earning, practice and understanding. It stands besides school science, research science and science used in industry as well as university and other aspects of sciences focused on training. However, everyday science in homes and communities is in action everyday but is seldom recognised. This paper reports on comments of tow different groups of parents on everyday science sessions, one in England and one in Bangladesh.

Keywords. Everyday Science, Parents, Informal Workshops.

1. Introduction

School science is familiar to many who received formal schooling particularly in their secondary years and more recently may have studied it in elementary school. Yet the application of any understanding acquires, the ability to identify facts acquired to recognise the science in action in everyday is limited.

Secondary children in science classes came with some understanding and ides about science [2] Moreover, at the same time other science educators recognised that children in their earliest years had some understanding, often based on their limited experience existed which was referred to as children's science [3] primary years) were also scientists explaining phenomena and experiences within the confine s of their knowledge and understanding and their culture. More recently it was recognised that there is everyday science, science in Action happening in communities [4]. School science is but one genre of science but it is that which adults who were able to attend school recall. In many instances the science taught was abstract and not explained as relevant to everyday life. Hence adults who learnt that way do not identify and recognise the science, engineering, technology and maths in action around them and in their activities and actions. Such and understanding is important in raising the scientific (STEM) literacy of a populations, literacy is not just facts but the ability to apply the facts, understanding them in action and apply them using what are referred toa s 21st Century skills[5] They are simply listed as Critical thinking, Communication skills: Creativity. Problem solving; Perseverance: Collaboration; Information literacy. Technology skills and digital literacy.

Adults who did not receive schooling, or if they did had no science and maths beyond numeracy, are effective practitioners of science, or rather STEM, in action but are unaware that this is what they a re practising. Two exemplars of Everyday science awareness on action are described in this paper; one of adults of children about to start formal school in England and the other of women who never received schooling in rural Bangladesh and their introduction to Everyday science in Action [3]. Facilitating these everyday practitioners to realise they use STEM in action these practitioners also receive the encouragement to explain what they see to their children whom may nor only develops their own everyday STEM in action awareness it develops children's vocabulary, observational skills and social skills together with communication, literacy in action in terms of STEM and of language.

2. Parental recognition of Everyday Science

Everyday science activities in both settings were using local everyday items and relate to their everyday. In the English sessions participants were shown a piece of bread and a similar piece toasted and asked what had happened. Eventually someone said it was toasted. They were then asked if the toast could be changed back into the bread. An important idea of science. However, when shown an ice cube hey quickly said the affirmative. Another example of irreversibility is the difference between cooked nd uncooled egg.

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The recognising that other foods cooked form various ingredients can not be changed back into the separate ingredients again. An example is of grained rice with husk and rice prepared for cooking is used in Bangladesh at Sreepur Village is an example.

Figure 1. Two examples of Change of State

2.1. English parents of children entering first school

Adults in England involved in caring for children under five including one who had just begin in the pre formal school year in English primary schools in a town in S E England were invited to Everyday Science workshop in their child's school hall.

These began half an hour before the end of school when the children joined them to explore the activities. The adults had time before the arrival of the children to interact themselves. Adults were very hesitant at first as these activities were not their remembered experience. They were expecting similar equipment and investigations to those they remembered form laboratories in their school days.

The other group of adult participants in Everyday Science classes were mothers at a purpose built village for rehabilitation of mothers in stressed circumstances, many having received no formal schools. T Sreepur village the learnt literacy and numeracy and skills to enable them to support themselves and their children when they returned to their villages.

2.2. Mothers at Sreepur Village Bangladesh

An interactive session of relevant everyday science in action is held weekly. The session reported here was about fire session- Putting out fire, its causes and how to extinguish the various types.

In the lesson the understganding of molthers ascertained. Their repsonses are sumamrised as *:"Through the brainstorming it was observed that very few participants have a little understanding about the cause of fire. From mothers, we get a few responses that are basically related to one another. They replied that they ignited the fire with gas. They also talked about some old topics. According to them, fire was generated in ancient times by individuals rubbing stones against stones. Some said that fire is ignited with the help of a match stick.*

In response to a question about fire extinguishment methods, they only explained one thing that more water should be poured on the incident place. And when they were asked about first aid, they said that potato, ointment, oil, salt water, paste, and so on should be applied to the burnt wound. However, they were unaware of the various sorts of fire and the methods to stop these sorts of fire in an immediate case."

After havign the cause of fires explained and ho the could be extnguihsed their feed back was

Figure 2. Mothers learning about putting out a fire by depriving it of oxygen photo SPP

We learned about the basic methods of fire extinguishment after the lesson. We came specifically to learn the various causes and sorts of fire ignition. Before the lesson, we only understood that in the case of a fire, water must be poured. But today we know that we can use dry sand, soapy foam, and a variety of other things in the case of a sudden fire.

We learned what procedures to take in the case of a sudden fire throughout this class. In the case of a sudden fire, first we must have faith in ourselves. And then try to keep ourselves in a secure place. Try to call the fire department immediately and also try to apply basic fire extinguishment methods. It was a useful class for us. ‘

3. Conclusion

Irrespective of their formal education of children and the school science remembered by adults, everyday science is an important recently recognised genre of science education. Everyday Science is an important part of Science Education and vital for communities and for children’s learning. It is science in action in their everyday world and unlike science concepts the science in action is shown in different ways depending on the culture in which they are being used.

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Live-Cell Imaging

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Abstract. To be able to study the cell in a more detailed manner, one of the most known techniques is microscopy, specifically the confocal fluorescence microscope. Fluorescence microscopy is a solution to confront biological obstacles such as observing organelles, smaller cellular components or even live cell processes. Its evolution has let us discover various techniques to acquire images obtained by using dyes, such as rhodamine and fluorescein, alongside with photons to our advantage. By doing so, we are able to access these cellular components in much greater detail and even select the ones we need for our research. Therefore, our main objective is to determine the methods used in fluorescent microscopy by making a detailed introduction on how the microscope works, followed by its uses in the biological field, such as enhancing 3D molecules of the cell and live-cell imaging, focusing more on the latter as we show as an example mitosis. Finally, we will state its advantages and consequences for the scientific field or on the living sample and the methods used to solve these problems, precisely fluorescence recovery after photobleaching (FRAP), fluorescence localization after photobleaching (FLAP), and fluorescence lifetime imaging microscopy (FLIM).

Keywords: Fluorescence Microscopy, Live-Cell Imaging, Mitosis, Photobleaching.

1. Mechanics of a fluorescence microscope

Fluorescence microscopy is a solution to imaging obstacles, as its techniques and equipment advance every day. It is a great tool in the molecular biology field as it lets researchers visualize small cell components, such as organelles, smaller molecules or live biological processes with much more clarity as the fluorescent dyes enhance their visibility. Before moving on to the applications of this microscope and its advantages or inconveniences, we have to make an understanding on how its mechanisms work, in addition to the protocols applied to the cellular sample, so it can be compatible with the microscope.

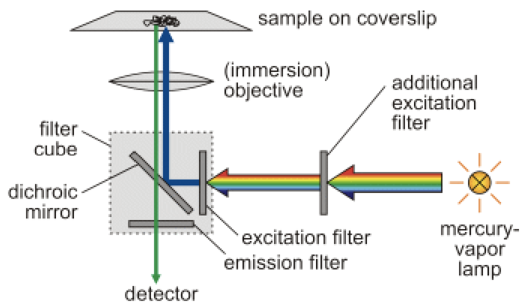

Figure 1. The image represents the basic parts of a fluorescent microscope and the direction that the photons from the light source are travelling to. The blue arrow signifies the photons that go through absorption from the fluorophores in the sample, and the green arrow is the emissions spectra

According to the image in Figure 1, a fluorescence microscope is composed by multiple parts and pieces that all contribute to its function. On one hand, we have the light source on one side of the machine that varies depending on the intensity of the light that we need to excite the dyes. Therefore, most of the most common light sources are mercury or xenon arc source, a high intensity LED or a laser source. Next we have the excitation filter that can either be single or multiple in a fluorescent microscope. The main purpose of this optical-glass is to select a specific wavelength from the light source that is compatible and the most efficient with the dyes used on the living sample. Following up is the dichroic mirror, which isn't very different from a common one that we can find in our bathroom. It is positioned in a certain angle, so the light passed through the excitation filter can reflect on it without being absorbed directly onto our sample located in a coverslip or a sample stage. This part of the microscope can be usually moved on the y, x and z axis by controllers of the microscope itself or a connected application on a computer. Next to the excitation filter and the dichroic mirror is the emission filter, most of the time located in a filter cube. Its sole function is to receive the light emitted from the specimen after bouncing off of it. In addition, it also removes any other wavelength of light that is not needed to obtain an image of our sample. These microscopes can also either have a detector to receive these wavelengths of photons to later project it onto a computer or trinocular set-up eyepieces that let

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the subject see the sample directly from the mechanism [1].

1.1. Excitation and emission

All processes that involve the use of a fluorescence microscope requires the sample to contain some sort of fluorescent molecule that will react to the photons and return a certain colour based off its excitation and emission levels. Depending on the light emission that the detector or eyepiece receives, we can obtain clear images of the cellular component, although the quality of the image may defer depending on the type of fluorescent microscope (WF or confocal).

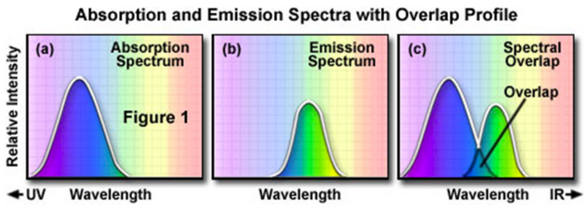

Figure 2. Representation of the absorption spectrum (a), emission spectrum (b) and spectral overlap (c) to compare wavelengths and point out the evident overlap that needs to be avoided by the microscope's absorption and emission filters [4]

Before explaining the principles of excitation and emission, we have to understand what fluorophores are. They are molecules that are added to the desire cellular components that have fluorescent properties that are compatible with the microscope [2]. Its electrons in their last orbital are the ones that determine how good they function according to the wavelengths that they receive and/or return. They can range from chemical compounds like rhodamine and fluorescein, amino acids such as tyrosine or fusion proteins like GFP and RFP. During the time that they are receiving light energy from the photons given from the light source, the electrons located in the last orbital can experience changes according to their energy level. They can jump up to a higher energy level orbital, further from the nucleus, creating the state that we call "excitation". The wavelength that they return during the emission state is always longer than the one they absorbed [3]. For the fluorescent to be more efficient, the ones that are used are the synthetic fluorophores that usually have conjugated double bonds (aromatic molecules), since the energy required for the electron to change to an excited state is minimum.

The intensity of the absorption and emission spectra can be represented in a graph (Figure 2). As we can see, the emission spectrum has less intensity in comparison to the excitation wavelength. When both are overlapped and put into a same graph, we obtain a spectral overlap in between. For the image obtained by the microscope to be high quality and well contrasted from other biomolecules that don't have the fluorescence, the adequate emission and absorption filters must be picked to eliminate any wavelength located in this overlapped zone [5].

2. Uses of the microscope in the biological field

Fluorescence microscopy is one of the most reliable techniques that scientists use nowadays to observe biomolecules or organelles from cell samples or tissues. Besides the general idea of what this type of microscope is used for, we can specify three of its uses in the biological field in relation to cellular samples.

2.1. Cell labelling

The simplest way to define this term is by saying that cell labelling is the action of observing and identifying parts such as organelles in a living cell. However, in fluorescent microscopy, Cell labelling is the process whereby in means of fluorescent chemical reporters, it is possible to observe and differentiate cellular structures. The difference is the use of the chemical components that give colour to the parts we want to study to make them clearer and contrast with the background. Without them, we would not be able to distinguish the different parts, since they are almost invisible to the naked eye. Also, this method helps in the visualization and study of biochemical processes in a cell.

The fluorescent dyes are biological molecules that contain at least one fluorophore. When it is excited with energy light, it emits characteristic bright colours. They can be designed or found in nature. For example, the Green Fluorescent Protein (GFP), protein synthesized by the jellyfish *Aequorea victoria*, which emits, as the name explains, a green fluorescence.

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But since the dyes are not only made of fluorophores, it is very important to be sure of the components of those dyes. They can be toxic and lethal to cells, so it is crucial to be careful with the techniques. As we can see in the image in Figure 3, the cell next to the mitotic cell has entered apoptosis. Apoptosis refers to the process of programmed cell death. In this case, it was due to the long and direct light the cell was exposed to, but an intoxication would lead to the same ending.

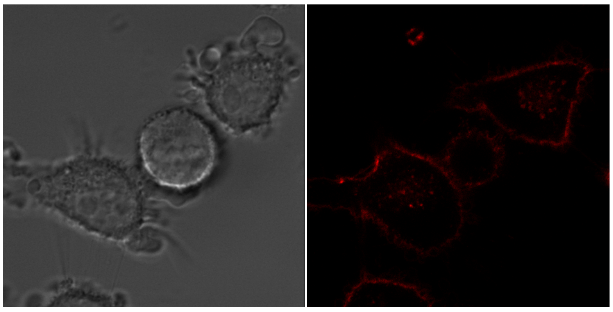

Figure 3. An image taken by a fluorescent microscope showing clear signs of apoptosis in the cells surrounding the one undergoing mitosis

Due to the fact that fluorophores can be used for a single structure in particular, it is possible to stain multiple parts of the same cell with different dyes without them getting mixed. Also, they can absorb and emit light in a specific wavelength. That is the reason why multiple colours can be seen in the same cell after the process.

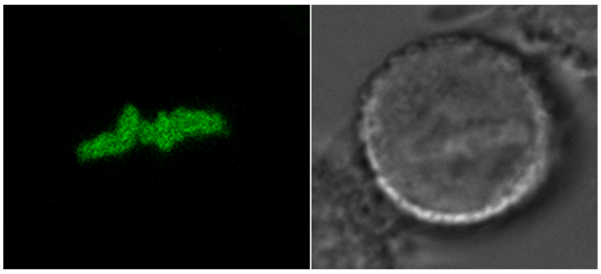

Figure 4. Comparison between two images extracted from a confocal fluorescence microscope. DNA in green dyes with GFP. Cell is undergoing mitosis (metaphase)

After applying the dyes on the cell we want to observe, the next step is to visualize them through a fluorescent microscope. As we can see on the picture below (Figure 4), we were able to study mitosis on a living cell. We can differentiate a cell in metaphase, and observe its chromatids get separated from each other. Without the fluorescent dyes, it would not have been possible to study in such a clear way this process.

This method is helpful but also complex, for that reason, it also comes with multiple disadvantages. Fluorescent dyes are not a perfect method, they require specialized equipment, like microscopes. They don't work with every structure in cells, there might be mistakes and, as said before, possible intoxication and death of the stained cell. And even when all the requirements and protocols are followed, fluorescent dyes can only be done in limited colours. For instance, if a study wants to observe six different structures, it might not be possible due to lack of contrast between the dyes, because there might not be six different colours [6] [7].

2.2. Protein characterization

Protein characterization is a similar process to the techniques used in cell labelling. However, the difference is seen in the purpose and focus of the analysis. In protein characterization, as the name says, it is not as important to identify parts of a cell, but to understand how the proteins in those structures work, their organization, the systems they form and their functioning. This method allows a more deep study of these biomolecules and the achievement of biological pictures *in vivo* and *in vitro.* This type of study is mostly used for understanding the beginnings of diseases and health problems, and their possible transmission [8].

2.3. Live-cell imaging

Live-cell imaging consists in a time-lapse technique used with this microscope to observe cell functions and dynamics. To do so, we have to dispose of 4 different axes to analyse the sample; x, y, z and t. In our case, we will only be focusing on wide-field and confocal microscopy.

For wide-field microscopy, the detector of the fluorescence microscope takes in all the different wavelengths emitted from the sample, including the cell's own autofluorescence. Therefore, compared to a confocal fluorescence microscope, the image quality isn't as good. Due to the fact that wavelengths originating from the surroundings of the thick sample are also observed on the computer produced image, we might obtain out of focus images with a possibility of blurry clouds around the fluorescent component due to the proximity of the fluorophores to other biomolecules. In addition, this microscope doesn't permit a 3D replica of the sample due to its lack of information from the z axis. In the image below, we have an example of a transgenic cell undergoing mitosis. On the left (A-E) we have the images obtained directly from the WF fluorescence microscope and on the right we have the deconvolved images, which are much clearer.

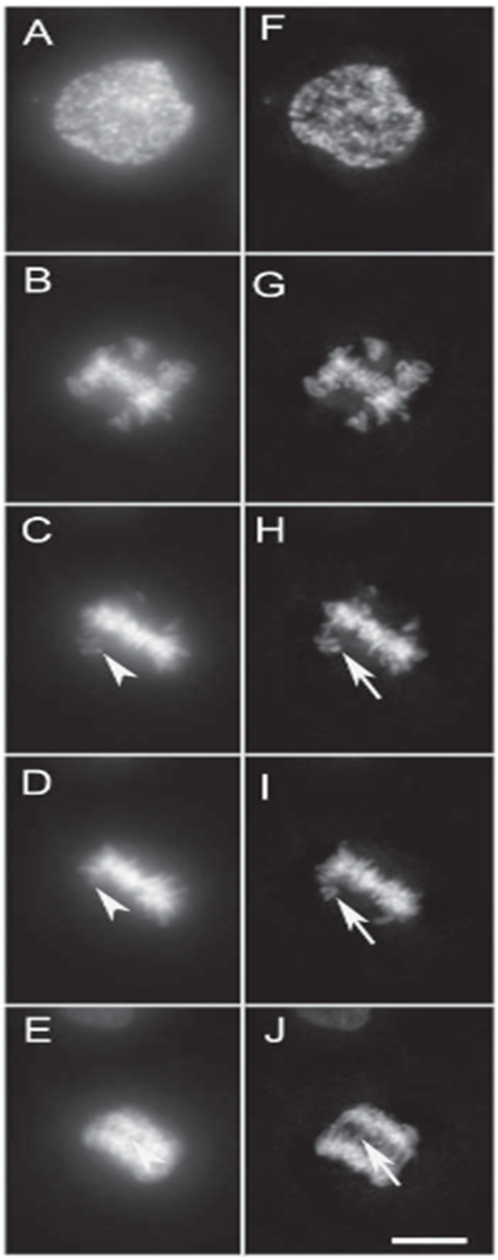

Figure 5. Image of a transgenic cell undergoing mitosis viewed by a wide-field microscope [9]

On the other hand, a confocal fluorescence microscope gives us a much clearer image due to the fact that it blocks out any out of focus light. But, by doing so, it is focusing more of its intensity on a single spot, causing more damages to the specimen and keeping the cell from functioning normally for a long time. Nevertheless, it is a very good technique to obtain 4D images of the sample, as the pinholes only focus the light on the fluorescent components within all the layers of a thick specimen.

As we have mentioned before, wavelength and the amount or intensity of the photons given to the living sample are very important aspects in fluorescence microscopy. The capacity of the detectors in the microscope must also be considered, since it can vary the dosage of photons that needs to be used to obtain a clear photo.

In the images in Figure 3 and Figure 4, we demonstrate a series of pictures done to a cell undergoing mitosis with the use of GFP dyes to bind with DNA molecules and red fluorophores to the membrane of the cells. Each image was taken at an interval of 5 seconds to create a short time-lapse of the biological process.

3. Downsides of the fluorescence microscopy

Fluorescent microscopy and the discovery of fluorescent dyes have changed and improved the molecular biology field and every scientific field related to investigation.

Nevertheless, not everything with this technique is helpful. It has some disadvantages and limitations that complicate the process.

Firstly, dyes are made of fluorophores (which give them the fluorescence) and other molecules. This component is very important, but it does not last forever. Eventually, it can get damaged and lose its ability because of photobleaching. This action is a chemical process that, due to a high-intensity illumination, makes the fluorophore's structure change, leading to the loss of the fluorescence characteristic.

Another downside of this technique is related to the process before the microscope is used. As it was seen earlier in this article, when using fluorescence microscopy, a preparation of multiple dyes and chemical treatment is needed for the cell that wants to be studied. That procedure is only useful for some of the structures of that cell. All the other parts become invisible to the naked eye, when in light microscopes could be seen.

Lastly, after all the proceedings are done, there still can be a risk that the analysis fails. Cells are very sensitive, and if the study that is being done has a living cell as its subject, it could be affected and die. Which means that, there are multiple reasons why a cell could end in apoptosis. The most common one is phototoxicity. If they are exposed to a short-wavelength light, the cell could malfunction or stop working at all.

3.1. Fluorescence recovery after photobleaching

As we have said before, photobleaching is a very common negative aspect of fluorescence microscopy, especially when we leave the sample under the intensity of the photons for a very long time. There are some ways to recover the colour of the fluorescent specimen by controlling the light dosage (FRAP), tracking down labelled fluorophores (FLAP) or providing a temporal dimension (FLIM) [10].

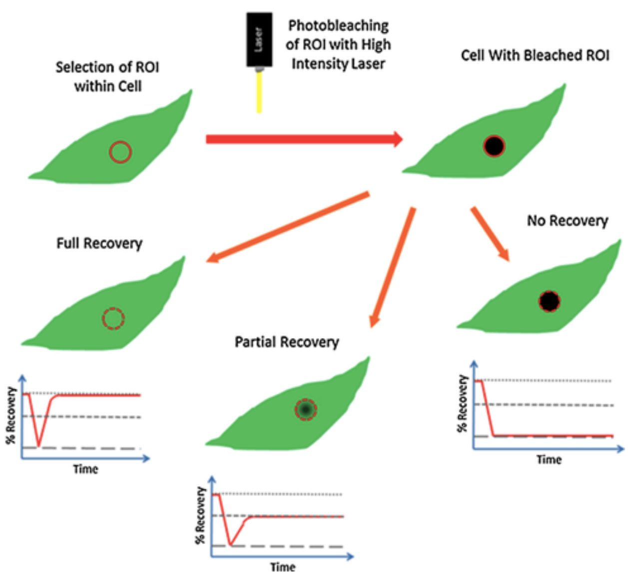

Figure 6. After monitoring the fluorophores' activity in the bleached area, three possibilities are shown after a certain time while FRAP monitors recovery rate and percent recovery

Fluorescence recovery after photobleaching consists in sending out a laser with the appropriate wavelength to monitor the movements of the bleached molecules and the fluorescent ones around it [2]. Photoswitching is a possibility since fluorescent molecules can recover after a certain time after being bleached, as well as surrounding cellular components in its surrounding moving in and out of the bleached zone. Therefore, the microscope can observe how the bleached fluorescents are recovered of replaced by other fluorescent molecules (Figure 6). One of the limitations of this technique is that photoswitching is very unlikely to happen in common experimental protocols.

3.2. Fluorescence lifetime imaging

Fluorescence lifetime imaging is a technique only used by wide-filed and laser scanning microscopes, hence its limitation to other type of fluorescence microscopes. Fluorescence lifetime indicates the period of time when the electron of the fluorophore is in an excited state before returning to its original ground state, emitting the photons that the microscope's detector will receive [11]. The data acquisition is obtained by measuring the time from when the laser excites the fluorescent until each pixel of the detector receives the corresponding photon, creating a histogram for each photon count after the laser pulse, creating a possible decay curve (each time there are fewer photons emitted) and displaying the images with colours corresponding to each lifetime value [3]. The main use of this microscopy technique is to determine relations between cellular components without depending on the light intensity or concentration. An example is the observation of changes in protein activity (FRET) [12].

3.3. Fluorescence localization after photobleaching

Last of all, fluorescence localization after photobleaching is a method that uses two fluorophores at the same time; one that will be prone to photobleaching and the other one that will be used as a reference. Both labels can be viewed individually or at the same time by the microscope [9]. The best outcome of FLAP is when both images (one of the location of the bleached molecules and the other one of the reference fluorophores) are very similar or mostly the exact same. The second image is obtained by subtracting the signal of the

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bleached fluorophores from the reference labels.

4. Conclusions

One of the most important things that determine whether a microscope is useful or not is the contrast that it provides, so we are able to visualize the cell's components in a clear manner. Fluorescence microscopy is a great solution to overcome problems related to contrast, and its techniques are advancing every day. This type of microscopy is not only used in biology, but also in immunology, oncology, dermatology, laryngology, pulmonology, gynaecology, and gastroenterology. It serves a big importance in medicine as it is also used to detect malicious tissues and cells that will later diagnose the patient. Therefore, it is a truth that without this microscope, most of today's scientific advances would not be possible.

On another note, it is crucial that younger generations, such as teenagers or young adults, get in touch with present scientific projects or advancements. Even though they themselves might not be able to be part of them, it is important that they are aware that these changes or improvements are not something that happened or that will happen, but something that is happening right now. Nevertheless, we need to consider the possibility that they might not have any interest in this area, but knowing how and why things work is never an aspect that affects lives negatively. In addition, getting to know about certain topics might even wake up a hidden passion of the person and lead them to a life that they had not planned before.

5. Acknowledgments

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Image Formation with Lenses, Pinholes and Slits in an Optical Box

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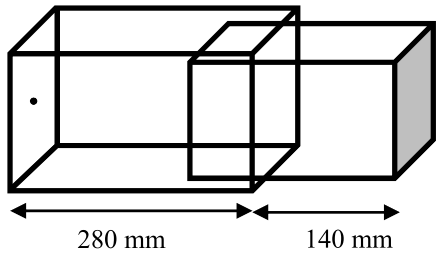
Abstract. Images formed by systems with small apertures, such as pinholes and slits, have very weak illumination. It is advisable an object with a high luminance and with considerable size to see these images. Besides, the device that performs the image must be solid and stable. In this work, a wooden box has been designed to obtain these images and to see them comfortably. In order to illuminate the object intensely, an LED ceiling light has been used. Images with slits and pinholes have been formed in the box. Geometrical relationships between the object and image sizes have been established and theoretical and experimental resolutions for different pinholes have also been compared. The device has also been used to form images with lenses and compare them with those formed by pinholes.

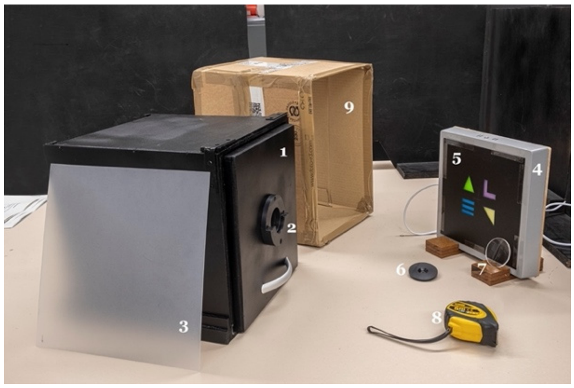
Keywords. Geometrical Optics, Lenses, Images, Pinholes, Physics Optics, Slits.

1. Introduction

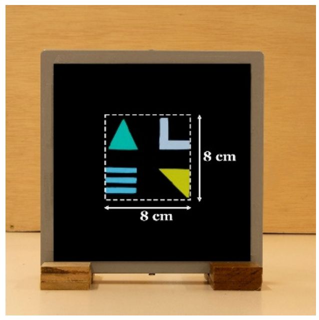
Image formation by lenses, mirrors and pinholes is a recurrent topic in all geometric optics curricula. However, many students have problems understanding it [1–3]. Images formed by systems with small apertures, such as pinholes and slits, have very weak illumination. To view this kind of images, you need, firstly, an object with a high luminance of considerable size and, on the other hand, a solid and stable device that allows to form the image. Several authors [4–6] recommend the use of a box to analyze the images formed by a pinhole. In this work, we propose the use of an LED panel to illuminate the object and a box to carry out a set of optical experiments referring to the formation of images with lenses, pinholes and slits. For this purpose, a sliding box formed by two parallelepiped wooden bodies has been designed according to the scheme and the dimensions specified in Figure 1(a). In the first body, the entrance side has a circular opening where a lens or a pinhole can be adapted and the exit side is uncovered. The second body, larger than the first, with the input and output faces uncovered, allows the first body to slide inside it. A translucent diffuser screen can be placed at the end of this second body.



(a)



(b)



(c)

Figure 1. a) Diagram of the sliding box. (b) Elements of the device. 1: Box, 2: Support to adapt lens and pinhole mount, 3: Screen, 4: Flat LED light source, 5: Object, 6: Frame to adapt pinholes or slits, 7: Lens, 8: Tape measure and 9: Box to protect stray lights. (c) Detail of the object with its dimensions

Figure 1(b) shows the elements used in image formation of this work. The sliding box (1) contains a support (2) to fit a lens or a pinole or a slit, the screen (3) is a plastic diffuser that fits on the end opposite (2). A flat LED light source (4) illuminates the object (5) which is made up of four transparent filters, of different colors and shapes (isosceles triangle, L, bars and right triangle), arranged within a square of 8x8 cm,

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placed on top of a black cardboard that shields unwanted light. The high luminance of the LED screen allows you to have an object bright enough to be able to see its image through a pinhole. The image-forming systems are the pinhole, the slits (6), located on a mount to adapt to (2), and the lens (7). A tape measure (8) will be used to measure the different distances. Finally, a cardboard box (9), of larger dimensions than the sliding box allows to shield lights around the image plane.

Figure 2 shows the device when it forms the image either through a lens, a pinhole or a slit. The Descartes coordinates *p*, *q*, *y* and *y'* used to perform the measurements are also shown.

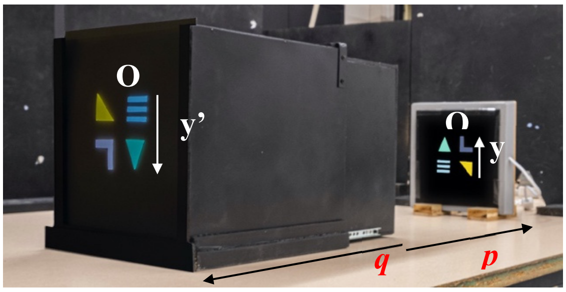

Figure 2. Experimental device

2. Characteristics of the images shaped by pinholes

Let a system formed by an object O, a pinhole of diameter Φ_P and a screen. The cones of light rays that leave each of the object points, after passing through the pinhole, form an image O' because the superposition of the different light spots of diameter Φ_I that are projected onto the screen. Figure 3 schematizes the image formation process.

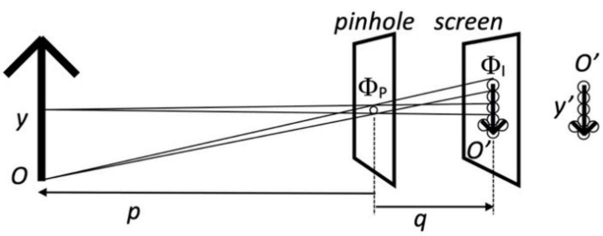

Figure 3. Scheme of image formation by a pinhole

If we take into account the lateral magnification definition *m*, in Figure 3, applying triangles similarity, we can establish:

$$m = \frac{y'}{y} = -\frac{q}{p} \qquad (1)$$

Image spot size or light spot size will depend if we consider light as a ray (geometric optics) or as a wave (wave optics), considering in this case diffraction.

Let be a point object O located at a distance *p* from the pinhole. The geometrical image spot diameter Φ_{IG} that will form a pinhole of diameter Φ_P on a screen located at distance *q* is obtained by applying triangles similarity in Figure 4 (a).

$$\Phi_{IG} = \Phi_P\left(1 + \frac{q}{p}\right) = \Phi_P(1 - m) \qquad (2)$$

If we consider light as a wave we will have to consider diffraction. When conditions are met [7]:

$$p > \frac{\Phi_P^2}{\lambda} \quad i \quad q > \frac{\Phi_P^2}{\lambda} \qquad (3)$$

You will have far-field or Fraunhofer diffraction. If we take into account that in our experiments the previous equations are fulfilled, the spot image of the Fraunhofer diffraction pattern is the one shown in Figure 4(b). The value of the diameter of the central disc, Φ_{ID}, also known as the Airy disc is:

$$\Phi_{ID} = 2{,}44\lambda\frac{q}{\Phi_P} \qquad (4)$$

Where λ is the average wavelength of light (λ= 550.10^{-6} mm).

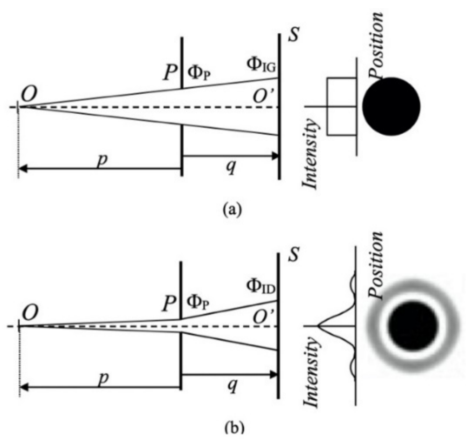

Figure 4. Spot image shaped by the pinhole P on the screen S. (a) Geometric image. (b) Diffracted image

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Young [8] established that the light spot diameter Φ_I will be the maximum value of the two above, that is:

$$\Phi_I = \max\{\Phi_{IG}, \Phi_{ID}\} \tag{5}$$

When $\Phi_{IG} \approx \Phi_{ID}$ for practical purposes we will consider that the image spot is determined by diffraction.

Because the image of a point is a spot, the images formed by pinholes present a certain blur. However, the images formed by the pinholes are resistant to the blur that occurs when the screen is moved. Figure 5 shows the effect of moving the screen and increasing the image blur.

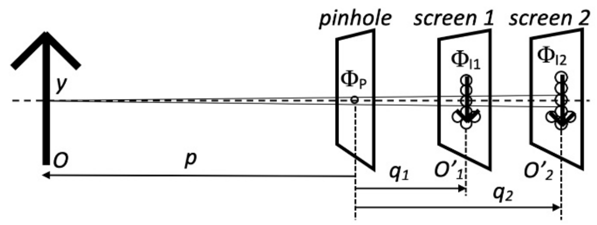

Figure 5. Images formed for different possitions of the screen

2.1. Images shaped by multiple pinholes

Figure 6 schematizes image formation by two pinholes. Each pinhole shapes an independent image and the number of images is equal to the number of pinholes.

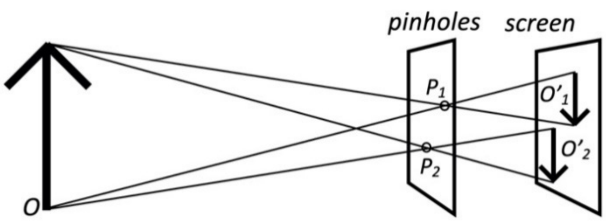

Figure 6. Images shaped by two pinholes

2.2. Pinhole resolution

Resolution of an optical system is its ability to reproduce detail, namely, it is the capacity of the device to display separate two very close object points in the image plane.

Consider a test object O formed by a set of white and black bars, highly contrasted and equal spaced as shown in Figure 7. When the image spots corresponding to the edges of two adjacent bars do not overlap each other the image O' will be resolved and the test bars continue to be separately (Figure 7(a). If, on the contrary, the spots overlap, the image may be not be resolved (Figure 7(b)). The shortest distance between two spots to be considered separate (resolved) depends on whether the spot is geometric or diffractive.

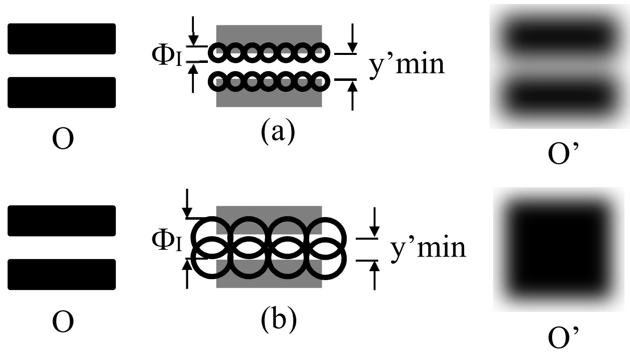

Figure 7. Bar test. (a) Resolved bars resoltes. (b) Non resolved bars

If the spot is geometric Young [8] established that the resolution $y'_{\min,G}$, that is, the shortest distance, in the image plane, between two circular spots to consider them as separate is:

$$y'_{\min,G} = \frac{3}{4}\Phi_{ID} \tag{6}$$

If the image spot is due to diffraction, the resolution is determined by the Rayleigh criterion which states that the resolution $y'_{\min,D}$ in the image plane is the Airy radius:

$$y'_{\min,D} = 1{,}22\lambda\frac{q}{\Phi_P} \tag{7}$$

Resolution in object space $y_{\min}$ will be obtained directly from the magnification equation (1).

In this way:

$$y_{\min} = \frac{y'_{\min}}{|m|} \tag{8}$$

Resolution is also expressed as image frequency u' and is measured in line pairs (lp) per millimeter (mm). The relationship between $y'_{\min}$ and $u'_{\max}$ is:

$$u'_{\max} = \frac{1}{y'_{\min}} \tag{9}$$

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The relationship between the maximum image frequency $u'_{\max}$ and the maximum object frequency $u_{\max}$ is given by:

$$u_{\max} = u'_{\max} |m| \qquad (10)$$

3. Characteristics of the images shaped by slits

If we change the pinhole by a small vertical slit, the image O' of an object O will be formed by the superposition of the light spots produced by the beams of light rays that leave from each object point and, after crossing the slit incide on the screen. In the same way as in the previous case, the spot can be geometric or diffractive. Since we do not have slits narrow enough to consider the case of diffraction, we will only consider the geometric image. Accordingly, the shape of the spot of light in the screen is the same as that of the slit and its size will be proportional to this. Figure 8 schematizes the image formation process.

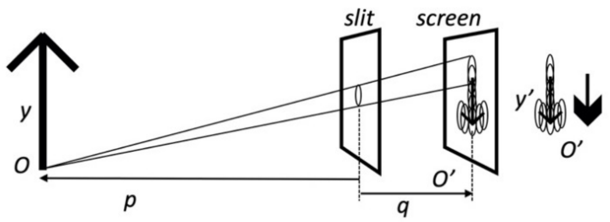

Figure 8. Image formation by a vertical slit

4. Characteristics of the images shaped by lents

In the case of the lens, the image O' will also be produced by overlapping light spots, although now they will be now much smaller. The diffraction theory of the image states that the image shaped by a lens of an object point O is a spot that shows a Fraunhofer pattern. Figure 9 displays the image spot O' formed by a lens of a point object O. An enlargement of this spot shows it the Fraunhofer pattern.

Since the lens is circular, the diameter of the image spot Φ_I in the focal plane is:

$$\Phi_I = 2{,}44\lambda \frac{q}{\Phi_L} \qquad (11)$$

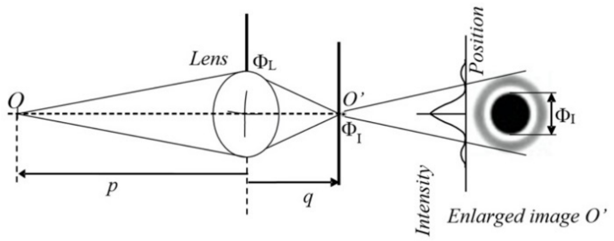

Figure 9. Image O' of a point O formed by a lens

For practical purposes, except when considering lens resolution, we will consider that the image spot shaped by a lens is a point.

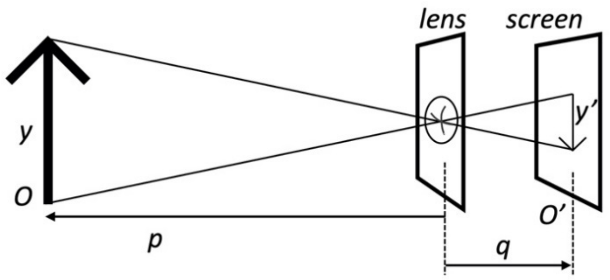

Figure 10. Image formed by a lens

Consider a positive lens of focal length f that forms a real image O', at a distance q, of an object O located at a distance p. Descartes equation relates the previous parameters according to:

$$\frac{1}{p} + \frac{1}{q} = \frac{1}{f} \qquad (12)$$

The relationship between the size of the image y' and the size of the object y defines the lateral magnification m, which can also be expressed according to formula (1).

If the image is formed in a different point of the focusing screen the image point will become a spot (defocus spot) of diameter Φ_D. Applying triangles similarity in Figure 11 we obtain:

$$\Phi_D = \Phi_L \left(\frac{q_2}{q_1} - 1 \right) \qquad (13)$$

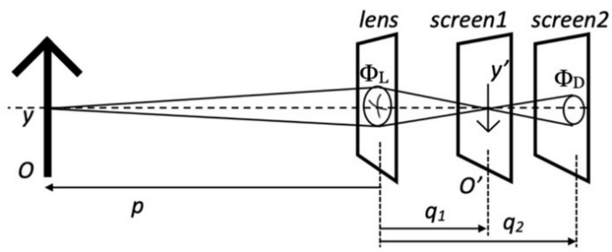

Figure 11. Image blur when scrolling the screen

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4.1 Lens resolution

Considering that the image of a point is the Airy diffraction spot, lens resolution y'_{min} will be obtained by the Rayleigh criterion. Therefore:

$$y'_{\min} = 1{,}22\lambda \frac{q}{\Phi_L} \qquad (14)$$

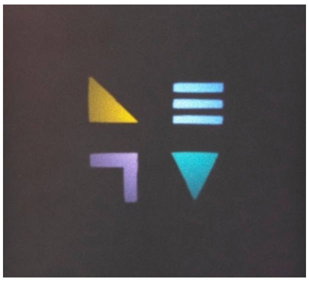
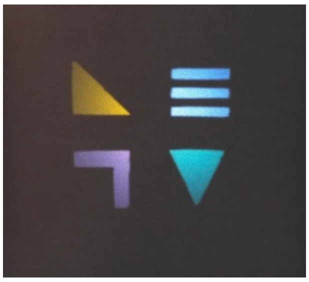
5. Results

Below we present the results obtained. The images have been captured by Fujifilm X-T20 camera with the XF-18-55 F2.8-4.0 lens.

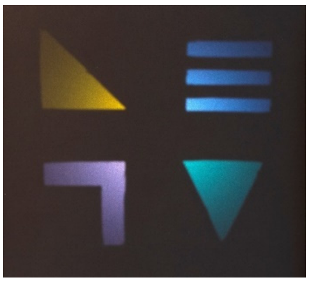
5.1. Image formed by a pinhole

Table 1. Size of the defocus spots for a pinhole of Φ_P = 1 mm.

Figure 12	p	q	m	Φ_{IG}	Φ_{ID}	Φ_I
(a)	400	430	–1,08	2,08	0,58	2,08
(b)	300	430	–1,43	2,43	0,58	2,43
(c)	230	430	–1,87	2,87	0,58	2,87

(a) (b)



(c)

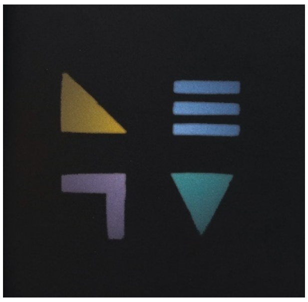
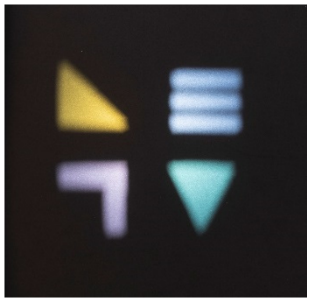
Figure 12. Images shaped by a pinhole of diameter Φ_P = 1 mm. (a) p = 400 mm, q = 430 mm, m = –1,1. (b) p = 300 mm, q = 430 mm, m = –1,3. (c) p = 230 mm, q = 430 mm, m = –1,9

We begin by displaying three images formed by a pinhole of Φ_P = 1 mm keeping constant q and varying p. Acording to (5) the image spot size must be calculated applying geometrical optics. In Figure 12 images appear with a small degree of blurring. Visually, there are no differences between them since the sizes of the image spot diameters have not varied much. To stand out that the lighting that appears on the screen is not uniform because it is not a perfect diffuser.

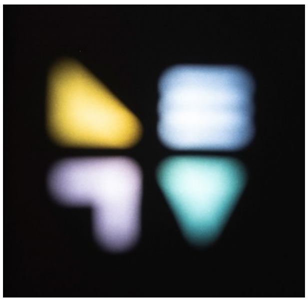
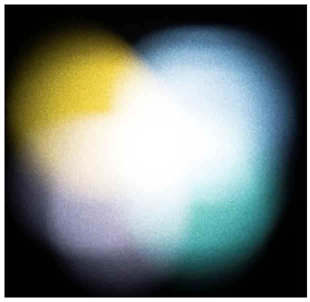
5.2. Relationship between image and pinhole size

Image has been formed for different pinhole diameters. In all cases the positions of the object and the image are the same, p = 300 and q = 430 with m = –1.4.

Pinhole diameters are: Φ_P = 1 mm, Φ_P = 5 mm, Φ_P = 10 mm, Φ_P = 40 mm. The results obtained are shown in Figure 13.

(a) (b)

(c) (d)

Figure 13. Images formed by pinholes with different diameters. (a) Φ_P = 1 mm. (b) Φ_P = 5 mm. (c) Φ_P = 10 mm. (d) Φ_P = 40 mm

Difracttion effecs has been neglected and image size spot has been calculated by geometry. This means that when the pinhole diameter increases the spot diameter increases too. At first glance, it can be seen that the sharpness of the image decreases as the diameter of the pinhole increases. For small values of the pinhole diameter, up to 10 mm, we can recognize the shapes of the object. For larger values, the information of the object starts to blur and information about the hole that forms the image gradually appears on the screen, as is the case in Figure 13(d) with a diameter of 40 mm.

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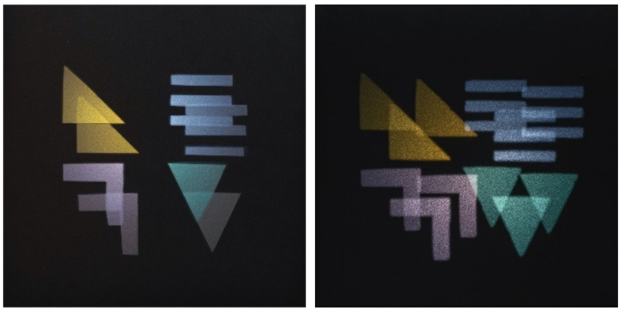
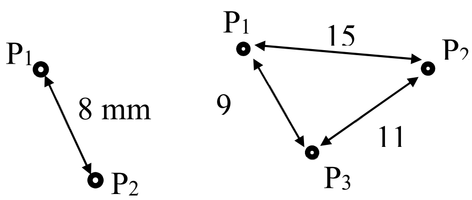
5.3 Images formed by multiples pinholes

Figure 14(a) shows the image shaped by two pinholes and Figure 14(b) the image shape by three pinholes. In all cases Φ_P = 1mm and the distances are p = 300 mm and q = 430 mm. The distribution and distances between pinholes are shown in Figures 14(c) and 14(d) respectively.

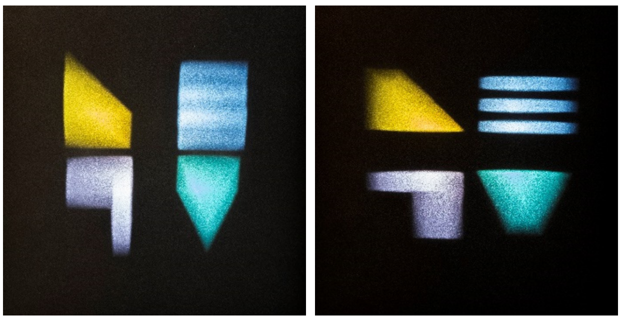


(a) (b)

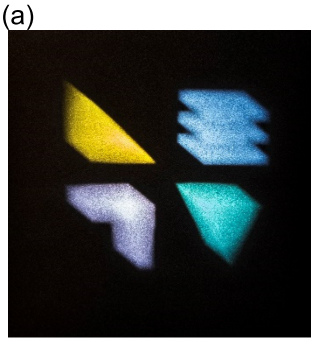


(c) (d)

Figure 14. Image formed by: (a) Two pinholes. (b) Three pinholes. (c) i (d) Pinhole distribution



(a) (b)



(c)

Figure 15. Images formed by the same slit with different orientations. (a) Vertical. (b) Horizontal. (c) 45º with the vertical

5.4. Images formed by a slit

Figure 15 shows the images formed by a slit 10 mm high and 1 mm thick. In Figure 15(a) the slit is in vertical position, in Figure 15(b) in horizontal position and in Figure 15(c) is forming an angle of 45º with the vertical. The distances are p = 300 mm and q = 430 mm.

5.5. Comparison between the image formed by a lens and the image formed by a pinhole

Below we compare the images formed by a lens of focal f = 200 mm and diameter Φ_L = 40 mm with those formed by a pinhole of diameter Φ_P = 1 mm. In both cases p = 660 and q = 290, coordinates that correspond to conjugated points by the lens L. Figure 16 shows the results obtained and it is verified that the two images are of the same size. More sharpness is observed in the case of the image formed by the lens.

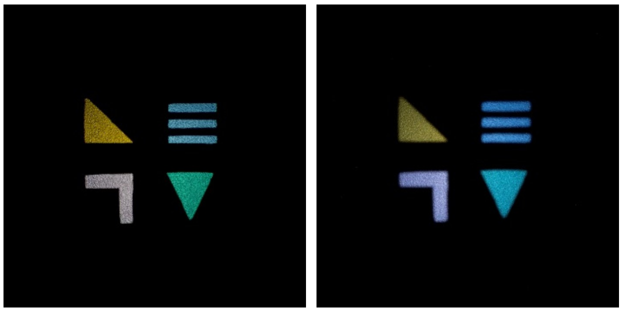
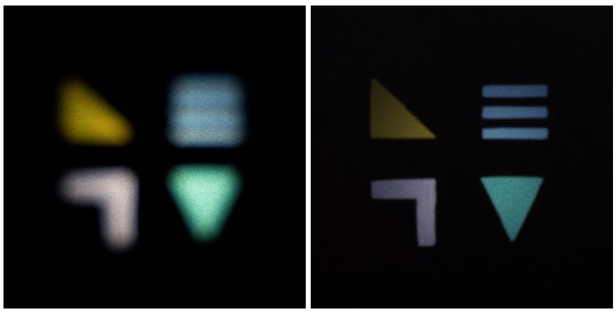


Figure 16. (a) Image shaped by the lent. (b) Image shaped by the pinhole



(a) (b)

Figure 17. (a) Defocus in the image formed by the lens. (b) Image formed by the pinhole

Figure 17(a) shows an image defocused by the former lens with coordinates p = 520 mm and q = 430 mm. Considering, applying (12), that the position where the image is in focus is q = 325 mm, applying (13) the diameter of the blur spot is Φ_D = 12.8 mm, enough size so that the aspect of the image appears out of focus. If we compare

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it with the image that forms a pinhole of diameter Φ_P = 1 mm by the same coordinates (p = 520 mm and q = 430 mm) this one looks much more focused than the previous one since applying (2) the diameter of the spot image is Φ_I = 1.8 mm. Much smaller value than for the case of the lens.

5.6 Pinhole and lens resolution

The resolution has been measured for different pinholes of Φ_P = 5 mm, Φ_P = 1 mm, Φ_P = 0.5 mm, Φ_P = 0.3 mm and Φ_P = 0.2 mm in diameter and also for a lens of focal f = 200 mm and Φ_L = 40 mm. The USAF test has been used used as an object test glued to the LED panel. The geometric characteristics are p = 400 mm and q = 400 with m = −1.

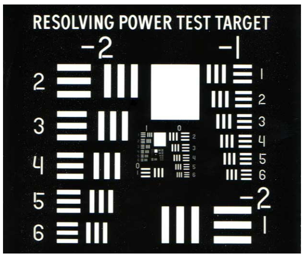

Figure 18. USAF test used to measure pinhole resolution

Figs. 19(a) to 19(e) shows the images obtained with pinholes and table 2 compares the resolution theoretical values with the experimental ones. The agreement between the theoretical and experimental values is good. The resolution is given by the geometric spot by the pinholes of diameters Φ_P = 5 mm and Φ_P = 1 mm. For values Φ_P = 0.5 mm and smaller the resolution is given by the diffraction spot. The maximum resolution, both theoretical and experimental, is given by diameter Φ_P = 0.5 mm. The effect of diffraction is also clearly observed for the diameters Φ_P = 0.3 mm and Φ_P = 0.2 mm since, despite being smaller than Φ_P = 0.5 mm, the resolution is worst.

Table 2. Relationship between the sizes of the image spots and the resolution

Φ_P (mm)	Φ_{IG} (mm)	Φ_{ID} (mm)	Criteria	y'_{min}(mm)	u'_{max} (pl/mm)	u_{max} (pl/mm)	$u_{max,}$exp (pl/mm)
5	10	0.1	Geometrical	7.5	0.13	0.13	--
1	2.0	0.5	Geometrical	1.5	0.7	0.7	0.63
0.5	1.0	1.0	Diffraction	0.5	2.0	2.0	1.78
0.3	0.6	1.8	Diffraction	0.9	1.1	1.1	1.00
0.2	0.4	2.7	Diffraction	1.3	0.8	0.8	0.56

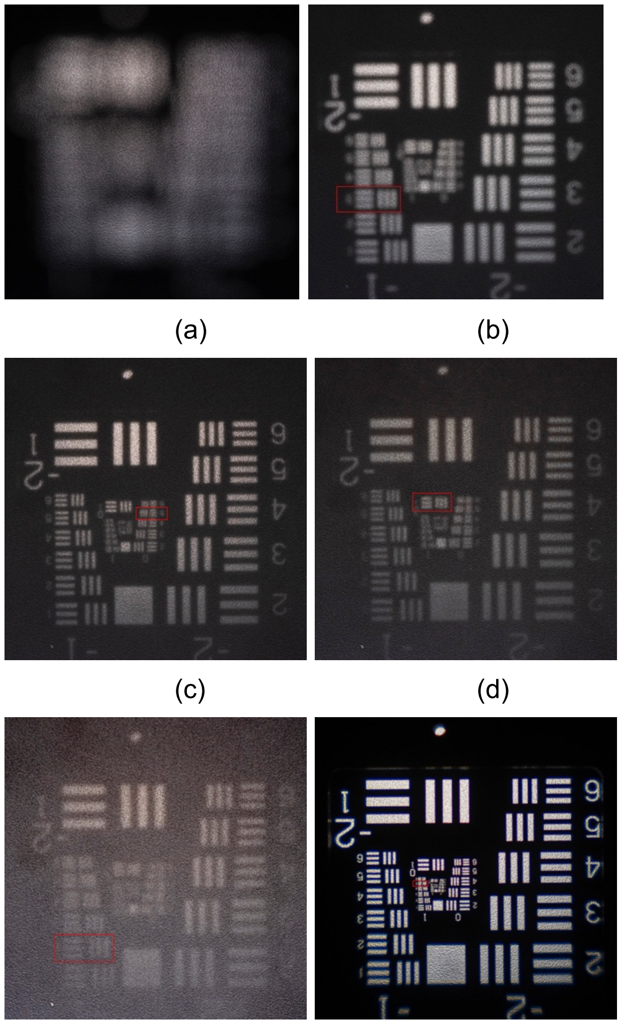

Figure 19. Resolution by the set of pinholes and the lens. a) a) Φ_P = 5mm, b) Φ_P = 1 mm, c) Φ_P = 0,5 mm, d) Φ_P = 0,3 mm, e) Φ_P = 0,2 mm i f) Lent de f = 200 mm i Φ_L = 40 mm

If we consider the lens as perfect, the resolution can be calculated by applying (7). Note that the resolution is y'_{min} = 0.0067 mm and u'_{max} = 149 pl/mm. This value is the theoretical limit for diffraction-limited systems, that is, systems where the image spots due to optical aberrations are smaller than the diffraction spot. However, this is not our case since the simple lens presents aberrations that decrease, and greatly, the value of the previously calculated resolution. It should also be added that the rough nature of the screen also reduces the resolution. The measurement obtained with the USAF test is shown in figure 19(f) and its value is $u_{max,\ exp}$ = 3.17 pl/mm, a low value, but which is almost twice the best value obtained with pinholes.

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6. Conclusions

The wooden box with an object illuminated by an LED screen is a simple, robust and very suitable device for the formation of images with pinholes, slits and lenses. The photographic record of the images obtained allow their subsequent visualization as well as the carrying out of measurements that permit the theoretical values to be compared with the experimental ones. Qualitative experiments have been carried out such as the formation of images with one and several pinholes, with slits and with lenses. The blurring and resolution in the images formed by the lenses and pinholes have been analyzed quantitatively.

7. References

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The Trees, a True History

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Abstract. The success of trees since their appearance 380 years ago is due to some very special characteristics. Their growth is modular and indeterminate, they are organisms with great plasticity to adapt and respond to changes in the environment, and although they do not regenerate tissues when wounded, their defence mechanism is highly efficient. This allows them to reach large sizes and long-life spans. The structure and chemical composition of their annual growth rings record their life history. Current climate change raises important questions about the set of traits that allow trees to survive.

Keywords. Trees, Tree-Rings, Wood, Tree Traits, Hydric History.

1. Introduction

We all know what a tree is; it is a living organism, a large plant. We find them in our streets, in parks and in the forests they form. We appreciate them for their fruits, for their shade, for their wood and other products, and we admire them for their beauty. We are so accustomed to their presence and the goods they provide us with that we are not fully aware of what kind of organisms they are, of their importance in the maintenance of biodiversity and in the functioning of the biosphere. However, their death surprises us because it is usually sudden due to fire, plague, drought or logging.

The appearance of trees on Earth some 380 million years ago was a major event for life and its subsequent history. Landscapes and terrestrial ecosystems were transformed and new habitats and resources created for other forms of life [1]. Trees, because of their large size, organize space in 3 dimensions, from the tip of the branches to the tip of the roots, creating a wide variety of habitats for other plant and animal species. Since then, trees have played a fundamental role in the formation of terrestrial ecosystems and have been (and still are) crucial to the balance and sustainability of life on Earth, e.g. by storing large amounts of CO2, trees have been able to slow down the worsening of current climate change.

Trees are the largest and longest-lived organisms on our planet. The size and age of trees vary greatly among species, but all are large (more than 2-6 m tall). Some trees are larger than whales or extinct dinosaurs and can reach more than 100 m in height [2,3]. The diameter of the trunk can exceed 10 m. In addition, the longest-living trees can live hundreds and thousands of years, in some cases more than 4500 years as has been documented for some trees in Scotland, Tasmania, North America as well as South America.

In Spain, the oldest living trees are found in the Pyrenees and in the Sierra de Cazorla where there are individuals of Pinus uncinata and Pinus nigra that are more than 1000 years old (Figure 1). Trees of species such as *Pinus halepensis* or *Quercus ilex* do not reach very high ages because their area of distribution coincides with land traditionally used for crops. In the case of *P. halepensis*, the oldest individuals in Spain are about 180 years old in the Monegros, but in the mountains of North Africa there are specimens over 400 years old.

We ask ourselves how is it possible that trees can live for so many years, overcoming climatic and environmental adversities of all kinds, bearing in mind that they are immobile organisms?. What are the secrets (strategies) of trees to live so long and be so big? What are the advantages and disadvantages of being so big?

Figure 1. Pinus nigra (PPNN Sierras de Cazorla, Segura y Las Villas). The tree was cored in spring 2005. In February 2007 the tree was uprooted by strong winds. Tree age is 812, height 14 m and diameter 2.30 m at 1.30 m from the base

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1.1. Advantages and disadvantages of being a tree

The advantages of being a tree must be many; otherwise, they would have become extinct. The first explanation we can give is that trees are organisms very well adapted to the environment, being able to change their growth and defense strategies (i.e. competition for light and fight against pathogens) depending on the place and climatic conditions. A great advantage of being large (tall) is that they can position their leaves at a great height, thus avoiding competition for light and being able to photosynthesize. The disadvantage is that they must supply the leaves with water over long distances from the ground. However, the trees at zero cost do this transport; each molecule of water that is evapotranspired through the stomata exerts a tensile force on those that are ascending.

Therefore, despite their large size, trees must be very efficient in obtaining and managing the resources they need (water and nutrients) in order to grow and reproduce. This must have been the case since their appearance on Earth, as they have appeared in many plant families and tree forms occur in all vascular plants (mosses, ferns, gymnosperms and angiosperms). Consequently, from a taxonomic as well as a phylogenetic perspective, the tree is an artificial category. However, from an ecological point of view, the tree can be considered a natural entity, as it represents an adaptive strategy of many different taxa to exploit and dominate aboveground habitat [1].

1.2. Why is it that trees can survive for hundreds and thousands of years?

This question appeals to everyone and still does not have a definitive answer. Undoubtedly, long-lived trees have been very lucky in that they have not succumbed to pests, fires, droughts, felling, or other catastrophes [4]. However, this is not all. Trees can become so large and long-lived due to a combination of evolutionary factors and structural adaptations that allow them to grow for many years. Trees grow so large because they grow on top of structures that have already been formed. Year after year, they add new twigs on top of the branches of previous years and new layers of wood (rings) on top of the structures (trunk, branches, and roots) already formed. Unlike, for example, daisies, which each year have to start their biological cycle, grow and develop from the seeds left over from the previous year. In contrast, trees are able to obtain the resources they need from the environment to continue growing and producing seeds for decades, centuries and millennia.

Their longevity is due to several factors. One is the use of building materials, cellulose and lignin, which are very difficult to break down, only some microorganisms (bacteria and fungi) have the enzymatic machinery to break down these molecules. In fact, cellulose and lignin are the two most abundant biopolymers on Earth, storing large amounts of carbon and preventing its release into the atmosphere. These two materials give trees great strength and flexibility. Lignin is the cement (strength) and cellulose is the steel bars (flexibility) [5,6].

Figure 2. Pinus sylvestris sampled in Baza mountais (Andalucía, Spain) in 2003. Strong winds kill part of the tree but the tree is alive, tree age about 300 years

Two, its functional organization is highly compartmentalized; this organization allows the tree to respond differently depending on the part of the tree affected. This organization also allows the tree to have a very effective defense system. Trees, unlike animals, do not regenerate tissue; thus, in the face of wounds and attacks caused by other organisms, the tree implements a set of anatomical and physiological responses to isolate, i.e. compartmentalize, the damage caused and prevent the spread of bacteria and fungi throughout the tree. The simile to understand this defense system is that of a submarine that closes its hatches when it has suffered damage to its structure. The damaged and compartmentalized part is rendered useless but the submarine can continue to sail [7] (Figure 2).

Three, their persistence is also due to the fact that they are able to respond quickly to climatic and environmental changes. First, the response is physiological followed by other mechanisms ranging from stomatal closure in response to drought to the combination of tissues and structures in different parts of the tree [8]. The diversity of responses to climatic change instability is in direct relation to local adaptation and phenotypic plasticity. Phenotypic plasticity is considered nowadays a central topic in ecology and evolution bringing enormous insights into the realized phenotypic variation that shapes species performance, ecological interactions, and selective change [9]. In fact, these phenomena are the basis for the potential adaptation of the species to future climate conditions, which in turn depends on genetic variation, dispersal as well as establishment rates.

However, despite their great plasticity and continuous modular growth, the increase in size and longevity of trees has limitations imposed by stressful ecological conditions and by functional constraints imposed on the vascular system and on the mechanisms involved in the upward movement of water and nutrients from the soil to the leaves at such a huge heights. Koch et al. [2] in their paper "Limits to tree height" estimated that the limit to tree height is about 122-133 m, a height similar to that of some present-day trees and large trees of past geological times.

For many tree species, it has been shown that there is a negative relationship between growth rate and lifespan so trees with large annual (wood) increments live fewer years [10,11]. However, it is interesting to note that even the oldest and largest trees maintain their ability to continue growing, even if only in some parts of their body; this means that cells of the primary (buds) and secondary lateral (cambium and phellogen) meristems continue to divide and form new organs (shoots, leaves, and fruits) and xylem and phloem. In addition, cellular processes associated with aging in animals such as cell death and increased mutations do not occur in trees. Wang et al. [12] found no evidence of aging and cell death in the cambium of *Ginkgo biloba*, a “living fossil” tree. In another study by Lanner and Connor [13] with pollen grains from the bristlecone pine, one of the oldest trees, they found no significant increase in mutation rates with age. Wang et al. [12] show that long-lived trees have evolved compensatory mechanisms to maintain a balance between growth and ageing processes. These include continued cambial divisions, high expression of resistance-associated genes, and continued metabolic capacity to synthesize protective secondary metabolites. Therefore, in this way, trees can be considered immortal through their germ cells and tissues.

Finally, it is worth noting that as trees get older, they benefit enormously from being made up largely of dead wood. In fact, an old tree can have up to 95% dead tissue. Therefore, wood does not require metabolic activity to maintain itself. It does not incur costs, so an old tree does not need to do much to continue living (Issartel and Coiffard 2011).

2. Tracking growth: tree rings

Tree growth, like that of all organisms, is a biological process that involves an increase in size (height, diameter, volume or biomass) over time. Growth is due to the formation, differentiation and expansion of new cells that give rise to tissues and organs. In the case of trees, growth is indeterminate, i.e. they can continue to grow over time, although the relationship between increase in biomass (size) and age is not linear. There are parts of the tree that can be lost, e.g. branches in the lower part of the crown often die and fall off due to lack of light, there is also loss of height due to pests or extreme drought or wind (Figure 2); after very dry years it is normal for the upper part of the trunk to die (pointed trees) as water has not been able to reach the higher parts.

The growth of trees and woody plants in general is due to the activity of primary and secondary meristems, tissues formed by undifferentiated cells capable of dividing and producing new cells. The primary meristems are responsible for height growth by lengthening the trunk and branches; these meristems produce new tissues and organs (flowers and fruits). The

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secondary meristem, which causes growth in thickness by accumulating wood, is the cambium. This is a thin layer of cells under the bark of the trunk, branches and roots. Its activity produces xylem (wood) towards the inside and phloem towards the outside, which eventually becomes part of the bark (Figure 3).

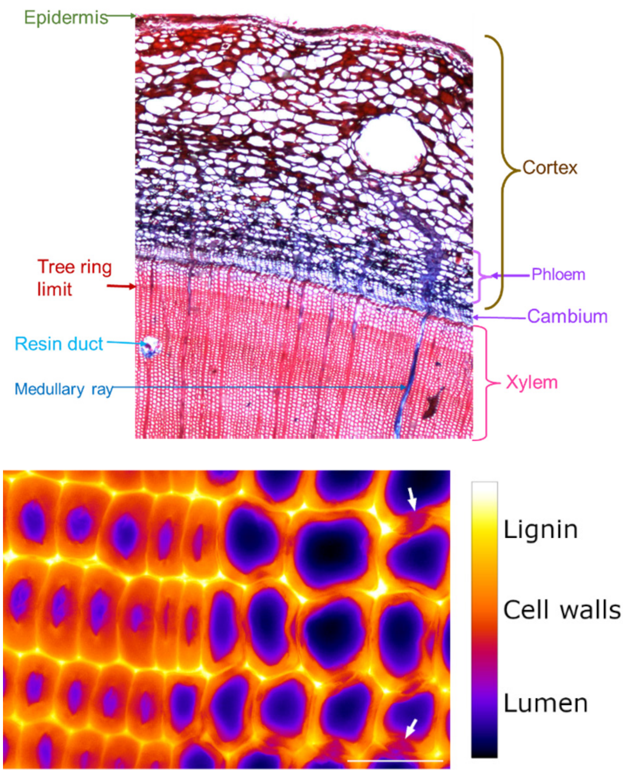

Figure 3. Top) Wood cross section of Pinus halepensis (Garraf, Barcelona, Spain), sampling date end of March 2002. The sample was stained with safranin that stains dead cells reddish and astra blue that stains living cells blue. The xylem (stained red) is made up of tracheids, dead, hollow cells for transporting water. P. halepensis is a gymnosperm and 95% of the wood consists of tracheids. Bottom) Wood cross section of Pinus pinea (riparian forests of the Llobregat Delta). The image shows tracheids of late wood (year t-1) and tracheids of early wood (year t). The differences between the two cell types are striking in terms of lumen and cell wall thickness. The cell walls are composed of cellulose and lignin, with lignin also gluing the tracheids together. Another important feature are the valves (white arrows) that direct the flow of water upwards

Growth is not a continuous process, sooner or later it is stopped by some internal or external factor that limits and interrupts growth, even in tropical trees. Each interruption leaves an imprint. When growth occurs at regular intervals (years), these growth imprints can be identified, the growth increment measured and dated absolutely by assigning each ring to the calendar year in which it was formed. This is the situation in temperate and cold regions (Figure 4). In tropical areas, the annual temperature oscillation is low and the mild climate generally allows for "continuous" growth throughout the year. As a result, most species do not form rings with well-defined boundaries between them, although growth bands are visible in a cross-section of the wood. Annual tree rings are formed in the tropical region if there is an annual seasonality such as trees from tropical dry forest and in the tropical rainforest, which are flooded annually.

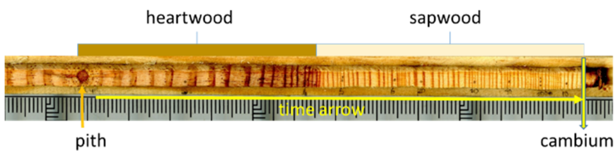

Figure 4. Tree core of Pinus pinea (littoral forests of the Llobregat Delta). The last annual ring dates from 2014, the first ring around the pith from 1925. Each annual ring is made up of two bands, the lighter being the early wood and the darker the late wood. Water is transported to the leaves through the sapwood. The heartwood does not transport water but has important mechanical functions and defense against micro-organisms

Under Mediterranean climate conditions, there are species of temperate and boreal origin, such as many conifers (sessile pine, black pine, fir, etc.) and deciduous trees (oak, beech, ash, elm, etc.), and species of subtropical or tropical origin, some of which are known as typically Mediterranean, such as holm oak and Aleppo pine. All these species alternate in the landscape according to the marked climatic gradients of altitude and latitude.

Under typical Mediterranean climatic conditions, low winter temperatures and lack of water limit tree growth in winter and summer, so that spring and autumn are usually the most favorable periods for growth. This seasonality determines a bimodal (sometimes trimodal) rhythm of cambium activity, which is reflected in the structure of the annual rings, which show intra-annual bands (false rings), making the identification and dating of annual rings difficult (Figures 5 and 6) [14-17].

2.1. Types of annual rings: wood anatomy

Figures 5, and 6 show two very different ring structures. *Pinus halepensis* is a gymnosperm and, like all gymnosperms, the wood is 95% tracheids, so it is a very homogeneous wood. However, we can distinguish two bands within each ring; the lighter band is the earlywood and the darker band is the latewood; the differences are not only in colour, in the earlywood the tracheids are larger, the cell wall is thinner and the cell lumen is larger than in the tracheids that form the latewood.

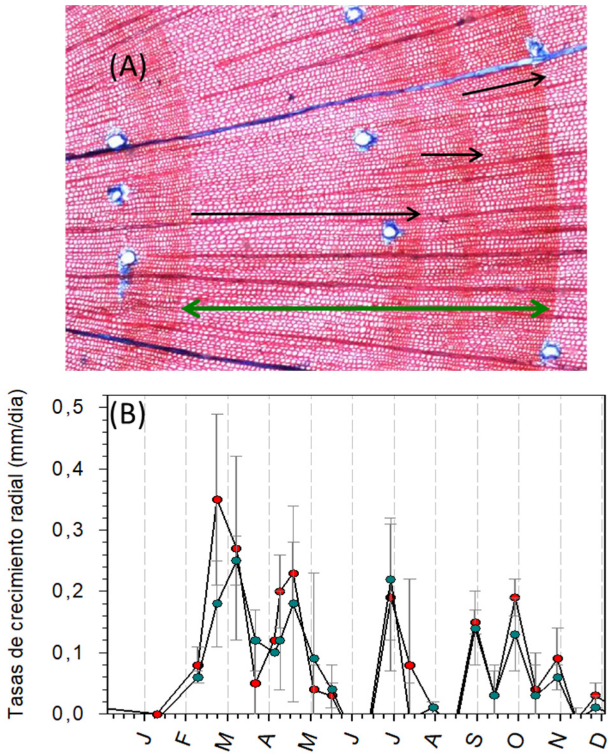

Figure 5. Growth dynamics and ring formation in 2001 of Pinus halepensis (Garraf, Barcelona). (A) Black arrows indicate the three sub rings formed (IADF, intranual density fluctuations) and the double green arrow indicates total xylem growth. (B) Average thickness growth rates (mm/day) of 5 pines located on a north-facing slope (green circles) and 5 trees located on a south-facing slope (red circles)

In contrast, Figure 6 shows the structure of the wood of *Quercus ilex*, an angiosperm species; trees in this group have a greater variety of cellular elements, they have vessels, fibers and fibro-tracheids. The anatomy of Q. ilex wood is semi-diffuse since the size of the vessels gradually decreases from the beginning to the end of the ring. In angiosperms, there are different types of rings depending on the arrangement and size of the vessels. For example, the ring structure of oak and chestnut is porous ring wood because the vessels are very large at the beginning of growth in spring (Figure 7). However, in other species, such as birch, the vessels are of the same size and evenly distributed along the ring [18].

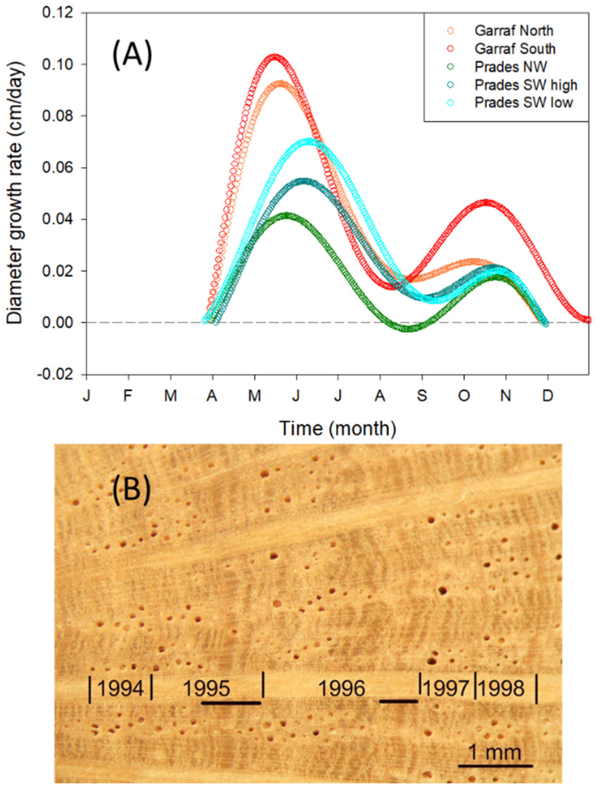

Figure 6. (A) Bimodal dynamics of stem thickness growth in Quercus ilex. Data from 1993-2002, sampling frequency every 20 days. Garraf (Barcelona) and Prades (Tarragona) sites, where Mediterranean climatic conditions prevail. (B) Cross-section of a wood sample showing several rings. Quercus ilex is an angiosperm tree and the wood is formed by vessels (holes in the image), fibers and parenquima

2.2. Why are tree rings a reliable record of tree life?

Tree rings are reliable records of tree life and environmental variation because the activity of the cambium records the passage of time and information about all the factors that have affected the tree's growth. This is because the cambium is very sensitive to the variability of environmental factors, and this sensitivity is reflected in the characteristics of the rings formed.

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Variability in climate, atmospheric composition, physical and chemical characteristics of the soil, water availability, disturbances, etc. modify the rate of formation of new cells, their number, size (e.g. lumen and thickness of cell walls) and the material used to build them (cellulose and lignin), which in turn determine the physical (thickness and density) and chemical (cellulose to lignin ratio, isotopes, heavy metals, etc.) characteristics of the rings.

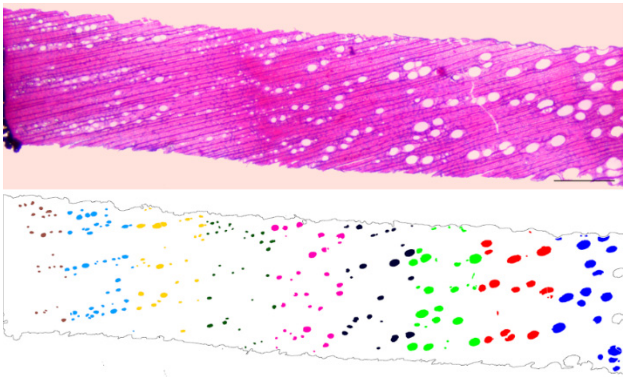

Figure 7. (A) Cross section of an 8-year-old wood sample of Castanea sativa (Montseny, Barcelona) (B) Distribution of vessels along the ring mm by mm. The wood anatomy is a porous ring, the largest vessels are located in the early wood measuring 4 mm. Tree ring of the year 2022

All of these characteristics can be quantified annually and seasonally in latewood and earlywood, ring by ring. From here, time series of different variables can be constructed: series of thickness, lumen and wall thickness of conductive elements (vessels and tracheids), density, isotopes, heavy metals, etc., depending on the research objectives [14,19] (Figure 4, Figure 8).

3. The impact of climate on tree growth

The influence of environmental factors on growth can vary in different ways over time and affect trees differently from place to place. Some factors may vary little and slowly over time, others may vary rapidly and repeat many or few times, and may affect many trees similarly and simultaneously, or they may affect a single tree or a few trees. However, of all the factors, climate is the most important ecological one and is common to all trees in a given region. The inter-annual and intra-annual variability of the climate in that region will affect all trees and will be reflected in a similar way in the ring formed in a given year by all trees living in that region.

This similarity between trees is remarkable when climatic conditions become especially limiting for growth. The rings that form are very narrow, for example, the 2015 and 2020 rings in most *P. pinea* trees in Catalonia (Figure 8). This pattern or sequence of characteristic (narrow) rings is characteristic of a certain period: it is the imprint of the climate that is recognizable despite it is usually mask by other environmental signals that have also affected growth. Moreover, this climatic signature is also the signature of time, since it is very unlikely that a given temporal pattern will repeat the same in another period [14].

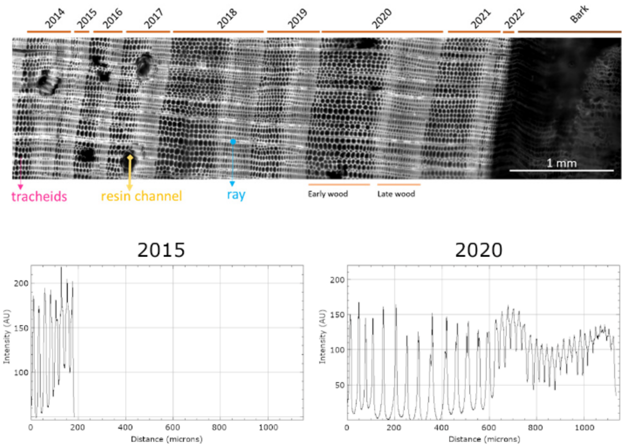

Figure 8. Top) Cross-section of a Pinus pinea stem core (littoral forests of the Llobregat delta, Barcelona). The last annual ring is that of 2022, the first ring in the image is that of 2014. The image clearly shows the boundaries between the rings and their characteristics. The narrowest ring is that of 2015, a very dry year, similar to 2022. The widest ring is that of 2020, a year with abundant rainfall due to the Gloria storm. Bottom). From the image of Figure 8a, grey intensity profiles of the rings of the 2015 (length 0.18 mm) and 2020 (length 1.28 mm). The lowest values correspond to the cell lumen and the highest to the cell walls. In the 2020 ring it is clear that there are two rings, growth stops due to lack of water in summer, but the autumn rains cause the cambium to resume cell divisions and a second false ring is formed. The maximum peaks correspond to the maximum density of the wood. The maximum values (density) of the first false ring is called an intranual density fluctuation

3.1. Climate change effects on tree growth

Climate change is one of the greatest challenges facing society today (IPPC 2013 report). Rapidly rising temperatures, erratic precipitation and an increase in extreme weather events are causing profound changes in the functioning of ecosystems, particularly since the 1980s. Rising temperatures cause changes in plant phenology by lengthening or shifting the growing season, with impacts on ecological systems, terrestrial gross primary productivity and the terrestrial carbon cycle [20].

Altered phenological responses can affect resource acquisition and tree survival. For example, in regions where growth is limited by low temperatures, a longer growing season may lead to increased resource acquisition and growth. In the Mediterranean basin, high temperatures have brought forward the growing season for many species, but summer droughts are also earlier and longer. This increasingly pronounced change in climate regime is leading to a bimodal growth response (Figures 5 and 6). This response is expected given the high plasticity of trees.

Many studies have been published on the plastic responses of plant traits, showing that plants are plastic for a remarkable range of ecologically important traits, ranging from various aspects of morphology and physiology to anatomy, developmental and reproductive timing, breeding system and offspring developmental patterns. For example, changes in physiological processes, seed longevity, phenology, leaf characteristics, etc. in response to elevated CO2 and temperature are well documented [21]. Some of these responses may be adaptive, others not [22].

Greenwood et al. [23] found a consistent global response: background tree mortality increased with drought severity, and there are no significant differences in the magnitude of the response between forest biomes or between angiosperms, gymnosperms, or evergreen and deciduous tree species. However, they also found that trees with denser wood and lower specific leaf area had lower mortality rates. This is a clear example of the value of tree traits in understanding patterns and mechanisms of drought-induced tree mortality. We can dig a little deeper into this result.

Normally, when wood density increases, growth is less (e.g. ring thickness), then this result makes sense, as there is a negative relationship betwenn longevity and growth. At this point, other questions arise about limits of tree traits plasticity to the face of climate change. For example, there must be a negative relationship between cell wall thickness and cell lumen, because the lumen cannot get very large without a proportional increase in wall thickness, otherwise the vascular system would collapse. Similarly, we can ask whether trees change the ratio of cellulose to lignin, since lignin has a negative relationship with growth. In short, many questions remain to be answered in order to determine the constellation of tree characteristics that survive climate change.

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The Young Reporters for the Environment Program: Impact, Methodologies, and Framework in the National and International Context

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Abstract. The Young Reporters for the Environment (YRE) program, coordinated by the Foundation for Environmental Education (FEE), is an initiative aimed at empowering young people from around the world to actively engage in addressing environmental issues, while also promoting scientific education among youth. Through the program, young individuals between the ages of 11 and 25, associated with a school or participating independently, develop skills in scientific research and communication, enabling them to take informed and conscious positions on various environmental topics of interest. The program provides a platform for them to express themselves through journalistic communication on science, in written article, photographic, or video form.

This article will address the international foundations of the YRE program, its methodology and objectives, its impact and reach at the national level, as well as highlighting relevant events and practical outcomes. It will categorize these aspects into various chronicles based on educational cycles, thematic focus, or types of communication. Furthermore, the article will discuss the future perspectives of the program and its alignment within the current educational context.

Thus, this article aims to emphasize the importance of science communication and scientific education for students' success in their academic journey. Additionally, it will present the YRE program, which has played a crucial role in promoting scientific education and nurturing young individuals with skills in science communication.

Keywords. Young Reporters for the Environment (YRE), Scientific Education, Journalistic Communication on Science, Scientific Education, Skills in Science Communication.

1. Introduction

Science is one of the main pillars of human development, responsible for the most significant advancements of our societies including in areas such as health, technology, and environmental protection. However, scientific knowledge often remains confined to experts in specific fields, making it difficult for the general public to access accurate and relevant scientific content. In this context, science communication emerges as a crucial tool to ensure that scientific knowledge is disseminated in a clear and objective manner, enabling citizens to access information that can contribute to informed decision-making and the development of freedom in critical thinking [1].

Practical scientific literacy means possessing a type of scientific and technological know-how that can be immediately applied to improve quality of life, addressing basic human needs such as food or health, as small fragments of scientific and technological information can make a difference in people's lives [2].

Scientific communication should be clear, precise, relevant, and accessible, allowing the public to understand and appreciate science and its contribution to human development [3]. It's a complex and challenging process that involves collaboration among scientists, science communicators, journalists, and other professionals, aiming to produce accurate and accessible scientific information. In order for science communication to be effective, it is imperative that different professionals work together to promote clear and accessible language without compromising the accuracy and relevance of the disseminated content, thereby avoiding the spread of inaccurate and/or incorrect information.

For this purpose, it is important for communicators to have access to reliable sources and receive proper guidance for research and writing of their communications. Additionally, science communication is important to stimulate the interest and participation of young people in science, aligning with the concept of scientific education by ensuring access to accurate and relevant

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scientific information at formative ages. This can contribute to the development of skills and abilities and also the formation of future scientists and professionals in related fields.

In resume, this article aims to present the Youth Reporters for the Environment (YRE) program and highlight its importance in science communication, scientific education of students, and the formation of young individuals with science communication skills. Finally, the article will present the results and impact of the YRE program in shaping young science communicators and improving the quality of teaching and learning in the national context.

2. Scientific education in young people

Science education is a social practice that has been increasingly expanded and developed in what is known as non-formal education settings and through various media channels. There is a consensus regarding the importance and necessity of creating policies and pedagogical strategies that effectively assist in the understanding of scientific knowledge through experiences outside the traditional school environment. However, initiatives focusing on non-formal education and science communication are still limited in scope [4].

Table 1. Comparison between inquiry-based and traditional teaching methods

Characteristics	Inquiry-based	Traditional
Principle Learning Theory	Constructivism	Behaviourism
Student Participation	Active	Passive
Student Involvement in Outcomes	Increased Responsibility	Decreased Responsibility
Student Role	Problem solver	Direction follower
Curriculum Goals	Process oriented	Product oriented
Teachers Role	Guide/facilitator	Director/ transmitter

2.1. Inquiry Based Science Education (IBSE) methodology

The IBSE (Inquiry Based Science Education) methodology is recommended for fostering critical thinking in young individuals. IBSE is a pedagogical approach that emphasizes scientific inquiry, critical thinking, and hands-on active participation of students in the learning process [5]. By adopting the IBSE methodology in the JRA program, students are encouraged to explore scientific questions through experimentation, observation, formulation of questions, and development of evidence-based conclusions. This approach aims to develop scientific skills such as informed decision-making, critical thinking, and intellectual autonomy, contrasting with the traditional teaching model.

2.2. Importance of journalistic communication of science

With the increasing access to social media and unfiltered online sources of information, the ability to critically communicate and interpret information has become an increasingly important skill for society as a whole, but even more so for young individuals. Scientific education in young people ensures access to accurate and relevant scientific information at formative ages, which can contribute to the development of skills and abilities and the formation of future scientists and professionals in related fields. Therefore, journalism plays a crucial role in disseminating accurate and reliable information about important events and current issues in an impartial or selective manner. Thus, news production based on scientific topics must be done with rigour and precision, avoiding the spread of incorrect information or leaving room for misinterpretations of the disseminated subject matter [6].

It is crucial that young people be educated about the importance of accuracy and reliability in journalistic communication. They should have access to reliable sources and learn to interpret information critically to avoid being influenced by false and sensationalist news.

One way to ensure that young people are prepared for journalistic communication is through education. Schools can include education in critical communication skills and journalism in their curricula to teach students how to interpret and produce accurate and reliable information. Teachers can also encourage students to engage in communication activities such as writing articles, blogs, or participating in school newspapers.

This work will help demonstrate the impact of the JRA program has had and can have on future generations within this context, so that they have the necessary skills to interpret critical information and make informed choices, reinforcing the importance of scientific education for young people and accurate and reliable

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journalistic communication, especially on scientific topics [7].

3. Methodology and international and national framework of the JRA program

This program aims to develop young people's knowledge about environmental issues, as well as competencies in communication, citizenship, individual initiative, teamwork, critical analysis, social responsibility, and leadership [7].

The JRA methodology uses a tried and tested four-step approach investigate, propose solutions, report, and disseminate (Figure 1):

I. The first step, investigate. Participants are encouraged to identify, define, and communicate a local environmental problem /issue. They should conduct original research using primary and secondary sources, and interview individuals or key groups to gather firsthand information. It is also important for participants to cover relevant historical, economic, social, and/or political implications and the potential consequences of the problem/issue. Lastly, they should link the local environmental problem and/or issue to the larger global framework [8].

II. The second step, propose solutions. Young reporters are challenged to identify possible solutions to the previously chosen problem, evaluating their likely effectiveness and presenting arguments for and against. They must develop and propose a solution based on facts and interview findings, without including personal opinions from the author.

III. The third step, report. Aims to communicate the local environmental issue and its possible solution through journalistic production. It is important for participants to identify the target audience and choose the best way to reach it, using the appropriate journalistic format and style. They should create a report in the form of an article, photograph, photo report with up to 12 photos, podcast, or video that documents the problem and/or issue related to the environment or sustainable development, whenever possible, suggesting a solution and presenting different perspectives. A positive approach focused on seeking change-inspiring solutions is adopted.

IV. The fourth step, disseminate the results to the local and global audience through various media [8].

Figure 1. YRE's 4-Step Methodology

To participate in the Young Reporters for the Environment (JRA) program, there are different registration options depending on the participant's profile. Two possible options are registration as a school group coordinated by at least one teacher and registration as a JRA Freelancer for young people over 15 years old. Additionally, it is now also possible to participate representing a Scout Group.

In the case of registration as a school group, a coordinating teacher must log in to the JRA portal and proceed with the school's registration. It is necessary to associate the project that will be the subject of investigation and reporting by the participating students. This way, the group will have the support and guidance of the teacher to develop activities related to environmental issues.

As a JRA Freelancer, registration is intended for independent participation of young people over 15 years old, not being affiliated with an educational institution. In this case, it is necessary to register on the JRA portal, indicating the project or theme that will be addressed in the publications. As a JRA Freelancer, it is possible to create and publish articles, photographs, or videos related to the project, as well as participate in national and international contests promoted by JRA [9].

Finally, there is also the possibility of participating representing a Scout Group. To do so, simply register on the JRA portal and specify that you are representing the respective Scout Group.

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4. YRE (Young Reporters of the Environment) - International

The Young Reporters for the Environment (YRE) program, coordinated by the Foundation for Environmental Education (FEE), is an initiative that aims to empower young people from around the world to actively engage in addressing environmental issues. Through the program, young people between the ages of 11 and 25 are equipped to take a conscious stance on environmental issues of their interest, providing them with a platform to express themselves through writing, photography, or video.

The implementation of YRE is carried out by National Operators in over 40 countries worldwide. Young people can join the program through their schools, youth groups, or individually by contacting the relevant National Operator. Depending on the country, National Operators organize workshops and events for YRE students, as well as national YRE competitions [10].

The international coordination of the FEE program is based in Denmark. This coordination organizes the annual International YRE Competition, develops opportunities for its YRE students, and sends YRE students to high-level conferences such as the Conference of the Parties (COP) and World Environmental Education Congress (WEEC). It also coordinates a range of partnerships and projects, including the highly recognized Litter Less Campaign conducted through YRE and Eco-Schools.

The mission of YRE is to empower young people to develop tools to have their voice heard on environmental issues in their region that they feel are not adequately addressed and reported on in the form of news, reporting, photography, etc. This approach creates a purpose for applying their knowledge in the dissemination of information. Additionally, the YRE program helps participants develop skills and acquire knowledge that will be useful throughout their lives, such as communication skills, individual initiative, teamwork, critical analysis, social responsibility, and leadership skills.

The program also aims to unite young people from all backgrounds with a sense of common purpose and encourages them to become environmental leaders in their communities. Every year, a competition is held to encourage young people from around the world to investigate and address a story that can clearly and succinctly explain an issue related to local, current, and real environmental development. Through all this work, YRE helps create a generation of environmentally committed leaders dedicated to sustainable development, with communication and critical competence.

In 2012-22, 22,763 works were selected and submitted by the 43 national operators, involving 336,263 students, 27,946 teachers, and reaching 4,907,374 people [10].

5. YRE - Portugal

As mentioned earlier, the Young Reporters for the Environment (YRE) program is an international program by the Foundation for Environmental Education, implemented in Portugal by the Association *Bandeira Azul da Europa* (ABAE). Its main objective is to contribute to the training of active and participatory citizenship, with a focus on environmental journalism. Through interviews, surveys, and other journalistic techniques, young people investigate and interpret relevant environmental and sustainability issues at the local level, developing skills in the areas of environment, foreign languages, new technologies, communication, citizenship, individual initiative, teamwork, critical analysis, social responsibility, and leadership.

The program begins with a local project in which young people investigate, report, and communicate through various media channels, including newspapers and the internet. Schools and young people in the YRE network have the opportunity to participate in various challenges, competitions, and activities, such as multi-day missions, as well as exchange opportunities with young people from other regions of Portugal and other countries within the international YRE network.

6. Goals of the program

In this chapter, we will briefly and specifically address the main objectives of the YRE program. The YRE program aims to educate for sustainability by encouraging the development of local projects that identify, investigate, and propose solutions to sustainability-related

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issues or environmental problems. It also focuses on developing skills in the areas of communication, journalism, exchange, and citizenship.

The program goal is to contribute to the development of active and participatory citizenship, with focus on environmental journalism. Young people involved in the program investigate and interpret relevant environmental and sustainability issues at the local level, using journalistic techniques such as interviews and surveys to deepen their knowledge in the areas of environment, foreign languages, and communication technologies. Furthermore, the YRE program aims to develop skills in citizenship, individual initiative, teamwork, critical analysis, social responsibility, and leadership.

The program begins with the implementation of a local project in which young people investigate, report, and communicate their findings through newspapers, the internet, and other media channels. ABAE also organizes field activities and training for the network of enrolled teachers and students, such as national YRE seminars and missions, as well as competitions and applications for international missions.

7. Participation of Portuguese Schools in the YRE program: Results of the School year 2021-22

The current chapter presents the results achieved by the YRE program in the academic year 2021-22, focusing on school participation, reporting modalities, topics addressed, and geographical distribution of activities. In the mentioned academic year, the YRE program had the participation of approximately 85 schools in Portugal, covering different levels of education, from the 2nd cycle to higher education (Figure 2).

In terms of geography, the municipalities of Lisbon, Braga, and Porto stood out as the locations with the highest number of reports produced by the *Jovens Reporters para o Ambiente* (JRA/YRE), according to the ABAE's activity report for the 2021-22 school year.

The presented results highlight the significant participation of schools, teachers, freelancers, and students in the *Jovens Reporters para o Ambiente* program in Portugal during the 2021-22 academic year. The chosen reporting modalities, the addressed topics (Figure 3), and the geographic distribution of activities reflect the young reporters' interest and commitment to current and relevant environmental issues.

The scientific communication promoted by JRA contributes to disseminating knowledge about the environment and raising awareness in society about the importance of environmental protection and sustainability (Report on the Activity of the Mobility Teachers Network 2023) [11].

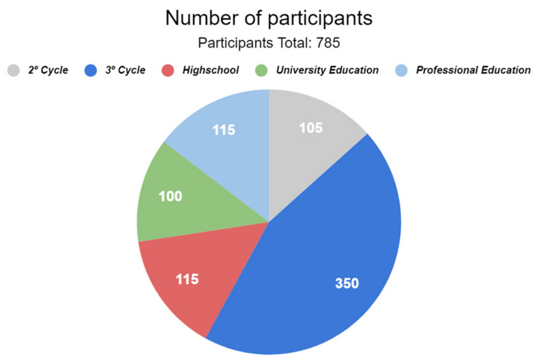

Figure 2. Work submissions by school cycle

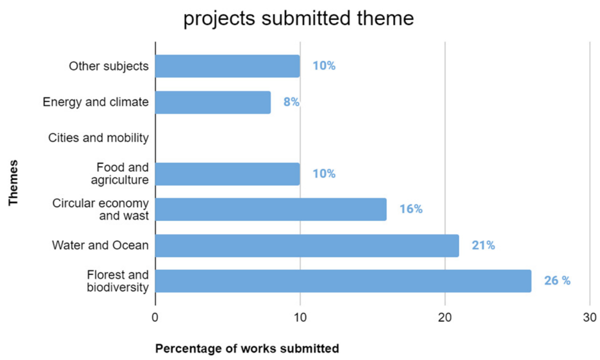

Figure 3. Work submissions by school cycle

8. Training within the scope of the JRA program

8.1. Mission Web Summit 2021

A *Missão* Web Summit, which took place from November 1st to 4th, 2021, targeted young people between the ages of 18 and 25. Students who were proficient in English and familiar with the *Jovens Repórteres para o Ambiente* (JRA) methodology were selected and were required to be available before, during, and after the event to conduct research on the speakers and

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produce reports. In this context, in partnership with Web Summit, the *Escola Superior de Tecnologia da Saúde de Lisboa* (ESTeSL), and Hyundai, four young individuals participated in this international event as accredited journalists.

The objectives of the Web Summit Mission were to develop skills in research, information gathering and processing, and communication among young people, within the framework of the *Jovens Repórteres para o Ambiente* program, to an excellent level. During the event, the young journalists had the opportunity to attend various talks, press conferences, and interview renowned participants. As a result, they produced 12 journalistic reports, including six articles and six video reports.

The Web Summit event is one of the world's largest technology summits, attracting thousands of attendees, speakers, and startups from various countries. The evaluation of the Web Summit Mission was very positive and impactful for the participating young reporters, as they had the opportunity to gain journalistic experience and produce content about an internationally significant event.

8.2. National JRA/YRE Seminar 2021

The National JRA Seminar, held in Braga on November 26th and 27th, 2021, targeted students and teachers from different levels of education who aspire to become *Jovens Repórteres para o Ambiente* (Young Reporters for the Environment). The event focused on providing training for students and teachers, with a total duration of 14 hours divided into 10 hours on the first day and 4 hours on the second day.

The main objectives of the seminar were to bring together students and coordinating teachers of the JRA Project, encourage communication (Figure 4), facilitate the sharing of common goals and experiences, implement the JRA project methodology through workshops based on a case study investigation, and develop articles for online publication. Additionally, the event aimed to discuss strategies and methodologies of the JRA project, with a special emphasis on research, journalism and the internet, photography, and multimedia. It also aimed to recognize and award the best reports of the year 2021.

In total, the event gathered 150 participants, including teachers from different levels of education such as, lower secondary school (2nd and 3rd cycle), upper secondary school, universities, polytechnics, and vocational education. Furthermore, other professionals with a multiplier effect, such as after-school activity monitors, employees of entities involved in the promotion of Environmental Education, and environmental technicians, were also present, totalling 15 participants. The event also had 40 participants whose category was not specified (Figure 5).

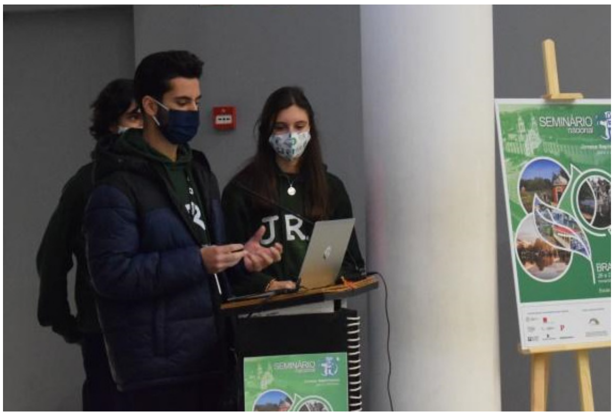

Figure 4. JRA communication presentations during the 2021 National Seminar

Figure 5. Representatives of entities involved in the promotion of Environmental Education

The event's website provided detailed information about the National JRA Seminar, as well as news and evaluation results of the event. During the seminar, over 80 young people and teachers from different regions of the country had the opportunity to explore and report on various aspects of sustainability in Braga, resulting in the production of 17 reports.

The event provided an important opportunity for students and teachers involved in the JRA Project to share knowledge, experiences, and contribute to the promotion of Environmental Education/Science through journalism and research

8.3. Webinars

Webinars as a training tool for the Young Reporters for the Environment (JRA) project have become a popular way to offer online training in various areas, such as environmental education, communication, and journalism techniques. Within the scope of the JRA project, a series of webinars was conducted with the aim of equipping students and teachers interested in participating in the project as Young Reporters for the Environment. In this chapter, the details of the conducted webinars will be discussed, including dates, target audience, format, objectives, partners, and the number of participants.

A total of four webinars were held on the following dates: October 28th and November 17th, 2021, January 17th and 18th, and February 23rd, 2022. They targeted students and teachers from various educational levels who were interested in becoming Young Reporters for the Environment.

The webinars were conducted in an online training format, allowing participants to access the content from anywhere with internet access. Each session had a duration of 1 hour and 30 minutes, totalling 6 hours of training across the four webinars. The primary objective of these webinars was to provide online training for students and teachers interested in participating in the JRA project. The main goals were to encourage project communication, facilitate the sharing of common objectives, and exchange experiences among participants. Additionally, the webinars aimed to implement the methodology inherent to the JRA project through workshops based on the investigation of a case study. Strategies and methodologies of the JRA project were also addressed, with a particular emphasis on research, journalism and the internet, photography, and multimedia aspects.

The webinars were conducted in partnership with the Politécnico de Lisboa, ESTeSL, Jornal Observador, Jornal Público, Escola Secundária São Pedro do Sul (ESSPS), and Gerador. These partnerships provided a diversified and knowledge-rich approach for the participants of the webinars.

A total of 200 participants, including students and teachers interested in joining the JRA initiative, took part in the webinars. The participants came from different educational levels, including preschool education, 1st cycle of basic education, 2nd cycle of basic education, 3rd cycle of basic education, secondary education, universities and polytechnics, and vocational education. Additionally, other professionals with a multiplier effect, such as ATL monitors, employees of entities involved in the promotion of environmental education, environmental technicians, among others, also participated in the webinars [11].

8.4. *Ex-situ* Conservation Mission

The *Ex-situ* Conservation Mission took place from April 8th to 10th, 2022, as part of the JRA Program aimed at students aged 15 to 25 interested in environmental research and communication. The mission was carried out in partnership with the *Junta de Freguesia de Benfica*, the Lisbon Zoo, and Hyundai, and involved the participation of 17 young reporters. Over the course of 24 hours, the participants had the opportunity to develop skills in various areas such as research, writing, photography, video, teamwork, journalism, and communication, while investigating best practices related to sustainable development and the importance of zoos in biodiversity preservation.

During the *Ex-situ* Conservation Mission, the participants conducted fieldwork, interviews, group work, and ultimately presented their reports. The main focus of their investigations was the role of the zoo in *ex-situ* conservation, which refers to the conservation of species outside their natural habitat. They also explored the environmental enrichment efforts undertaken by the zoo in recent years and their success stories.

The participants were divided into teams and had the opportunity to interview experts and zoo staff, as well as make observations and gather information on-site. They investigated the different species present in the zoo, the conservation measures implemented, captive breeding programs, and the reintroduction of species into the wild. In addition, the young reporters learned about the challenges faced in ex-situ conservation and the proposed solutions, such as environmental education, scientific research, and public awareness [11].

The participants also had the opportunity to learn about other best practices related to sustainable development, such as waste management, energy efficiency, and biodiversity conservation education. They highlighted the importance of zoos in conserving endangered species, raising public awareness about the importance of biodiversity, and promoting environmental education. The young reporters also emphasized the need for more ex-situ conservation actions to protect endangered species and contribute to biodiversity preservation.

The results of their investigations were presented in different formats, including written articles, photo reports, and videos. The participants demonstrated communication, writing, photography, and video editing skills, as well as the ability to work as a team and meet deadlines. The reports addressed relevant issues related to *ex-situ* conservation, highlighting the successful measures implemented by the Lisbon Zoo and the knowledge gained.

8.5. Rock in Rio Mission 2022

The Rock in Rio Mission, held on June 16th, 17th, 18th, 19th, and 20th, 2022, was an initiative promoted by the JRA Program aimed at students between the ages of 15 and 25, with the goal of addressing sustainability concerns associated with the organization and participants of a music festival. The mission was conducted in a journalistic format, and participants had the opportunity to apply the program's methodology, involving environmental research and communication, as well as develop various skills such as research, writing, teamwork, and English proficiency. The Rock in Rio Mission was carried out in partnership with Rock in Rio Lisbon, Colégio Valsassina, and Hyundai, and involved a total of 20 participants from different educational levels.

The Rock in Rio Mission had a total duration of 34 hours, spread over the four days of the festival, with different activities planned for each day. On the first day, participants had 10 hours of work, which included field research activities, interviews with festival organizers and participants, and group work to identify the main sustainability concerns related to the event. On the second and third days, participants also had 10 hours of work each, with similar activities but focusing on researching sustainable development best practices associated with the festival. On the fourth day, with a reduced workload of 4 hours, participants had the opportunity to finalize their work and prepare the reports that would be presented at the end of the mission.

Throughout the four days of intense work, the 20 participants of the Rock in Rio Mission produced a total of 27 report works, including 12 articles, 10 photo reports, and 5 videos. The reports covered a wide range of sustainability issues, such as waste management, natural resource consumption, sustainable mobility, circular economy promotion, environmental education, and raising awareness among festival participants about the importance of sustainability. The reports were presented in digital format, through the event's website and the social media channels of the JRA Program, reaching a wide audience interested in environmental and sustainability issues [11].

The Rock in Rio Mission provided participants with a unique opportunity to experience environmental journalism in practice, applying the methodology of the JRA Program in a real and current context, such as a large-scale music festival. Participants were able to develop different skills, such as research, writing, teamwork, and communication, and had the opportunity to interact with other young people from different regions of Portugal, promoting exchange and the sharing of experiences (Figure 6).

Figure 6. JRA working as a team to create reports

9. Impact of the program

The main impact of the Young Reporters for the Environment (JRA) Program is to give young people a voice for sustainability, and it is realized through the development of skills in students, particularly in terms of communication, autonomy, teamwork, and research (JRA 2023). Based on the results obtained from the Young Reporters for the Environment (JRA) program and the Young Reporters for the Environment International (YRE) program, it can be stated that initiatives that promote autonomy and stimulate collective creativity are fundamental for the development of cultural and social changes. These programs provide an environment free from rigid curriculum content, allowing teachers to promote activities focused on reflective science teaching and its applicability in society [12].

Within these programs, the scientific spirit of investigation and communication is introduced to be combined with the knowledge acquired in school. Students are encouraged to investigate, search for sources and information, and present them officially to the school community and the Association for Environmental Education (ABAE), using active learning methodologies such as Problem-Based Learning (PBL) or Inquiry-Based Science Education (IBSE) [4]. This requires students to respect guidelines, support everything presented, work in teams, and adhere to a schedule. Furthermore, the need to justify a report or work leads students to promote critical reflection on everything they read and to listen to and debate all sides of the issues under study.

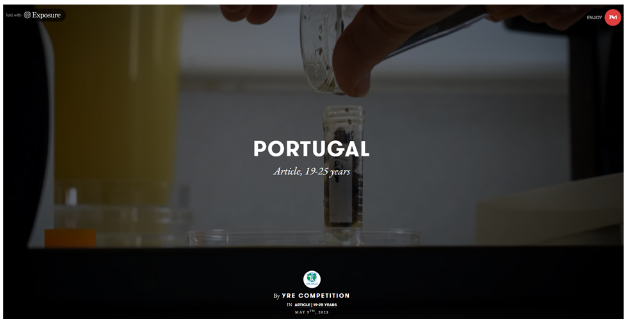

Figure 7. Article on environmental DNA selected for the international YRE Competition

An important aspect is the national and international competition present in the project, with international collaborations carried out by the students themselves. This competition encourages students to showcase the quality of their reports, representing and valuing their own work before the school and the jury (Figure 7). Learning becomes a metacognitive experience when students are encouraged to develop clear intentionality in their actions, becoming reflective in the planning, execution, and evaluation of activities [13].

Being an investigative activity, the use of PBL or IBSE throughout the process of carrying out the activities adds meaning to the concepts addressed, as well as providing a clear representation of them. This allows students to acquire critical and reflective skills, providing the necessary means for mobilizing thinking and facilitating the dynamics of constructing their own knowledge. Additionally, the self-reflection stimulated by the programs is promising in promoting self-esteem, enabling students to develop assumptions and seek to support them, thus promoting the construction of knowledge and skills in a comprehensive manner [5].

Programs like JRA and YRE can be instrumental in promoting science communication in schools. These programs provide an environment free from rigid curriculum content, encourage collective creativity and the scientific spirit of investigation and communication, as well as fostering critical reflection and self-reflection. The results obtained from JRA and YRE are significant for the development of critical and reflective skills in students, providing the necessary means for mobilizing thinking and facilitating the dynamics of constructing their own knowledge.

The use of active learning methodologies such as PBL and IBSE throughout the process of carrying out the activities adds meaning to the concepts addressed and provides a clear representation of them. This allows students to acquire critical and reflective skills, providing the necessary means for mobilizing thinking and facilitating the dynamics of constructing their own knowledge. Additionally, the self-reflection stimulated by the programs is promising in promoting self-esteem, enabling students to develop assumptions and seek to support them, thus promoting the construction of knowledge and skills in a comprehensive and observation-supported manner.

The Young Reporters for the Environment Program and the Young Reporters for the Environment International Program have a significant impact on the development of scientific and social skills in students, promoting science communication in schools, and encouraging collective creativity and the scientific spirit of investigation and communication.

10. Conclusion

It is recognized that science and communication are critical development factors. Depending on the attitude and behaviour of each individual it may allow to reach the highest standards of personal achievement while simultaneously contributing to the development of the societies they are part of. Following the reasoning of how science and the communication of the knowledge generated by it can transform human lives, it must be taken into account that science also has a role in promoting reflection on how its achievements are impacting society [14].

Therefore, science education in schools, through its curriculum, can develop knowledge, techniques, attitudes, and values that allow students to interpret, understand, and act in a scientifically informed manner about the physical and social reality that surrounds them.

The implementation of the JRA and YRE programs in schools has allowed for student engagement and mobilization to investigate, think, and create something scientifically supported and communicable. It has been observed that collaborative construction is interconnected with other areas of knowledge, and that mental structuring and verbalization are processes that trigger valid metacognitive processes. The use of active learning methodologies, such as PBL and IBSE, contributes to the acquisition of critical and reflective skills and to the construction of one's own knowledge in a comprehensive manner, supported by the observation and verbalization of their investigations. The development of reports has allowed for the development of skills in presenting ideas, defending and arguing, as well as adopting the most appropriate strategies for specific tasks, which are relevant for the construction of logical and scientific reasoning.

The implementation of this program has revealed great advantages for the intellectual development of students, resulting in a clear improvement in logical and scientific reasoning processes, the construction of mentally consistent connections, and the validation of knowledge by the students themselves, contributing to the success of the teaching-learning task. The research, construction, and dissemination of reports based on scientific processes confer positive competencies, and the use of science and communication enhances mental connectivity [15]. The transposition of scientific concepts to a situation of investigation and communication provides lasting knowledge that is firmly rooted in scientific understanding, empowering students with the concrete ability to create, understand, criticize and communicate everyday situations.

11. Acknowledgements

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The Volcano of La Palma. A Retrospective Look

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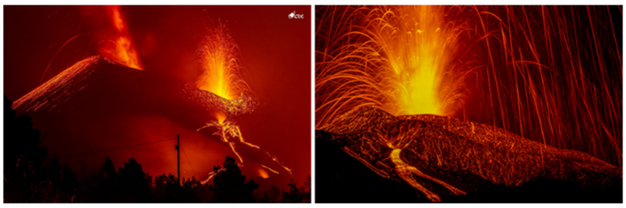
Abstract. On Sunday, September 19th 2021 at 14:12 hours (UTC) a new volcano erupted in the Cumbre Vieja Natural Park on the island of La Palma in the Canary Islands. For days, even weeks and years, the seismic activity that was detected there did not bode well. In fact, since 2017 a number of seismic swarms had indicated that something was happening in the depths of the island and the process concluded with the longest volcanic eruption in its history that officially lasted 85 days and 18 hours and ended on 25th December, just on Christmas Day. After visiting the island three times, one during the eruption and two more after it was completed, the information offered in this article was collected.

Keywords. Volcano, Canary Islands, Eruptive Process, Social Effects.

1. Introduction

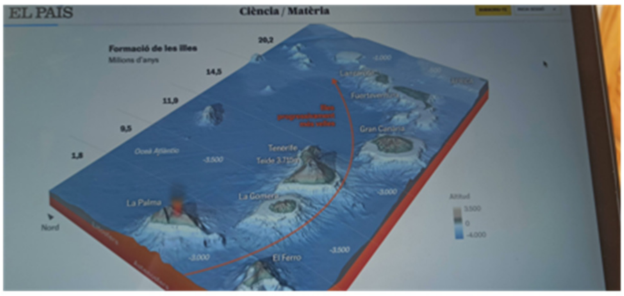
On Sunday, September 19th 2021 at 14:12 hours (UTC) a new volcano erupted in the Cumbre Vieja Natural Park on the island of La Palma in the Canary Islands. For days, even weeks and years, the seismic activity that was detected there did not bode well. In fact, since 2017 a number of seismic swarms had indicated that something was happening in the depths of the island and the process concluded with the longest volcanic eruption in its history that officially lasted 85 days and 18 hours and ended on 25th December, on Christmas Day.



After visiting the island 3 times, one during the eruption and two more after it was completed, the information offered in this article was collected, which has been elaborated in 4 hands, those of the tour guide of La Palma Néstor and those of the author, Dolors, a chemist. Several impacts of the volcanic eruption hit the valley's population.

2. Volcanic origin of the Canary Islands

All the Canary Islands are of volcanic origin. The Earth's crust in that area is very thin and shifts northwards by the magma currents below and just overlies a fixed hot spot in the Earth's mantle, an area that accumulates magma from the Earth's interior. Along with the movements caused by the faults of the area, the magma passes through the Earth's crust and gives rise to a new volcano that first grows under the sea, but can reach the surface and form an island.



As the Canary crust continues to slide northward, the islands formed about 20 million years ago (Lanzarote and Fuerteventura, already heavily eroded and flat, will disappear in the very distant future) have already separated from the hotspot. Ten million years later approximately, Gran Canaria, Tenerife and La Gomera formed and, about 2 million years ago, younger islands began to form: La Palma and El Hierro. Below the sea, new islands (such as Tagoro Volcano, in the volcanic building of El Hierro Island, whose volcanic cone was only 80 m from the surface, can be done in future eruptions. These new islands called "children" of the earlier ones that accompany the first missing Canary Islands, the "grandmothers" islands underwater.

In the case of the island of La Palma, for 540 years eight historical eruptions have been

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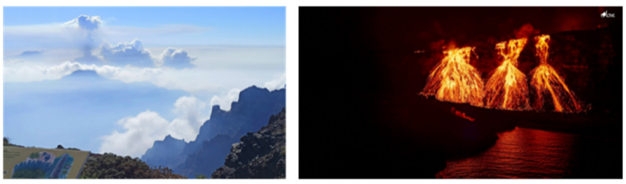
documented that have affected both the structure of the island and the populations, agriculture, pastures, apiculture, ... But they have also contributed to the formation of the landscape. Just as the 50th anniversary of the eruption of the last volcano, Teneguía, was celebrated, the new volcano in Cumbre Vieja, in the middle of La Palma Island, the Tajogaite volcano (a name of Benehoarite origin, aboriginal population of the island) erupted.

3. Eruptive process

The internal structure of the Tajogaite volcano is strombolian, like those of Hawai, and is determined by two fissures that affect more than half a kilometre in length, but at some point simultaneous episodes of possible volcanic eruption types occurred: strombolian (combine explosive phase with periods of calm), Hawaiian (non-explosive resulting in very fluid lava flows), phreatomagmatic (by contact with groundwater), and Vulcanian (explosive). At some point similar to a Plinian eruption by the large gas and pyroclastic generated column reached more than 4 km high. Despite being considered a medium-to-low-category volcano, it led to very spectacular and high-powered eruptions that ejected a large volume of gases in columns up to about 6 km high and 50000 tones some day and twelve lava flows of different features (fluid or viscous) overlapping each other, widening and filling the terrain waves as they progressed to some point more than 60 m thick.

Lava is a material that initially reaches a high temperature, but once on the outside, its surface cools rapidly. It then forms a rough, irregular, large-scale coastal malpais (badland) which, in the case of La Palma, was greater than 1200 ha and with almost 215 million m^3 of volume. The floods buried localities, the first lava arrived on the first day of the eruption at El Frontón, Alcalá and El Paraíso and later others, such as El Paraíso, Todoque and Los Campitos. Half of the urban center of La Laguna was buried and some houses burned and even the lava passed over the gas station, whose deposits had been previously cleared.

The industrial estate of the Callejón de La Gata disappeared under the lava, with the consequent destruction of jobs. Typical architecture of the island is one-story painted earth houses that are scattered throughout the territory and surrounded by fields or crops of banana and avocado trees, ... Because of the idiosyncrasy of the island and the family tradition, a land initially owned by grandparents or grandmothers, has been spread among members of a family over time and thus we find houses of grandparents, sons, daughters, uncles, cousins, ..., grouped in a certain area, so those who were on the colada's trajectory disappeared all and so entire families lost their house.



In Las Manchas cemetery, just in the days of All Saints, a metre of volcanic ash or sand had

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been accumulated, one of the pyroclastic materials launching the volcano, the particles of which may be up to 2 mm in diameter and may be removed in the future. As they are not heavy, the wind spread them and about 10 million m^3 of ash covered more than 7000 ha. Around the volcanic cone there are other larger mineral particles, up to 6.4 mm. It is the lapilli or *granzón* as known on the island. And the third type of pyroclastic material on the volcano, the largest particles are volcanic bombs that can reach dimensions of even over half a metre. Because of their weight they go out very vertically from the cone (with very little inclination angle), they fall very close to the volcano.

Days later, lava flows entered Las Manchas Cemetery. When cooled, it formed a hard basalt rock. This lava is not known if it can be removed. Fortunately, the structure of the cemetery withstood pressure. The lava buried more than 2888 villas (permanent or holiday tourism), more than 70 km of roads and 10 km of streets. And other public buildings (schools, medical consultants, places), and private buildings for economic use (such us bars, restaurants, supermarkets, workshops, rental car) were affected. As you can see, urban impact was critical.

As in Teneguia, "the friendly volcano" as they called it because of the little impact it produced (it came very close to the sea and only destroyed two houses, although it caused the death of one person by gas inhalation), the eruption of the Tajogaite attracted the attention of people who gathered to observe it from safe viewpoints such as that of the Tajuya Church, El Time, the Roque de los Muchachos Astronomical Observatory, even from the neighbouring island of Tenerife. But sadly in this eruption, among the public were those who owned homes, farm estates and other buildings that, to their great sorrow, saw the lava bury them. This wasn't a friendly volcano. It was "the *diablo*" or "the *bicho*" as people refer to the island. In late September the type of eruption changed and the volcano entered an episode of Hawaiian lavas. The lava emerged at a high temperature (at some point it reached 1140 °C), advanced at a high speed and melted everything in its path. It could travel 700 m in just one hour and passed over previously consolidated colades.

The unstoppable advance of the drops brought the lava to the sea where it precipitated through the cliffs on 29th September and formed two *fajanes*, low islands or lavique platforms, which are the surfaces gained to the sea by lava (over 40 ha), one of which left the Playa de los Guirres, frequented by surfers, unusable. At night, the contrast of light and darkness was impressive. But by day, the desolation of the enormous lava layer formed on the island and the production of large amounts of steam at the point of contact of the lava with the sea was seen to produce toxic gases and forced the lockdown of the nearest population, Tazacorte. Fortunately, only water vapor was produced. Within a few months, new small black sand beaches began to form with the ash of the new volcano. The marine fauna and flora were also affected because seawater temperatures rose to 51 C.

Fortunately, months later they were recovering. The seabed is now regaining its normal appearance. The fisheries sector also suffered consequences. As an eruption in an urban area, this volcano has been controlled by several state and international scientific bodies and also by population protection organizations and was closely monitored by the media during the months of the eruption.

4. Social effects of the volcano

The area of the affected island of La Palma has been El Valle de Aridane. Although previous eruptions, the island is now much more inhabited, especially in this area that has a better climate and attracts tourism, also that of European origin (Germany, Great Britain, Denmark, etc.) and the houses that had been built have also been affected.

This time they had been warned that the area was at risk of volcanoes and had them secured. Of the 32,000 inhabitants of the valley, about 7000 (one in five) were affected to some extent by the eruption. When the volcano exploded, the volcanic traffic light was yellow and suddenly passed to red. The population wondered why they didn't warn with the orange light. The administration's response was to "not alarm the population". The scientific community had been warning the administrations of the eruption's imminence for days, but they did not change the color. The color green indicates doing normal activities. The color yellow is pre-alert, and indicates low danger and can be made to live normal. The color yellow of alert is a pre-warning

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condition due to volcanic anomalies which indicate a possible pre-eruptive period, may involve personal self-evacuation and require attention to be paid to official communications. The orange color is the maximum alert, an emergency phase, and means that it is already in a pre-emptive phase and can begin evacuation at any time. Finally, when the traffic lights are in the red, it indicates an emergency and the eruption has already started, the immediate, urgent and compulsory evacuation of the affected population is taking place, and it will have to cooperate with the authorities. The color orange has never applied during this volcanic crisis because the administrations feared the reverse response of the evacuated population if there was not an eruption at all.

So at first, only the neighborhood of the area where the eruption was predicted was notified at neighborhood meetings about how to act in case of danger and only persons with reduced mobility were evacuated. The site of the eruption was predicted in Jedey because the land had inflated about 20 cm (according to measurements of the instruments installed on the island and also of the satellite Copernicus). But the magma found another path, possibly an old lavic tube from the nearby volcano of San Juan and the volcano erupted further up from Las Manchas in El Paso municipality, about a mile or two from the predicted point. On 19th September, with the volcanic emergency light in yellow, as it normally was, people were carrying the normal life of a Sunday. Somebody had gone hunting, or to work the land, on excursion around the island, cooking lunch, etc. The eruption left them away from home, without documentation, belongings or animals (who were killed or injured) and had to be housed in hotels, family homes or friendships, in some cases having to leave to other islands with relatives or friends. Some people decided to leave the island once and for all, an exodus that is not officially quantified at present -one and a half years after the eruption was completed. They later organized themselves, the best they could, to overcome the chaos that prevailed in crisis management in the early days because, incredibly, on a volcanic island they did not had any protocols to follow. Access was punctually allowed to the villas to which the lava had not yet arrived to take belongings and souvenirs with the help of firefighters or anybody with a suitable means of transport.

A sports pavilion was set up to classify and distribute the donations that came from all over in a huge show of solidarity that the people of the valley do not know how to thank. But the economic management that was made of the official aid that arrived is highly questioned by the population. At first, the money was distributed to anyone who said it was affected, without planning the distribution or prioritising the most serious cases, such as those who had lost their houses. But not all the promised aid arrived. The assessment of the management of the volcanic emergency by the population, according to a Google form by the author, is positive in relation to the municipalities, but negative in terms of the management of the Cabildo de la Palma, the Government of the Canaries, the Spanish Government and the European Union.

On the other hand, teaching activity (just in the middle of the COVID pandemic) was affected by the presence of gases or directly because lava arrived in one of the schools. The school of Todoque and Los Campitos and the classrooms of the La Laguna school disappeared. At Puerto Naos they could not access due to the presence of gases. The boys and girls were relocated to take classes at the House of Retamar culture and Princesa Acerina College of Los Llanos de Aridane. For 85 days, the population lived surrounded by the volcano's roar, noises and movements of the magma below from the earth’s crust even hearing the underground noises from the nearby Tenerife Island.

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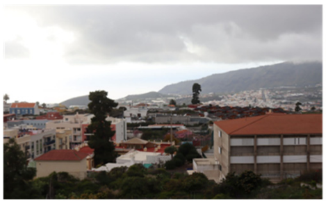
The continuous explosions, the openings of new craters, the gases they had to breathe, the smells, the continued fall of pyroclasts, the earthquakes, the lava, the dogs' barks and the cock's song that predicted what was coming, ... It was a great deal of negligence and uncertainty that tested the strength of those living in a strong stress situation and caused them a strong emotional and psychological impact that will be difficult to overcome. Volcanic ash or sand are formed by particles of many hard and abrasive sizes. They fell on people like a constant black rain for almost three months. Heavier particles were deposited more quickly on the ground, covering the white lines of street traffic signs with the danger that this entailed with reduced visibility to a scarce metre, and ripples such as those of the beach sand were created that affected the dampers and windscreens of cars that were circulating blindly.

Moreover, finer ash particles that stayed longer suspended in the air also affected. They literally obstructed masks and prevented breathing, and when ash entered their mouths when speaking they rubbed with their teeth. The umbrellas, protective goggles and long sleeve and long pants were common elements of the clothing of the few people who were seen in the street. The ash is one of the most difficult and scary elements to forget by the people of the valley.

In a first attempt to resettle the population that had been left homeless, in November 2022, the first wooden houses were delivered to the municipality of El Paso and metal containers to Los Llanos de Aridane for affected people, containers that, both because of the very visible and unobtrusive location and the living conditions installed in full sun, are qualified by the population as "the ghettos".



To this day (June 2023) there are still people who are still in exclusion zones who have not been able to return home due to ash or lava accumulation and in the population centres of Puerto Naos and La Bombilla, due to the presence of toxic gases, specifically accumulation of CO_2, which represent a severe danger to life. On 2nd January 2023, the High Court of Justice of the Canary Islands, the TSJC, certified that a person's death in November 21 was caused by inhalation of toxic gases, and not by an accident while cleaning up the ash from his house roof as was initially said. Studies are being carried out in population groups in the valley to determine the effects of the volcanic episode on the health of the people affected, both by the gases, the ash and the emotional impact with the final consequences that this has had on the population.

5. The cultivation of bananas in La Palma

For The lava affected an important banana surface between the municipalities Los Llanos de Aridane and Tazacorte. This is the best banana zone in the Canary Islands as it has the highest number of sunshine hours throughout the year, an aspect that notably favors banana cultivation, accounting for 60% of the island's economy's GDP. The ash drop on the petiole of the leaves drowned the banana trees, and they had to collect the banana branches (about 70 kg in weight each) in a hurry to try to market those that were not badly damaged by the ash in a solidarity campaign.

As they progressed slowly, the very viscous lava flows of about 10 m high entered the fields and the banana paths as well. When the lava cools, it forms a very hard layer that covers the land for thousands of years and the only way to recover it is to add fertile soil as had been done in previous eruptions. But now the Cumbre Vieja area sees that the land to take the soil to cover lava is listed as a Natural Park, protected with strong environmental constraints and soil no longer can be extracted. The flow flooded infrastructures, such as power lines, drinking water and irrigation pipes, roads, telephone lines, ... The installation of desalination plants near Puerto Naos did not solve the problem due to the low quality of the water they produced (in addition to the noise and the economic cost involved). By the time the eruption ended, the landscape had changed: a volcanic cone had formed more than 200 m high.

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Seismic movements, tremor, gaseous emission, smell, ash deposits continued every time windy days would spread again and the cleaned areas would be dirty again, ... The feeling was that the volcano, already in the process of degassing, was not stopped and the population did not trust it. Now, in June 2023, more than a year and a half later, geophysical and geochemical parameters are not yet normal.

6. Reconstruction

From January 2022 the reconstruction of the infrastructure began and in June the new road connecting La Laguna and Las Norias was opened, reducing the journey time from one and a half hours (when half of the island had to travel a long way to avoid the lava flow) to half an hour. Constructing the road was hard work because gases and heat from the flow were still emanating and the machinery used with water had to be continuously refreshed. First, a solid lava layer up to 6 m high (which was hard but fragile) was battered and then the road was put to level but without asphalting it, because the high temperature inside (about 800 ^{o}C) discouraged them as asphalt could be melted for the energy coming out.

An asphalt technique similar to the Roman was then applied. The battered lava was mixed with lime and salt water, but the firm is not flat and the conduction causes uncomfortable unevenness. Vehicles were allowed to run at certain times, without stopping and always accompanied by security services. You cannot go on foot or on bicycles and make noise because of the danger of gas emanation.

On rainy days, when the water was being drowned inside the casing, the water evaporated by the temperature of the indoor lava and the water returned to the surface in the form of steam that complicated visibility with danger to the people circulating and the road had to be cut off. It is known as the "coast road", and was not without controversy for the definitive layout, which was opposed by some of the population as it damaged fields and properties that had not been affected by the lava and would now be affected by a new"asphalt flow".

The management of aid to the population (not everyone had insurance or property documents) created unrest among the affected people who organised themselves on citizen platforms increasingly called demonstrations to demand compliance with the promises. The losses are estimated at around EUR 982 million. The aids of town councils, Cabildo, autonomous government and state government will have to provide solutions to the issue of housing, businesses and the management of the future of an island that has been in everyone's mouth and but no longer now.

The population feels insecurity, uncertainty, sorrow, depression and anxiety and is afraid to lose the little the volcano left them. There are still homeless people. The population exodus is not quantified. Until 31st December 2022, a year after the eruption ended, the volcanic alert light did not pass from red to yellow.

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7. Visit the island of La Palma. A show of solidarity

Type Following the eruption of the Tajogaite volcano, the audiovisual production company I Love the World went to La Palma to collect images for the company. In a few days, after grasping the enormous human tragedy that the eruption was causing, it decided to stop other projects and stay on the island to help, in an entirely altruistic way, the population with its drones.

The affected persons passed the coordinates of their houses and they flew the drones to capture images in 360º and, at the end of the day, shared them so that people could know the state of their properties, since the public administration did not allow them access, nor did it provide them with information, nor did it allow the flight of private drones who made observation of the properties and even fined the owners in some cases, or confiscated the drones.

After many journeys that had to be interrupted to recover emotionally from everything they were seeing, I Love the World decided to write and publish a book where all the people they wanted could share their story. In May 2022, the book *Las otras historias del volcán Tajogaite* was published, in Spanish, English and German, a solidarity book whose profits are currently managed by the NGO Tierra Bonita and of which more than 12,000 copies have been bought mainly by companies, municipalities and other institutions that have afterwards given them away.

Both the special edition with photographs printed with the latest technology and the most popular edition have collected more than 150,000 euros which serve the legal orientation in group of the people concerned. A praiseworthy action by the company I love the World that is still continuing. Some of the images in this text are from iLove. National Geographic also used some in their documentary *Nacidas del fuego*.

Despite the volcanic eruption having ended a year and a half ago, what has not been ended is the human, social and environmental crisis that triggered the eruption of the Tajogaite. But nobody is talking about it anymore.

The central administration has forgotten the population and has failed to keep the promises made on so many journeys to the island in which the politicians or well-known personalities were given the typical photographs to accompany the corresponding note of press release by the political propaganda. And, so far, the indignation is shared by so many people that we can do little more than remember what happened with articles like this.

Adding that the proportion of the island affected is a small part, it can be visited without any danger because only visiting the region can support the people of the Valle de Aridane and help by tourism the island by spending some night there, enjoying a few days of one of the most precious corners which surely must be among the most beautiful on Earth.

Within a few square kilometers we can find a great diversity of landscapes and ecosystems

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that the volcanic nature of the island has created.

As has been said, there are many attractions on an island of just over 700 km^2 with a diversity of landscapes, microclimates, culture which represents a wealth for the rest of humanity and which we must support.

Black sand beaches, the Los Tilos area, the Taburiente Caldera, the Roque de los Muchachos Astronomical Observatory of World Reference and its interpreting center (the volcano is in the bottom right), the Fuencaliente salt lake, the San Antonio Volcano and the interpreting center, Teneguia, the ancient *fajanes*, "los charcos", the villages, landscape and its typical architecture, sports activities, cultural, ...

And now also the newest land in Spain, on the European continent and on the African continent to which the islands belong geographically. We are referring to the Tajogaite volcano and its *fajanes*. With a visit we will be looking forward to returning to a territory which, if Darwin had studied it, would also have been able to tell us many things about the evolution of species.

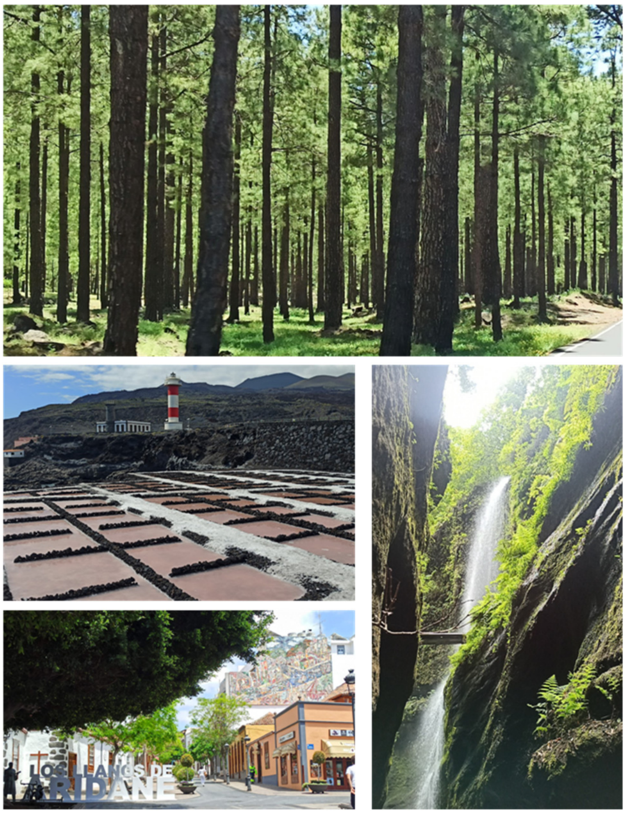
8. Experiences and thanks

Finally, thanks that cannot be short. I will take this opportunity to describe part of my passage through the island in the three journeys made so far. I would like to express my sincere thanks to Néstor Pellitero, the tour guide to La Palma, who selflessly introduced me to the study of the volcano, thanks to whom I have become involved and have continued to study the eruption of La Palma from a social and scientific point of view. In the *Papers dels Ports* magazine to give me a space for my first article about the volcano when no one else spoke about it and he encouraged me to write everything that was not included in the article.

To the Telegram group "Volcán de La Palma" which from the beginning of the eruption enabled me to become aware of details that the televisions did not explain. And so many people from La Palma with whom I came into contact in the second and mainly on my third trip to the island, personally or later by telephone from my home in the peninsula.

Fran, who from the second trip sent me photographs of the volcano's degasification process and contacted Toni. Noelia, my hostess of the El Paso Airbnb where I stayed on the third trip. Silvia, who volunteered and moved from her home in Las Manchas and now lives in El Paso and with whom I shared, along with her daughter, very nice moments in which she taught me precious corners that I would not have known alone.

In El Paso City Hall for the attention and time given to me by Delio, the city council psychologist, Ángeles, the then Social Services Concejala and current mayor of the municipality, Carlos, city council technician who accompanies the scientists of the IGN and the IGM from the outset and who knows everything about volcanology.



In Germán and Roberto, fire-fighters from La Palma who described me the chaos and the state of shock the population was in. In Toni, a victim who told me the invisible details that only a person who is within a mile of the affected area can tell and who contacted me with Pedro Fernández, a scientist who works with INVOLCAN, whom I thank for providing me with the sources for adequate scientific information.

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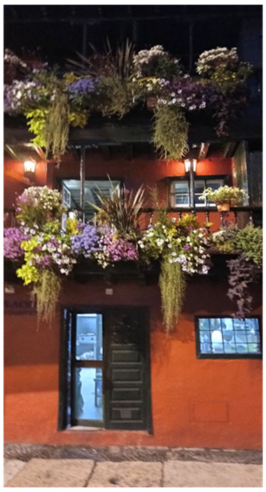
To Mila, to share with me without knowing me, and described me as no one what is going on beneath the soil of his valley. María, the producer of the book *Las otras historias del volcán Tajogaite,* of I love the World, we will always be able to say that I maintained the longest telephone conversation and for your effort to come from Madrid to promote the book at the XVI Science in the Street Fair that took place last May in the city of Lleida and in which we shared stand.

Also the people I spoke to on the street. Manuel, whom I shared on Sunday morning at the Agrocanarias Fair in Los Llanos de Aridane. "Ana" as I have baptized the woman I don't know the name of and we spoke early morning alone on the right side of the colada. Her house on the top of the road had been saved from the lava, not the ones his family had on the bottom of the colada.

In the guide at the same point in the colada, Guillermo, with whom I learned a lot, as well as the guide from the other side of the colada, through the area of Las Manchas, who I do not know the name of and which I hope passes the oppositions exam he was preparing.

Both of them helped me take more beautiful lapilli samples deposited on the ash layer on the edge of the road, before all the people tread on them. These are displayed in a small bag as if they were diamonds. To the young couple from Poland who like me had to take the bus along the road and allowed me to guide them and show them the corners Néstor showed us on the second journey. Above all, I do not want to leave the woman who guided us when we were going to the bus, affected that she lost her house and now lives in La Laguna, near where the new road begins, because of the lesson she gave me of strength and positivity in the adversity that it had been up to them to live. She holds the morale of the family. To the Miranda del Ebro family I came back with by their car down the unstable solid road off the coast and turned them on the guide again.

To Manel, for his help in the translation review. And at the College of Chemistry of Catalonia and Hands on Science for this call. It is a pleasure to share with everyone, the hours of talk that I hope to be able to reflect sooner rather than later in a letter that I will also share to prevent the volcano, and especially its people, from falling into oblivion. As far as I can. I make a desperate appeal to the Spanish and European administrations which are watching, paying attention and solving the volcanic emergency in La Palma.

The European Union says that this eruption in La Palma has been the most destructive in Europe since the eruption of Etna in 1949, that is true, but it does not help despite the fact that some of our taxes pay for this institution, among other things, I suppose to cover unexpected emergencies. Our taxes now need them in the Valle de Aridane, we do not need them to buy weapons to kill.

9. Future

Finally, I would like to explain the prospects for the future in the variety of the difficulties caused by the Tajogaite volcano. On several occasions (Institut Dertosa, de Tortosa, XVI Science Fair in Lleida Street, workshops Observatori de l'Ebre, in Roquetes) have been tested.

Very simple classroom didactic experiences have enabled the dissemination and interpretation of the background accompanying a volcanic eruption, such as seismic swarms, terrain deformation, the emanation of certain gases causing the eruption, the formation of crystalline structures and analysis of its appearance and properties -such as size or density-, volcanic mouths, the eruption itself, the properties of the formed gases (odor, density), ...

All together using models and models, hand-crafted or computer posters, photographs, samples of volcano materials obtained directly

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from the paths through which it can pass without bans, participation in the Kahoot “What do we know about volcanic systems?”... [1]

The proposed activities are simple and allow students to approach the reality of what a volcano is and to understand the effects caused and, above all, to be aware that these effects do not end when the eruption ceases, as well as to emphasize with the people who are suffering it. In order to be able to continue to assess the general public's opinion on the last eruptive episode in the Canaries, a Google form [2] has been designed that I am inviting to fill in anyone who wants to collaborate and do our part to help track this event, regardless of place of residence. From the assessment of the responses, there are already aspects that could easily be improved in the face of future volcanic events on the island which is actually being born at the expense of volcanic eruptions.

And now yes, finally my thanks for the interest of the people who read this text and invite them to visit the 'Bonita Island', or the 'Green Island' as the heart-shaped island of La Palma is known.

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[1] https://create.kahoot.it/details/9aa9fdca-d25a-48a2-b1b4-de6001ae8054

[2] https://docs.google.com/forms/d/1TiAJwAAtgB1mo_dZLWkQ_BkK-g7qof__4hxwl34VEcY/edit

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Eggs on Science

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Abstract. Experiments with objects that pupils would not expect to see in class are very motivating in physics lessons. Such unusual physics objects include eggs. In our contribution we will focus on different experiments with eggs. These experiments are suitable for teaching mechanics and can be used to show how nature uses the laws of physics in an interesting way. We will concern at the shape of an egg and the associated mechanical properties of the shell, we will use egg experiments to show the properties of rotating bodies, examine the airflow around eggs, concern on hydromechanics and other interesting egg-experiments.

Keywords. Physics, Experiments, Eggs, Mechanics.

1. Introduction

Physics is still one of the least popular subjects for many pupils. It is therefore important to find ways to make it interesting to them. There is no doubt that experiments are an important part of learning physics. They engage pupils, allow them to 'feel' physics with their own hands and often emphasize the practical side of the topics discussed. Sometimes it is useful to include experiments with unexpected tools in physics lessons. If the teacher uses an inclined plane or a pulley machine in a physics lesson, the pupils will probably not be surprised. Such devices belong in physics. However, when the teacher pulls an egg out of the pocket at the beginning of class and says that this will be our topic for today, it is sure to pique the pupils' interest. In this article, we will describe a few experiments that we have selected from our conference presentation entitled "Eggs on science".

2. Selected experiments with eggs

2.1. Egg in water

This experiment is well known, but it is unique in one thing. It has already appeared in the book [1]. This book was written in the seventeenth century and aimed to make the teaching of science interesting for pupils. It is therefore one of the earliest published school demonstration experiments. So, let's repeat it some 350 years later.

Aids: two glass containers, one filled with pure water, the other with water with dissolved salt, raw egg.

Demonstration of the experiment:

Prepare the salt water in advance. Preferably the day before. Dissolve a large amount of salt in the water to make a saturated solution. This can be done simply by adding salt, stirring, and only stopping when the salt has stopped dissolving and settles to the bottom of the container. Allow the solution to stand overnight and pour the water into another container before starting the experiment (this gets rid of the salt settling at the bottom and gives a clear liquid indistinguishable from unsalted water).

Ask the pupils if the egg floats in the water. They will probably answer that it does not float, but sinks. We then place the egg in the unsalted water. It will sink and stay on the bottom. Then we take the egg out from the water and put it in a second container of salted water. Now the egg floats. Discuss with the pupils how this is possible, remind them of Archimedes' law, etc.

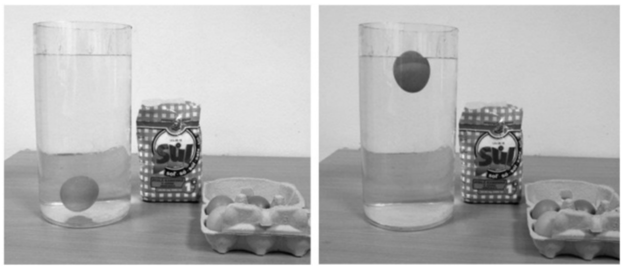

Figure 1. Egg in pure and salty water

You can also demonstrate a fancy version of this experiment. Pour water into a tall glass cylinder so that it is filled, for example, to one third of its height. Ask if the egg floats, put it in the cylinder and it will sink. Now you take a glass of salted water and slowly pour it into the cylinder. After a while, the egg will float up. When the egg is about halfway between the bottom and the surface, stop pouring the salt water. From above, push with a long thin stick into the egg. The egg will begin to oscillate gracefully around its original position. Continue adding salt water until the egg floats to the surface.

2.2. Hard egg

This experiment will show that an egg can be surprisingly hard.

Aids: raw egg with an intact shell, a plastic bag, a glass to crack the egg into, a narrow screwdriver.

Demonstration of the experiment:

Choose a helper from among the pupils for this experiment. The helper takes the egg in the palm of his/her hand, puts the plastic bag on the hand with the egg and holds it with the other hand so that it fits tightly around the wrist. He/she tries to crush the egg by squeezing it with his/her hand - it fails.

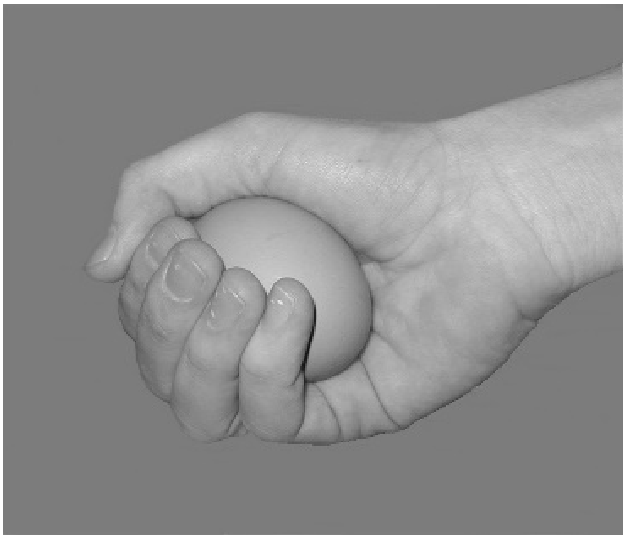

Figure 2. Egg seems to be very hard

Take the egg back from the helper and crack it into the prepared glass. This is to show that the egg has not been tampered with in any way. Show an interesting feature of the shell - when you hold it in your hand and try to break it with the tip of a screwdriver, you can't do it from the outside of the shell, but you can do it quite easily from the inside.

In conclusion, we can tell the pupils that we have just demonstrated the perfection of nature. The egg is arranged to withstand a certain amount of external pressure. This is needed, for example, when a female is sitting on the egg. If the egg is to hatch into a chicken, it must be able to do so easily. The inside of the shell is therefore more fragile than the outside. Next, we can take a moment to consider how man learns from nature. Show the pupils a photograph of a load-bearing arch (choose, for example, a prominent building in the neighborhood that contains such an arch). Draw the arch, indicating its building blocks, on the board and analyze the forces when it is loaded (similar to the Figure 3). From the drawing, it is immediately apparent that the arch can withstand a lot of external loading. However, if we applied a force from the inside, we would break it. Point out to the pupils that the egg is similar in shape to the arch and so the explanation of its resistance to external stress is similar.

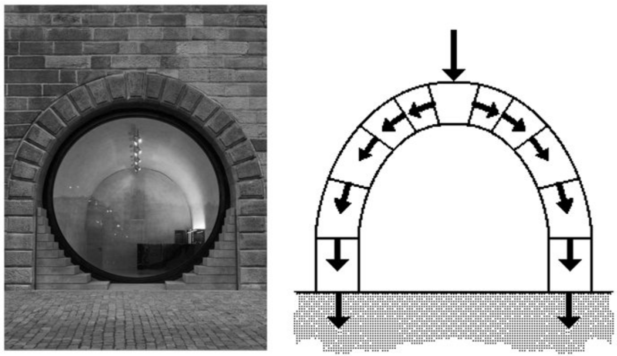

Figure 3. The load-bearing arc and the forces acting in it

2.3. Eggs under pressure

Aids: two wooden triangular boards with holes drilled in the corners (described in more detail below), three raw eggs with intact shells, various weights, a short board, two buckets of water, a plastic tablecloth or sheet of wrapping paper.

Boards' preparation: Prepare the boards by cutting two equal equilateral triangles from a suitable piece of wood (the sides should be approximately 30 cm long). A suitable material is e.g., a wooden furniture shelf. Place the boards on top of each other and drill holes in the corners. The holes should be approximately 20 mm in diameter and must be exactly on top of each other. If you do not have a drill of sufficient diameter, use a round rasp to enlarge the holes. Finally, using a rasp, file and sandpaper, work one side of the holes on each plate to create a smooth hole into which the egg can be placed.

Demonstration of the experiment:

Place a plastic tablecloth or sheet of paper on the table. Place one triangular board on it, with

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the holes facing up, and place three eggs in the holes. Cover the eggs with the other board from the top. Place a weight on the top plate, then a bucket of water, then a plate with a weight on top, then another bucket, etc. Surprisingly, the eggs can be loaded with quite a lot of weight. In our case, the beam can reliably carry a load of 20 kg. The explanation of the experiment is similar to that of the "hard egg" experiment.

Figure 4. Loaded egg beam

2.4. Shooting into eggs

Aids: two eggs with thread stuck on - one raw, the other hard boiled, photographic (or other) bowl, shot trap, air rifle.

Preparation: Prepare about a meter of strong thread. Make a large knot at one end. Put some glue on the flatter side of the egg and insert the end of the thread with the knot. After the glue has partially dried, tape the knot with adhesive tape.

Demonstration of the experiment:

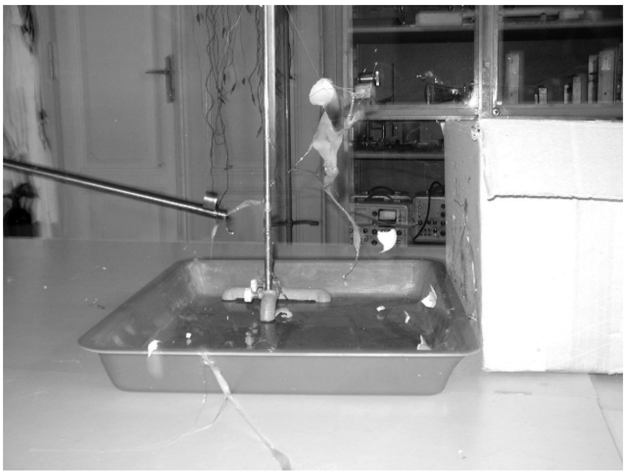

Figure 5. Raw egg after being hit by a bullet

Place a photographic bowl on the experimental table and set the stand in it. Attach the egg to the stand with a thread. Place a shot trap behind the bowl. Start with a boiled egg. Shoot it with an air rifle. The bullet will fly through the egg and leave a narrow tunnel in it, or part of the egg will break off and fall into the bowl.

Repeat all with the raw egg. (It is a good idea to put a plastic tablecloth, a sheet of paper or something similar under the bowl.) The egg will splatter in all directions when hit by the bullet.

2.5. The collision of eggs

Aids: two raw eggs on strings (as in the previous experiment), a large photographic bowl, two stands.

Demonstration of the experiment:

Place the photographic bowl on the table and place the two stands in it. Attach a thread with an egg glued on it to each stand so that the eggs are lightly touching. Swing the eggs sideways and drop them against each other.

One will break, the other won't. Interestingly, when the experiment is repeated, only one egg will always break.

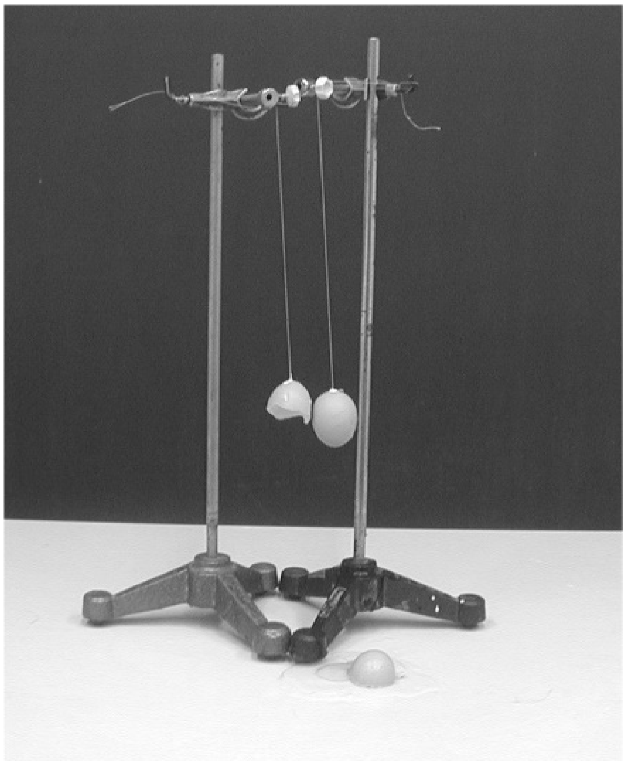

Figure 6. Eggs after collision

2.6. How to distinguish boiled eggs from raw eggs?

Aids: raw and boiled egg.

Demonstration of the experiment:

We can easily distinguish boiled eggs from raw eggs simply by spinning the eggs. A boiled egg is easy to spin, a raw egg is reluctant to spin.

Figure 7. Spinning the egg

It is easy to understand. A boiled egg behaves like a solid body. We spin it all at once and we can give it quite a lot of angular velocity. A raw egg is liquid inside. So we spin the shell and some of the mass underneath. There is a great deal of internal friction involved in spinning the other layers of the egg's contents, so spinning is not easy.

2.7. Egg races

Aids: raw and boiled egg, inclined plane (preferably with some guide grooves).

Demonstration of the experiment:

Let the raw and boiled eggs roll down the inclined plane. It is advisable to use a plate with longitudinal grooves as an inclined plane - it used to be part of Galileo's demonstration trays. Ask the pupils which egg will win the race (i.e. which will roll down first - drop them from the same height). If we have shown the egg rolling experiment before, pupils are likely to say that the boiled egg will win. But it will work the other way round - the raw egg will win.

We can understand the result of the experiment if we realize, for example, that both eggs have the same potential energy at the beginning and that this energy changes into kinetic energy as they move. The kinetic energy is in the form of translational and rotational energy. The boiled egg rotates as a whole, whereas in the raw egg only part of the internal liquid content under the shell rotates the most, the rest of the egg enters the rotational motion with a delay and with a smaller angular velocity. Thus, in a raw egg, we can expect a smaller moment of inertia during rotation, hence a smaller rotational kinetic energy. Thus, more energy is left for the translational part and the raw egg acquires a higher velocity.

Figure 8. Eggs ready to race

2.8. Bernoulli`s eggs

Aids: two eggs on thread (as in previous experiments), two stands, an egg without thread, two egg cups.

Demonstration of the experiment:

Hang the two eggs on threads on the stands. The eggs are hung so that there is a gap of a little more than 2 cm between them (it is a good idea to test in advance what is the appropriate gap in our particular case). When we blow

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between the eggs, they come closer together. We will explain this using Bernoulli's principle. There is less pressure in the moving air between the eggs than in other still air.

Another variation of the experiment will be shown with an egg placed in a cup. When we blow sharply over it, it lifts up (again because the pressure above it has dropped and the air below has lifted it). If we are very skillful, we can put an empty cup next to the cup with the egg. Blowing vigorously from the right direction will move the egg into the empty cup.

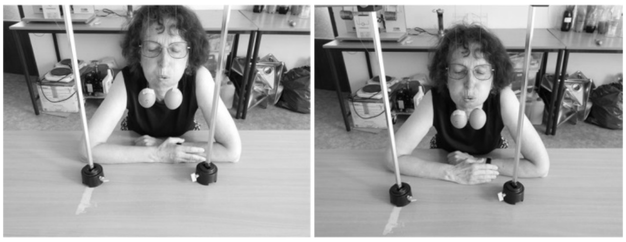

Figure 9. Blowing between the eggs

2.9. Eggs size and price

Aids: two different cartons of eggs – smaller and larger eggs.

Problem:

When buying eggs, you may have noticed that the eggs are sorted by size. You may have noticed that a box of smaller eggs is cheaper than a box of larger eggs. But the difference in price tends to be small (if any). Is it better to buy small eggs or large eggs? A little geometric knowledge will help us with answer. Although an egg has a complex shape and pupils probably won't be able to calculate its volume, we can measure the volume (for example, by dipping the egg into a graduated cylinder of water). We will find out what our intuition should also tell us. The volume of an egg increases with the third power of the change in its linear dimension. So if we buy an egg 1 cm longer, we are buying a lot more than it would appear. By comparing the price and volume of the eggs we buy, we conclude that it is more profitable to buy larger eggs.

3. Conclusions

The described experiments with eggs are not only an attractive diversification of teaching. Students will take away the knowledge we want to give them in physics lessons, and they will also see that physics allows us to make smart choices (e.g. when buying eggs). With physics we are able to understand much of what we encounter on a daily basis.

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Understanding and Teaching the Complexity of the Water Cycle and its Management. Integrating Science with Geography, Politics, and Economics

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Abstract. Science teaching today must endeavour to be relevant to students at all levels and give them information which will be useful in their adult lives. Frequently the inclusion of practical work in a lesson achieves better understanding of complex processes particularly if the students present their own ideas for examining concepts. The paper extends science issues into the real world of politics, economics and climate change.

Keywords. Science, Geography, Politics, Economics, SDGs.

1. Introduction

Water is an everyday essential commodity which we (in the developed world) are able to access by just turning a tap. But how does the water get to our taps?

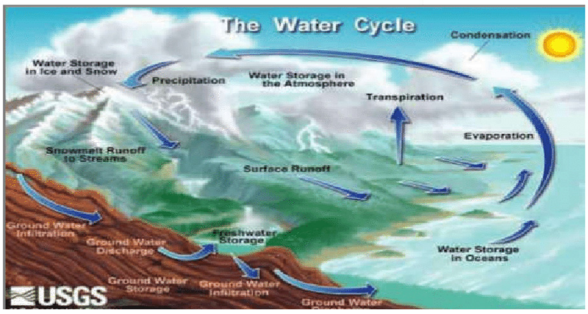

Figure 1 Water Cycle basic diagram [1]

The water cycle is one of those topics which almost everyone will have heard of during their schooling, but few were really taught it thoroughly and in depth. It is one of those areas that everyone knows about, but to understand it requires much earth science ---- geology, meteorology, biology, physics, chemistry and of course an understanding of the physical landscape of an area. I don't think most people really understand the complexity of how we get water out of our taps! Whilst talking to science post graduate secondary trainee teachers at Oxford one day I asked them where their tap water came from. Incredibly only one person had any idea of the links between the water cycle and drinking water. So it seemed to me an ideal topic for a teaching talk and a follow up workshop incorporating plenty of simple practical ideas that can be carried out at any level.

2. Background

Water is stored on our planet in several ways – either as a gas or in a liquid or solid form such as in the diagram below:

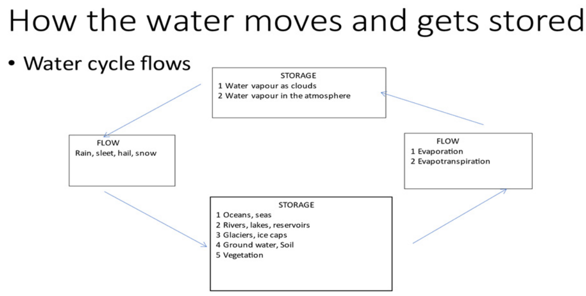

Figure 2 Flow and storage diagram

Water moves around from one storage place to another but as it is a closed cycle nothing is lost and no more can be brought in. Total water on planet: 96.5% of all water is stored in our oceans and seas, 1.7% is in ice – ice caps and glaciers and 1.4% is stored in rock and soil. A small amount – ie 0.4% is held in the atmosphere as water vapour and a tiny amount is held in plants.

3 The Processes

The cycle really begins with the evaporation (chemistry) or evapotranspiration (biology) of water into the atmosphere in a gaseous form. Water from seas, oceans, lakes and rivers, when warmed, changes into water vapour gas molecules in the complicated physics/chemical process of evaporation and thus moves into our atmosphere. Water is transpired or breathed out by vegetation (evapotranspiration) and being warmer than its environment is also in the form of water vapour gas. This gas can rise in the atmosphere as the particles are less dense than surrounding cooler air and will continue rising until the air is cold enough to become saturated with moisture, its dew point. The Dew Point occurs where adiabatic lapse rates meet at saturation (more physics) and where the cloud base forms.

At this point all sorts of meteorological processes take over. Air pressure differences, warm and cold air masses, wet and dry air masses combined with the spin of the earth collaborate to form winds which move the clouds. There is a great deal of complicated physics involved here – fine at sixth form or university level but not necessary otherwise!

3.1. Practical: Make your own rain

A practical way of showing this is to produce your own rain using the method below. Some schools may have a commercially produced rain maker but a home grown one works just as well. You need a table lamp plugged in to power, a clear plastic box with a lid, some sand, some water and some ice. Set the system up before the session starts to give time for evaporation and condensation to occur. Quite quickly condensation droplets form over the 'land' on the underside of the box lid- RAIN!

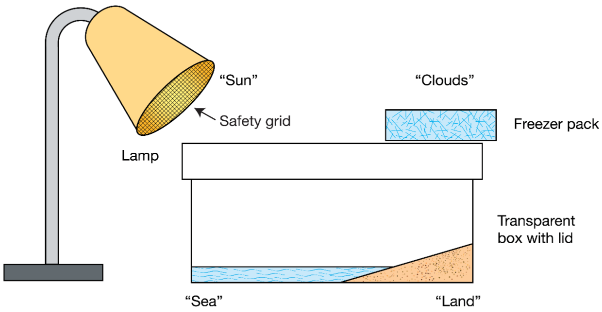

Figure 3. Make your own Rain [2]

For older students one can go into the formation of clouds from evaporated or transpirated water forming water droplets attached to condensation nuclei, but at lower levels this is not necessary. The idea that warm water turns into water vapour gas which rises and condenses back into water on cooling is good enough at primary level. Condensation too can be easily shown - very cold water (or wine!) poured into a glass produces condensation on the outside of the glass as the warm environment containing water vapour cools rapidly on meeting the cold glass surface.

Once we have rain, where does it go when it falls to earth? There are numerous pathways: when the rain falls, it can fall into the sea or ocean (about 97% of the total), reservoirs, lakes or rivers (all termed 'storage'.) It is then 'available' for use or even to be evaporated again. Most rain falls onto the ground, infiltrating then percolating through the soil –less than 1% being available for plant growth.

Figure 4. Set up for percolation practical [2]

Percolation is quite a complex process and again older students can examine this in more detail. Percolation too can be shown by a simple practical as seen in the diagram. In reality, water can be drawn through to dry areas or can move upwards through capillary action. Minerals go into solution as the water moves downwards through the soil and are taken in by plant roots for use in growth.

3.2. Percolation/Infiltration practical

It can be set up as above, pour the same amount of water onto each side and watch what happens. On the bare soil, water flows over the surface taking the soil with it, whlist it infiltrates into the vegetated soil. (hint – landslips?) But rain can also fall as snow and accumulate to form glaciers and ice caps storage – more complicated changes explained through physics and chemistry. This method of storage may last for many years and in fact stores three quarters of the world's *fresh* water (just 2.1% of all the world's water). However, with our current change in climate, this storage could be reduced. The water continues its downward journey and goes further into the rock layer where it is stored as groundwater (about 0.6% total or 24% of the freshwater store). A practical demonstration session can show this.

3.3. Demonstrating water storage in rocks

Using sandstone, limestone and granite samples plus water in small clear beakers it is

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easy to show which rocks can store water and it is possible to calculate how much they can store. Set the students the problem to find out amount of water storage in a rock, given these simple resources. Of course plants and all animals store a certain amount of water too, probably less than 1% of the world's store.

Figure 5. Water storage in rocks [2]

3.4. Water storage zone in rocks (aquifers)

Rocks which can store water are known as aquifers and may be at shallow or considerable depths. Water moves very slowly through these aquifers - it can take 9 months for rain water to move through this system – experiments have been carried out to show how long it takes for rain water entering a cave system to emerge into rivers. (You can make your own aquifer!)

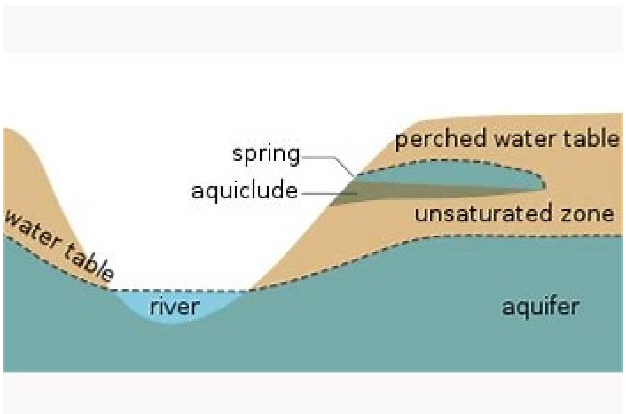

Figure 6. Diagram to show an Aquifer [3]

Water falling in mountainous areas travels through these aquifers and may emerge as rivers hundreds of miles away. Aquifers underlie many dry areas although frequently at some depth. Major examples are the Sahara and Atacama Deserts which have underlying water at depth. The Central Arizona Project relies on water from its underlying aquifer which is carefully monitored to ensure that not too much water is taken out before the system can recharge. In other areas, ie London and Detroit, industry initially used much water from aquifers, but when the industry declined, the reduction in water extraction led to rising levels in the aquifers and consequent flooding in basements of buildings.

These days in Britain at least, many people have paved their driveways and water cannot seep through into underground storage. The water has to go into the drainage systems, be cleaned, returned to rivers and back into the cycle. Some drainage or storm water may pass into the sewage system to be cleaned and reused. The water in the River Thames is extracted, cleansed, used, and recycled so the many towns and villages along the Thames are using water previously used up stream.

4. Water sources

Many of the world's largest rivers have their sources in highland mountainous or marshy regions eg Amazon (Andes), Nile (tributaries ie Atbara in Ethiopian Highlands), Ganges and Indus from the Himalayas. These rivers depend on rain falling in their source regions which may be tied up as snow for part of the year. The water may travel through groundwater systems until it emerges at the surface.

Water from these different sources and manmade surface reservoirs is piped to homes and industries through various systems. Frequently it passes through a cleansing process before it is deemed fit for consumption. Some countries have dual water systems – drinking water and other water which is not so expensively cleansed. All waste water returns through sewage systems to be cleaned and either reused or returned to the sea. Londoner's use water which has been taken from rivers, used, cleaned and reused numerous times. Some water companies in Britain draw water from boreholes which is then piped for use by households and industries. Systems are complex and cleansing processes are carefully monitored to ensure water has no harmful bacterial content. Water being returned to the sea in Britain is subjected to many laws to

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ensure that the coastal water is kept clean and suitable for bathing.

Once back in the sea, the whole process begins again. However, recent climate changes are altering rain patterns and areas of desertification are likely to increase. It will be all the more important to use this valuable resource carefully and wisely.

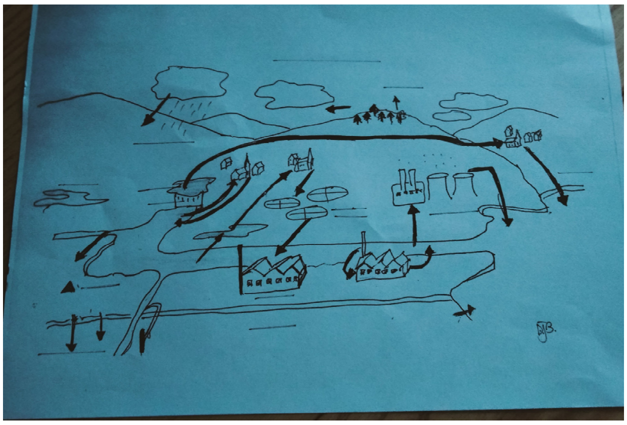

Figure7. Diagram to show water movement from storage facility to usage points [4]

Figure 8. World water storage map [5]

5. Politics and Economics

But this isn't the end of the story. Water is now very much a political resource with so-called 'water wars' in prominence. For many years Mexican farmers have complained about the sparsity of water flowing down the Colorado River at certain times of the year – since the building of the Colorado dam. The new Chinese Friendship Road running through Tibet – is very much aligned with the need for water

In Algeria some water is taken from deep underground aquifers in a project. The inhabitants of Tamanrasset, the big city in the Hoggar region, rely on the waters drilled under the sand of the neighbouring Wilayah, and are transferred 700km journey across the desert. Much of the rest of Algerian water is supplied through desalinisation plants.

Libya now has good water supplies due to Gaddafi's pipeline which brings fossil water into the Great Man-Made River project [6] started in 1984 which extracts water from the Nubian Sandstone aquifer.

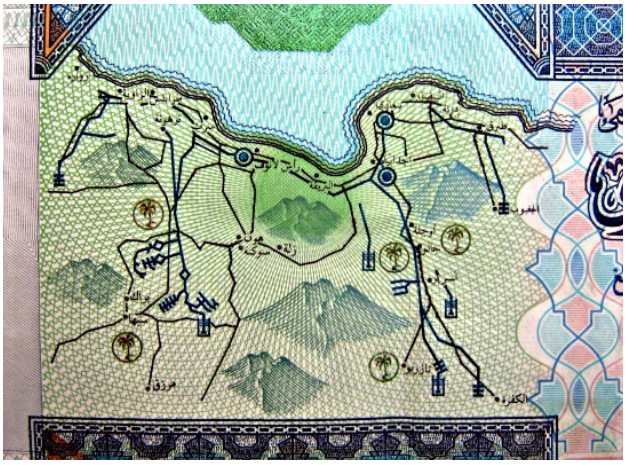

Figure 9. Libyan Great Man-Made river project [6]

This water is at a fraction of the cost of desalinsation but whilst some estimates are that there is enough water to last 1000 years others say that the water could quickly be depleted if there is no recharge.

China is pressing for change in the Myanmar border so that the headwaters of the Irrawaddy River are in her territory. China's new Friendship Road across Tibet is also looking to transfer water from the Himalayas to Chinese cities. Other areas with water conflicts are on the Nile, the Ganges-Brahmaputra and Tigris-Euphrates

6. Conclusións

The United Nations World Water Development Report [7] suggests groundwater accounts for approximately 99% of all liquid freshwater on Earth and has the potential to provide societies with tremendous social, economic and environmental benefits and opportunities. Groundwater already provides half of the volume of water withdrawn for domestic use by the global population, including the drinking water for the vast majority of the rural population who do not get their water delivered to them via public or private supply

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systems, and around 25% of all water withdrawn for irrigation. However, this natural resource is often poorly understood, and consequently undervalued, mismanaged and even abused.

Groundwater is central to the fight against poverty, to food and water security, to the creation of decent jobs, to socio-economic development, and to the resilience of societies and economies to climate change. Reliance on groundwater will only increase, mainly due to growing water demand by all sectors combined with increasing variation in rainfall patterns.

The report describes the challenges and opportunities associated with the development, management and governance of groundwater across the world. It aims to establish a clear understanding of the role that groundwater plays in daily life, of its interactions with people, and of the opportunities for optimizing its use in order to ensure the long-term sustainability of this largely available yet fragile resource.

Unlocking the full potential of groundwater will require strong and concerted efforts to manage and use it sustainably. And it all starts by making the invisible visible.

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Physics Experiments Connected with a Fairy Tale Story – Educational Program for Primary School

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Abstract. The contribution introduces the educational program O magické bouři (About the magical storm) as a tool for primary school teachers seeking engaging activities to integrate into their science classes. The educational program includes a fairytale story, didactic sheets with descriptions and methodology of four experiments for teachers, and worksheets with additional activities for pupils. The contribution also describes the process of development of the educational program.

Keywords. Science Experiments, Hands-on Experiments, Story, Fairy Tale, Primary School, Elementary School, Physics.

1. Introduction

Most of the population views physics as a challenging school subject, deeply theoretical, and connected with unpopular mathematics [1]. Such views are often transmitted to children by their parents and siblings long before their first contact with physics in school and a lot of children take them as their own. Even primary school teachers often view physics as difficult and as a subject in which they aren't sure how to present it to the children [2]. To capture children's interest and enhance their positive attitude towards sciences, the educational program *O magické bouři* (About the magical storm) [3] was developed.

The program serves as a ready-to-use tool for primary school teachers, that can be incorporated into natural science classes. It includes a fairy tale combined with science experiments. The main character is a boy named Luky, who is the same age as the pupils, and together with his magic friend makes the adventurous journey to save their home. In this contribution, the author shall present the educational program and its development.

2. Educational Program

The educational program is designed for pupils from second to fifth grade of primary schools (children from 7 to 11 years of age). It is intended to span a whole month with one sixty-minute lesson per week. During each lesson the teacher reads a section of the fairy tale story to the children, then the pupils conduct the experiment and in the end, the teacher concludes by reading another small part of the story to build anticipation for the next lesson.

The educational program consists of a fairytale story, didactic sheets with descriptions of four experiments for teachers, and worksheets for pupils. The following paragraphs will provide more detailed information about the individual components of the program.

2.1. Fairy Tale Story

The story follows a boy named Luky and his friend Mobi, who happens to be a magical creature. The boy doesn't have any magical talent, so instead he must solve problems with the help of science. Each time Luky employs physics, the pupils conduct their own experiments, such as making a strawberry propeller, a rainstick, a marshmallow catapult, and a rainbow.

The story is written in a language that is easily understood by primary school pupils. Its length is adjusted so that it can be read in the classroom before conducting the experiments. The goal of the story is to convey the message that science is just as useful and interesting as magic.

2.1.1. Annotation of the story

Once upon a time in a magical kingdom there lived two friends: a boy named Luky, who couldn't use any spells but had a strong grasp of physics, and his magical friend, Mobi. However, their wonderful home was plagued by a dangerous storm, so the friends decided to seek help and protection from a powerful sorceress. In order to be heard out, they brought her a gift of giant strawberries. To safely gather the giant strawberries from high cliffs, they constructed a **propeller**.

Thanks to their offering, they were allowed into the sorceress's house. But a mischievous servant destroyed one of the sorceress's

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artefacts – a **rainstick** and fled. The heroes feared that the sorceress would blame them for the incident, so they quickly repaired the artefact. The sorceress listened to their pleas and promised to help them if they fed her pet with the giant strawberries. To their surprise, the pet turned out to be a huge monster with three tongues. The friends devised a plan to safely feed the creature using a **catapult**.

The sorceress was impressed by their success and fulfilled her promise by granting them a protection spell. This spell could only be activated with a help of a **rainbow**, so the friends had to experiment again. After the rainbow activated the protection, a lightning conductor was added to their house and their home remained safe forever.

2.2. Experiments

All the experiments included in the educational program are described in didactic sheets. The didactic sheets provide instructions on how to perform the experiments, explanations of the experiment in a child-friendly manner, additional information for the teacher, and photos of the experiments. Each didactic sheet also contains a variant for remote teaching, ensuring that the program can be adapted for distance learning. In the following paragraphs, the experiments will be introduced in more detail, along with one complete didactic sheet.

2.2.1. Strawberry propeller

Figure 1. Strawberry propeller

The first experiment in the educational program involves creating strawberry propellers. Each child makes their own origami propeller, and then the whole class tests the flying properties of their creations. While paper folding may add a level of difficulty, it also enhances the memorability of the experiment and aids in the development of children’s motor skills. The development of coordination of movements is important for school success [4]. In Figure 1 we can see the completed propeller.

2.2.2. Rainstick

The second experiment chosen for the educational program is creating a rainstick. It is inspired by a musical instrument which is traditionally used by Aboriginal people to summon rain. This experiment aims to enhance scientific thinking in children. Before the lesson, the teacher makes one rainstick as a demonstration. During the lecture children's task is to create their own rainstick without looking inside the teacher's rainstick. So, they must come up with an idea of how to do it and then compare the sound of their rainstick with the teacher's one. This experiment encourages collaborative work among the children, as they work in groups to complete the task. The completed rainstick can be seen in Figure 2.

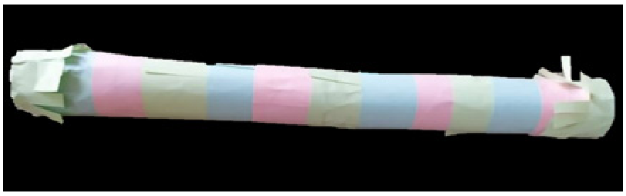

Figure 2. Rainstick

2.2.3. Marshmallow catapult

The third experiment in the educational program is the marshmallow catapult (Figure 3). The goal is for children to construct a model of a catapult and investigate how it launches objects. This experiment is highly popular among children, primarily due to the use of candies and the exciting opportunity to launch projectiles from the created model. It is possible to organize a long-range or most accurate shooting competition with created catapults.

2.2.4. Rainbow

In the fourth experiment, children try to create a rainbow with the help of a mirror, water, and

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flashlight as depicted in Figure 4. This experiment also aims to improve children's scientific literacy. The children formulate a hypothesis by colouring a picture of a rainbow. Then, they proceed to create a rainbow and colour another picture of a rainbow based on the appearance of their created rainbow.

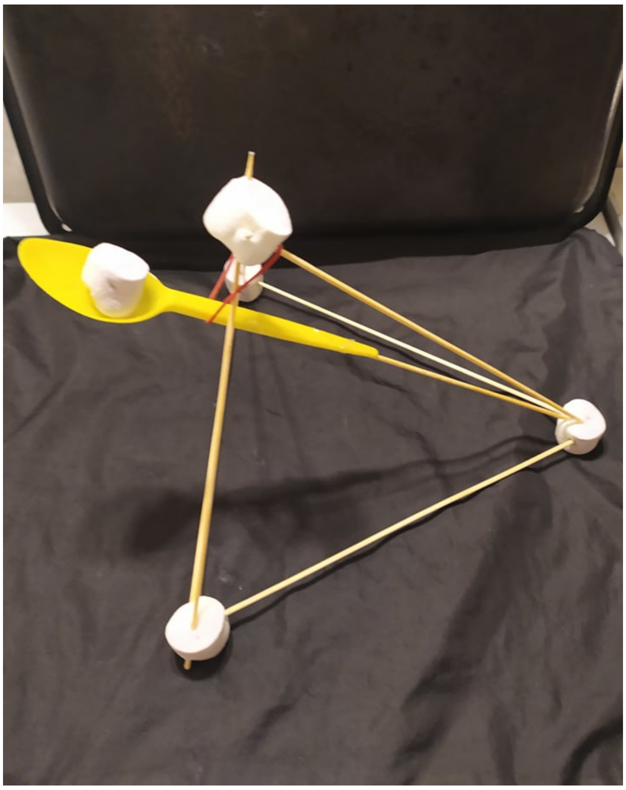

Figure 3. Catapult

Figure 4. Rainbow

2.3. An example of a didactic sheet with the experiment with a marshmallow catapult

When carrying out this experiment, children work in groups. The best number of children in one group is four.

2.3.1. Material

Each group: 5 marshmallows, 7 skewers, a plastic spoon, scotch tape, a kitchen rubber band

2.3.2. Process

1. Take 3 marshmallows and 3 skewers and form a triangle from the skewers by placing the marshmallows at their vertices.
2. Using another marshmallow and three skewers, construct a pyramid above the triangle.
3. Attach the plastic spoon to the last skewer using scotch tape.
4. Loosely place a rubber band on top of the pyramid.
5. Insert a skewer with a plastic spoon into one of the marshmallows at the base of the triangle.
6. We can shoot: Take the last marshmallow (ammunition), put it on the spoon, pull the spoon down and then release while holding the marshmallow where the spoon is attached.

2.3.3. Variant for distant learning

Inform the children in advance about the materials required. If a child does not have the materials ready for the lesson, they can be tasked with brainstorming how to create a catapult using items they have at home. If possible, they can try to build it using items such as a ruler or books.

2.3.4. Recommendations

After some time of using the catapult, it may be necessary to replace the marshmallow with the most skewers in it. Teachers should warn children to be careful when working with skewers. It's a good idea to test the rubber bands in advance, as they have the greatest effect on the functionality of the catapult - I recommend using kitchen rubber bands.

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When shooting, it is better to hold the marshmallows, so that the whole group is involved in the shooting. With created catapults, it is possible to organize a long-range or most accurate shooting competition.

2.3.5. Explanation

When the shot is fired, the potential energy of the rubber band is transformed into the kinetic energy of the spoon and then the projectile. A fired projectile travels in an arc that is not uniform because the projectile is being slowed down by air. We call this trajectory the ballistic curve.

2.3.6. Review questions

Q: What were catapults used for in the past?

A: Catapults were used to besiege cities and castles, specifically to break down walls.

Q: What was commonly used as ammunition?

A: Ammunition included stones, burning tar, and sometimes animal corpses.

Q: Are catapults still used today?

A: Catapults are still used in certain events like fairs and amusement parks.

2.3.7. More information for teachers

A catapult is a siege warfare machine that uses the torsional moment of twisted ropes or sinews to launch a larger projectile, usually stones or other objects, over a long distance without gunpowder. Catapults were mainly used to break down walls during sieges of castles, cities, and fortresses so that the army could penetrate inside. However, pitch or burning tar, dead animals, or even faeces were also shot at the opponent.

They were already used in ancient times - they were used in ancient China and also by the ancient Greeks and Romans. They were used massively in the Middle Ages. In the modern age, they were gradually replaced by cannons. The last combat use was during WWI in trench warfare - they fired hand grenades.

Interesting fact: In 2011, a catapult was found that was used to smuggle marijuana from Mexico to the US. [5]

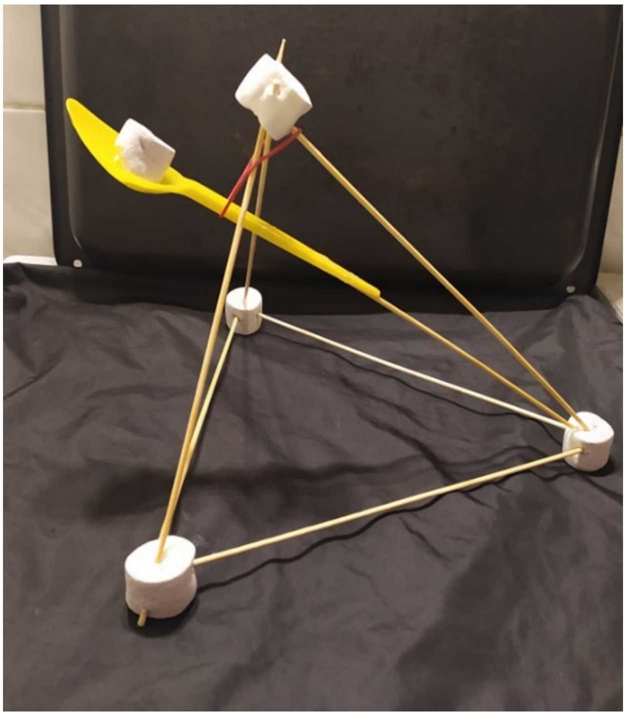
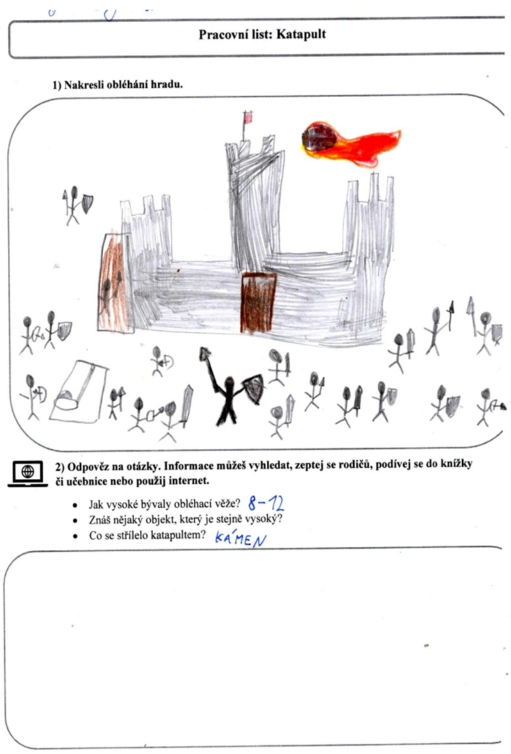


Figure 5. Built catapult

2.4. Worksheets

The educational material includes worksheets for pupils which accompany every experiment. Worksheets offer creative activities, puzzles, and exercises focused on searching for information.



Pracovní list: Katapult

1) Nakresli obléhání hradu.

2) Odpověz na otázky. Informace můžeš vyhledat, zeptej se rodičů, podívej se do knížky či učebnice nebo použij internet.

- Jak vysoké bývaly obléhací věže? 8–12
- Znáš nějaký objekt, který je stejně vysoký?
- Co se střílelo katapultem? KÁMEN

Figure 6. Worksheet

Worksheets can be used in lessons with experiments, in other lessons – for example in arts, or children could do them at home. In Figure 6 the first part of a worksheet connected with the experiment catapult is depicted together with a pupil's solution.

3. Development of an Educational Program

The development of the educational program could be divided into five stages as shown in Figure 7. In this chapter all stages will be described in more depth.

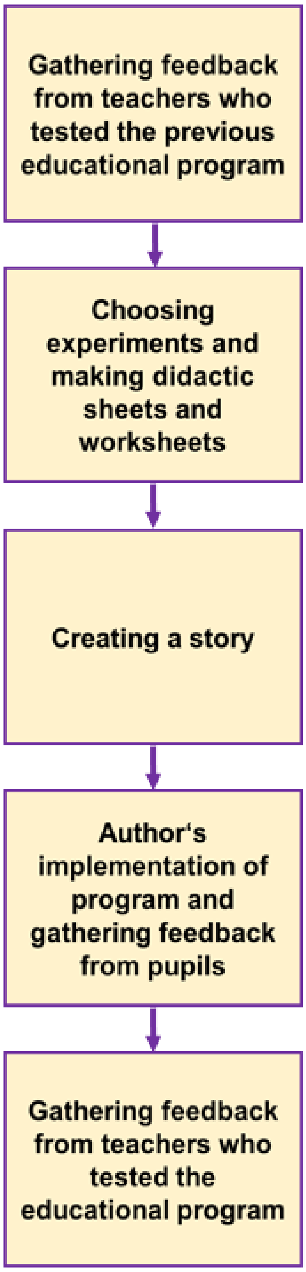


Figure 7. Development of program

3.1. Gathering feedback

The first stage of the development was getting feedback from educators on the previous program *O podstatě magie* (About the nature of magic) created as a part of the author's bachelor thesis [6]. The teachers were asked to read the educational program and give feedback by questionnaire. They of course could try the program in a classroom but it was not required. The questions in the questionnaire were focused on the connection the story has to experiments, how clear and useful the didactic sheets are according to teachers and what is the teacher's overal opinion about the usefulness and useability of the educational program.

The questionnaire was filed by nine teachers. The majority of respondents were satisfied with the educational program and found it suitable for implementation in primary school education. All respondents would recommend the material to their colleagues. Seven of them anticipated that they could also use the material with other classes. The format of the educational program was satisfactory to all teachers, so the author used the same format in the following program *O magické bouři* (About the magical storm).

3.2. Choosing experiments

The second stage of the research was choosing experiments to include in the program. In addition to creating a set of criteria for this selection that experiments must fulfil, the author tried to ensure that all chosen experiments would be as diverse as possible and that they will cover various areas of physics. At the same time, all experiments should be conducted directly by the pupils, not the teacher. While the teacher can explain the procedure, provide assistance, and offer guidance, the majority of the experimentation should be done by the children themselves.

The first criterium was a **duration**. Children should be able to perform each experiment within approximately thirty minutes. The second criterium was a **difficulty**. The experiments were designed for primary school, so they should not require excessive manual dexterity such as tying numerous knots or intricate cutting. Similarly, the success of the experiment should not depend on very precise execution.

The third criterium was a **material**. The materials for each experiment should be affordable and available, and their buying should not burden the pupils, their parents or the teacher. Another criterium was if the experiment helps with improving a **scientific thinking**.

The fifth criterium was an **attractivity** of the experiment. The aim of the didactic program is to foster a positive attitude towards natural sciences. For this reason, it is important that the selected experiments support this goal. The experiments should be interesting, easily observable, engaging, and possibly colourful. Each chosen experiment should sufficiently differ from the others, and ideally, each one should captivate children with something unique.

And the final criterium was whether the experiment can be **adapted for distance learning**. Experiments were also chosen according to the Czech **curriculum framework**. Didactic sheets and worksheets were then created for each selected experiment.

3.3. Writing the story

The third stage of development involved the preparation of a fairy tale story that would connect all selected experiments. The story had to be written in the language of children and also show that physics can be just as useful as magic or even more so. The story also includes themes that are important to children such as friendship. Furthermore, during the adventurous story, the main characters exhibit good manners in non-forceful ways.

3.4. Implementing the program

The fourth stage of the development was the author's implementation of the created program in elementary school and obtaining feedback from the pupils, who were part of this realisation. The realisation was done with pupils in second grade. The class was bilingual and consisted of fifteen pupils. The class looked like they enjoyed experimenting and the whole program. The experiment catapult was the best rated by the children. The worst was the strawberry propeller however the resulting average ratings of the experiments did not differ significantly from each other.

According to their class teacher, the program was interesting for the children, and she was very pleased that her class could participate in it. She considers it beneficial for her pupils. In Figure 8 is captured the moment when the class tried their strawberry propellers.

Figure 8. Children with strawberry propellers

3.5. Feedback from teachers

The final stage of the development included gathering feedback from teachers who tried the program with their pupils. The opinions were collected through a questionnaire, the responses were analysed, and changes were made in the program accordingly.

The questionnaire was filled out by seven respondents, all of whom teach in primary schools. The format of the educational program was satisfactory to the majority, so it could be left unchanged. The majority of the respondents praised the educational program and were satisfied with it. They also stated it engaged their pupils from all seven classes whose teachers participated in the testing. The distribution of classes according to age is in Table 1. All respondents believed that it is suitable for inclusion in education and should continue to be used.

Grade	Age of children	Number of classes
Second	7 - 8	4
Third	8 - 9	2
Fourth	9 - 10	1
Fifth	10 - 11	1

Table 1. The participating classes in the educational program

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4. Conclusion

The educational program *O magické bouři* (About the magical storm) was developed to foster children's interest in physics and enhance their positive attitude towards science. It consists of a fairy tale story, experiments and other activities designed for primary school pupils.

During the development of the program, feedback from educators was gathered to ensure its effectiveness and suitability for implementation in primary school education. The majority of the teachers found the program satisfactory and recommended it to their colleagues.

The whole program (so far only in Czech) can be found on the website [7] which can be accessed by QR code in Figure 9.

Figure 9. QR code to the educational program

5. Acknowledgements

The work was supported by the grant SVV no. 260712.

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"Core Sustainability Lab". Hall Escape Online to Work on the SGDs in the Secondary Classroom

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Abstract. The "Core Sustainability Lab: (ODS 2150)" project, which we will refer to by the acronym CSL_ODS for its acronym in Spanish, is based on activities, visits and collective games in a hybrid, face-to-face and collaborative online format, applying the Science, Technology, Engineering, Arts and Maths (STEAM) methodologies and the gamification of learning.

Thanks to CSL_ODS, Secondary Education students, target of the project, will be able to to discover the operation of a Research Support Center, with highly complex scientific instrumentation. And to understand the important contribution of scientific research to the achievement of the Sustainable Development Goals (SDGs) included in the Agenda 2030 of the United Nations

Keywords. Secondary School, SDGs, STEAM, Virtual Hall Escape, Transmedia Storytelling.

1. Introduction

The STEM/STEAM field is an area of high employability worldwide and particularly in our closest environment. It must also be added that the COVID-19 crisis has affected people with lower educational levels much more, increasing social inequalities. [1]

However, despite the fact that scientific-technological careers represent one of the largest employments and salary niches, they are not attractive to many young people. According to the European Round Table, [2] the low birth rate and the low number of students choosing STEM careers pose a challenge for the selection of human resources in most European countries. For all these reasons, it is essential that from an early age scientific vocations and the interest of the youngest in learning and developing new skills and abilities are encouraged.

But if this need to promote scientific vocations is key in young pre-university students, the problem increases when we talk about the female gender. A recent study [3] showed that from the age of six, girls attribute intelligence to people of their gender to a lesser extent than boys, thus associating intelligence and masculinity. At this same age, girls start not to be interested in games that they consider to be aimed at highly intelligent people. That is, the problem of female self-esteem arises already in the early stages of life to continue in adolescence and perpetuate itself in adulthood.

On the other hand, with covid19 we have learned that the online resource can also be an essential tool in saving time and financial resources. At the same time, digital platforms allow us, with increasing efficiency and realism, to bring environments closer to people, bringing multiple advantages, especially when displacement is a significant handicap (due to distance, functional diversity, risks linked to the environment, etc.). Our aim, therefore, will be to bring the laboratory closer to high school classrooms, virtually bringing the scientific facilities to young people who otherwise (even without a pandemic) probably would not have the opportunity to meet. It is not very feasible to take hundreds of students to a Research Support Center like ours, but it is feasible to create a virtual experience that brings the laboratory closer to the educational center. Through CSL_ODS, a virtual trip will be made to the CCITUB facilities that will consist of a series of stages designed so that:

- Students develop the ability to think logically and independently, through scientific methodology, acquiring resources and key skills to solve real problems;
- The students see science as something natural so that they participate in a challenge that leads them to develop scientific-technical vocations, especially promoting the active participation of girls in scientific projects, including women scientists and technologists;
- The teaching staff of non-university educational centers learn new tools and activities that allow them to

project to their students a dynamic and attractive vision of science, technology and innovation as a complement to academic curricula;
- Students learn new scientific concepts through activities that encourage the formulation of questions, arouse their curiosity, concern and commitment to science;
- Students understand the eminently multi and interdisciplinary nature of science and technology, stimulating in them transversal skills such as teamwork, collaboration, leadership capacity, entrepreneurship, innovation, creativity, etc.;
- The impact of science on the development of our society is made known at an early age.

On the other hand, the main format chosen, the called "Hall escape" (virtual) an alternative to "escape room" format, brings the most suitable elements for our educational objectives. On the one hand, it transfers prominence to the virtual space where the experimental laboratories are presented, allowing access to complex infrastructures and instrumentation, which often carry risks associated with the experiments that are carried out.

Likewise, the “Hall escape” format allows much more flexibility with the execution time of the activity. This allows the teachers to match the game with the teaching of the subject that they consider best suited to the subject matter or curriculum. Finally, the instrumentation visited virtually is located in small spaces (not intended as high-capacity classrooms) and centralized in main urban centers. These factors make it difficult for students to visit in person, even more so if they come from towns far from the big cities.

Educational simulation based on games, objects or dynamic processes is a didactic tool can improve the understanding of the subject content, since it opens the understanding of abstract ideas and concepts. Educational simulation is ideal for manipulating and modifying the learning process, depending on the educational needs of each moment, and it is useful for transporting us to a place and time that would be impossible to reach through a real classroom experience. [4] Furthermore, the emotions in the activity are related to an initial feeling of stress, followed by satisfaction as the students solve the challenges. The evolution of feelings is related to the self-confidence that students experience during activities regardless of the results of the game. All this applies, specifically, to what we could call "Educational Hall Escape (EHE)", [5] like ours, consisting of the execution of the game by several teams of students in the same educational space (classroom) and in a collaborative environment. The EHE motivate, promote and strengthen the skills and knowledge related to the topic of the subject. The EHE also offer two important positive elements added to the "educational escape rooms" on which they are based: 1.- the existence of several teams collaborating to achieve the same challenge at the same time and place; 2.- Eliminate the condition of leaving the room as the final objective.

Another very useful element for our project is that several aspects of the EHE can be evaluated by analyzing the results of the students, such as the level and adaptation to the challenges, or the time allocated. To obtain this information, a virtual web space, such as the one we propose, records and monitors student activity. This type of virtual resource offers the possibility of sending automatic feedback to the students, to guide them during the process, whether the answer is correct or not, and to determine whether or not they should repeat the challenge. Another important aspect is that they also allow you to incorporate additional information that is not necessary to complete the challenge. In other words, starting from an equal basis for all students, they allow those participants with the greatest curiosity to satisfy their concerns without penalizing the rest.

Finally, the reinforcement of the aforementioned "transmedia narrative" or "transmedia Storytelling" to the "virtual escape hall" provides a very immersive and interactive educational experience. This type of activity is increasingly recognized for its methodological innovation and its effectiveness, both in university and pre-university education. [6] The projects where transmedia reinforcement is used show that the creation of narrative worlds can be used to fulfill educational objectives and support the implementation of strategies that combine effective storytelling with transmedia techniques. In fact, the successes in transmedia learning environments suggest an urgent redefinition of curricular learning, bringing learning processes closer to real contexts where

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people socialize, entertain and learn informally [7].

2. Objectives of the CSL_ODS project

The CSL_ODS project offers the possibility of getting to know the Scientific and Technological Centers of the University of Barcelona (CCITUB). [8] The specialized technical staff from various CCiTUB laboratories, together with research staff from the University of Barcelona and other institutions, have coordinated to show the different possibilities offered by the different experimental laboratories, placing special emphasis on the lines of scientific research that are most in line with the achievement of the SDGs. In this way, through experimental techniques and state-of-the-art scientific instrumentation, students will be able to understand the great potential offered by scientific research, as well as concrete ways to face real challenges such as climate change, the preservation of terrestrial and underwater ecosystems, health, etc. The main objectives of the project are:

1. Disseminate and value the importance of the Sustainable Development Goals through the contribution of scientific-technological research in the main experimental disciplines.
2. Promote the interest of young pre-university students in scientific-technological disciplines through direct contact with the research method and practice.
3. Promote the vocations of students, specially girls, in the STEAM field, through reference figures that make visible the role of women in Science and other actions.
4. Bring and manage technological infrastructures of high complexity and high cost to the youth, increasing their scientific vocations, their scientific language and their scientific acculturation.
5. Value the relevance of research in the challenges of society in order to improve the quality of life of its citizens.
6. Raise awareness of the implications of research at the level of results and costs.
7. Raise awareness about the implications and relevance of science and technology in today's society.
8. Publicize the work of experimental research support centers, as well as their contribution to achieving the objectives and goals of the 2030 agenda for sustainable development

2. Methodology

From the methodological point of view, CSL_ODS is based on a set of actions focused on "gamification". [9] These actions allow a significant improvement of the scientific-technical knowledge of the students on a wide range of lines of research, promoting the acquisition of scientific skills of the beneficiaries of this project and, above all, they will foster their curiosity and interest that, at one stage Later, it will lead these young people to want to delve into the field of Science and Technology.

The approach is the promotion of scientific activity from a gamified development and with “transmedia” reinforcement, which allows a more immersive and participatory experience. The use of "transmedia Storytelling" or transmedia narrative implies a process in which learning is carried out through research, analysis and discussion in multiple channels. Thus, applying narration techniques combined with the use of multiple platforms, immersive learning is promoted, creating a unified and coordinated experience, where each medium makes its own contribution to the development of the story that is the axis of the gamified activity. They are usually online web 2.0 tools that facilitate dynamic connection between members of the educational community.

The gamified development is reinforced with the "transmedia narrative", allowing a type of story in which the story unfolds through multiple media and communication platforms, and where a part of the participants assumes an active role in the process of creation. activity. The idea is to tell the same story using the potential of each medium, which allows an immersive, participatory, interactive and as collaborative experience as possible. In our case, the "Hall escape" is resolved in phases, over one or several weeks (depending on the availability of each educational center and the research support center).

This increase in time, compared to the traditional "escape rooms", allows a better adaptation to the curricular content of the educational centers, an aspect that will be

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agreed upon with each participating school. This type of activity, increasingly recognized for its methodological innovation and its effectiveness in pre-university education, allows the incorporation of a wide variety of materials tailored to the project to support and reinforce a plot line that is attractive to students. Thus, the plot line is essential to make transmedia teaching materials fit, through video blogs, xats, monitoring on various social networks, virtual tours, questionnaires, etc. On the other hand, since students are very used to and feel very comfortable in immersive virtual environments, they easily immerse themselves in the activity, which allows them to interact with the different elements and the tension of the game provides them with great concentration.

3. The virtual tours

The technical foundation of the project rested on the vital decision to create a 3D website rather than an app. This strategic choice was influenced by the objective of inclusivity, aiming to make the platform universally accessible for all students and teachers. The rationale behind this decision was to sidestep the barriers posed by app installations and to ensure that users can directly access the educational material, irrespective of the device used. Whether on a desktop or a mobile device, users can engage with our project effortlessly, thereby reinforcing our goal of broad accessibility.

Our chosen development tool for the website was Playcanvas, a decision made after thoughtful analysis of various available options. Initially, we considered Unity, a tool recognized for its robust capabilities. However, the WebGL content created through Unity is significantly larger to download, raising potential issues of long load times and compatibility problems. We also evaluated the merits of Three.js, which, while being powerful and optimized for performance, poses considerable complexity in the development of high-quality content. In contrast, Playcanvas, being WebXR native, offered us a more balanced blend of power, compatibility, and simplicity of development. Its seamless integration with WebXR played a significant role in our decision, considering our focus on creating an interactive, 3D website experience.

One of the unique elements of our virtual tour is our friendly guide - a 3D robot character. The robot provides the narrative, explaining the game's objectives and leading users through the activities. This interactive character was designed with particular attention to user engagement, aiming to sustain interest and involvement throughout the tour. The interactive character serves as a companion to users, adding a dynamic layer to the virtual tour experience.

Figure 1. 3D reconstruction of a SEM microscope shown by the robot

We aimed to offer an immersive experience, which led us to develop a realistic 3D scenario set in the year 2150. This future world is despicted in a dire environmental state, which underscores the urgent, real-world environmental problems that need addressing. The apocalyptic scenario serves as a backdrop for the virtual tour, emphasizing the gravity of our current environmental predicaments and the crucial need for sustainable solutions.

The virtual tour also features a detailed 3D map of Barcelona, constructed to showcase the Core Sustainability Lab Facilities. The creation of this map involved a multi-step process, beginning with the collection of imagery and topography data from the Institut Cartogràfic i Geològic de Catalunya. We transformed the raw data from topography curves into a comprehensive 3D model. The orthophotos were projected as textures to enhance the realism of the model, which was further optimized for smooth web visualization. The end product is a user-friendly and interactive 3D representation of Barcelona that users can navigate seamlessly.

On selecting a laboratory, the user is introduced to a virtual tour that skillfully blends 3D models with 360 panoramas. We utilized an 360 photography camera to capture between 10

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to 30 panoramas for each laboratory. These images were meticulously aligned and positioned within a 3D space, and projected onto spheres. Additionally, we created a schematic 3D model of the walls and openings to serve as a visual guide, as well as a mask that occluded the spheres on adjacent rooms. To enhance the illusion of movement within this 3D space, we developed seamless transitions from one sphere to another, animating the 3D position of the user and creating a sense of being and physically moving within the laboratory, with the robot as our guide.

A key aspect of the virtual tour is the ability to view and interact with laboratory equipment and microscopes virtually. To recreate this equipment, we used photogrammetry and Time-of-Flight (TOF) sensors to generate high-resolution 3D models. These models were then meticulously reconstructed by our team of expert 3D modelers who created stylized yet accurate digital replicas of the equipment. For added depth, we also created schematic 3D models of the equipment's inner workings, which could be shown by making the exterior transparent. This feature provides users with a unique opportunity to explore the inner mechanisms of the machines in a way that would not be possible in a real-world tour.

Overall, the technical development of the virtual tours involved a synergy of advanced web technologies, high-quality 3D modeling, and user-friendly design principles. Our primary goal was to create an immersive, interactive, and educational experience that is both engaging and informative for all users. Each decision and development step was undertaken with the user experience at the forefront, ensuring that our final product is not just technologically impressive, but also offers meaningful educational value.

4. Hall Escape development

Given that the didactic materials and their design revolve around a very clear plot line, it is very important that its construction and that the transmedia resources developed conveniently converge on it.

The development of the plot is responsible for guaranteeing the level of immersion in the story used, reinforcing participation and reducing dropouts in the development of the project, maintaining the interest and motivation of the participants throughout the development of the activity. . Thus, in our case, a common thread is chosen that narrates a dystopia, a planetary collapse, where the inaction of the population has led to the decline of natural resources, massive contamination and generalized shortages of water and food, a scenario that leaves few hopes of salvation for the planet and its inhabitants. An idea that allows us to convey the importance of the SDGs and that serves to visualize the serious problem that we face globally.

To solve this situation, which is located in the not too distant future, 2150, the opportunity arises to return to the present, through a machine that offers the opportunity to use the scientific-technological resources of the Core Sustainability Lab (CSL Lab) in 2023. In this way, students are urged to find a possible solution to the challenges posed in the 2030 Agenda before the collapse occurs. This gives rise to 360 virtual visits to the laboratories that explain the potential of their equipment, access to didactic files and the approach to challenges and specific investigations linked to sustainability that can be carried out in these facilities.

As the story progresses, the participants verify the social relevance of the research carried out there, in addition to knowing, through concrete examples, such as the experimental design of research related to water, energy, conservation of terrestrial and underwater ecosystems, etc The plot timeline will also be taken care of for its coordination with the curricular contents of secondary education, the level of difficulty, news and communications presented on social networks and video blogs, etc. In this way, time is given to work in the classroom on topics related to the subjects taught, also to solve online questionnaires that give access to the actions that start the game, as well as the resolution of doubts that may arise.

For the dynamics of the game, a web application will be developed. 2.0 "responsive web" (adapted to smartphones and tablets) that allows access to content in an accessible and clear way. The website will have access for three user profiles: student, teacher and mentor. The web environment will have a main access to the

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control terminal from where relevant information can be accessed such as:

- Proposed investigations in progress: Considering the links with various SDGs so that students can identify them, as well as their relationship with the subjects studied.
- Virtual access to the facilities of the experimental laboratories through 360 videos.
- Challenges to solve according to the narrative of the game.
- Videoblogs: dramatized audiovisuals that pose new challenges or problems to be solved (timed depending on the progress of the activity).
- Work teams: allows visualizing the components of the different teams formed in the classroom regarding the activity and how they advance in the game. Each team will have a female leader.
- Chat with the Researcher/Mentor. Each work team may consult the assigned Mentor during the period of execution of the activity.
- Didactic materials. Sheets of each technological laboratory, didactic dossiers, information on the SDGs, FAQs, Instructions, etc.

Currently, online platforms allow us to reach schools throughout the territory, including rural areas, without the limitations of a face-to-face activity. The online format will allow us to bring the experimental laboratories to the classroom in a didactic way to a large number of students who suffer comparative grievances due to relocation, since they do not have easy access to the resources that those who live in large urban areas do have. or close to them.

For an adequate development of the activity, the teaching staff of the schools and institutes will also be provided with material in pdf format that can be printed by the center and allows the classrooms to be set up in a process in which it is recommended to involve the students, for which said material will be designed to promote the so-called visual thinking (visual thinking) during the decoration of the classrooms. This will already be a first step to excite students with striking, attractive images, and will make them visually locate themselves in a scientific-technological environment.

5. Testing in schools

The program has been carried out in two secondary schools in Barcelona, Spain:

- INS Narcís Monturiol
- Escola Virolai

In both cases, it was carried out in the first year of high school (15-16 years old) in two sessions of 1h (Monturiol) and 1h30 (Virolai).

Figure 2. Storytelling example

The dynamic began with a short presentation of the project and the dynamics of the game. The students carried out the activity divided into teams of two, and started the dynamic:

- In the first place, the dystopian situation is presented, with a devastated world.
- Students have to find two types of samples (drosophila fly) and water to be analyzed respectively in Confocal Microscopy and SEM Microscopy.
- Different didactic documents are presented to learn how the different equipment works, what type of sample they have, what type of analysis they seek, what type of results they expect, etc.
- The different SDGs are presented, so that later, the student has to link the solution obtained to a specific SDG problem.

- Students begin virtual visits to the laboratories until they reach the equipment to use (Confocal and SEM).
- The equipment is presented in 3D format differentiated by the different parts, which are explained to the students.
- The students analyze the samples with the equipment, obtaining a result.
- With a dynamic of creativity, the student has to look for possible solutions to the SDG challenges through the results obtained to prevent the dystopian future.
- The students, in storytelling format, will present their solutions.

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How "Kahoot" Settled at the National Technical University "Kharkiv Polytechnic Institute"

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Abstract. Kahoot, a popular online learning platform, gained significant popularity and settled in the National Technical University "Kharkiv Polytechnic Institute" in Kharkiv, Ukraine with the outbreak of war. The university uses Kahoot as an effective tool to increase the involvement of students, schoolchildren and teachers, as well as improve the quality of learning in a playful way.

Kahoot's interactive nature and playful approach has made it an ideal choice for a university that promotes active participation and retention of knowledge among students and pupils. And also allows you to conduct master classes for teachers on the use of LMS. Customizable quizzes, quizzes and platform discussions have been integrated into various courses and projects such as Holiday with Politech, Professional & Open Days and Day of Light, allowing educators to create interactive learning programs tailored to their specific subject as well as to motivate students to choose a future professions and areas of study.

Using Kahoot, the National Technical University has transformed traditional lectures into dynamic and interactive classes, encouraging student collaboration and competition. Real-time feedback using the Telegram channel with live streams and leaderboard features make students feel excited and motivated, making the learning process more enjoyable and rewarding.

In addition, the accessibility and user-friendly interface of Kahoot contributed to its seamless integration into the technological infrastructure of the university. Students and schoolchildren can easily access Kahoot on their personal devices, providing flexibility and convenience.

In general, the presence of Kahoot at the National Technical University "Kharkiv Polytechnic Institute" has revolutionized the way students, schoolchildren and teachers interact with course content, promoting active learning and academic success and the emergence of motivation.

Keywords. Kahoot, Involvement, Playful, LMS, Interactive Learning Programs, Collaboration and Competition, accessibility.

1. Introduction

The problem of low popularity of science and mathematics subjects in secondary and high school, as well as science and mathematics and engineering and technical specialties in universities of subjects and specialties among young people is not new for Ukraine and the world. But, based on the demographic situation that has developed in Ukraine since 201X, when the number of school graduates/university applicants began to decrease sharply, and in parallel with this, a shortage of engineers, technologists and designers was created at the country's enterprises due to the retirement of the older generation and a shortage of university graduates our team, at that time young scientists and the admissions committee of NTU "KhPI", since 2017 developed a new strategy for career guidance work among schoolchildren and students and launched new regular events in the STEM style with the aim of popularizing these directions.

2. Innovative approaches to career guidance: fusion of STEM and online formats

A number of ongoing events were created, including: "Holidays with Polytech", "STEMcamp School", "Scientific Saturdays with Polytech", "Open Days in a new format", "International Day of Light" (within the framework of the UNESCO global initiative) and others As part of these ongoing activities, various formats of interaction based on STEM methods were tested: visual experiments and experiments, master classes, workshops, demonstrations, interactive lectures and projects. Even created its own term describing the format of the event - "Laboratory-experimental zone". The implementation of measures took place both on the basis of our university (NTU "KhPI") and abroad, which allowed us to share our approaches not only with residents of the city of Kharkiv, but also with schoolchildren, students, teachers and those who are simply interested in science from other regions of Ukraine. The geography of our events

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in addition to the city of Kharkiv and the settlements of the Kharkiv region, which have been held offline since 2017: the city of Poltava (Poltava region), the city of Kropyvnytskyi (Kirovohrad region), the city of Kreminna and the village of Krasnorichenske (Luhansk region), Kramatorsk (Donetsk region), Pology (Zaporizhia region).

In parallel with offline events from 2017 to 2019, together with the educational project "On the Lesson", we started experimenting with the online format and implemented several new original projects. These were: "Online laboratory works" (a series of laboratory works that can be reviewed and reproduced together with the teacher in class) and "Footprints of CHORNOBYL" (a study guide and a series of online lectures that examine the Chernobyl disaster from the point of view of various sciences and subjects and show, which was done by people to eliminate the consequences, which in our opinion is a vivid example of what it is necessary to acquire knowledge and skills). Our first online practices turned out to be successful, which was confirmed by a large number of views and positive feedback from participants.

We began to receive positive results from the introduced career guidance strategy and the implementation of ongoing activities in 2019, when, based on the results of the admissions campaign to our university, the recruitment of students for engineering and technical specialties, which are in acute shortage for the country, began to increase. According to the main (largest) majors with acute shortages that benefit from special support from the state, NTU "KhPI" takes the leading positions among Ukrainian universities in terms of admission to study after school (for example, majors: 131 "Applied Mechanics" - 2nd place; 141 "Electrical Engineering, electrical engineering, electromechanics" - 2nd place; 142 "Energy" - 1st place; 161 "Chemical technologies and engineering" - 2nd place).

Then, COVID-19 began, which forced an urgent change to exclusively online formats of conducting career guidance events. Live broadcasts on Facebook, Instagram, and a little later Telegram were chosen as the basis for online events. Thus, our main events: "Holidays with Polytech", "STEMcamp School", "Open Days in a new format", "International Day of Light" (within the framework of the UNESCO global initiative) received their continuation and new life during the pandemic.

Gradually, Telegram became the main platform for holding online events for us due to its convenience (you can hold an event with only a phone at hand), multifunctionality (for example, there is a screen demonstration), accessibility (any gadgets and a relatively small load on the Internet), wide administration capabilities and popularity among the population of Ukraine, especially the youth. The main advantage for its implementation was "Video-chat", which can be created on the basis of already created groups. Group settings are very flexible, you can make both a closed group and a dynamically open one. Thus, by holding events in groups, we extended their "lifetimes": first the announcement, then the event itself, during the event and after it - comments and discussions in the group, and then the announcement of the next event and all over again. Thus, we have two main Telegram groups at the university for conducting online events: "Open Day of KhPI" and "Holidayss with Polytechnic".

In Ukraine, we have a saying "There is no evil without good." This is how, through the COVID-19 pandemic, we gained the experience of effective online communications and conducting online events, which we really needed at a critical moment.

3. STEM Education during the war in Ukraine

24.02.2022 - the war began. Kharkiv - refrained. He received the official title of "Hero City" and the national titles of "Unbreakable" and "Zalizobotonny". Using the experience gained during the pandemic helped us to resume the educational process and successfully graduate. And we began to look for new formats that would be effective in the conditions of martial law and hostilities.

The main drawback of the previous online events was the low interactivity of the participants. The maximum that participants can do live is to send comments. This is not enough, especially when people have a real "hunger" for communication. The solution was suggested to us by our students. They offered to hold a Kahoot quiz during the annual "Dedication to

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Students" event. And we did it. The effect was "Wow". At the same time, 500 players competed for victory and did not drop out of the live broadcast. The decision was made - our new strategy for 2022 - 2023 AD. became the involvement of Kahoot for conducting online events. We wrote a cover letter to Kahoot and soon received 30 EDU Kahoot accounts for the university. Accounts were received by our "Leaders of opinions" on career guidance work and popularization of STEM and engineering and technical education, as well as structural subdivisions of NTU "KhPI".

The main technical solution for conducting online events was the holding of a Kahoot quiz with a live moderator in a Telegram video chat, which was created on the basis of an existing Telegram group. Such a decision allows to maximally involve guests, schoolchildren and students to participate in the event. Now, in addition to comments in the group, they were constantly included in the activity through the quiz game. In addition, after the quiz with the host ends, for those members of the Telegram group who could not participate in the live broadcast, a link to independently pass the same Kahoot quiz is sent to the group. In this way, we managed to maximally activate our audience, which gradually began to grow. Gradually, our Telegram groups "Open Day of KhPI" and "Holiday with Polytech" became centers of youth and educators interested in STEM and engineering and technical education.

4. Kahoot: Playing for Knowledge and Victory!

Starting with "Autumn Holidays with Polytech 2022", Kahoot quizzes were developed for events. And then everything went according to our developed plan, when each project consists of a series of activities united by a theme. For example: "Winter Holidays with Polytech" was held under the theme "Safety" and included 52 activities; "Spring Holidays with Polytech" was held under the theme "Great scientific ideas that changed the world" and consisted of 24 thematic events; "Open door days in a new format" for which a Kahoot-based game was specially developed, as well as "International Day of Light" (within the framework of the UNESCO global initiative), which consisted of a total of 28 events. These are the main projects whose activities are aimed at the popularization of STEM and engineering and technical education among young people in 2022-2023.

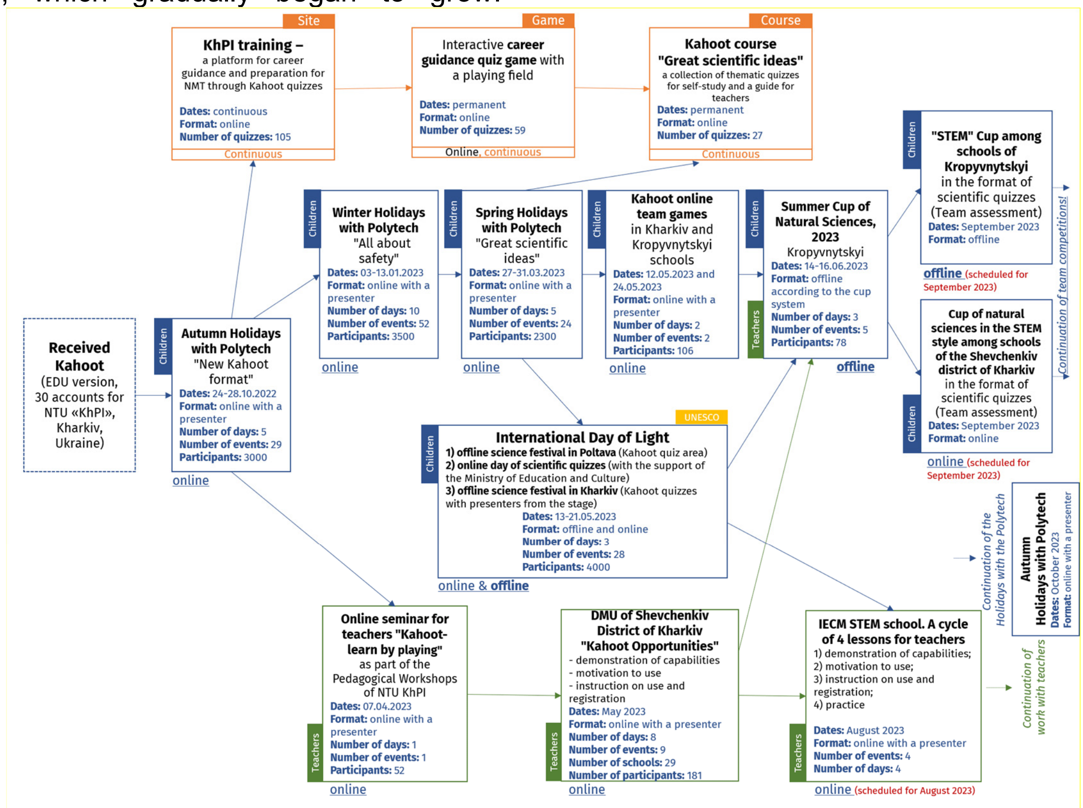

Figure 1. Events diagram

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In parallel with this, we started the development of new permanent online projects based on Kahoot for the independent participation of players. The website of the platform "KhPI Training" [6] was created, the purpose of which is both preparation for taking state exams for admission to the university, and preparation of the applicant for an informed choice of his specialty. Both directions are implemented through Kahoot quizzes for self-study, divided into two corresponding catalogs. More than 100 quizzes for familiarization with specialties are presented on the "KhPI Preparation" website, and this number is constantly updated. The general catalog of quizzes for preparation for state exams for admission to universities consists of more than 150 quizzes in such disciplines as: mathematics, Ukrainian language, history of Ukraine, geography, biology, chemistry and physics.

Another online project was an interactive career guidance quiz game with a playing field "Play, learn, choose together with NTU "KhPI" in which the classic playing field with cubes was combined with links to 59 Kahoot quizzes. The presentation of this project took place during the "Day open doors in a new format". You can play at the link [7].

Currently, we continue to work on the direction of large projects for independent participation and soon the Kahoot course "Great scientific ideas that changed the world" will be announced, consisting of 27 popular science quizzes and a study guide from the team of event authors, the highlight of each section is a laboratory a technique that can be replicated in the classroom with students.

Having gained experience with Kahoot, looking at statistics and effectiveness of engagement, as well as positive feedback from participants. We decided to start the third direction of activities - familiarization of educators with the possibilities of Kahoot. The first such activity was participation in the online seminar for teachers "Kahoot-learn by playing" as part of the annual conference "Pedagogical Workshops of NTU "KhPI". The teachers were interested in this format. This event was continued in a larger format - a district methodical "union for teachers of the Shevchenkiv district of Kharkiv, which brought together 181 educators from 29 educational institutions. For 8 days, teachers got acquainted with the possibilities of Kahoot (including playing thematic quizzes with leaders in their disciplines in the role of students), and also received instruction on use and registration in Kahoot.

According to the feedback of Kharkiv teachers after the events, Kahoot is an extremely effective and important tool for the educational process, especially in the conditions of a forced distance format. At the same time, many teachers noted that although they had encountered Kahoot before, they did not know about all its possibilities.

Let's stop and briefly consider the functionality, technologies, settings and formats of its application. In the administrative panel there are several important items, among which: explore, library and reports. The "explore" section allows you to use public quizzes to conduct your own classes. It is equipped with convenient search and filters. The "Library" section stores your quizzes and courses. Pay attention to the possibility of creating courses with quizzes. This will allow you to easily create your own interactive courses, which will consist of a series of topics (quizzes), which can be additionally structured into modules within one course. Try it, we have made a course for you to familiarize yourself with us [8]. The "Reports" section turns a simple quiz game into a real LMS, which, by the way, we also use in the educational process in working with students.

Among the important settings for creating and using quizzes, it should be noted: firstly, visibility - your quizzes can be public (everyone can see and use them) or private or hidden (only those who, in your opinion, should see them); the second application - you can conduct a quiz live with the host, or you can provide a link to independent passing (so-called "assigned" quizzes); thirdly, play with anyone, anywhere - quizzes can be held both online and offline; fourthly, you can play quizzes, both individually and as a team.

Basically, our experience that was given above was implemented on the basis of Kahoot quizzes for individual play. That is, as a result of each quiz, a tournament table is built based on the individual score of the players. This approach is interesting, but we continued to experiment and at the end of the 2023 school year, we switched to a team format of Kahoot competitions. Team competitions became the next real discovery of Kahoot for us. We held online competitions between classes in Kharkiv schools in an online format, as well as organized and held the Natural Sciences Cup in Kropyvnytskyi. Where according to the cup system (1/4, 1/2, final), 8 schools of the city competed for victory. Feedback from this format exceeded all our expectations. Thanks to Kahoot, we were able to bring quizzes between schools to the level of a real competition with intrigue, emotions and sports excitement of the participating teams.

5. Conclusions

The article examines the problem of the low popularity of science and mathematics subjects and specialties in Ukraine, especially in the context of a decrease in the number of school graduates and university applicants. In order to popularize these directions and solve the personnel shortage of engineers and technologists, a career guidance strategy was developed and regular STEM-style events were implemented.

The article also describes the introduction of new online formats of career guidance events through experiments with the educational project "On Lesson". Events such as "Vacation with Polytech", "STEMcamp School" and others were successfully implemented both offline and online.

After the introduction of restrictions related to the COVID-19 pandemic, the events moved to an online format, in particular on the Telegram platform. This made it possible to expand the audience and ensure the convenience of events. The use of online communications and the holding of events in this way have become important in the conditions of martial law.

The conclusion of the article indicates the successful results of the implemented career guidance strategy and the implementation of ongoing measures, which led to an increase in the recruitment of students for engineering and technical specialties that are in acute shortage. The introduction of the online format made it possible to adapt to the conditions of the pandemic and martial law, ensuring the continuity of the educational process.

In addition to the above, the COVID-19 pandemic and the war, which became difficult tests for Ukraine and Kharkiv, revealed the need to look for new formats and methods of communication to ensure effective career guidance work. The successful implementation of online events on the Telegram platform made it possible to overcome challenges and ensure the continuation of career guidance work even in difficult conditions.

The use of video chat and the creation of groups based on Telegram made it possible to expand the possibilities of holding events and attract a wide audience. This platform has become popular among the population of Ukraine and young people, providing convenience, accessibility and multifunctionality.

Thanks to the introduction of online formats of career guidance events, KhPI National Technical University was able to effectively interact with schoolchildren and students not only from Kharkiv and the region, but also from other regions of Ukraine. This made it possible to spread the popularization of natural and mathematical subjects and engineering specialties among young people throughout the country and contributed to an increase in the number of students who choose specialties in acute shortage at the university.

Thus, with the help of new innovative approaches to career guidance, including the fusion of STEM and online formats, NTU "KhPI" achieved positive results in increasing the popularity of natural and mathematical subjects and engineering and technical specialties. This was an important step in ensuring human resources for the development of the technological sector and innovative economy of Ukraine.

Based on the results of the team competitions, we propose to take an innovative step together and hold European intellectual team competitions in the field of STEM in the format of Kahoot quizzes between students of schools with which our universities (institutions) cooperate. This event will be a powerful impetus for motivating students and their conscious choice of STEM specialties to build their own successful educational trajectory.

In the 2022-2023 academic year, we at NTU "KhPI" have a case for the implementation of gamification in the framework of career

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guidance of middle classes for a conscious choice of an educational trajectory, which includes: 11 thematic projects were implemented, within which 350 quizzes were created and 150 events were held, in which participation of more than 13,000 participants.

Thanks to the implementation of this case, we can confidently say that Kahoot is an effective tool not only for solving distance learning problems, but also for classic offline work in the classroom, as well as an indispensable tool for unification: team games and competitions. A presentation of a new topic, a slice of knowledge, or a refresher during a difficult topic is a Kahoot. And both students and educators like it, because it is a vivid example of gamification as a modern educational trend.

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Studying Bovine Leukemia Virus as a Risk Factor for Breast Cancer Development

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Abstract. The main type of cancer that affects women is breast cancer. Nowadays, its specific causes are unknown, but there are many factors that contribute to its development, known as risk factors, such as age, reproductive history, hormones, genetics and lifestyle [1]. Therefore, it's essential that everyone (starting at young ages), is aware of this cancer, its symptoms and its risk factors. Its conscientization and diffusion shall be done in many ways, in order to reach all types of public, with an emphasis on teenagers, via programs like *Crazy About Biochemistry* done by universities or schools. Besides, the presence of Bovine Leukemia Virus (BLV) has been detected in breast cancer tissue samples, according to some studies [2]. The aim of this research is to study breast cancer in the human body and find out if the presence of BLV in mammary tissue is implied in human breast cancer development. The conclusion reached is that the significant differences between studies do not allow us to achieve a clear verdict. Therefore, further research is of paramount importance in order to confirm BLV as a risk factor for human breast cancer development.

Keywords. Bovine, Bovine Leukemia Virus (BLV), Breast cancer, Breast tissue.

1. Introduction

Having the young population informed and aware of medical issues is crucial. It's important to disseminate information about the different types of cancer, especially breast cancer, as it is the most commonly diagnosed cancer around the world. It is also highly relevant to explain its symptoms and how it appears. Breast cancer begins when breast tissue cells start to grow uncontrollably. This may happen when tumor suppressor genes stop codifying for proteins such as p53 [3]. Breast cancer includes many different types of cancer of their own, depending on the part of the breast tissue affected. For example, if the affected area are the ducts, the tubes that carry milk to the nipple, then we address it as ductal cancer. The two most common types of breast cancer are invasive ductal carcinoma and invasive lobular carcinoma. The prefix "invasive" does not mean that it metastasizes to other organs but that it spreads to other parts of the tissue, although it could still metastasize. The opposite of invasive is "in situ", which is used to refer to the cancer cells that have stayed right where they first appeared [4].

1.1. Impact on population

According to the International Agency for Research on Cancer (IARC), one out of every ten cancer cases globally registered is breast cancer. It occupies the fifth place when addressing mortality. Taking into account that breast cancer affects mainly women, these numbers must ring a bell on the importance of finding out how to fight against breast cancer and prevent it.

1.2. Male breast cancer

Breast cancer is most common in women, but men can also develop cancer in their breast tissue.

The disinformation about male breast cancer can cause men to ignore their symptoms and their prognosis isn't as developed as women's. Despite that, it's important to bear in mind that male breast cancer represents less than one percent of all breast cancer diagnoses. [5]

1.3. Risk factors

As previously stated, every year, millions of people get diagnosed with breast cancer, yet the odds of having cancer are far from being equal for every individual. The likelihood of someone's breast tissue cells developing cancer varies due to a compound of aspects known as risk factors. These risk factors [6] can be classified into two groups, depending on whether a person can interfere and make changes in order to lessen or eradicate them. Among the list of risk factors that you cannot change are: getting older (over 50 years old), mutations on the genes BRCA1 or BRCA2, having dense breasts and having ancestors with breast or ovarian cancer. In contrast, being physically inactive and the consumption of alcohol, are two of the risk factors that can be avoided for the sake of decreasing one's chances of developing such a genetic disease.

The main risk factors that add up for men to have breast cancer are the exposure of the chest to radiation treatment and high levels of estrogen [7]. The consumption of cattle and dairy products may be part of the latter but this will be discussed later in this article.

Besides those risk factors, most breast cancers in both women and men are estrogen receptor positive-invasive ductal carcinomas.

1.4. Symptoms, treatment and prevention

When someone sees a cancer case up close, their mind might start to overthink the possibility of having cancer themselves. The symptoms an individual may face while fighting against breast cancer are many. Yet the most common are: getting a new lump, pain, redness, thickening, swelling and irritation; all of those, of course, in the breast or armpit area [7]. In case you are aware that you have one of the symptoms stated before, far from looking them up on the internet, the best thing that can be done is consult a doctor or a professional in this field of medicine. If the specialist confirms a case of breast cancer, the procedure implied for treating it can differ from the following: surgery, chemotherapy, hormonal therapy, biological therapy and radiation therapy [8]. It is essential to be aware of the symptoms and get check-ups from time to time.

2. Bovine leukemia virus

If we go to the other side of our investigation, we have to introduce the Bovine Leukemia Virus (BLV), a retrovirus that infects cattle's white blood cells. It can cause either a benign condition called persistent lymphocytosis or tumors known as lymphosarcomes. This virus can infect both beef and dairy cattle, which are its natural hosts. [18]

2.1. Presence in cattle

Recent surveys in the United States showed that 89% of dairy farms and 38% of beef farms had cows that tested positive for BLV. However, there are currently no specific federal regulations in place to control the spread of Bovine Leukemia Virus among cattle in the United States. The transmission of BLV from an infected bovine to an uninfected one typically occurs through the transfusion of infected blood during common farm practices such as ear tattooing, dehorning, rectal palpation, or injections. Some insects, like large biting flies, can also transmit the virus. Additionally, BLV can be transmitted from an infected cow to her fetus during pregnancy, maternal release and feeding. Once infected, cattle develop a lifelong antibody response to the virus. [9] [10]

2.2. Ways of transmission to humans

Out of the total infected animals, 95% show no visible signs of illness, and despite that, those animals are still used for producing beef and dairy products. [10] The BLV can pass from infected cattle to humans if we consume bovine-derived products, such as raw beef and fresh milk, from infected cattle. Consuming unpasteurized milk could be a possible way for the virus to spread, especially in developing countries, where raw milk is commonly consumed. [9]

2.3. BLV as a cause of breast cancer

Evidence for the transmission of BLV from cattle to humans through consumption of dairy products is shown in some studies where women with lactose intolerance, which implies a low consumption of milk and dairy products, present a lower risk or likelihood of developing breast cancer. As a result of the study, the dietary pattern of those lactose-intolerant women has decreased their risk of developing some cancers, including breast cancer, but this decrease has not been found in their lactose consuming relatives. Consequently, the consumption of dairy products and milk can be directly related to a possible infection with BLV and the risk of breast cancer development. [11] This claim is supported in a more visual way by the obvious correlation between the map of people who do not produce enough lactase, the enzyme that breaks down lactose: Figure 7, and the map of people that suffer from breast cancer Figure 8, although this could possibly be just a coincidence, it is still a strong point to take into object of study.

2.4. Actual research: presence of BLV in human breast cancer cells

There has been found out the presence of BLV DNA in human breast cancer tissue cells in

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some investigations. [2] For instance, there is a study that suggests that the presence of BLV DNA in human breast tissue is significantly associated with breast cancer. [1]

Contrarily, evidence for the active transcription of BLV genes in breast cancer tissues has not been found. [12]

Hence, we see that with the controversy between those studies and many other articles we found, clear conclusions cannot be given.

3. Methodology

To investigate the presence of BLV DNA in a human breast tissue with cancer, we wanted to conduct a BLAST.

3.1. BLAST tool

The Basic Local Alignment Search Tool is an algorithm that finds regions of similarity between biological sequences by comparing nucleotides to sequences from databases, in our case, for example. After that, it calculates the statistical significance of the matches.

3.2. BLAST session

We used this tool in the practical session of the *Crazy About Biochemistry* program, where we studied if there is more evolution similarity between the sequence of the enzyme LDH (lactate dehydrogenase) of the rabbit's cardiac and striated muscle tissue or between the LDH of the rabbit's and cow's cardiac tissue.

First, we found the protein sequences of the LDH enzyme in the NCBI database [13] from: the rabbit's cardiac tissue [14], the rabbit's striated muscle tissue [15] and the cow's cardiac tissue [16]. Then, we aligned the sequences using the BLAST tool. On the one hand, we compared the sequence of the enzyme LDH from the rabbit's cardiac and muscle tissue. On the other hand, we compared the LDH enzyme sequence of the rabbit's and cow's cardiac tissue

Then, we obtained the results of the query cover, the identity and the positive percentage, corresponding to the evolution similarity. The results are shown in the figures below. In Figure 1 and Figure 2, we see the first BLAST, between the sequence of the enzyme LDH from rabbit cardiac and muscle tissue. In Figures 3 and 4, it's shown the BLAST between the sequences of the enzyme LDH from rabbit's and cow's cardiac tissue.

Scientific Name	Max Score	Total Score	Query Cover	E value	Per. Ident	Acc. Len	Accession
Oryctolagus c...	336	336	98%	9e-122	71.03%	332	7P4G_P

Figure 1. BLAST results between the LDH enzyme from rabbit's cardiac and muscle tissue

Score	Expect	Method	Identities	Positives	Gaps
336 bits(862)	9e-122	Compositional matrix adjust.	152/214(71%)	185/214(86%)	0/214(0%)

```
Query  2    KFIIPQIVKYSPNCIIIVVSNPVDILTYVTWKLSGLPKHRVIGSGCNLDSARFRYLMAEK  61
            KFIIP +VKYSP+C ++VVSNPVDILTYV WK+SG PK+RVIGSGCNLDSARFRYLM E+
Sbjct  118  KFIIPNVVKYSPHCKLLVVSNPVDILTYVAWKISGFPKNRVIGSGCNLDSARFRYLMGER  177

Query  62   LGIHPSSCHGWILGEHGDSRLAVWSGVNVAGVSLQELNPEMGTDNDSENWKEVHKMVVES  121
            LG+H  SCHGWILGEHGDS + VWSG+NVAGVSL+ L+PE+GTD D E WK+VHK VV+S
Sbjct  178  LGVHALSCHGWILGEHGDSSVPVWSGMNVAGVSLKTLHPELGTDADKEQWKQVHKQVVDS  237

Query  122  AYEVIKLKGYTNWAIGLSVADLIESMLKNLSRIHPVSTMVRGMYGIESEVFLSLPCILNA  181
            AYEVIKLKGYT+WAIGLSVADL ES++KNL R+HP+STM++G+YGI+ +VFLS+PC+L
Sbjct  238  AYEVIKLKGYTSWAIGLSVADLAESIMKNLRRVHPISTMLKGLYGIKEDVFLSVPCVLGQ  297

Query  182  RGLTSVINQKLKDDEVAQLKKSADTLWDIQKDLK  215
             G++ V+   L  +E A LKKSADTLW IQK+L+
Sbjct  298  NGISDVVKVTLTSEEEAHLKKSADTLWGIQKELQ  331
```

Figure 2. BLAST graphic summary results between the LDH enzyme from rabbit's cardiac and muscle tissue

Scientific Name	Max Score	Total Score	Query Cover	E value	Per. Ident	Acc. Len	Accession
Bos taurus	435	435	99%	1e-160	96.76%	334	Q5E9B1.4

Figure 3. BLAST results between the LDH enzyme from rabbit's and cow's cardiac tissue

Score	Expect	Method	Identities	Positives	Gaps
435 bits(1118)	1e-160	Compositional matrix adjust.	209/216(97%)	214/216(99%)	0/216(0%)

```
Query  2    KFIIPQIVKYSPNCIIIVVSNPVDILTYVTWKLSGLPKHRVIGSGCNLDSARFRYLMAEK  61
            KFIIPQIVKYSP+CIIIVVSNPVDILTYVTWKLSGLPKHRVIGSGCNLDSARFRYLMAEK
Sbjct  119  KFIIPQIVKYSPDCIIIVVSNPVDILTYVTWKLSGLPKHRVIGSGCNLDSARFRYLMAEK  178

Query  62   LGIHPSSCHGWILGEHGDSRLAVWSGVNVAGVSLQELNPEMGTDNDSENWKEVHKMVVES  121
            LGIHPSSCHGWILGEHGDS +AVWSGVNVAGVSLQELNPEMGTDNDSENWKEVHKMVVES
Sbjct  179  LGIHPSSCHGWILGEHGDSSVAVWSGVNVAGVSLQELNPEMGTDNDSENWKEVHKMVVES  238

Query  122  AYEVIKLKGYTNWAIGLSVADLIESMLKNLSRIHPVSTMVRGMYGIESEVFLSLPCILNA  181
            AYEVIKLKGYTNWAIGLSVADLIESMLKNLSRIHPVSTMV+GMYGIE+EVFLSLPCILNA
Sbjct  239  AYEVIKLKGYTNWAIGLSVADLIESMLKNLSRIHPVSTMVKGMYGIENEVFLSLPCILNA  298

Query  182  RGLTSVINQKLKDDEVAQLKKSADTLWDIQKDLKDL  217
            RGLTSVINQKLKD+EVAQLKKSADTLW IQKDLKDL
Sbjct  299  RGLTSVINQKLKDEEVAQLKKSADTLWGIQKDLKDL  334
```

Figure 4. BLAST graphic summary results between the LDH enzyme from rabbit's and cow's cardiac tissue

With this study, we could see that there is more evolution similarity between the sequence of the LDH enzyme of the rabbit's and cow's cardiac tissue than between the rabbit's cardiac and striated muscle tissues.

In summary, in this case, the evolution similarity is higher in the LDH from the same tissue but different animals rather than in the same animal but different tissues.

3.3. BLV and breast cancer BLAST

Getting back to our main investigation, we aim to use this BLAST nucleotide alignment tool to compare the nucleotide sequence of the Bovine Leukemia Virus (BLV) DNA with the DNA of a breast tissue cancer cell in order to find out if the BLV DNA is present in the DNA of breast tissue cancer cells. Then, if possible, determine if its presence in the breast cells is directly related with cancer development. First, we found in the NCBI database the BLV complete genome sequence. [17] Unfortunately, because we didn't have any way of obtaining breast cancer tissue DNA, and those are highly confidential, we couldn't use the breast cancer tissue DNA to compare it with the BLV DNA and look for the presence of the virus in the breast cancer tissue.

4. Results

The topic that we have chosen to write this article about is extremely controversial since, from one side, a lot of money from different industries is jeopardized in the final verdict. Despite that, we have been completely neutral and have just pointed out the actual accepted facts.

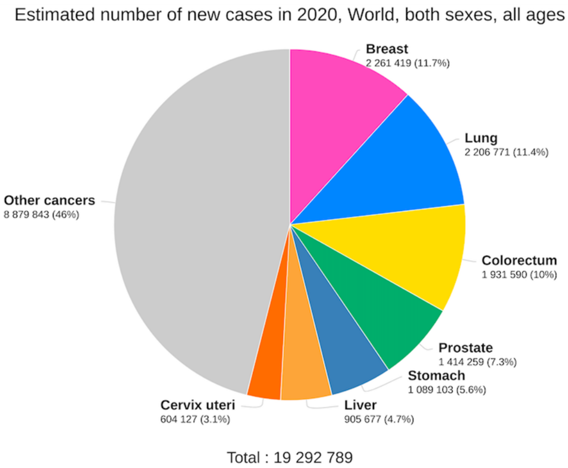

Figure 5. Estimated number of neu cancer cases in 2020, World, both sexes, all ages

Through the data we could acquire on the website of the International Agency for Research on Cancer, the IARC, with over 2.2 million new cases in the year 2020, breast cancer was the main type of cancer diagnosed worldwide, followed by lung cancer, as shown in Figure 5. The estimated deaths were about 700,000, occupying 5th place, followed by esophagus cancer and led by stomach cancer Figure 6. Breast cancer, unlike the other shown in Figure 6, affects mainly women, so finding all its risk factors is of paramount importance.

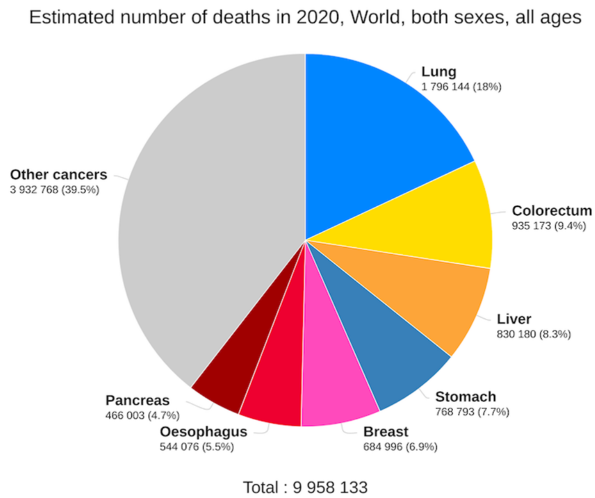

Figure 6. Estimated number of deaths by cancer in 2020, World, both sexes, all ages

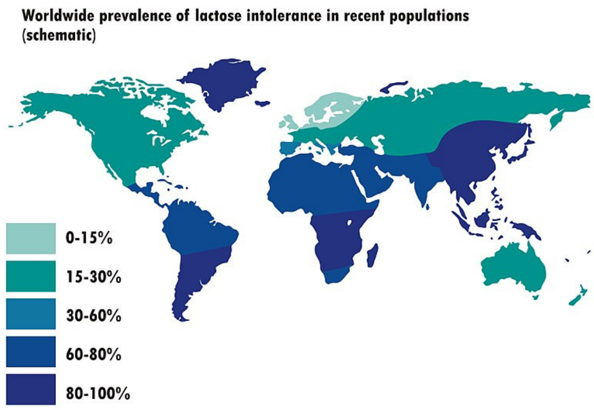

Figure 7. Map of prevalence of lactose intolerance in recent populations

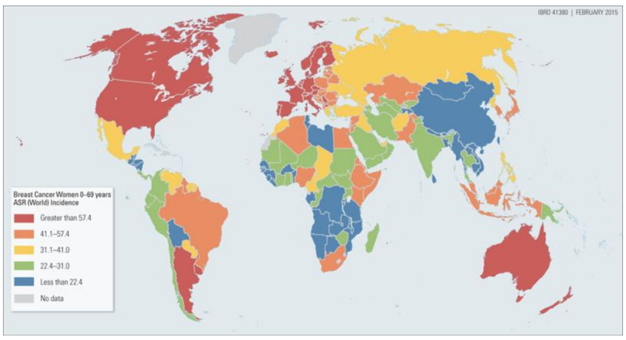

Figure 8. Map of breast cancer incidence

Figure 7 presents in a clear way, which parts of the world are more likely to be lactose intolerant; as we can see, people in the south have the highest rate. Consequently, Figure 8. indicates the incidence of breast cancer in every country. If we compare these two figures, we reach the conclusion that having breast cancer could derive from the consumption of dairy products and the bovine, yet this statement needs to be verified with an in-depth investigation.

5. Conclusions

With our limited investigations, we could see that there is a need to keep the research active on this topic, in order to determine if the presence of BLV in human breast tissue is a risk factor for cancer development and, if proven right, raise awareness and take action. A clear sign of this need for more research, was that the bibliographic revision we did has shown us that some experimental work supports a direct relation between breast cancer and the presence of BLV and some do not. Not only was it difficult for us to find information that supported our research, but it was also tough to spot DNA tissue samples to compare. Public data, such as scientific papers or charts, is still far from helpful for the issue of BLV in breast cancer. Despite that, it can always give us tools to direct further research more accurately. It's not easy to draw clear conclusions from the controversial articles we have found. This also complicates the spread of breast cancer awareness among young people. This is why we believe that further research and study should be carried out in order to achieve clear results.

6. Aknowledgments

We wanted to thank the *Crazy About Biochemistry* program by *Fundació la Pedrera* done in the Universitat de Barcelona labs, for giving us the opportunity to do this research article, especially to Dr. Josep Maria Fernández Novell, for coordinating the program.

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Reviewing Didactic Experiments for Whole Society

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Abstract. Science is all around us, our backyard, our kitchen, our bathroom, and also the street, a car or a plane, at university or industrial laboratory, they are places with science. Physics, medicines, chemicals, solids, liquids and gas are words which sound in our daily life. On the other hand, Hands on Science science fair is an interactively showcases research projects and innovations through presentations, hands on experiments and games. The science fair gives us an opportunity to discover and participate in mind-blowing hands-on experiments and many others activities for the classroom. In this new edition, authors have prepared a sort of science experiments for everybody.

Keywords. Science Fair, Chemistry, Physics, Biology, Scientific Experiments, Education, Whole Society.

1. Introduction

Science is all around us, is in everywhere. Physics, medicines, chemicals, density, forces, pressure, solids, liquids and gas or DNA (Deoxyribonucleic acid) or GMO (Genetically modified organism) are words which sound in our daily life. Science is important in our life, and it should be for everyone. Science is a tool for understanding the world.

We want to bring science knowledge to everyone with a series of easy experiments. Science produces changes and progress in our societies but at the end people must involve in scientific decisions.

Can science be fun?

Yes, science is wonderful! The science fair [1] is fantastic and it gives us an opportunity to discover and participate in mind-blowing hands-on experiments and many others activities directed to the classrooms and whole society.

Furthermore, to convey an important message about chemistry as a natural and safe science to whole society is important for The Professional College of Catalan Chemists (COQC) [2]. This message could increase interest in science in general.

Finally, all scientists must to elevate the voice of science to obtain more influence in solving scientific problems and fight against counterbalance misinformation and fear.

2. Experiments

Just a few words about the experiments:

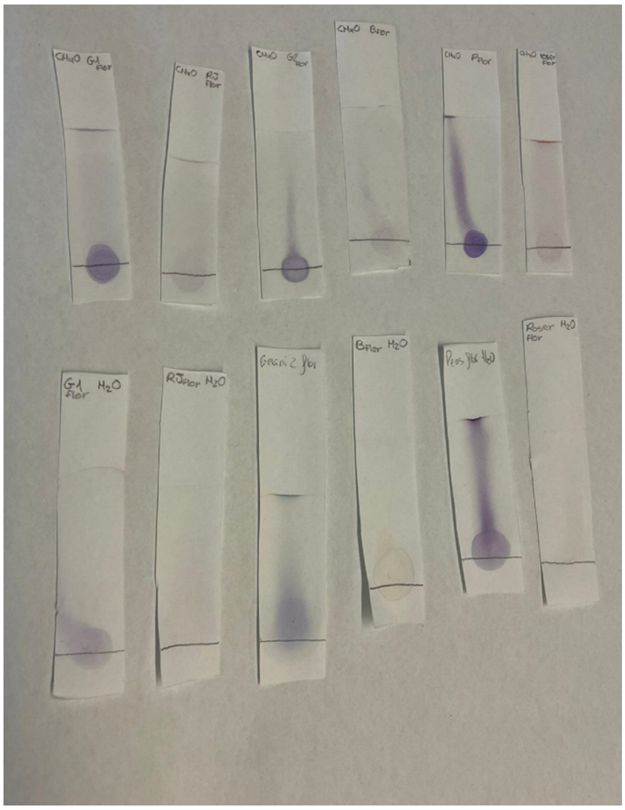

Figure 1. Separation of pigments from flower extracts and from the green leaves of the same flowers by paper chromatography. Picture from Oriol Buch and Lidia Casanovas

Pigments Chromatography. Extract the pigments from leaves and flowers, verify that those of some flowers act as a pH indicator (acidity and basicity) and then separate their components by chromatography. It is a

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technique used for the separation of compounds based on the differential solubility in the stationary phase and mobile phase (solvent) [3].

Figure 2. Rainbow colors in a glass jar. Picture from the authors

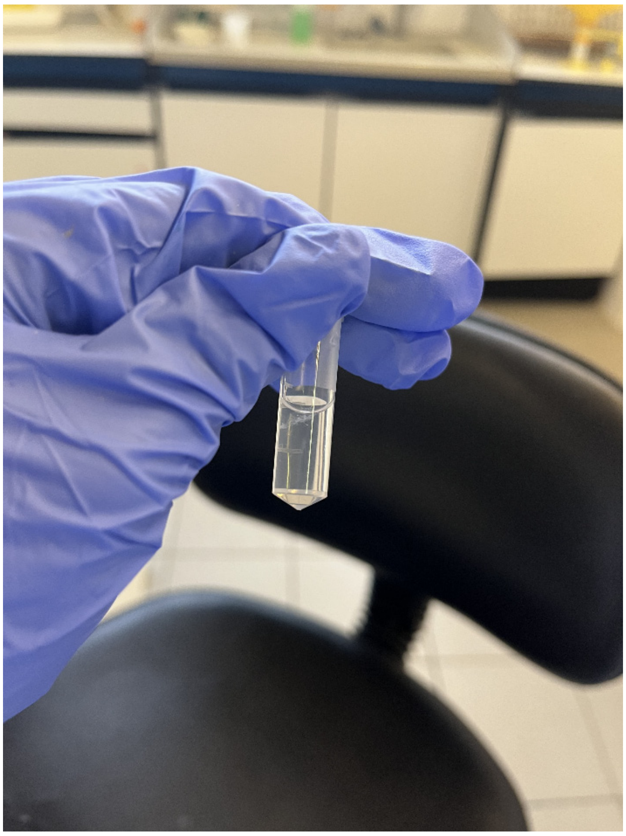

Figure 3. DNA obtention. Picture from Lidia Casanovas and oriole Buch

Figure 1 shows an example.Density, prepare liquids with different density using the liquid itself or adding food coloring. Then carefully put them in a test tube or glass and observe the result. The density of a liquid is a measure of how heavy it is for the amount measured. If you weigh equal amounts or volumes of two different liquids, the liquid that weighs more is denser. If a liquid that is less dense than water is gently added to the surface of the water, it will float on the water. [4]. Figure 2 shows an example.

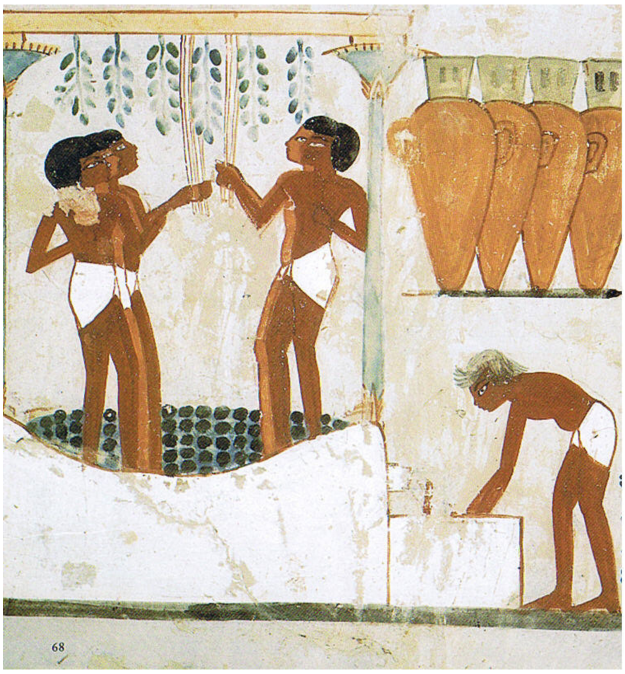

Figure 4. Grapes being trodden to extract the juice and made into wine in storage jars. Tomb of Nakht, 18th dynasty, Thebes, Ancient Egypt obtention. Picture from Wikipedia, public domain. Unknown author

Obtain DNA from plants and flowers, which have used for chromatography. DNA is an acid in the chromosomes in the centre of the cells of living organisms, and determines the particular structure and functions of every cell and is responsible for characteristics being passed on from parents to their children [5], contains the genetic information responsible for the development and function of an organism. DNA preparation is made fast and easy. For preparation, use basic wash solution, extract the DNA with the lysis buffer, centrifuge and carefully add cold ethanol to the supernatant, more information in [6]. Figure 2 shows an example.

Yeasts are eukaryotic unicellular organisms. The *Saccharomyces cerevisiae* converts carbohydrates such as glucose to carbon dioxide (CO_2) and alcohols such as ethanol through the process of fermentation. In food processing, the most people engage with

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one of the three types of fermentation: lactic-acid, ethanol and acetic acid styles of fermentation. Fermentation is a metabolic process using yeast or bacteria under oxygen-free conditions. Fermentation usually implies that the action of microorganisms is desired, more information in [7]. Figure 4 shows an example.

The rest will be a surprise that you can discover at the fair. More information about some of these experiments in [8].

5. Acknowledgements

Authors would like to thank students who participated in previous experimentations and presentations, especially to Lidia Casanovas and Oriol Buch.

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Science Communication for Society: Challenges and Opportunities

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Abstract. Science communication has an important role in disseminating scientific knowledge to society. However, in the age of fake news and post-truth, science communicators face significant challenges. The proliferation of false and distorted information makes it increasingly difficult for the public to distinguish between established scientific facts and deception, leading to misunderstandings, confusion, and even detrimental decisions for people's health and well-being. In this context, the dissemination of fake news and pseudoscience has become fertile ground for post-truth, whose objective is to establish a situation where false information, laden with strong emotional appeal and based on personal beliefs, outweighs true information in order to influence public opinion. Often, fake news contains a part of the message or public knowledge that can be "verified," but omits another part that is true, distorting the public's understanding of scientific subjects.

Given these challenges, it is crucial for science communicators to be qualified and possess a solid scientific knowledge in their respective fields. Only with a deep understanding of the meaning of science, of scientific concepts and principles can they convey accurate and precise information, providing the public with a proper understanding of scientific subjects. Additionally, it is essential for communicators to develop critical evaluation skills in order to discern the soundness and quality of knowledge received from external sources such as laboratories and reputable institutions, avoiding the dissemination of misleading information and ensuring that only scientifically grounded knowledge is conveyed.

If properly conveyed, science communication may play a crucial role in the process of building scientific knowledge, enabling the sharing, debate and critical reasonning, leading to the application of scientific discoveries in various areas and dimensions of society. Growing from universities and research centers, scientific communication has evolved and structured itself through formal and informal channels, driving innovation and socio-economic development. Therefore, it is of utmost importance to address the challenges of science communication, combat fake news and pseudoscience, and strengthen trust in science, thus promoting an informed society engaged with scientific knowledge.

Keywords. Fake News, Pseudoscience, Qualification of Communicators, Science Communication, Science Knowledge.

1. Introduction

Science communication aims to play a major role in disseminating scientific knowledge to society [1]. As we navigate a progressively complex and interconnected world, the importance of an effective communication between the scientific community and the general public becomes increasingly evident. However, this task faces a range of contemporary challenges that require a careful and strategic approach.

One of the main challenges science communicators currently face is the proliferation of fake news and fake science [2]. With the rise of social media and the ease of information sharing, it often becomes difficult for the general public to distinguish between established scientific facts and inaccurate, distorted, or outright false information. Such misleading information can lead to misunderstandings, confusion, and even harmful decisions for people's health and well-being. Fake news provides fertile ground for the post-truth era, where false information, laden with strong emotional appeal and based on personal beliefs, surpasses true information with the aim of influencing public opinion. In general terms, we can state that fake news contains a part of the message or public knowledge that can be "verified," but omits another part that is true. In this sense, science is affected as it deals with information of public interest and holds a position of credibility among the population. Consequently, news about science is widely disseminated and gives rise to groups that not only share these messages, but also make

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decisions based on this information.

In this context, the need for qualified science communicators becomes clear. It is crucial that these communicators possess a solid scientific knowledge or are experienced scientists in their respective fields. Only with a deep understanding of the nature and meaning of science, of the scientific method, and scientific concepts and principles can they convey accurate and precise information, providing the public with a proper understanding of scientific subjects.

Furthermore, science communicators must develop critical evaluation and validation skills to discern the quality of information and knowledge received from external sources such as laboratories and institutions regardless of how prestigious they are. This critical discern ability is essential to avoid the dissemination of misleading information and ensure that only scientifically grounded knowledge is conveyed.

Addressing the challenges of science communication, it is important to highlight that the construction of scientific knowledge is a continuous and cumulative process that follows a clear and well-established process, the scientific method. Communication can play an important role in this process as it enables the sharing, debate and critical discussion, and application of scientific discoveries in various areas of society. Since the early days driven from the universities and the growth of open research activities, scientific communication has evolved and structured itself through formal and informal channels, driving innovation and socio-economic development.

Therefore, this article aims to raise some points of discussion and explore the challenges and opportunities of science communication for society. It seeks to emphasize the importance of combating fake news and fake science, underscoring the need for qualified science communicators who are committed to critically conveying accurate and reliable scientific information and knowledge. Through the analysis of these aspects, the goal is to strengthen trust in science and promote an informed society engaged with scientific knowledge.

2. The importance of scientific communication

The importance of scientific communication is increasingly significant, being a relevant topic in today's society. Scientific communication can be a way for scientific knowledge to be disseminated in an effective manner, enabling access to accurate, relevant, and up-to-date information for everyone, hopefully. Furthermore, scientific communication is an important tool in building more informed and participatory societies, which is why it is crucial that high rigour and precision are maintained in the production of such content, whether it is science communication or journalistic articles based on scientific topics, thus avoiding the dissemination of incorrect information. In this way, scientific communication can contribute to informed decision-making by citizens and the maintenance of freedom of critical and well-founded thinking [3].

In addition to the mentioned aspects, it is important to highlight that scientific communication can contribute to the development of critical thinking and metacognitive skills. By promoting reflection on the process of producing and disseminating scientific knowledge, scientific communication can help develop the ability to evaluate and question information, identify reliable sources, and consider different perspectives and approaches. Thus, scientific communication can play a fundamental role in shaping more critical and conscious citizens who are capable of making informed decisions and contributing to the construction of a more informed, just, and sustainable society.

In the context at hand, scientific communication, generated from the scientific method, is a generic term that includes other forms of communication such as scientific diffusion, dissemination of science, and popularization of science, with the aim of reaching both the general public and scientific peers [4]. In other words, scientific communication is a way of transmitting knowledge in an accessible and understandable manner to all, regardless of their level of expertise.

Scientific communication is a comprehensive term that encompasses different aspects and specific concepts. Scientific communication can

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be divided into horizontal and vertical dimensions. The horizontal dimension is directed towards scientists and consists of scientific dissemination, which can be intra-peer or extra-peer. The vertical dimension, on the other hand, is aimed at the general public and is characterized by science communication, which makes scientific language accessible to non-experts (Figure 1).

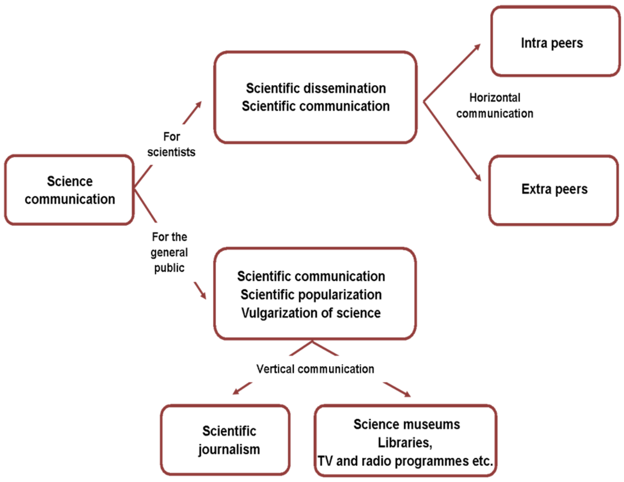

Figure 1. Model of scientific communication [3]

Scientific communication also encompasses other forms of communication that vary according to the language used or the entity of the communication process. It includes both internal communication directed at the scientific community and external communication aimed at the general public. It is important to highlight that, due to the vast number of specialized fields, scientists can become non-experts in other areas of knowledge. The terms dissemination, popularization, vulgarization, and public communication of science are synonymous and aim to generate public perception of science as a result. On the other hand, terms such as scientific education, public perception of science, public understanding of science, and scientific literacy focus on the recipient and the results and competencies generated from the communication process [4].

Scientific education is a prerequisite for the public perception of science and is essential for public understanding of science. From that point on, individuals can develop the set of skills characteristic of being literate. There are three types of scientific literacy: practical literacy, applying scientific knowledge in everyday life; cultural literacy, appreciating science as a cultural activity; and civic literacy, empowering citizens to exercise citizenship, being aware of the problems, results, and perspectives that equip them for citizenship.

Scientific communication is crucial for the dissemination of scientific knowledge and its understanding by the general public. Moreover, scientific literacy is essential for individuals to apply scientific knowledge in their daily lives and exercise citizenship consciously and informedly.

3. Challenges of Science Communication

Science communication faces a series of challenges that can hinder the effective transmission of scientific knowledge to society. Some of the main challenges faced by science communicators, using as example the current situation in Portugal, are:

3.1. Complexity of scientific topics

One of the main challenges in science communication is dealing with the complexity of scientific subjects. Often, scientific concepts and theories are intricate and require specific technical language. However, in order for scientific information to be understandable to the public, it is necessary to translate this complexity into accessible and clear terms. Science communicators must find ways to simplify complex concepts without compromising the accuracy of scientific data.

3.2. Bias and selective interpretation

Science often deals with uncertainties and results that can be interpreted in different ways. This can lead to different perspectives and interpretations of scientific data. Science communicators must be careful to avoid bias in the selection and presentation of information. It is essential to provide a comprehensive and balanced view of scientific issues, highlighting the available evidence and avoiding hasty or exaggerated conclusions [4].

3.3. Proliferation of misleading information

The dissemination of misleading information, such as fake news and pseudoscience, is a significant challenge for science communicators. In Portugal, as well as in other places, there is a growing proliferation of false news related to science. This false information can confuse the public and undermine trust in

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science. Science communicators must be prepared to combat this misleading information by providing reliable and verified sources of scientific knowledge. Promoting scientific literacy and education on how to identify false information are important strategies in this regard [5].

3.4. Lack of scientific literacy

The lack of knowledge and understanding of science in society is an obstacle to effective science communication. Many people struggle to comprehend basic scientific concepts and interpret scientific data. Science communicators must address this gap by promoting scientific literacy through educational strategies. It is important to explain scientific concepts in a clear and accessible manner, using everyday examples and avoiding unnecessary technical jargon [4].

3.5. Time and space constraints in dissemination

In science communication, there are often time and space limitations to convey complex information. Whether in articles, interviews, or presentations, it is necessary to find effective ways to condense and communicate essential scientific information. Science communicators must be able to synthesize complex concepts clearly and concisely while maintaining the accuracy and relevance of the content. The use of visual resources such as graphs, diagrams, and infographics can be an effective strategy to visually convey information in an appealing and understandable way.

3.6. Access to scientific information

Access to up-to-date and reliable information is a challenge faced by science communicators. It is not always easy to access the latest research and scientific discoveries. Obtaining relevant scientific information requires effort and contact with the scientific community. Science communicators must stay updated on scientific advances in their areas of expertise and seek reliable sources to support their communications. Collaboration with scientists and research institutions can be a way to ensure access to reliable and up-to-date information.

3.7. Building trust

Building trust between science communicators and the public is a crucial challenge. In Portugal, as well as in other places, there is a growing distrust towards science and scientific institutions. The dissemination of misleading information and lack of transparency in some areas of science contribute to this mistrust. Science communicators must strive to build trust by being transparent, objective, and presenting solid scientific evidence. It is important to establish two-way communication, listening to the concerns and doubts of the public and responding in a clear and well-founded manner.

By addressing these challenges, science communicators have the opportunity to promote understanding and appreciation of science, as well as to combat misinformation and lack of scientific knowledge. Through effective communication strategies based on scientific evidence, it is possible to strengthen the relationship between science and society, promoting active and informed participation of the population in the scientific process.

4. Building Trust in Science and an Informed Society

Building and strengthening public trust in science is crucial for societal advancement and promoting an informed and engaged population. Trust in science is a fundamental pillar for evidence-based decision-making, both at an individual and collective level.

Effective communication plays a crucial role in building this trust. Science communicators have the responsibility to convey scientific knowledge accurately and precisely, making it accessible and understandable to the public. This involves using clear language and avoiding unnecessary technical terms, using everyday examples to illustrate complex concepts.

Furthermore, it is important for science communicators to be transparent about the sources and methodologies used in obtaining scientific findings. Sharing information about the research process and presenting underlying scientific evidence helps build trust and credibility. This entails sharing information comprehensively, presenting different perspectives, and critically discussing the

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limitations and uncertainties related to the establishment and evolution of scientific knowledge.

The accurate and precise dissemination of scientific knowledge can promote an informed and engaged society. When scientific information is communicated clearly and accessibly, people are empowered to understand the challenges and opportunities of science and make informed decisions on issues related to health, the environment, technology, and other relevant areas [3].

An informed and engaged society is capable of actively participating in the scientific process, contributing ideas, questioning, and even conducting investigations. Open science is proving this daily in different fields of science. Moreover, an informed society is less susceptible to the spread of misleading information, such as pseudoscience and scientific misinformation.

Therefore, strengthening public trust in science through effective communication is an essential goal. This requires a collective effort from scientists, academic institutions, media outlets, and science communicators. It is important to invest in communication strategies that promote scientific literacy, stimulate critical thinking, and provide reliable and verified information. In doing so, it will be possible to build a society that recognizes the value of science, makes informed decisions, and actively collaborates in scientific and technological progress.

5. Ethics and Responsibility in Science Communication

Ethics and responsibility play a crucial role in science communication. It is essential for science communicators to follow ethical guidelines when conveying scientific information to the public. This involves ensuring the accuracy and truthfulness of the information, avoiding distortions, exaggerations, or sensationalism. Communicators should be transparent about their sources and conflicts of interest, providing a fair and balanced representation of different scientific perspectives.

Furthermore, science communicators must be aware of the ethical implications of their communications. This includes considering the social, environmental, and human impact of scientific discoveries and ensuring that the public is fully informed about these issues. Communicators should also respect the privacy and rights of individuals involved in scientific research, obtaining appropriate consent and protecting the confidentiality of data.

Responsibility in science communication also involves promoting scientific literacy, equipping the public with the necessary tools to critically understand and evaluate scientific information. Communicators should encourage scientific thinking by teaching the scientific method, evidence analysis, and critical thinking. They should be willing to answer questions and clarify doubts, facilitating dialogue and active participation of the public in the scientific process.

Science communicators must recognize the importance of diversity and inclusion in scientific communication. This involves the equitable representation of different groups and perspectives, avoiding stereotypes and prejudices. The inclusion of diverse voices enriches the scientific discussion and promotes a more just and equal society.

Ethics and responsibility in science communication are fundamental to establish public trust, promote scientific literacy, and ensure that scientific information is conveyed accurately, transparently, and inclusively. By adhering to ethical and responsible principles, science communicators play an essential role in building an informed and engaged society with science.

6. Innovative Strategies for Science Communication

The production, dissemination, and utilization of information are crucial elements for the development of scientific communities. Throughout the centuries, communication through informal and formal channels has played a fundamental role in building new knowledge [6].

Science communication is constantly evolving, driven by the advancement of new technologies and communication platforms. Innovative strategies that leverage the opportunities offered by these tools to effectively

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and engagingly disseminate scientific knowledge include the use of social media, educational videos, podcasts, and other interactive forms of science communication. Network technologies have allowed new modes of organizing scientific literature in all aspects and elements that constitute it [6]. Taking advantage of the opportunities of new technologies, social media plays a significant role in science outreach, enabling the rapid and accessible sharing of scientific information. Platforms such as Facebook, Twitter, Instagram, and LinkedIn promote dialogue and interaction with the public, while also offering targeting features to direct specific content to interested groups [7].

Educational videos have become a powerful tool in science communication. Platforms like YouTube and Vimeo enable the creation and sharing of visually appealing audiovisual content, allowing for the explanation of complex concepts, showcasing experiments, and presenting scientific discoveries in a visually compelling manner. Furthermore, the interactivity of videos allows for audience participation through comments, questions, and shares.

Podcasts have experienced a significant increase in popularity, offering a convenient and flexible way to access scientific content. Produced by scientists, specialized journalists, or science communicators, podcasts delve into discussions, feature interviews with experts, and explore scientific stories in an engaging manner. Listeners can access episodes at their own convenience while engaging in other activities [7].

In addition to these strategies, there are other interactive forms of science communication that explore gamification, virtual and augmented reality, e-learning platforms, among others. The goal is to create immersive and captivating experiences that ignite the audience's interest in science and facilitate the understanding of scientific concepts.

By harnessing the opportunities offered by new technologies and communication platforms, science communicators can reach a broader audience, make science outreach more accessible, and spark people's interest in scientific knowledge. These innovative strategies pave the way for more dynamic, engaging, and effective communication, contributing to the closer connection between science and society.

7. Final considerations

Challenges of scientific communication, with a special emphasis on the dissemination of false news related to science were briefly addressed in this communication.

It is important to highlight the importance of scientific communicators having a deep and critical knowledge in their respective scientific fields.

Considering that the spread of false news and false science is constantly present in our daily lives, it has become a political, ideological, and economic strategy that is detrimental to society as a whole [8]. The propagation of fake science is a serious problem that affects the credibility and trust in science, and is now identified as a symptom of a broader framework of informational disorders [5]. It is essential for science communicators to be able to transmit their own scientific knowledge that is correct and accurate, or to have the ability to critically evaluate and validate the information they receive from other sources. This implies being scientists themselves or having a deep knowledge, study, and learning in the field of science they operate in.

The role of science communicators goes beyond mere dissemination. They should be able to comprehensively understand scientific concepts, critically analyze evidence and evaluate research methodologies and results, and gather and match information from trustworthy sources, filtering reliable information before disseminating it to the public. This critical and validation capacity is essential to combat the spread of fake science and ensure the dissemination of established scientific knowledge.

Furthermore, it is important to emphasize that science communicators should also be aware of the limitations of their own abilities both in what concerns knowledge and communication, constantly seek updating and deepening. Science is constantly evolving, with new discoveries and perspectives emerging all the time. Therefore, it is crucial for communicators to be open to learning and updating themselves

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in order to transmit accurate and updated scientific information [5].

Science communication faces everyday the challenge of dealing, avoiding and dismantling fake science. To do so it is necessary for communicators to act and be scientists in the broadest sense. This indeed helps to enable the transmission of accurate scientific knowledge and the ability to critically evaluate the information received before disseminating it. Well-prepared and critical science communicators play a fundamental role in the dissemination of reliable scientific knowledge and contributing to a more informed society that is aware of the advancements of Science [4].

8. Acknowledgements

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Science and Technology Teacher Training Project Based on Social Inclusion

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Abstract. This paper reports an experience carried out in the Master Degree in Compulsory Secondary Teachers, Upper Secondary Education, Professional Training and Language Teaching, specialization in Technology, of two Spanish public universities. This experience promotes a higher education based on collaboration and social inclusion. Work teams from both universities developed technological projects that respond to needs of people with autism spectrum disorders, supervising those of their respective mirror teams, considered as sister, from the other university. In this way, we work on a large number of transversal competencies, which are crucial for university students and, especially, for these future teaching professionals.

Keywords. Collaborative Learning, Social Engagement, Sustainable Development Goals, Technology, Transversal Competencies.

1. Introduction

The development of transversal competencies requires education in citizenship [1] and the inclusion in teaching of activities aimed at the mastery of basic social skills [2], such as effective communication, respect, social inclusion and assertiveness. Although the reports of the degrees of the Spanish university system usually include these competences, there are very few subjects in our degrees in which collaborative learning activities with solidarity objectives are developed, especially in those of a technological nature [3, 4].

In this paper we present an experience carried out in the first quarter of the academic year 2022-2023, involving professors and students of the technology specialization of the master's degree in teaching from two Spanish universities. This master's degree provides professional qualification for teaching in compulsory and specific subjects of Technology, Digitization and Digital Education, as demanded by today's society, immersed in a dizzying process of digital transformation driven by the pandemic context of recent years [1, 5].

This experience, which begins in September 2022, is based on the development, by the students of these masters, of science and technology projects aimed at people with autism spectrum disorder (ASD). These projects include in university teaching activities focused on achieving the following three sustainable development goals: number 4 (quality education), number 10 (reduction of inequalities) and number 17 (partnerships for the goals). In order to foster collaborative learning, the projects developed by each work team are supervised by a sister team from the other university. In addition, three associations from the environment of these universities, which are dedicated to the care of people with ASD, also participate in the development of the projects to advise on their adaptation to the characteristics of this group. Finally, science and technology fairs were held at both sites, with the aim of providing the students of the master's degree and the users of these associations with a meeting place for mutual learning and in which direct personal interaction is essential.

2. Project description

The project takes place from September 2022 to January 2023 in two Spanish public universities, located in different and distant Autonomous Communities, which makes any face-to-face contact impossible. In both cases, the students were taking the course Technology for teachers of Compulsory Secondary Education in a master's degree program for teachers. The entire project is divided into the phases described below:

- Phase 1: Organization of the activity. The professors of both universities hold several meetings, prior to the beginning of the academic year, to learn about the organization of their respective subjects, in terms of both content and schedule. From these meetings, on the one hand, a common calendar for the joint presentation of the activity, the development of the projects and the realization of the science and technology fair is agreed upon. On the other hand, the staff of each university holds, in turn, meetings with the entities dedicated to the care of people with ASD that are in its

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immediate environment, to coordinate their collaboration in the different activities. In addition, an online environment is created to support the projects and facilitate assessments through surveys and forms.

- Phase 2: Presentation of the activity. The objective of this phase is the explanation of the activity and also to know the interest of the students on the development these collaborative projects to support people with ASD. This phase involves three groups of people:
  - Students, who receive information from the other agents and can actively participate by making comments or asking questions.
  - Professors, who are in charge of presenting the project to their students in the context of the master's course and explaining the criteria and assessment procedures of the activity.
  - Professionals from associations for people with ASD, who are responsible for explaining the needs and interests of the users of their services, and clarify the doubts of students and professors on the implementation of activities.
- Phase 3: Project development. The objectives of the activity were two: 1) the development of a science and technology project adapted to the needs and interests of people with ASD; 2) the creation of a collaborative environment among students from different universities. Three groups are involved in this phase:
  - Student teams: The work teams are made up of three students at each university, supervised by a sister team at the other university. Each team has to propose a science and technology project and prepare a summary sheet. This sheet is doubly analyzed by the sister team, which initially makes comments to improve the quality of the work presented and then check the final result of that project, after addressing those initial comments. Online forms are used for these mutual reviews.
  - Professors: The proposal of each work group is reviewed by the teaching team of each university (made up of 1 or 2 teachers) to verify the adaptation to the requirements of the entities and the characteristics of their users.
  - Professionals from entities: These professionals participate in a training session in the university classroom to transmit orientations on the autistic condition, in general, and its users, in particular, and also accompany them on the day of the fair.
  - Phase 4: Science and technology fair. A science and technology fair is held in both universities, so that the students can present their project to the users of those entities.

3. Project results

After the meetings of staff from both universities for activity organization during the months of September, October and November, contact was made with three entities (two close to site 1 and one close to site 2) that agreed to participate in both the presentation of the project and the fairs. Since the fairs are held at the facilities of each of the universities, two of the entities decide to bring the users to those facilities, but another one chooses, on the contrary, to hold the fair at its own facilities, although in a smaller version, both in terms of number of projects and users.

The presentation of the activity (Phase 2) consists of a panel discussion, in online mode, with the participation of teachers, students and professionals from the associations. After a brief speech given by the professors, professionals of the three entities make a presentation of approximately 20 minutes each, whose central theme is to show the difficulty that people with ASD have to integrate into the education system and the many barriers they have to face every day. In order to solve it or, at least, minimize its impact, they indicate some minimum guidelines to follow when elaborating the projects and exhibiting the activities during the fairs. The panel discussion ends with a question-and-answer session and a short debate among all participants.

Table 1 summarizes the data of the participants and results. A total of six projects are carried out at each university by work teams composed of three students. The groups present their ideas and collect them on an A4 sheet. The worksheet should contain the name of the scientists, materials, an explanation of how to carry out the experiment and contain some images to support that explanation. Each

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sheet is reviewed by the sister team of the other university, which answers two questions via an online form:

Table 1. Experience data

Item	University 1	University2
Number of students	18	18
Number of teachers	2	1
Number of entities	2	1
Number of users	35	6
Number of technology projects	3	4
Number of science projects	3	2

- Question 1: Comment here what positive aspects you find in the worksheet in terms of structure, content and the experiment itself.
- Question 2: Comment here on what aspects could be improved, trying to come up with ideas for improvement.

It should be noted that the teams paid special attention to the fact that the explanations were clear and made suggestions for improvement both in the wording and in the aesthetics, following indications of the entities. In addition, many teams congratulate the sister team for their work.

As an example of the projects, Figure 1 shows the sheet for the construction of a Theremin using an Arduino board. Figure 2 shows the sheet of a robot that uses a sensor for object detection, so that users can play at modifying the trajectory by placing different objects around it. Both works were carried out by students from university 1. Figure 3 shows a pulsometer that introduces electrical circuit concepts in a playful way and, finally, Figure 4 depicts a cutting and engraving system that uses software developed by a team from university 2.

The activity culminates with a fair at each of the universities, of which some photographs are shown in Figure 5. The fair at the site of university 1, referred to as site 1, is attended by approximately 20 people divided into three groups: a first group of eight children under 18 years of age, attending different secondary schools in the area; a second group of four adults, and a final group, also of eight people, aged between 10 and 12 years. The entity that holds the fair at its headquarters has approximately 15 users between 13 and 15 years of age. Finally, the second site is attended by 6 elderly people who live in the association's residence. Although the association has an educational centre attended by children under 18 years of age, in the end none of them participate because the activity is organized outside school hours.

Figure 1. Sheet for the construction of a Theremin using an Arduino board (in Spanish)

Figure 2. Sheet for the construction of a robot for obstacle detection (in Spanish)

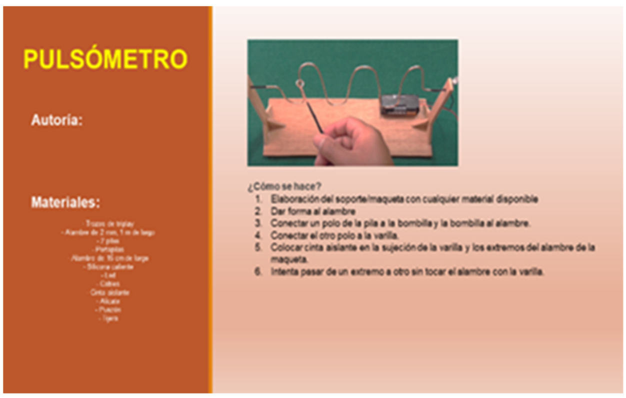

Figure 3. Sheet for the construction of a pulsometer (in Spanish)

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All these groups of people attend accompanied by the professionals of the entities that usually work with them. In addition, a professional from one of the entities of university 1 comes to the fair to get to know all the projects and choose three of them to be carried out in their facilities.

Figure 4. Sheet for a cutting and engraving system (in Spanish)

Figure 5. Photographs of the projects shown in the science and technology fairs

The students had the opportunity to give their opinion about the project. In particular, these are the answers received to the question "What do you think is the main strength of the service-learning project carried out?":

- "Dealing with external agents of the university."
- "Being able to interact with people outside the centre."
- "Meet students with possible difficulties and motivate them with the use of technologies."
- "Contact with students of similar ages to those we will encounter in our future work."
- "The face of children."
- "Collaboration between the different associations."
- "To get to know other realities, understand differences and value sharing experiences."
- "The material realization of the projects and the staging."
- "The usefulness that the activity has in the social fabric."
- "That everyone who participates learns from their own perspective."
- "To be able to put into practice the knowledge acquired with a real group."
- "I find it an innovative methodology and it does social good."
- "To be able to influence the community in a direct way and to do interesting and motivating teaching."
- "Having real contact with students with difficulties allows you to learn about them: how to deal with them, their behaviour and their likes and dislikes and concerns."
- "Better understanding of the needs of the association's users."
- "Applying knowledge in real life. Dealing with people."

4. Discussion and conclusions

Collaborative learning is the educational approach that seeks to improve the acquisition of competencies through teamwork. In the experience presented in this paper, collaboration takes place between members of the same university, but also through twinning with members of another university located in a different Autonomous Community. In general, the first type of collaboration, of an internal nature, can be easily carried out and is frequently used as a work methodology in the university context. On the other hand, the second type, of an external nature, is very infrequent, and presents problems not only of synchronization of academic calendars for its realization but also of differences between obtained results, both in terms of projects carried out and assessments through surveys and forms.

The implementation of activities aimed at people with ASD is very positively valued by the students of both universities, which is important because the master's degree trains future secondary education teachers who will surely find students with ASD in the classrooms.

In addition, very good rates from assessments have been received from the three entities that have participated in the experience, which highlight, above all, the involvement of students and professors. One of the greatest satisfactions of this experience has been, without a doubt, the great interest of those attending the fairs on the projects that the students had developed, actively participating in the proposed activities and interacting with students. Many have shown their intention to replicate the projects at home or in their entities, and have even shown interest in the possibility of repeating the events next year.

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The Inter-Rater Reliability of the Scientific Inquiry-Supported Classroom Observation Protocol (SISCOP)

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Abstract. This study examines the inter-rater reliability of the SISCOP, a protocol for observing scientific inquiry in classrooms. The data was collected through a four-level professional development program that included online mentoring. The analysis involves calculating inter-rater reliability between mentor scores, self-assessment, and mentor scores, as well as peer assessment and mentor scores, using the SISCOP to evaluate course videos. The findings reveal high inter-rater reliability among mentors, indicating consistent observations. The agreement between self-assessment/peer assessment and mentor scores is comparatively lower. However, as implementation levels advance, the inter-rater reliability coefficients increase, suggesting enhanced proficiency in evaluating scientific inquiry.

Keywords. The Scientific Inquiry-Supported Classroom Observation Protocol, Inter-Rater Reliability, Mentor Assesment, Self-Assesment, Peer Assessment.

1. Introduction

A classroom observation protocol is a structured form or process utilized to measure and evaluate the effectiveness of instruction and learning within a classroom setting. An observation protocol generally comprises an identified set of standards or criteria that an observer utilizes while monitoring the behaviors of the teacher or student [1,2]. It is beneficial for assessing the impact of resources and the learning environment on students' educational progress. Furthermore, it provides evidence to teachers on how they can enhance their teaching [1,3]. It refers to the consistency or agreement among different observers or raters when using the same protocol to assess or evaluate classroom behaviors, teaching practices, or student outcomes.

Inter-rater reliability is crucial within observation protocols to fulfill their intended purposes effectively [3]. It quantifies the level of agreement between two or more coders who independently provide ratings or assessments of specific features related to a group of subjects [4]. When evaluating and assessing classroom behaviors, instructional techniques, or student results, inter-rater reliability refers to the degree to which many observers or raters consistently use the same procedure [5].

Inter-rater reliability provides that the same classroom events or actions are scored or evaluated in the same way by various observers. Evaluations are fairer and more objective when several observers follow a consistent technique and reach high levels of inter-rater reliability. It ensures that the teachers or classes are evaluated in the same manner and reduces the possibility of bias [6]. Feedback and teacher professional development are common uses for classroom observation techniques. Multiple, reliable observers' ratings of instructors' performances enable useful comparisons and the pinpointing of areas of concern. Teachers have more opportunities to make informed decisions regarding their teaching techniques and address particular areas of concern when there is high inter-rater reliability [7,8].

There are several types of inter-rater reliability measures that are commonly used to assess agreement among different observers or raters, such as Cohen's Kappa, the intraclass correlation coefficient, Krippendorff's Alpha, and percentage agreement [1,2,9]. The type of measure employed is determined by the characteristics of the data and the purpose of the research or evaluation [5]. The choice of measure depends on the characteristics of the data and the purpose of the research or evaluation [5]. Notably, observation protocols frequently employed in the literature, such as the Reformed Teaching Observation Protocol (RTOP) [10], the UTeach Observation Protocol (UTOP) [11], the Oregon Teacher Observation Protocol [12], and the Four Dimensions of Classroom Practice [13], demonstrate a high level of inter-rater reliability. Additionally, the high inter-rater reliability exhibited by these observation protocols enhances their credibility and utility in accurately capturing and assessing various aspects of classroom behaviors and teaching practices.

The current research aims to examine the inter-rater reliability of the SISCOP. The primary purpose of the SISCOP is to assess a teacher's familiarity with the nature of scientific inquiry. By utilizing this protocol, it becomes possible to identify the teacher's strengths in implementing scientific inquiry in the classroom and to gather evidence regarding specific attributes that may require further development. This protocol is utilized within a mentoring-based and scientific inquiry-supported professional development program. The study aims to determine the agreement among different scoring methods, such as inter-rater reliability between two mentors, self-assessment, and mentor scores, when using the SISCOP to observe and assess course videos.

2. Method

The research data was collected from a scientific inquiry-supported professional development program that relied on online mentoring. During the project's implementation, 20 teachers conducted courses that addressed the specific learning outcomes in the curriculum and recorded videos of their courses as part of the project. The implementation took place across four different levels. In each of these levels, teachers were assigned mentor groups consisting of two experts.

At Level 1, teachers developed a course plan using their existing knowledge and experience and subsequently implemented this plan in their respective classrooms. After implementing their course plans, the teachers performed a self-assessment by analyzing the videos they had recorded for the course using the SISCOP, which was developed specifically for the project. Simultaneously, the recorded videos were analyzed by two science education experts who served as mentors. Each mentor was paired with a specific teacher, and both mentors utilized SISCOP for the analysis of the videos. At Level 2, teachers were provided with activity kits that included course plans and activity materials specifically designed for scientific inquiry. The teachers conducted their courses by following the provided course plans. The course videos were assessed through both teacher self-assessment and assessment by two mentors. The course videos were investigated through both teacher self-assessment and assessment by two mentors. At level 3, teachers conducted their courses with the activity kits provided to them. In addition to self-assessments and mentor assessments, the teachers also utilized SISCOP to investigate course videos of their peers who were at the same level. At Level 4, teachers developed and conducted their courses, drawing from their experiences in the professional development program. These courses were tailored to align with the knowledge and skills gained during the program. The course videos investigated through self-, mentor, and peer assessment.

The current research utilized the SISCOP scores of the course videos analyzed at each of the four levels as the dataset for the study. The following scores were utilized for the analyses, based on each level:

- Level 1: 40 mentors and 20 self-assessment SISCOP scores
- Level 2: 40 mentors and 20 self-assessment SISCOP scores
- Level 3: 40 mentors, 20 self-assessment, and 20 peer assessment SISCOP scores
- Level 4: 40 mentors, 20 self-assessment, and 20 peer assessment SISCOP scores

The SISCOP consists of four themes: descriptive information (I), course structure (II), course overview (III), and teacher–student communication (IV). The descriptive information (I) theme determines the general features of the course and contains information about the subject of the video, grade level, number of students, etc. The course structure theme (II) has three sub-themes: classroom environment (IIA) with nine items, supporting investigation (IIB) with sixteen items, and classroom communication (IIC) with eleven items. This theme focuses on a detailed examination of the scientific inquiry that occurred during the course. This theme is evaluated by the observer using a four-level scoring system: no evidence (1), inconsistent evidence (2), acceptable evidence (3), and consistent evidence (4). The course overview theme consists of eight items that are rated on a 5-point semantic scale, including an item specifically designed for cases where the related behavior could not be observed. The

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purpose of this theme is to evaluate the overall structure of the course holistically. Finally, the theme of teacher-student communication (IV) encompasses a single item that can be evaluated using four distinct scoring options: non-interactive/authoritative, interactive /dialogic, interactive/authoritative, and non-interactive/dialogic. These scoring options represent different modes and styles of communication between the teacher and the students within the context of the course. To summarize, the SISCOP comprises a total of 45 items, with the exception of the descriptive information theme.

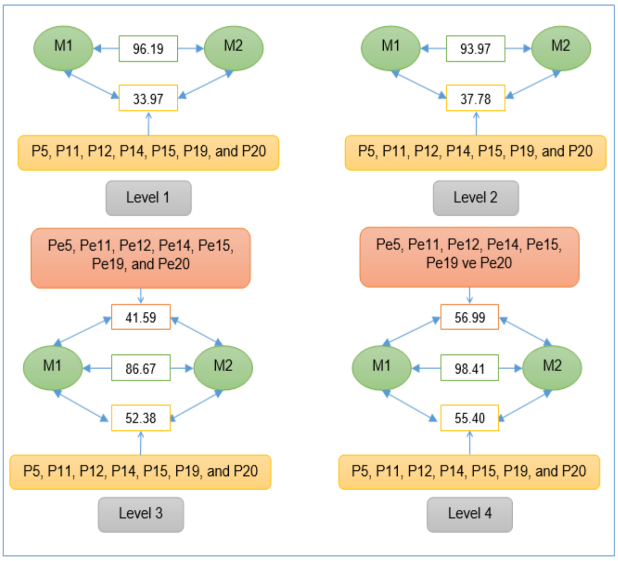
Inter-rater reliability between the raters was calculated for the data sets obtained from the implementation. These calculations were performed within the context of the 45 items of SISCOP, and the coefficients were determined for the following categories:

- Inter-rater reliability coefficients between two mentors' scores for level 1, 2, 3, and 4 course videos
- Inter-rater reliability coefficients between teachers' self-assessment scores and two mentors' scores for level 1, 2, 3, and 4 course videos
- Inter-rater reliability coefficients between teachers' peer-assessment scores and two mentors' scores for level 3 and 4 course videos

To calculate the reliability coefficients in the three categories mentioned above, the formula of inter-rater reliability was employed. The formula is as follows: [Number of items with consensus/(Number of items with consensus + Number of items with disagreement)] x 100 [9]. In the presentation of the findings, pseudonyms were assigned to maintain anonymity for the mentors, participants, and peer-assessed course videos. Specifically, the pseudonyms M1–M6 were used for the mentors, P1–P20 for the participants, and Pe1–Pe20 for the peer-assessed course videos. In the findings' presentations, figures were used to present the reliability coefficients of concordance categories between two mentors' scores, teachers' self-assessment scores and two mentors' scores, as well as teachers' peer-assessment scores and two mentors' scores. To calculate the scores, the arithmetic mean is used. The agreement among raters is assessed within each mentor group and within each level separately. The figures provided a comprehensive visual representation and facilitated a comparison of the different inter-rater reliability categories.

3. Findings

The research findings are presented by considering both the mentor groups and the implementation levels as the basis. Figure 1 shows the arithmetic mean of interrater reliability for the SISCOP total scores obtained in the context of the M1-M2 mentor group for 7 participants.

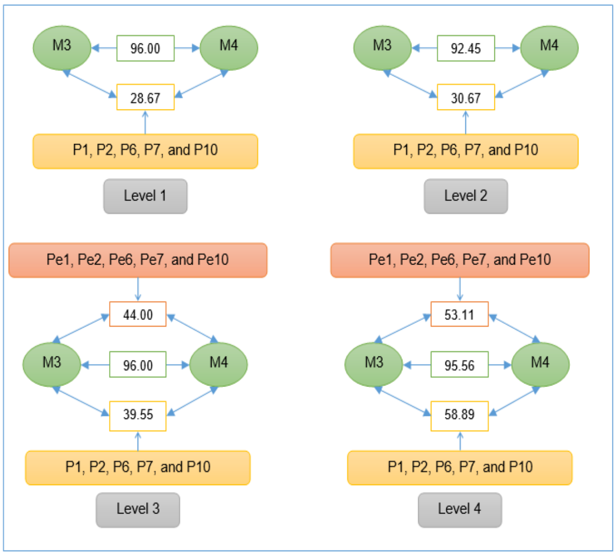


Note: M: Mentor assessed course video, P: Self-assessed course video, and Pe: Peer assessed course video.

Figure 1. The arithmetic means of interrater reliability for the SISCOP total scores obtained in the context of the M1-M2 mentor group

According to Figure 1, the mean inter-rater reliability between Mentor 1 and Mentor 2 SISCOP scores is 96.19% at level 1 implementation for 7 course videos. Additionally, at the same level, the mean inter-rater reliability between the self-assessment scores of the participants for the course videos and the scores of the M1 and M2 mentor groups is 33.97%. Moving on to level 2, the mean inter-rater reliability between mentor groups is 93.97%, while the mean inter-rater reliability between the self-assessment scores of the participants and the scores of the mentor group is 37.78%. At level 3, the mean inter-rater reliability between two mentors, self-assessment and mentor scores, and peer assessment and mentor scores are 86.67%, 52.38%, and 41.59%, respectively. At level 4, the mean inter-rater reliability between two mentors is 98.41%. The mean inter-rater reliability between self-assessment scores and mentor scores is 55.40%, and the mean inter-rater reliability between peer assessment scores and mentor scores is 56.99%.

Figure 2 shows the arithmetic mean of interrater reliability for the SISCOP total scores obtained in the context of the M3-M4 mentor group for 5 participants.

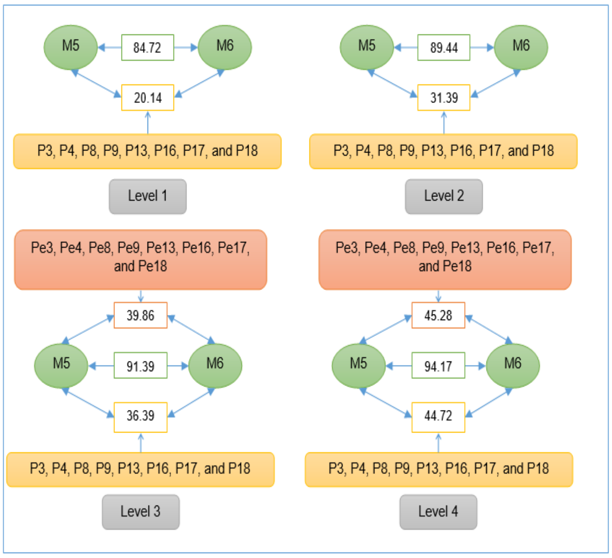


Note: M: Mentor assessed course video, P: Self-assessed course video, and Pe: Peer assessed course video.

Figure 2. The arithmetic means of interrater reliability for the SISCOP total scores obtained in the context of the M3-M4 mentor group

Figure 2 shows that the mean inter-rater reliability between Mentor 3 and Mentor 4 SISCOP scores is 96.00% at level 1 implementation for 5 course videos. Additionally, at the same level, the mean inter-rater reliability between the self-assessment scores of the participants for the course videos and the scores of the M1 and M2 mentor groups is 28.67%. Moving on to level 2, the mean inter-rater reliability between mentor groups is 92.45%, while the mean inter-rater reliability between the self-assessment scores of the participants and the scores of the mentor group is 30.67%. At level 3, the mean inter-rater reliability between two mentors, self-assessment and mentor scores, and peer assessment and mentor scores are 96.00%, 39.55%, and 44.00%, respectively. At level 4, the mean inter-rater reliability between two mentors is 95.56%. The mean inter-rater reliability between self-assessment scores and mentor scores is 58.89%, and the mean inter-rater reliability between peer assessment scores and mentor scores is 53.11%.

Figure 3 shows the arithmetic mean of interrater reliability for the SISCOP total scores obtained in the context of the M5-M6 mentor group for 8 participants.



Note: M: Mentor assessed course video, P: Self-assessed course video, and Pe: Peer assessed course video.

Figure 3. The arithmetic means of interrater reliability for the SISCOP total scores obtained in the context of the M5-M6 mentor group

Figure 3 represents that the mean inter-rater reliability between Mentor 5 and Mentor 6 SISCOP scores is 84.72% at level 1 implementation for 8 course videos. Additionally, at the same level, the mean inter-rater reliability between the self-assessment scores of the participants for the course videos and the scores of the M1 and M2 mentor groups is 20.14%. Moving on to level 2, the mean inter-rater reliability between mentor groups is 89.44%, while the mean inter-rater reliability between the self-assessment scores of the participants and the scores of the mentor group is 31.39%. At level 3, the mean inter-rater reliability between two mentors, self-assessment and mentor scores, and peer assessment and mentor scores are 91.39%, 36.39%, and 39.86%, respectively. At level 4, the mean inter-rater reliability between two mentors is 94.17%. The mean inter-rater reliability between self-assessment scores and mentor scores is 44.72%, and the mean inter-rater reliability between peer assessment scores and mentor scores is 45.28%.

4. Discussion and Conclusion

The findings of the current study shed light on the inter-rater reliability of the SISCOP scores between different mentors and various assessment methods at four levels of implementation. These results provide valuable insights into the consistency and agreement among the raters, which is essential for ensuring the reliability of a classroom observation protocol.

Considering the agreement between mentors SISCOP scores, the calculated reliability mean ranged from a minimum of 84.73% to a maximum of 98.41% for all levels. This indicates that the reliability of the observations made by each group of mentors, comprising field expert researchers at all levels who utilized SISCOP, is very high [9]. Such high inter-rater reliability underscores the consistency of the observations made by these mentors. The inter-rater reliability results suggest that, similar to other observation protocols such as the Reformed Teaching Observation Protocol (RTOP) [10], the UTeach Observation Protocol (UTOP) [11], and the Oregon Teacher Observation Protocol [12], the SISCOP protocol successfully enables a collective comprehension and interpretation of the observed behaviors and instructional practices depicted in the course videos.

The range of the mean inter-rater reliability between self-assessment scores and mentor scores was from 28.67% to 58.89% for all levels. Additionally, at level 3 and 4 implementations, the mean inter-rater reliability between peer assessment scores and mentor scores ranged from a minimum of 39.86% to a maximum of 56.99%. This indicates that the reliability of the observations made by participants for self- and peer-assessment is fair to moderate when compared to mentor assessments [9]. It is reasonable to expect such a situation considering the teachers' limited understanding of scientific inquiry [14]. However, from level 1 to level 4 of implementation, there is a growing convergence between self-assessment and mentor assessments, implying that teachers are increasingly inclined to evaluate themselves with a deeper grasp of the principles of scientific inquiry. At levels 3 and 4, the increase in inter-rater reliability between peer assessment and mentor assessment indicates that teachers are capable of assessing instructions underpinned by scientific inquiry in a more consistent manner, even when evaluating course videos from classes other than their own.

5. Acknowledgements

This study is based upon work supported by The Scientific and Technological Research Council of Turkey, 1001-Scientific Technological Research Project Support Program under Grant 220K080 entitled “Designing and Evaluation of the Effectiveness of Scientific Inquiry Supported Online Mentoring (e-scaffolding) in In-service Teacher Training.”

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ADHD: Embracing the Neurodivergent Mind in Science

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Abstract. ADHD (attention deficit hyperactivity disorder) is a neurodevelopmental condition that affects around 4% of the worldwide population. This syndrome affects the dopamine and serotonin levels in the brain, causing a variety of symptoms such as hyperactivity, inattentiveness, and impulsivity. The disorder is primarily seen in children due to the fact that, with age, the severity of the symptoms usually diminishes.

Often seen as disadvantages, ADHD traits if well managed, can result in great assets in the learning process and work environment. Their brains work differently due to the decreased levels of certain neurotransmitters, which allows them to see the world from another perspective and be excellent at problem-solving, characteristics necessary in science. A great scientist is someone with a hunger for knowledge who thinks outside the box and passionate about their work—traits found intrinsically in people with this condition, which are usually called "ADHD superpowers”.

In conclusion, ADHD comes with some disadvantages but also a great gift, when taught to cope with it at a young age. Children with this condition need to be rewarded, and not punished, for their ability to function differently and could benefit from a more hands-on way of learning. By giving them the right tools educators can help them accomplish their full potential.

Keywords. ADHD, Dopamine, New Learning Tools, Problem-Solving Potential.

1. Introduction

ADHD (attention deficit hyperactivity disorder) is a neurodevelopmental disorder whose symptoms not only depend on the genetics but also by the environment children are raised in. This disorder affects approximately 4% of the worldwide population and the symptomatology can present as hyperactivity, inattentiveness and impulsivity [1]. ADHD can be classified into 3 different types taking into account the symptoms shown in people's behavior: The hyperactive/impulsive type, the inattentive type and finally the combined type, the most common type of ADHD.

Some of the factors known that could cause ADHD can be classified into three different groups: Genetics, environmental and prenatal factors [2].

Genetics: ADHD is highly heritable, however the heterogeneous phenotype and the complex epigenetic factors are still a challenge to identify the exact genes affected in this disorder [3].

- Environmental: this factors includes exposure to toxins (especially to Lead) [4], infections such as encephalitis, child abuse and head injuries.
- Prenatal: maternal usage of drugs, alcohol and cigarettes; brain damage during or post birth and prematurity.

ADHD affects the development of many areas of the brain, which causes a 3 year delay in the brain maturity [5] (Figure 1). Some areas affected are:

- Prefrontal Cortex: is the intersection for attention, emotions and behavior, this causes the inattentiveness in ADHD.
- Limbic System: it regulates emotions.
- Basal ganglia: regulates inter-brain communication.
- Reticular Activating System: controls premotor and modulatory functions.

Other factors that contribute to ADHD are low levels of dopamine and serotonin Figure 2. Some of the reasons that may explain why this happens are because neurons fail to discharge an adequate amount of neurotransmitters, the receiving neurons coil encounter difficulties capturing them or neurotransmitters may be reabsorbed too quickly by the sending neuron, impeding a proper connection [6].

2. ADHD symptoms and traits

ADHD symptoms can pose various challenges in the educational setting[1]. One of the primary effects of ADHD in school is related to the difficulty of paying attention and being

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focused for extended periods of time. This could also affect their ability to complete assignments and organize. This critically affects their productivity and meeting deadlines.

still for prolonged periods of time.Thiscan lead to disruptions in the classroom, difficulties on staying focused and participating in group activities.

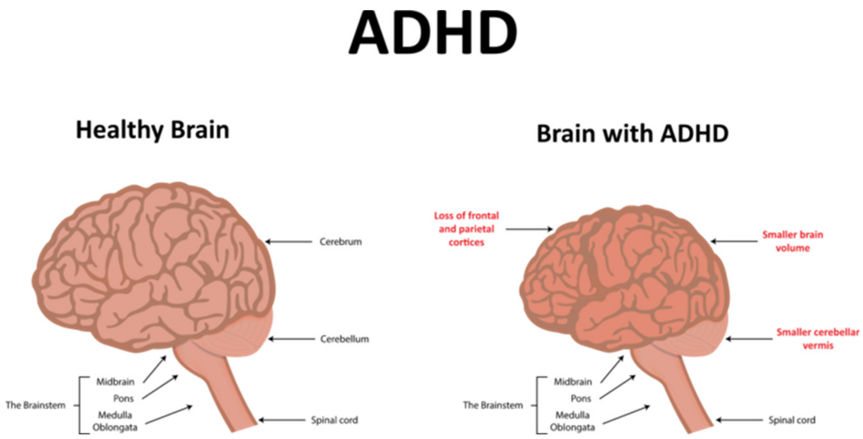

Figure 1. Ilustration showing the difference between a healthy brain and an ADHD brain. Source: ADHD and School - 5 Tips for Beating The School System with ADHD https://adhdboss.com/adhdandschool/?utm_content=cmp-trueAccessed:2023-06-27

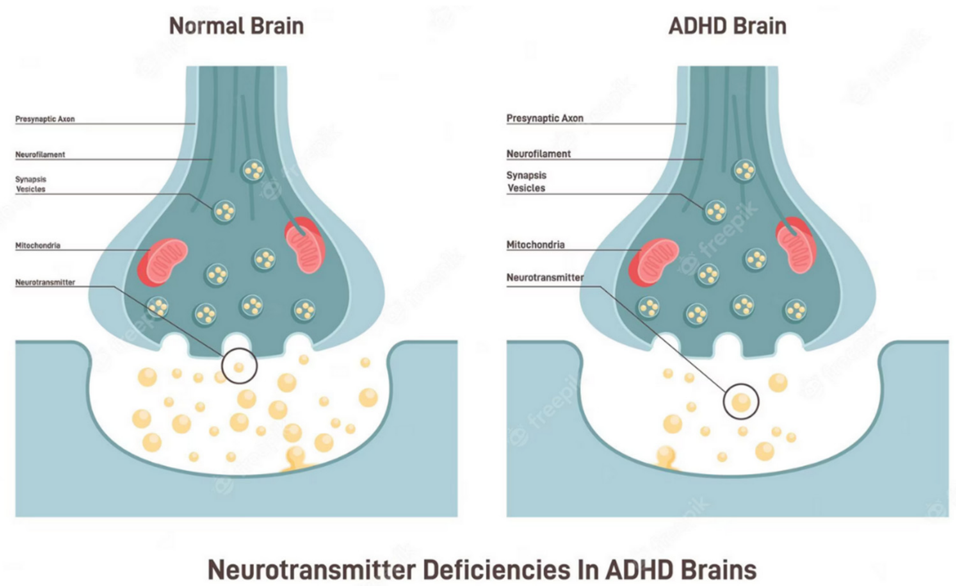

Figure 2. Ilustration showing the difference between a healthy brain and an ADHD brain. Source: https://br.freepik.com/fotos-vetores-gratis/distraido/19

Impulsivity may lead students to act without considering consequences, leading to impulsive decisions. This can be seen as disruptive behavior, interruptions during class and difficulties following rules. Hyperactivity can also present challenges in the school setting. Children with ADHD can experience restlessness, difficulty sitting down and being

Their excessive energy levels can impede their ability to complete tasks that require sustained mental effort.

The effects of ADHD extend beyond academic performance. Social interaction can also be impacted. For this reason the schooling system has to adapt in order to prevent

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academic failure and low-self esteem, which could lead to severe mental issues Figure 3.

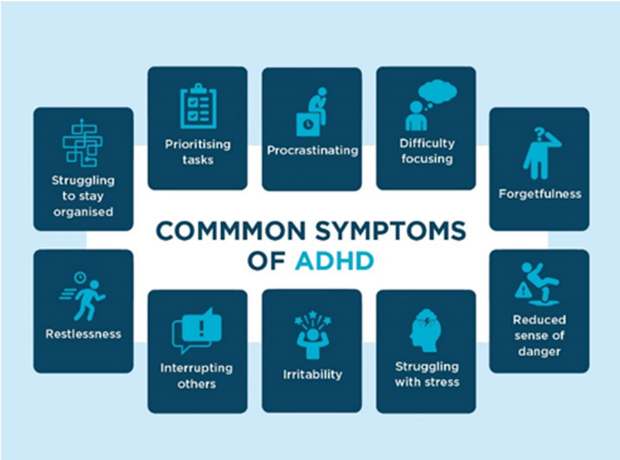

Figure 3. Common symptoms of ADHD. Source: https://www.priorygroup.com/blog/step-by-step-guide-for-an-adult-adhd-diagnosis

While ADHD presents its fair share of challenges, it's important to recognize the advantages and streghts associated with this condition, known as "ADHD superpowers" [7] (Figure 4).

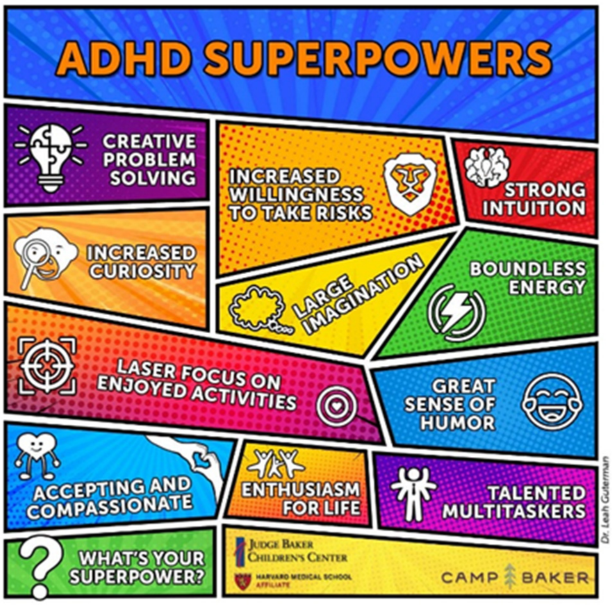

Figure 4. ADHD positive traits also known as "ADHD superpowers". Source: https://clairepechcareers.com/the-role-adhd-can-play-in-career-progression-and-planning/

One potential advantage of ADHD in the school setting and work environment is creativity. Many individuals with attention deficit hyperactivity disorder possess a remarkable ability to think outside the box and to come up with innovative ideas. The hyperactive minds can lead to unique connections in order to approach problems from unconventional angles. Another advantage is hyperfocus, they can experience periods of intense focus and concentration in prolonged periods of time, often triggered by topics that capture their interest. Individuals with ADHD demonstrate high levels of resilience and adaptability. Their ability to think quickly and adapt to changing circumstances allows them to identify alternative solutions and to find innovative ways to overcome challenges. Moreover, needless to say, it is a total misconception that people with ADHD have a lower IQ, it is known that there does not exist any correlation with ADHD and IQ. Finally, it is worth mentioning that children who suffer from this disorder can excel at school

How can we relate these traits to science? Being a great science cannot be measured by grades, someone can be great on paper but be a disaster working. A great scientist is someone with a hunger for knowledge, who sees the world from different perspectives and is passionate about their work—traits found intrinsically in people with this condition. Science requires knowledge but also needs people to be creative and without fear of failing.

3. New learning systems

Thus, knowing the great potential of ADHD minds to science, it is needed to find ways in which teachers can increase their potential. Everything stars at childhood, it is extremly important to stablish systems to identify and diagnose at the earliest possible age children who suffer ADHD. These kids with the adequate social, educational and psicological suport can learn to manage the negative traits of ADHD and exploit the positive parts of the disorder.

The role of educators is to make sure no children are left behind regardless of their circumstances, not a lot of families can afford extra care for children with ADHD and education professionals should do everything in our power to help these kids to succeed.

Some improvement proposals that can be implemented at schools are Individualized Educational Plans, children with ADHD would benefit from personalized accommodations and modifications based on personal strengths and preferences. It does not only extend to a personalized study plan and assignments to keep their focus in class, these educational plans can extend to small things like preferential setting, extended time for assignments and tests. More hands-on learning approaches by incorporating more practical and even physical activities to engage with students who have trouble paying attention could help with comprehension and participation. Encouraging open communication to fully understand the needs of individuals with ADHD it is extremely important to reinforce communication between parents, therapists, teachers, but more importantly, with the students with ADHD. The collaboration with all parts allows adjustments in their education and progress updates.Emotional support is vital for the development of individuals with attention deficit and hyperactivity disorder to acknowledge the emotional part of suffering from this disorder. Teaching how to deal with their different ways to function will help them develop a better self-esteem and healthier relationships with the rest of the classroom.

Implementing this new way of learning teachers help enduring education to children with ADHD. However, as they grow up, how can be interest in science brought to them? Some effective ways to spark interest in science among children and teens with ADHD:

- Project-based learning: engaging in practical activities and individual or group projects, especially in science subjects, this calls students to engage more and to understand scientific concepts through direct experience. Furthermore, participating in group activities encourages them to be collaborative and to exchange ideas, which promotes teamwork, communication skills and critical thinking.

- Real world applications: linking scientific knowledge to real-life problems and issues highlights the importances of science. Discussing how science contributes to solving global challenges can inspire them to see the relevance of science.

- Autonomous work: providing the opportunity of choosing topics of interest, giving presentations or designing their own experiments within the science curriculum enhances engagement. People with ADHD thrive learning about topics they are interested in.

- Extracurricular activities: science fairs within the school or field trips to research institutes or industries expose children with ADHD to real scientific environments. Additionally, encouraging participation in clubs and competitions will offer networking and skill development.

4. Conclusion

In conclusion, ADHD comes with some disadvantages but also a great gift, when taught to cope with it at a young age. Children with this condition need to be rewarded, and not punished, for their ability to function differently so they are able to let their creative minds flourish. By implementing these new strategies and building a more inclusive educational environment, educators can help them accomplish their full potential.

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Genome Editing with CRISPR-Cas: Simple, Fast and Visual

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Abstract. The gene editing technology based on the CRISPR system and the Cas9 endonuclease has had a significant impact in the science field, and currently, the discovery of this new technology is in the public eye. The CRISPR-Cas gene editing technology represents a revolutionary breakthrough with significant implications across scientific disciplines, particularly in the realm of gene therapy, although many bioethical aspects are still being debated. Therefore, it is important to teach these new technologies to new students and aspiring scientists since CRISPR-Cas technology will have a huge impact in the new researching fields and they should get familiar with this technology.

Here we report the importance of introducing this topic to the students and we show how to present this new technology to the new apprentice and how they could practise in the lab with CRISPR-Cas gene editing technology to learn and see how this technology works.

Keywords. β-galactosidase, Bioethic, Cas9, CRISPR, *E.coli*, Gene Editing Technology, Lab, Lac Operon, Learn, Modify, Teach, Transformation.

1. Introduction

The CRISPR-Cas9 technology allows us to perform targeted mutagenesis. Its components are as follows [2]:

- **gRNA (guide RNA):** It contains a specific sequence capable of directing the Cas9 protein to the appropriate region of DNA.
- **Cas9 (CRISPR-associated protein 9):** A non-specific endonuclease with the ability to produce a DSB (Double Strand Break). The specificity is provided by the gRNA.
- **PAM (Protospacer Adjacent Motif):** It is a 3-base sequence necessary for Cas9 action. The DSB will occur 3 nucleotides upstream of the PAM.

When the dsDNA is cut, two repair mechanisms can be activated:

- **Non-homologous end-joining (NHEJ):** If no donor template DNA is provided to serve as a template for repair, a mechanism is activated that joins the broken ends. This process generates variable-length insertions and deletions (although perfect repair can also occur). Since no donor template is used, the incorporation of nucleotides into the DNA is random. Therefore, there is a risk of disrupting the reading frame of the RNA (ORF) or the binding sites of trans-acting factors (such as TFs) in promoters or enhancers.
- **Homology-directed repair (HDR):** In this case, a donor template is used, which is a DNA template with an identical sequence to the broken one, to achieve homologous recombination. The DNA can be perfectly repaired based on the sequence of the donor template. If an exogenously modified donor template is introduced (with an extra sequence, a deletion, a point mutation), the DNA sequence that was just cut can be modified as desired.

If a random break occurs in the DNA, one of these two DNA repair mechanisms will take place [3]. The same applies when using Cas9. The difference is that with Cas9, the cut occurs at a specific site and not randomly, allowing for precise targeting of the locus where the mutation will be introduced. This locus can be repaired by both NHEJ and HDR. If a donor template is introduced, it will result in a perfectly edited genome (HDR) by incorporating the specific sequence variant present in the donor template.

2. Educational impact

In this project we would like to promote the divulgation of scientific knowledge about the new gene editing technology CRISPR-Cas to students from high school. We take a term this project in the program Bojos per la bioquímica from the Fundació la Pedrera, that promotes the divulgation of knowledge to high school students to enrich the minds of the new apprentices. At

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first, we did a theorical class to introduce some topics of molecular genetics, genetic engineering and gene therapy. The objective of this class was to introduce the next concepts:

- DNA, RNA and protein functions: We explain the basic DNA, RNA, and protein structure and function to understand how dose the cell operated. We describe to the transcription and translation process as the elements that have a gene (promoter, regulation sequences, termination sequences…).
- Regulation of DNA expression: We show some of the most important transcriptional system to regulate the expression of genes like strong promoters, regulation elements of some DNA sequences (operons) and epigenetics.
- Systems of repairing double-stranded breaks in DNA: Gene editing involve two steps: cutting the double-strand of DNA and repair the damage because if it's not repaired de cell will die. For this reason, is important to make an appointment in introducing the mechanisms that the cells have to patch and repair the DNA damage: the homology directed repair system (HDR) and the nonhomology end joining system (NHEJ).
- Bacterial transformation: We introduced the topic of transformation bacteria with plasmid because in the lab lesson this phenomenon will be performed. For this reason, we explained the chemical proprieties of bacterial cell walls and DNA to introduce the plasmid into the cell and insert new genetic information.
- Genetic engineering: we introduce what is the directed mutagenesis and different methods that exist to modify the genome of a cell, like restriction enzymes, QuickChange ©
- CRISPR-Cas technology: We introduced to the students how those this technology functions by the endonuclease protein Cas9, that cuts DNA whit precision directed by a guide RNA and the potential that this technology has.
- Bioethical and legals aspects of the use of CRISPR-Cas technology in gene therapy: We bring up to the pupils a debate of which downsides could have this gene editing technology and why it's vital to educate the next generation, promote responsible utilization, and harness this powerful tool to unravel the mysteries of the genome and improve human health.

After the introduction of all these topics to the students they should be capable to understand the laboratory session and do some activities to improve their critical thinking skills.

The following part of this project was to manipulate the genome of a *E.coli* to appreciate how this gene editing technology functions. In the lab they will modified the β-galactosidase gen of the Lac operon from *E.coli* to see how their appearance change by using CRISPR-Cas technology. With this modification the colonies previously blue will turn white, making it easy to identify the colonies that had been transformed and modified by the CRISPR-Cas and the efficiency of this technique.

3. Laboratory lesson: Genetic manipulation using CRISPR-Cas

In this laboratory lesson the students used CRISPR-Cas technology to disrupt the Lac Z gene from *E.coli*. The Lac operon encodes the enzyme β-galactosidase, enzyme that allows the bacteria to hydrolyse lactose in galactose and glucose to obtain energy. The enzyme β-galactosidase can also hydrolyse an analog of the lactose called X-gal, and one of these final products it's a blue pigment that stain the cells. Being the bacteria with operon lac induced and operative blue, because β-galactosidase is expressed and will hydrolyse X-gal in a blue pigment.

The students edited the chromosomal lacZ gene in *E.coli* by transforming them with plasmid-based expression systems for donor template DNA and guide RNA. With the CRISPR-Cas gene editing technology they performed a cut in the DNA sequence of the β-galactosidase gene from operon Lac, and HDR machinery will use a donor template DNA to repair the break and introduce a stop codon into lacZ gene (gene that encodes de enzyme β-galactosidase). This will not allow the bacteria to transcript the β-galactosidase and consequently will not hydrolyse X-gal. So, the bacteria transformants modified by the CRISPR-Cas technology will be white meanwhile those

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bacteria that where not transformed our modified by CRISPR-Cas technology will stay blue.

3.1. Materials

The materials used to elaborate this laboratory practise where obtain from Bio-Rad [1]. This company sell kits and products for life science research, clinical diagnostics, classroom education, molecular testing etc. In particularly we bought the kit Out of the Blue CRISPR Kit to perform all this lab assays. This kit contain: *E.coli* HB101-pBRKan, lyophilized, Donor templated DNA plasmid (pLZDonor), Donor templated DNA and guide RNA plasmid (pLZDonorGuide), KIX mix, Spectinomycin, L(+) arabinose, LB nutrient agar, LB broth capsule, inoculation loops, petri dishes and transformation solution.

3.2. Methods and activities

In this practise the students began with bacteria grown on two different plates with different mediums: 1 plate IX and 1 plate IX/ARA.

Table 1. Composition of the plates

Plate	Kanamycin	IPTG	X-gal	Ara	Spt
IX	✓	✓	✓	✗	✗
IX/ARA	✓	✓	✓	✓	✗
IX/SPT	✓	✓	✓	✗	✓

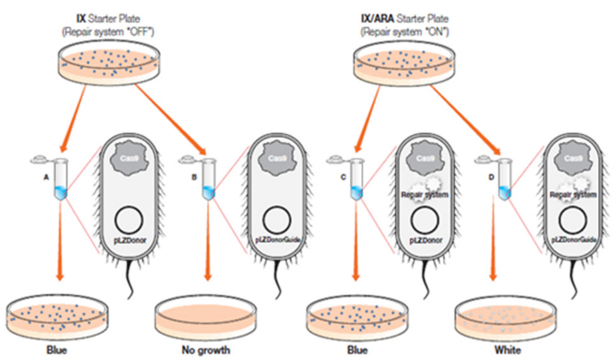

Figure 1. Scheme of the experimental part of the project. From Bio-Rad instructor protocol [1]

The expression of HDR machinery is controlled by an arabinose-inducible promoter, letting the bacteria have a machinery to repaired the doble-strand DNA break. The plate with IX medium do not express the enzymes required for HDR so if these cells have a DNA break, the bacteria will not be capable to recover and will not survive. In the other hand, the plate with IX/ARA medium will express the enzymes required for HDR so if a doble-strand DNA break is induced the cell will be capable to repair the cut.

From each plate the students will pick some colonies of *E.coli* HB101-pBRKan, and will transform them with one of two plasmids, each of have different elements in it:

- **plZDonor (control) –** Includes a Donor template DNA sequence that will be used by de HDR machinery to fix the doble-strand DNA breaks. The donor sequence includes a stop codon that will impair *LacZ* function when it's insered.
- **plZDonorGuide -** Includes a Donor template DNA sequence and a sequence that codes for the sgRNA that will guide de Cas9. The bacteria with this plasmid will be capable to use the Donor template to repair the doble-strand DNA break and transcribed the sgRNA that will guide the Cas9 protein where to cut *LacZ*.

Bacteria transformed with plZDonor will not have the sgRNA needed to guide Cas9 to cut *LacZ.* Therefore, no gene editing will occur and transformants will be blue regardless of whether the repair system in ON or OFF. On the other hand, bacteria transformed with plZDonorGuide will hav both the sgRNA and donor templated DNA. For this reason, the protein Cas9 will be guide to a specific region of the LacZ operon and will cut the sequence. Depending of the medium the bacteria had been exposed lately they will or will not survive.

Bacteria from both stared plates will be transformed with either plZDonor or plZDonorGuide and we will create 4 different conditions:

- **Condition A -** These bacteria come from the IX plate, so they do not express the enzymes required for HDR (repair system OFF). They will be transformed with plZDonor, and they will not have sgRNA so the Cas9 will not be guide and no cut will occur. For these reasons, no

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gene will be cut and edited, so they will be blue.

- **Condition B -** These bacteria come from the IX plate, so they do not express the enzymes required for HDR (repair system OFF). They will be transformed with pIZDonorGuide, and will have sgRNA to guide the protein Cas9. The HDR system is not expressed, Cas9-mediated cutting will occur, but no DNA repair will occur. For this reason, the cells will not survive and will die. No growth will be observed.
- **Condition C -** These bacteria come from the IX/ARA plate, so they express the enzymes required for HDR (repair system ON). They will be transformed with pIZDonor, they will not have sgRNA so the Cas9 will not be guide and no cut will occur. For these reasons, no gene will be cut and edited, so they will be blue.
- **Condition D -** These bacteria come from the IX/ARA plate, so they express the enzymes required for HDR (repair system ON). They will be transformed with pIZDonorGuide, and will have sgRNA to guide the protein Cas9. The HDR system is expressed, cas9-mediated cutting will take place and HDR machinery will use the donor templated DNA from pIZDonorGuide to patch the cut and introduce a STOP codon into the *LacZ* gene. For these reasons, this transformants colonies will be white.

When the different bacteria had been transformed, the students spreaded the bacteria transformed in 4 plates of IX/SPT, each condition will be spread in their own plate. Spectinomycin in the IX/SPT agar media selects for the bacteria that were successfully transformed.

During the practical practice we prepare some question to do after, during, and before the practice to make sure the students understand what where they are doing and what was happening in every moment. Before seeing the results, we ask them what we should expected to see in each plate and why.

While we were preparing the material to do the practice, we decided to swich the pIZDonor plasmid with the pIZDonorGuide plasmid to promote the pupils to have critical thinking of what could have happened for not obtaining the results we expected.

3.3. Results

The results we obtained were satisfactory and consistent with what we expected. However, it is worth noting that the samples are labeled differently compared to the BioRad protocol. Plates A correspond to, B to, C to, and D to.

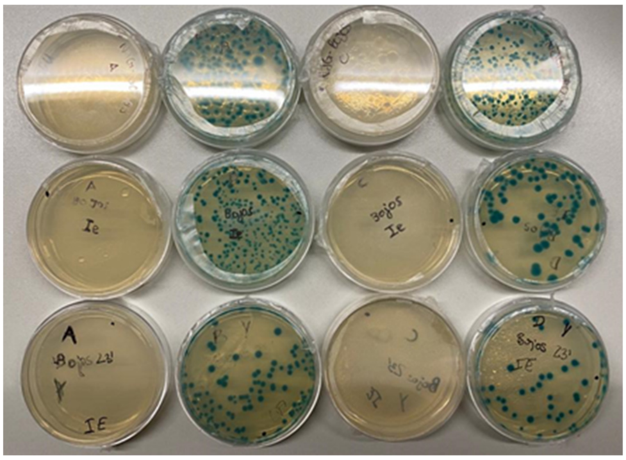

Figure 2. Results obtain by all the students

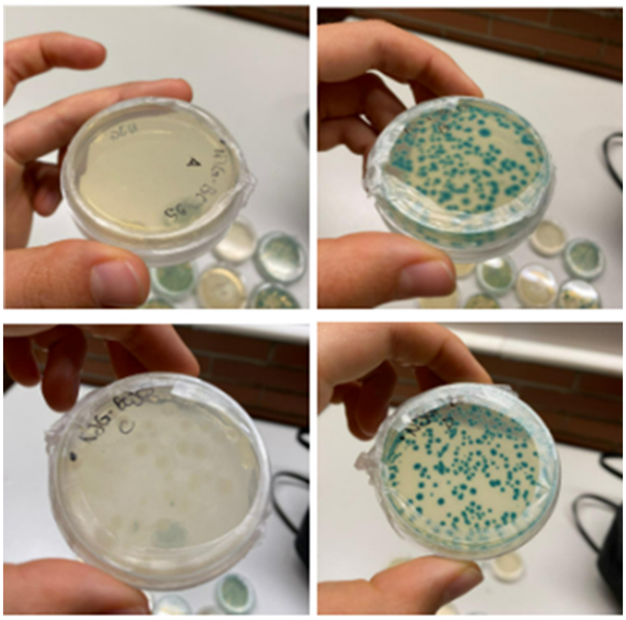

Figure 3. Image of each plate: (A) Plate A with Condition B, (B) Plate B with Condition A, (C) Plate C with Condition D, and (D) Plate D with Condition C

Regarding the personal experience of carrying out this practical session, it is worth noting that the students we had were 16 to 17-year-old high school students. Therefore, they had never dealt with topics related to genetic engineering within the framework of mandatory education. For this reason, before starting the practical session, we conducted an introductory class on the basic principles of genetics. However, when we started working in the laboratory, it became evident that the knowledge was not fully internalized, as we had to repeat multiple times the reasons for adding certain reagents, how the practice worked, and what results we expected to see.

Although it is true that we initially faced difficulties in getting started as it seemed tedious and complicated to the students, they eventually understood it, which made it even more rewarding for them. As a tip to make the session more dynamic and understandable, we consider it vital to continuously receive feedback from the students by asking them what they understand and what results they expect to obtain.

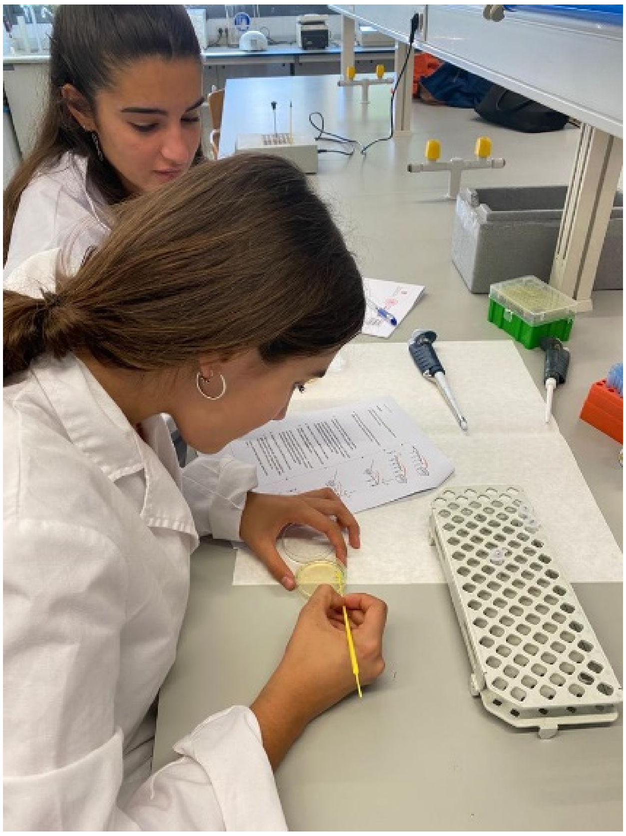

Figure 4. Image of the students reproducing the protocol steps to edit *E.coli* genome

Once the practical session was understood, we delved into details, and the students got down to work following the "out of the Blue" protocol from BioRad [1] meticulously. The procedure is straightforward, so we didn't encounter any problems or inconveniences in carrying it out. It is a simple experiment that can be completed in less than two hours (not considering the 24-hour incubation period for plate observation). Furthermore, it is rewarding as the results are visual, making them easy to interpret, explain, and understand.

Figure 5. Students paying attention to our explanation the practice before starting the protocol

3.4. Conclusions

CRISPR technology has revolutionized the field of genetic engineering due to its immense potential in various scientific fields, particularly in gene therapy. However, the ethical aspects surrounding the use of this technique and the dangers associated with irresponsible manipulation still need to be debated. That is why it is crucial to educate the younger generations about these new tools and how to utilize them wisely and responsibly. The practical session we conducted with students aged between 16 and 17 was characterized by its simplicity. We implemented a straightforward and efficient protocol. Moreover, the obtained results have been easy to explain as they were visually straightforward.

4. Acknowledgements

We would like to thank Dr. JM.Fernandez Novell (University of Barcelona) for letting us prepare theses theorical classes and the laboratory lessons and always giving us his experts advice as encouraging us to carry out this project. We thank to David – for his support and providing us with installations and material that we need to prepare the practices as his expert advice. This work was supported by La Fundació la Pedrera in the program Bojos per la

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Bioquímica 2023 to divulge scientific knowledge about biochemistry to students from high school.

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SDS-PAGE for Protein Separation

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Abstract. One of the most used ones in the field of Biochemistry to be able to understand and study the separation of proteins by their molecular weight is the electrophoresis of proteins, concretely the SDS-PAGE (Sodium Dodecyl Sulfate Polyacrylamide Gel Electrophoresis). PAGE, or Polyacrylamide Gel Electrophoresis, is characterized by the use of β-mercaptoethanol to denaturalize proteins to avoid interferences in the displacement along with SDS, or Sodium Dodecyl Sulfate, to modify the electronic charge of different proteins to make its charge negative. SDS-PAGE is a commonly used and well-known technique in the fields of genetics, medicine, and biochemistry. Finally, the main objective of this work is to show the importance of this technique to separate proteins.

Keywords. SDS-PAGE, β-mercaptoethanol, Stacking Gel, Resolving Gel, Loading Buffer, Running Buffer.

1. Introduction.

Sodium Dodecyl Sulfate Polyacrylamide Gel Electrophoresis or SDS-PAGE for shortening is the main technique of Electrophoresis utilized for the separation of proteins. As said in the name it is a PAGE, which means it uses a Polyacrylamide Gel to cause resistance to the displacement of proteins, and said displacement is caused by Electrophoresis. Since the molecular conformation of polyacrylamide gel is a kind of grid [3], we could also understand that the polyacrylamide gel is a kind of stainer that selects the proteins that can pass through and which determines their displacement in the function of their mass and form [4].

The main difference between SDS-PAGE in front of other forms of PAGE is the use of SDS, a surfactant soap that causes the denaturalization of proteins. This is useful because, in a simple PAGE, 3 factors influence the distance of displacement of proteins: the mass of the protein, since more massive objects cost more to move [2] ; the form of the protein, because it affects how the protein can navigate through the matrix of the polyacrylamide gel; and the electric charge, which affects how much is the force of displacement. With the denaturalization of proteins caused by SDS and β-mercaptoethanol the form factor is eliminated and the changes in the protein structure cause the electric charge of the protein to be proportional to the mass and always negative, which eliminates the charge factor and allows a PAGE of negative and positive charged proteins. Thus SDS-PAGE is a PAGE in which the displacement of a protein is solely dependent on its mass. [2,9,10]

2. Procedures

The main components of an SDS-PAGE are the buffers and the Polyacrylamide Gel.

2.1. Gel preparation

The Polyacrylamide gel is divided into two parts, which have a different concentration of acrylamide,the stacking gel and the running gel. The stacking gel has a lower concentration of acrylamide, around 5%, as the proteins are not supposed to separate in this medium. However, the running gel has a higher concentration of acrylamide, of about 12%, so proteins are expected to separate in the running gel. This second part works as a kind of web and causes resistance to the displacement of proteins based on their molecular mass, due to the fact that SDS solution equalizes their electric charge making them all negative. As a result, those proteins with a major molecular weight will be in a higher position in the running gel than those with an inferior molecular weight, due to the fact that the heavier the protein is, the more resistance they will have in the running gel to displace. [1,4,8]

The first part of the process consists of the gel preparation, which will imply the formation of the medium through which we will carry on the electrophoresis in order to separate the proteins we will be studying.

Polyacrylamide gels (Figure 1) are composed "horizontal" chains of polymerised monomers of acrylamide (Figure 1) with some eventual inclusions of "vertical" bisacrylamide, or N,N'-Methylenebisacrylamide, (Figure 1) in two chains simultaneously that bond the parallel "horizontal" chains forming the polymer which is the polyacrylamide gel.

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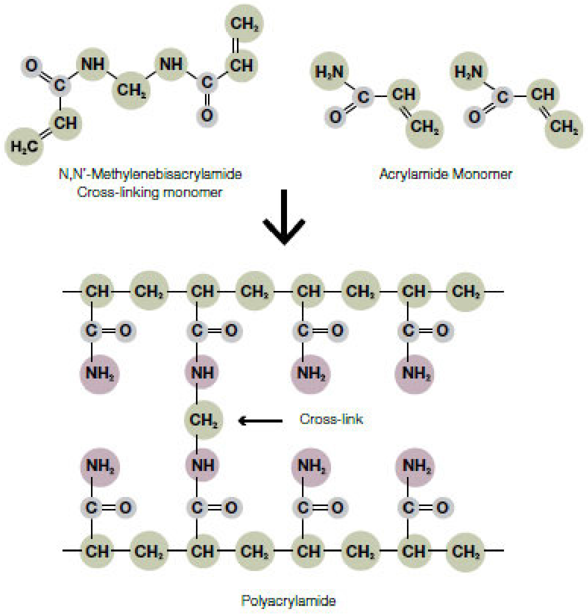

Figure 1. Bisacrylamide molecule (upper left), two acrylamide molecules (upper right) and a schematic polyacrylamide gel (center down). [Taken from: https://www.bio-rad.com/es-es/applications-technologies/introduction-polyacrylamide-gels?ID=LUSPBRM5B]

To do a polyacrylamide gel we prepare two different solutions with different acrylamide concentrations.

The first one is the resolving solution which is composed, in our case though quantities and concentrations may vary, of 3 mL 30% acrylamide, 2,25 mL 1,5 M Tris-HCl Buffer pH 8.8, 90 µL 10% SDS, 90 µL 10% APS, and 4,5 µL TEMED and 3,61 mL of water. (Table 1)

The second solution, also known as stacking solution, is made out of 0.396 mL 30% acrylamide, 0.9 mL 1.5 M Tris-HCl Buffer pH 6.8, 36 µL 10% SDS, 50 µL 10% APS and 3.6 µL of TEMED and 2,23 mL of water. (Table 1)

Table 1. Recipe for the preparation of the resolving gel (left) and of the stacking gel (right). [Own source]

Resolving Gel

	Volume	Stock Concentration	Final Concentration
Acrylamide	3 mL	30%	10%
Tris HCl 8.8	2.25 mL	1.5 M	0.37 mM
SDS	90 µL	10%	0.10%
APS	90 µL	10%	0.10%
TEMED	4.5 µL	100%	0.05%
Water	3.61 mL	100%	39,91%
Total	9.0445 mL		

Stacking Gel

	Volume	Stock Concentration	Final Concentration
Acrylamide	0.396 mL	30%	3.29%
Tris HCl 6.8	0.9 mL	1.5 M	0.37 mM
SDS	36 µL	10%	0.10%
APS	50 µL	10%	0.14%
TEMED	3.6 µL	100%	0.1%
Water	2.23 mL	100%	61,68%
Total	3,6156 mL		

The reaction of formation of a polyacrylamide gel is a chain reaction that for it to start needs the formation of a free radical in one of the carboxylic groups of a acrylamide or a bisacrylamide. In order to achieve this in the mix APS, Ammonium Persulfate, (Figure 2) is added, which tends to generate free radicals in presence of TEMED, the abbreviation for Tetraethylenediamine (Figure 2) [1]. The created free radicals absorb one hydrogen from some of the carboxylic radicals of acrylamide and bisacrylamide, creating one free radical on each of them. These new free radicals cause a covalent bond between the 2nd carbon of the acrylamides with the 3rd carbon, the carbon of the carboxyl radical of another acrylamide. This process repeatedly ends generating the so-called polyacrylamide gel. [3]

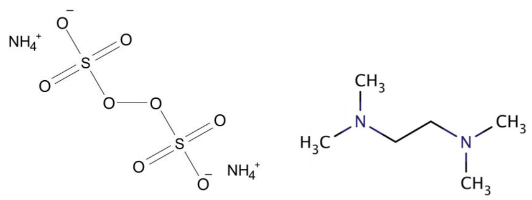

Figure 2. APS molecule (Left) and a TEMED molecule (Right). [Taken from: https://www.chemicalbook.com/CAS/20180703/GIF/CB83067684.gif and https://upload.wikimedia.org/wikipedia/commons/thumb/4/42/Tmeda_is.svg/640px-Tmeda_is.svg.png]

The number of concentrations of the inclusions of bisacrylamide can be regulated through the concentrations of bisacrylamide present, APS, and TEMED. And thus the resistance found to the protein in the displacement and therefore the displacement experimented.

The stacking gel has to have a low concentration of bisacrylamide inclusions in order to allow the easy displacement of proteins to the border with the resolving gel that has a higher concentration of bisacrylamide inclusions. All of this is made to assure that approximately all proteins start moving from the border of the gels at the same moment [4].

The Tris-HCl (Figure 3) buffers are added due to two different reasons. The first one will be in order to settle a difference in the pH that characterizes the two components of the polyacrylamide gel, the stacking gel and the running gel, to ensure the correct reaction of the proteins to the development of the process. The second one will be in order to open the path for the proteins through the running gel, since the chemical compound will be dissociated in the

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solution form and therefore the chlorides will be attracted to the opposite pole of the gel due to the difference of charges between the positive pole that the solution at the bottom has and the natural negative charges from the chloride. [4]

Over and under the SDS-PAGE we will put a running buffer that will help us to conduct the electricity through the gel, ensuring the displacement of the different proteins. Moreover, the solution will also include Tris-Glycine (Figure 3), or tris(hydroxymethyl)aminmethan united to an amino acid, concretely the glycine (Figure 3). The natural state of this compound in a dissolution is to be splitted between the organic part and the amino acid, which has a natural negative charge in higher pH like the ones in the resolving gel. Therefore, the glycine will help the proteins to move through the gel by pushing the samples from above and ensuring the displacement of the different compounds during the realization of the electrophoresis [4].

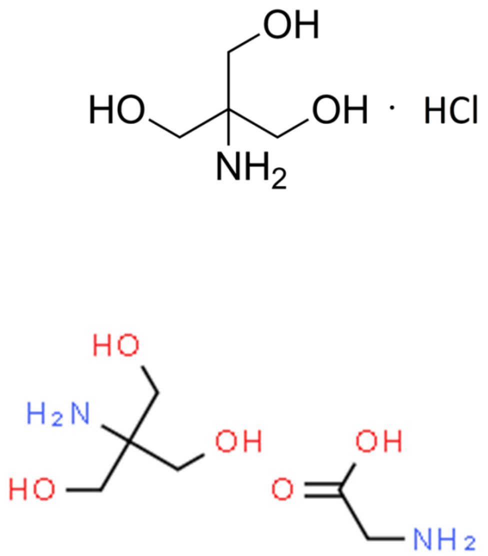

Figure 3. Tris-HCl molecules (Up) and Tris-Gly molecules (Down). [Taken from: https://i0.wp.com/www.differencebetween.com/wp-content/uploads/2018/02/Difference-Between-Tris-Base-and-Tris-HCl-1.png?resize=556%2C245&ssl=1 and https://www.chemspider.com/ImagesHandler.ashx?id=15017722&w=250&h=250]

The resolving solution is poured into the casting frame and it is left to solidify. Once the resolving solution has solidified turning into a resolving gel, the stacking solution is poured into the casting frame over the resolving gel. Before it solidifies the comb is put over the stacking solution to give it a completely straight surface once it solidifies. The gel is retired, removing the glass frames. [1][4]

2.2. Sample preparation

Before using the sample directly into the SDS-PAGE procedure, the aim is to prepare those materials by denaturalizing the proteins that will be used and make them to acquire an electric charge that will ensure the displacement of those through the polyacrylamide gel.

In order to achieve denaturation of the proteins a loading buffer solution is prepared with 2 mL SDS 10%, 1 mL of glycerol, 262 mL 14.3 M β-mercaptoethanol with 0.0025 g of bromophenol blue (Table 2). Different combinations of the Loading Buffer and the different samples can be realized and tested.

Table 2. Table with the loading buffer components. [Own source]

Loading Buffer	Volume/Mass	Stock concentration	Final concentration
SDS	2 mL	10%	4%
Glycerol	1 mL	100%	20%
β-mercaptoethanol	0.262 mL	14.3 M	750 nM
Bromophenol blue	0.0025 g	100%	5·10^-4 g/mL

Fill with water until 5 ml

The objective of this procedure is to denature the proteins to a level with which the form of the proteïn cannot interfere with the displacement of the proteïn through the running gel. We need to denature the quaternary and tertiary structure of the proteïns, as the quaternary and tertiary structure is what determines whether the protein has a filamented or any other amorphous form, denaturing the secondary layer is not necessary as proteïn denatured to a secondary structure is just a polymer of more or less elongated and linear α-helixes and β-sheets. Thus we need to break the hydrophobic, hydrogen, ionic and disulphide bonds as well as the Van der Waals forces in order to avoid other variations on the structure of the protein. [6]

Firstly 2 β-mercaptoethanol (Figure 4) molecules react with the disulfide bonds and replaces the hydrogen sulfides of the β-mercaptoethanol with one sulfur of the disulfide bond, thus breaking the disulfide bond on the proteïn and forming two cysteine residues (Figure 5) [6].

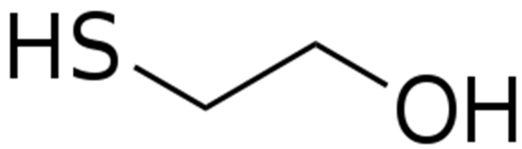

Figure 4. β-mercaptoethanol molecule. [Taken from: https://upload.wikimedia.org/wikipedia/commons/thumb/6/6a/2-Mercaptoethanol.svg/320px-2-Mercaptoethanol.svg.png]

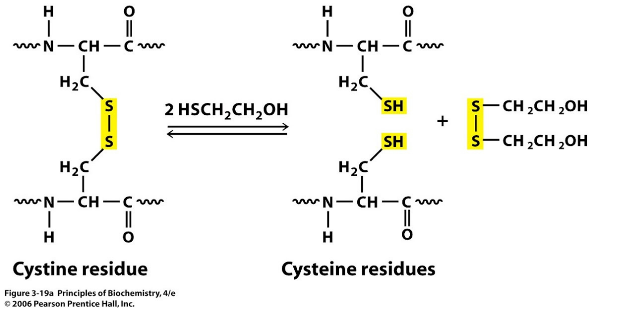

Figure 5. Cysteine sulfuric bond being destroyed by two molecules of β-mercaptoethanol. [7]

SDS (Figure 6) is a surfactant soap, thus it has a highly polar head and a nonpolar, therefore hydrophobic, tail. When dissolved in water SDS separates in a sodium cation and a dodecyl sulfate anion, which retains the nonpolar tail and has a polar and negative charged head. The tail attracts itself to the hydrophobic bonds of the protein and other hydrophobic parts, breaking the hydrophobic bond.

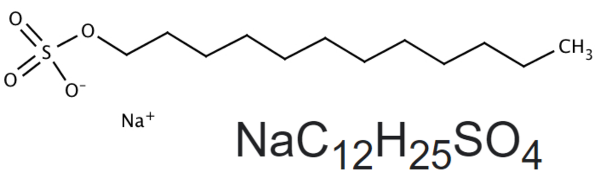

Fig 6. SDS molecule. [Taken from: https://www.genaxxon.com/media/image/a7/1a/39/sds_m3290_m32915707aefb8779f_600X600x600X600.jpg and retouched]

The dodecyl sulfate anion forces the breaking of the other bonds of the protein by the force of repulsion executed by the negatively charged head of the anions. Finally achieving approximately straight proteins. The final protein is not exactly straight by the not totally perfect efficiency of the reactions, secondary structures that may remain even if forced to denature by the repulsion force of the anions and unusual bonds that the combination of SDS and β-mercaptoethanol has not been able to break [6].

Glycerol is added to the LB to help the proteïns bind in the wells of the stacking gel. Bromophenol blue is added to stain the proteins and keep track of them during electrophoresis. [4][2]

2.3. Separation of proteins or electrophoresis process

Once the polyacrylamide gel is prepared, the samples are correctly treated and all necessary materials are identified, we will carry on the electrophoresis process in order to finally separate the proteins.

An electrophoretic deposition process is needed to make possible the separation of our samples by their molecular mass. Next the polyacrylamide gel is put into the gel caster inside the electrophoresis tank and the last filled with a running solution/buffer made of 3.025g of SDS in powder, 14.4g of Glycine and 10 mL 10% Tris (Table 3).

Table 3. Table with the running buffer components. [Own source]

	Running Buffer		
	Volume/Mass	Stock concentration	Final concentration
SDS	3.025 g	100%	25 nM
Glycine	14.4 g	100%	192 nM
Tris base	10 mL	10%	0.1%

Fill with water until 1 L

All protein samples are deposited in the different wells on the top of the stacking gel. In the superior part of the tank is the cathode (where negative charge enters into the tank) and in the inferior part the anode (where negative charges are received). When the cathode and anode are connected to a supply of energy a electrical circuit is made through the tank. Due to the difference of potential this generates, the negatively charged proteins with dodecyl sulfate anions are pushed by the difference of potential with help from the chloride ions that cause greater difference of potential and move with the proteïns.

The proteins are displaced to the border between the two gels, where there they are slowed due to the major density of the resolving gel, allowing thus that all proteins start moving into the resolving gel more or less at the same time. [4]

The electrophoresis should be stopped when proteins are sufficiently separated for the purposes they might serve, and before any protein trespasses the whole length of the gel.

2.4. Coomassie blue staining

After the electrophoresis is realized to get results it will be necessary to apply a staining or realize a western plot. The most commonly used staining is the coomassie blue, as we did in our experiment.

To realize a coomassie blue staining we have to start by separating the polyacrylamide gel from the support in which we carried the electrophoresis by cleaning the plates and applying 500 mL of a gel-washing solution during 1 hour that will ensure the correct state of the medium once the procedure has ended. That gel-washing solution contains water in 40% of volume, ethanol in 50% of volume and acetic acid in 10% of volume.

Once that procedure has ended, we will place our gel in 500 mL of a gel-fixing solution made out of 50% in volume of methanol, 40% water, and 10% acetic acid, this will help our gel to become more stable so as to fix the proteins in the gel. We will carry on this phase for as long as we can.

Then, we will stain our gel by putting it with 400 mL of a staining solution at room temperature with constant movement for 3 to 4 hours. This staining solution is formed with 0,1% in volume of Coomassie blue R350, 20% in volume of methanol, 10% in volume of acetic acid, and 69.9% in volume of water.

After this process the whole gel will turn dark blue, making it barely possible to identify the different protein bands, so we will destain it with 250 mL of a destaining solution made out of 50% in volume of methanol, 10% in volume of acetic acid, and 40% in volume of water. We will make this process with constant movement until we can observe that the gel is destained and the protein bands can be perfectly identifiable thanks to a characteristic blue color.

Finally, we will have to place our polyacrylamide gel in 500 mL of a storing solution, made out of 5% in volume of acetic acid and 95% in volume of water, that will ensure the proper conditions for the maintenance of the gel and for its usage. Once the staining has been realized we analyze the results of the SDS-PAGE. [5]

3. Conclusions

Looking at the gel we can obtain multiple conclusions. We can more or less deduce the number of proteïns present on the analyzed samples (or at least the minimum) by looking at the number of lines, as each line is composed of one protein or multiple proteins with similar mass.

Looking at the thickness and density of each line we can try to deduce the quantity of each proteïn or at least compare if there is more of one protein than other.

Adding in one well of the gel a series of previously identified proteins (reference proteins) we can sort the reference proteins by mass knowing then which line corresponds to each protein. With this we can deduce that in a well that contains an almost identical line or at least the same distance of displacement of one of the lines of an identified protein, the sample of that well contains that identified protein.

With the lines of the reference proteins we can try to deduce the mass of the proteins that generated each line compared with the reference proteins, since the heavier ones will be placed higher and the lighter ones will be lower in the gel.

If required we can cut the polyacrylamide gel to isolate a certain protein and conduct further experimentation on it. [1,2,4,5]

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Higher-Order Conditioning: from Classical Conditioning to Mediated Learning

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Abstract. The world constantly changes, so associative learning is crucial for the survival of animals and humans. Classical conditioning is a well-established form of learning, but other forms play a central role in daily decision-making. One such type is higher-order conditioning, also known as mediated learning, assessable through behavioral tasks like sensory preconditioning (SPC) and second-order conditioning (SOC). These types of learning help us comprehend complex phenomena such as the placebo effect and the effect of drug overdose. This knowledge could enhance the integration of behavioral and pharmacological therapies for health disorders, promoting better synergy.

Keywords. Associative Learning, Classical Conditioning, Sensory Preconditioning, Second-Order Conditioning.

1. Introduction

The main topic of the Hands-on Science conference is scientific education, so it would be interesting to analyze what learning means from a scientific perspective. Learning is a broad concept consisting of many forms, from complex declarative memories to more fundamental forms like associative learning. From the point of view of evolution, this latter, more elemental type is a tool to promote survival in a constantly changing world. Indeed, events around us happen in a bundle that seems to make no sense. However, animals and humans can see a particular order in this apparent chaos. Thanks to associative learning, they isolate the causes and consequences of this tangle and establish connections between them. Having this knowledge, animals can better predict future events, modify their behavior, and, thus, increase their chances of surviving [1].

Consequently, the primary mechanism behind learning is deep-rooted in the evolution tree, as it offers an advantage to survive. There is no need for a complex brain to learn. Focusing on simple organisms, like the worm *Caenorhabditis elegans*, with a nervous system of 302 neurons [2], we already observe the learning capacity. When exposed to a light followed by an aversive stimulus, like an electric shock, they learn to react with fear to the light alone because they associate it with the aversive stimulus [3]. Therefore, this example shows us that the mechanisms behind the most basic forms of learning do not require the presence of a complex structure of 86 billion neurons, like the human brain [4]. Instead, associative learning exploits the basic biochemical mechanisms that drive Hebbian plasticity, that is, the formation of new synapses, which then leads to the acquisition or suppression of different behaviors [5].

2. What is learning?

Finding a good definition of learning may take time and effort. We may consider it a conscious process to acquire knowledge that will change our future behavior. However, the type of learning that influences the most behavior is undoubtedly unconscious. People make most decisions without thinking, following a hedonistic pattern (i.e., searching for pleasure and avoiding pain). This hypothesis that we learn from the positive or negative consequences of actions converged during the 20th century into behaviorism, the first theory of learning. According to it, behavior can be explained without all mental life, just paying attention to what can be objectively measured [1].

Therefore, there is a close relationship between learning and behavior. Indeed, according to the American psychologist Michael Domjan, learning is "an enduring change in the mechanisms of behavior involving specific stimuli and responses that results from prior experience with those or similar stimuli and responses." This definition implies that learning begins with the interaction with a particular stimulus and causes a change in our way of behaving toward this stimulus [1]. A classic case to exemplify it is food aversion, in which the organoleptic properties of a specific flavor become associated with a negative experience, like indigestion. This coupling promotes learning mechanisms and changes the future behavioral response toward the same taste [6]. What used to be an ordinary flavor is now considered an aversive stimulus objectively measurable by the externalization of dislike responses.

However, considering learning solely as a behavior change is an error, as behavior relies on many other factors. For instance, one will not react to an aversive food under certain circumstances, like being asleep. Therefore, an individual's response at a particular moment is a consequence of different contributions apart from learning. That is why Domjan typically refers to it as performance instead of behavior and suggests describing learning as a change in "behavioral mechanisms" to distinguish it. Unlike performance, observing learning may only be possible under specific conditions and involves a change in the architecture of the neural networks [1].

3. Different types of learning

The most straightforward type of learning is called non-associative learning. It receives this name because it does not arise from the association between two stimuli but from the repeated stimulation of a single one. Regarding behavior modification, non-associative learning consists of two opposite forms: habituation, which decreases the vigor of response to the stimulus, and sensitization, which increases the magnitude of the response. Both types of learning contribute to the global performance of an individual by choosing which stimuli are worth noticing and which can be ignored. For example, one becomes habituated to an irrelevant auditory stimulus, like a clock's ticking, thanks to habituation, allowing focussing on other, more relevant stimuli. Therefore, non-associative learning could be regarded as a prelude to a more complex cognitive process, namely, associative learning [7].

Using associative learning, animals determine which stimuli and responses come together by establishing cause-and-effect relationships. By knowing these relationships, they can make useful predictions and interact more effectively with the environment. This idea was first tested by the Russian physiologist Ivan Pavlov and the American psychologist Edward Thorndike, who respectively discovered classical conditioning and operant conditioning [7]. While operant conditioning associates the subject's actions with their consequences, like pressing a lever and escaping from a box in Thorndike's experiments with cats, classical conditioning associates stimuli outside the subject. This latter situation would be the case of food aversion, in which the stimuli are independent of the responses of the individual. The indigestion earns the name of Unconditioned Stimulus (US) because it triggers a discomfort reaction without prior training. On the other hand, the specific flavor, like vanilla odor, is called the Conditioned Stimulus (S1) because only after associating it with the US produced a conditioned response of dislike [1].

4. Beyond classical conditioning

Associative learning has been long studied using classical conditioning as a reference model. Still, alternative types of learning are also receiving attention since they may be more common and important in daily decision-making. A well-known example is higher-order conditioning, also called mediated learning, in which non-reinforced stimuli cause attraction or aversion without being directly paired with a US. The reason is an accidental association between low-salience cues (S2) and directly conditioned stimuli (S1) [8].

Therefore, mediated learning consists of two separate stages: an association between two low-salience stimuli, for instance, chocolate (S2) and vanilla (S1) flavors, and a classical conditioning pairing involving the S1 and the US. Depending on the order in which the two phases are presented, higher-order conditioning is divided into two behavioral paradigms: sensory preconditioning (SPC) and second-order conditioning (SOC). The two protocols (i.e., SPC and SOC) aim to acquire a new conditioned response to S1 and S2, although S2 is never directly associated with the US. In SPC, individuals are first exposed to the preconditioning phase between S2 and S1, and then S1 is directly conditioned to the US. Meanwhile, the first step in SOC is the classical conditioning association, and the coupling between S1 and S2 comes after [9].

In the case of food aversion, an SPC protocol would involve first eating a food containing both flavors, like an ice cream made of chocolate (S2) and vanilla (S1), and then consuming an indigestible food just containing vanilla. After this experience, one may develop a deep dislike for vanilla but, surprisingly, also for chocolate. The same outcome would result in a SOC protocol,

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i.e., when inverting the order of the conditioning steps (Figure 1).

At first glance, it could seem that SPC and SOC may be processed similarly, but the truth is that both types of higher-order conditioning significantly differ in their neural substrates. Their brain processing still needs to be fully understood, but different studies suggest that it may vary depending on the stimuli's nature and order of presentation [10]. Future research should address the brain areas involved and the neural mechanisms of mediated learning, considering the differences between SPC and SOC.

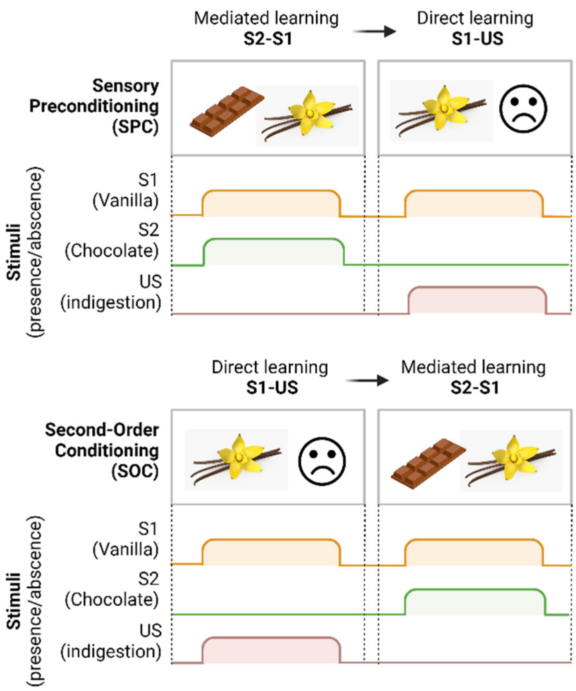

Figure 1. Protocols for food aversion based on SPC (top) and SOC (bottom). Created with BioRender.com

5. Associative Learning as a Working Tool

Classical and higher-order conditioning help explain different phenomena from daily life. One such case is the placebo effect, which consists of an apparent improvement in health after taking a fake treatment. The cause of the placebo effect is merely neurological and receives a strong influence from mediated learning. It all begins with the context that usually surrounds the world of medicine, including the treatment itself with its characteristic packaging. Throughout life, people often repeat this ritual as if in a direct conditioning phase, associating the context of the drug and the effects caused by its active ingredient with health improvement. Therefore, thanks to classical conditioning, a future fake treatment administered in a similar context will trigger a conditioned response of improvement, activating the brain's reward centers and decreasing stress hormones, such as cortisol and catecholamines. Moreover, thanks to second-order conditioning, all the stimuli associated with the fake treatment, like the person administering it, may also acquire the ability to elicit a pain-relive effect on the patient [11].

Context conditioning is a potent tool, not just to explain the placebo effect. It is well known that context plays a role very similar to the placebo effect in many fields, such as drug addiction. A well-known example is people who consume a specific drug of abuse, like cocaine, in the same environment and with the same crowd. Cocaine produces alterations to the body that the organism must compensate for; that is to say, the body must work to counteract its effects. Over time, these compensatory effects are conditioned to the surrounding environment of cocaine abuse. Each time consumed in this situation, the environment's stimuli activate the compensatory mechanisms, and the person notices the effect of cocaine moderately. However, when the consumption occurs in another context than usual, the lack of direct and mediated stimuli prevents compensatory mechanisms from being activated. Although the dose is the same, the effect will be high as if an overdose had been taken [1].

6. Conclusions

Studying learning and its different forms, from classical to higher-order conditioning, provides valuable insights into the complex mechanisms governing behavior. While classical conditioning focuses on the association between a neutral and an unconditioned stimulus, higher-order conditioning, also known as mediated learning, establishes connections between low-salience stimuli. Thanks to all forms of learning, we find an explanation for phenomena like the placebo effect and the conditioned overdose in drug abuse, emphasizing the influence of environmental cues on behavior. Understanding these learning processes deepens our knowledge of how organisms adapt to their surroundings and has practical applications in different research fields. By unraveling the intricate connections between stimuli and behavior, we can better understand ourselves and the world around us.

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Memory: What Is it?

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Abstract. Memory is a highly complex ability present in most humans and animals, and numerous studies have been conducted throughout history to discover its mysteries. This article provides a comprehensive approach to the definition of memory, explains the different sorts of it that exist, and analyses the diseases that impact this capacity, including Alzheimer's disorder, two types of amnesia, and other forms of dementia. To add value to this work, an explanation about an experiment conducted with rats (Rattus) where the short-term memory of these animals has been evaluated. This article has provided valuable information to understand how memory works and how it is related to human diseases.

Keywords. Memory, Amnesia, Brain Regions, Long-Term Memory

1. Introduction

Memory is a cognitive process and a function of the brain that involves the ability to acquire, store, retain and retrieve information. This can occur either voluntarily or involuntarily. Similarly, certain information is permanently stored in our brains, while other information is quickly forgotten. However, it is essential to our identity as well as our ability to think, learn, and make decisions.

1.1. Types of memory

Memory consists of various types that play different roles in our lives. Firstly, we have short-term memory, which allows us to retain and manipulate an amount of information for a brief period. On the other hand, there is long-term memory. This is the type of memory that enables us to store information permanently, used to remain for a lifetime.

Regarding unconscious memory, we have conditioning, which is a learning process that relates stimulus and response. A famous example is Pavlov's experiment with dogs, where dogs were conditioned to associate the sound of a bell with food, resulting in a salivation response.

Additionally, we have skills, which refer to the learning and retention of motor skills and methods. These skills are acquired through practice and repetition and are stored in implicit memory. That means that they are expressed automatically, without conscious awareness of how the task is performed. For example, remembering how to write or ride a bike.

Within long-term memory, we can distinguish two main types: explicit or conscious memory and implicit or unconscious memory. Explicit memory refers to our ability to consciously recall facts, specific events, and past experiences. For example, we can remember a trip or a graduation.

On the other hand, semantic memory is part of explicit memory, and it allows us to store and retrieve general knowledge and abstract concepts. This includes word meanings, historical concepts, and mathematical knowledge, among others.

Summarizing, memory is divided into short-term memory and long-term memory. Within long-term memory, we find conscious memory (including episodic and semantic memory). On the other hand, unconscious memory covers conditioning and motor skills. Each type of memory is essential in our everyday lives.

1.2. How memory works

Memory functions through different stages. The first step is encoding in which sensory information we perceive is converted into a format that the brain can process and store. We select certain stimuli to pay attention to. The way information is encoded can be through visual images, auditory sounds, or the semantic meaning of what we perceive. Factors such as attention, concentration, and association with previous knowledge influence the fulfillment of encoding.

The following phase is storage. Once the information has been encoded, it is stored in various memory systems distributed throughout the brain. Short-term memory, also known as working memory, holds information for a few seconds or minutes and has a limited capacity to retain it. It can be transferred to long-term memory if the information is important or is

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repeated frequently. Long-term memory has a greater capacity and can retain information over longer periods of time that can go from minutes to years.

Retrieval: In this stage, the stored information is accessed and recalled when needed. This phase can be triggered by stimuli or associations related to the stored information.

Memories are stored in different areas of the brain depending on which types of memory they are. For instance, memories that are linked with emotions such as fear are associated with the amygdala whereas learned skills are located in the striatum. The hippocampus plays a crucial role in the formation, retention, and retrieval of explicit memories. The temporal lobes play a key role in the creation and retrieval of memories.

1.3. Diseases that affect memory

In order to understand how memory and forgetfulness work, the study of amnesia had a great impact on it. This disease is often the result of head trauma, brain tumors, or chronic alcohol abuse. In other words, it is the result of brain damage.

There are two main types of amnesia. The first one is retrograde amnesia, which incapacitates the ability to remember information or events that occurred before the brain injury. The second one is anterograde amnesia when the brain injury limits the ability to create new memories after the traumatic event.

One of the most well-known cases of anterograde amnesia is that of Henry Molaison, also known as H.M. In 1953, parts of Molaison's brain were removed in a desperate attempt to treat his severe seizures. Although Molaison retained memories of much of his childhood, he was unable to form new explicit memories. This meant that every time someone visited him, he had to be reintroduced, as he could not retain the memory of previous visits.

Alzheimer's disease is a brain disorder that slowly incapacitates the ability to use memory, thinking skills, and eventually the ability to perform even the simplest tasks. During the early stage of Alzheimer's disease, toxic changes are occurring in the brain, including the abnormal buildup of proteins that form amyloid plaques and tau tangles. Neurons, which were previously healthy, stop functioning, lose connections with other neurons, and die. Many other complex brain changes are believed to play a role in Alzheimer's disease as well.

2. Methods

The experiment conducted aims to test the memory of rats (*Rattus*) who have been under a treatment that stimulates memory, using a closed circuit or maze composed of three corners. This circuit features a center from which three different corridors extend, which we will refer to as A, B, or C. With this test, the objective is to evaluate the quality of the short-term memory of this rodent.

As expected, the animal will seek to explore new areas, so theoretically, it should follow a pattern repeatedly where the letters are not repeated at any point. In other words, if the first three corridors visited are ABB, we would be determining that the rodent has not a good short-term memory capacity because it doesn't remember that corridor B has already been visited.

Table 1. Rat’s route in the circuit

Rat’s code	Route	Correct entries
1st rat (1R 1388)	ABACBACBCBABC ACBBACABCBCBA CBCB	15
2nd rat (1R1L 230001389)	BCABACBACBACB BAACABACCAACB ABABABCACBABA	18
3rd rat (NN 1390)	ABCABCABAACBC BACBCBBACABAC ABCABCABCAC	22

The method is simple: the rat is placed at one of the ends, it doesn't matter which one, but it is essential to have a clear understanding of which is which. Then, we let the rodent freely explore the circuit, allowing it to inspect it on its own, without any kind of stimulus. We will observe how it moves and which end it heads towards based on the end it came from and evaluate the quality of its short-term memory, considering the route it has taken and the letters it moves towards. It is worth mentioning that we will consider the rat to have entered a particular corridor when both hind legs cross the marked line in each corridor. If this condition is not met, we will consider that the rat has not moved from the central position.

The experiment was done with 3 rats.The sequence is counted by threes and if all of the three are different we count the first letter as correct. Next, we look at the 2 letters remaining and the following letter to have a new trio and we follow the same procedure until we have only two letters left. Finally, we count how many corridors have been visited and how many of them are correct to calculate the % of correct entries.

Table 2. % of correct entries

Rat's code	Total entries	Correct entries	% correct entries
1st rat (1R 1388)	30	15	53,57
2nd rat (1R1L 230001389)	38	18	50,00
3rd rat (NN 1390)	37	22	62,86

3. Conclusions

The study of memory is fundamental to understanding how cognitive processes work in humans. Throughout this article, different aspects related to memory have been explored, including its types, stages, and mechanisms involved. The existence of short-term memory and long-term memory has been highlighted, which play different roles in the storage and retention of information, in addition to different diseases that negatively affect it. Finally, after doing an experiment in which the memory level of 3 rats is tested, it can be determined that despite having a fairly small memory capacity, they do have short-term memory.

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Notions of Genetic Engineering in E-coli

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Abstract. Genetic engineering is a powerful tool that allows scientists to manipulate the genetic material of organisms. In this experiment, we employed genetic engineering techniques to introduce the green fluorescent protein (GFP) gene into *Escherichia coli.* The GFP gene, originally derived from a jellyfish, produces a protein that emits green fluorescence when exposed to certain wavelengths of light. By successfully integrating the GFP gene into the *Escherichia coli* 's genome, we were able to visualize the expression of the protein in live cells. This experiment demonstrates the potential of genetic engineering and GFP as a versatile tool for studying gene expression and protein localization.

The implications for such a technology (genetic engineering) vary greatly from the livestock and agricultural industry to medicine and sustainability. Although some ethical issues are raised, genetic engineering shows significant promise.

Keywords. Escherichia coli, Genetic Engineering, GFP, Protein Localization.

1. Our interest

Our goal for this experiment is to genetically engineer E. coli to incorporate the GFP protein while making it resistant to ampicillin. The findings of this experiment have the potential to greatly benefit various scientific fields due to its remarkable versatility.

To begin, let's outline the key concepts of genetic engineering. By manipulating the genetic material of organisms, we can modify their traits. This process involves four main steps. First, we isolate the desired gene from the organism's genome [1]. Next, we modify the gene as required. The third step involves introducing the modified genome into the organism, although in some cases, this step can be bypassed if the genetic alteration occurs within the organism itself. Finally, the organism is placed in an optimal environment to express the desired traits, such as in this case, the GFP protein [2*.

In summary, the experimental pathway involved using the GFP protein, originally derived from a jellyfish, known for its ability to emit fluorescence in the dark. The host organism used was E. coli, which was cultivated in an LB medium.

2. Research design

In this experiment, we utilized genetic engineering techniques to introduce the green fluorescent protein gene into *Escherichia coli*. The methodology involved several steps to successfully achieve this integration and visualize protein expression:

First, solid LB (Luria-Bertani) media with Ampicillin was prepared. LB media, containing tryptone, yeast extract, and agar, provides the necessary nutrients for bacterial growth. Ampicillin was added to select for bacteria that had taken up the GFP plasmid.

Next, we inoculated E.coli (50µl of cells + 1µl of GFP plasmid): cells were mixed with the GFP plasmid, which contains the genetic material for GFP, through gentle pipetting. This ensured the distribution of the plasmid among the cells.

The cell-plasmid mixture was incubated on ice for 15 minutes. Following the ice incubation, the cells were subjected to heat shock. The mixture was transferred to a thermal cycler set at 42ºC and incubated for 44 seconds.

After heat shock, the cells were returned to ice for 5 minutes. LB medium was added to provide nutrients for cell survival and growth.

Subsequently, we incubated it at 37ºC for 45 minutes. This allowed the expression of resistance genes within the GFP plasmid and supported the multiplication and growth of the cells.

Once the incubation period concluded, the cells were centrifuged at 14,000 rpm for 5 minutes. 200µl of LB medium was added to resuspend the bacterial pellet. This provided the necessary nutrients for ongoing bacterial growth and subsequent experimental steps.

3. Main findings

For this experiment there have been four different bacterial growths, having some of them Ampicillin, Arabinose, both or none of them.

Table 1. Bacteria samples and the added components

E. Coli samples	Contains Ampicillin	Contains Arabinose
Sample 1	True	False
Sample 2	False	True
Sample 3	True	True
Sample 4	False	False

After all the process explained in the previous section, the samples are seeded in petri plates with agar, letting the bacterial growths rest in order to multiply them. After the wanted time, the four samples have significant differences, starting with the bioluminescence. The bacterias that absorbed the GFP can have bioluminescence when they are exposed to ultraviolet light. However, this characteristic is only given to the bacterias that contain Arabinose. As a final result, we can determine the next statements (Table 2).

Table 2. Different GFP expression

E. Coli samples	GFP expression
Sample 1	False
Sample 2	True
Sample 3	True
Sample 4	False

4. Conclusion

4.1 Discussion

Our objective given this experiment was to genetically engineer E-Coli to express the GFP protein, numerous scientific sectors would benefit from this, the following are just some of the many uses of protein expression in E-Coli: Detection of biological processes through real-time monitoring of particular biochemical processes, rapid and non-destructive assessment of protein expression, gene expression analysis within regulatory regions such as promoters in gene expression, highly accurate and thorough screening and identification of drugs.

Moreover, E-coli can serve as a host for the production of recombinant proteins, GFP can be used as a reporter in this case and allow researchers to observe the progress of certain reactions. The resulting benefits demonstrate the wide range of applications of E-coli as a host organism for GFP expression and its contributions to several fields of biological study, including molecular biology, cell biology, genetics, genetic engineering and biotechnology.

4.2 Conclusion

In this experiment, four different bacterial growth samples of E. Coli were studied, each with varying combinations of Ampicillin and Arabinose. The objective was to observe the effects of these components on bacterial growth and GFP expression, which is associated with bioluminescence.

The results showed that the presence of Arabinose had a significant impact on GFP expression and subsequent bioluminescence. Sample 2, which contained Arabinose but not Ampicillin, exhibited GFP expression and demonstrated bioluminescence. Sample 3, which contained both Ampicillin and Arabinose, also showed GFP expression and bioluminescence. On the other hand, Sample 1, which only had Ampicillin, and Sample 4, which had neither Ampicillin nor Arabinose, did not exhibit GFP expression or bioluminescence.

5. Acknowledgements

As a team, we want to thank first of all to the University of Barcelona and the members of the "Crazy about Biochemistry", which was the one who offered us this magnificent opportunity. Without them anything of this project would be possible.

Also we thank the Hands on Science organization for letting us present our work and present it in front of world-renowned eminences in the world of science that are attending the presentation of our project. In the end the E-coli was immune to ampicillin and furthermore, it glowed in the dark which means the main goal

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was reached fully without any compromise. The significance of the results is therefore not compromised either and all of the mentioned above can be achieved through the results attained.

Last but not least, we want to thank our families for supporting us during this time doing the program “Crazy *a*bout Biochemistry” and advise us of choosing to do this incredible opportunity.

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MateMusiC: Mixing Maths and Music in an Interactive Show

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Abstract. Making maths accessible to the general public and to students is not an easy task, but what happens when you can "hear" that maths? We present in this article a show performed together with musicians that unravels the mathematical secrets hidden behind the music. The show is interactive so that at the end of the performance the public can play music together with the musicians.

Keywords. Maths, Music, Physics, Waves, Acousitc.

1. Introduction

Music is (luckily) all around us. Maths also. But the former is much more evident than the last. It is very interesting to make the general public and students discover the maths of everything, but music offers us an opportunity to make it from an artistic point of view. Moreover, the importance of introducing music in an educational context is of the greatest importance, both to change the view of maths and to make accessible music that, otherwise, would not reach some of the students [1].

MateMusic is a project that was initiated by the collaboration of a physicist (the author of the present communication) and two musicians:

- *Nuria Balcells*: Profesional violinist that plays very different styles ranging from folk music to classical music [2].
- *Juanjo Molina*: Trompetist from Moby dixie: a Dixieland Jazz Band playing in several festivals and open-air shows [3].

The shows have been played in science festivals, in TIBIDABO amusement park [4] and at the Polytechnic University of Catalonia (UPC). They are designed to be participative and very dynamic in order to keep the attention of the public all through the half an hour duration of the performance… and all through a journay where we introduce concepts that are not easy.

2. Show structure

The design of the show has been done to clearly state three very clear "take home messages". The concepts are:

- Sound is due to the change of air pressure that results in "movement".
- Tone is related (both in string and wind instruments) to length
- Musical notes have a mathematical relationship when played with an instrument: both in the length of the tube or string, and also intheir frequency.

We also show which are those mathematical relationships. However, as puzzling as it might seem, the exact relationship is not the main goal of the spectacle. We would be glad if the public (at least) remembers that all musical notes can be produced using a string or a tube shorter and shorter, until it reaches half the size. Our real main goal is to cause "surprise" on how to see reality with "mathematician eyes": the same surprise that most probably drove Pitagoras to the study of the maths behind the music.

The structure of each concept is organized in the show (again) in three parts:

- Experimental action. This is done to cause perplexity, or at least curiosity that leads to the question "what happens here?"
- *"Theoretical" explanation*. We briefly explain (in a more or less mathematical way, depending on public age) what they are seeing.
- *How does it sound?* The musicians play a short musical themes which is related to the experiment or the mathematical relationship we have "discovered".

The organization in groups of three is done intentionally. It is proven that a talk structured in blocks of three is the best received by the audience [5].

Two shows have been produced so far: one is dedicated to investigate how music is peformed with a string instrument such as the violin and another one is focused on wind

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instruments with the help of the aforementioned Dixieland band: Moby Dixie. Each show is slightly different being the first one dedicated to teenagers / adult audience, and the second one to primary school students.

3. Infographic structure

The concepts given in the talk are visually supported by a poster with movable structures. The ideas behind this infography is twofold:

- First, we think that it is very important that we can really "grab" musical notes, equations, waves… and hold "the concept" in the hand while making the speech.
- Second, we "construct" the talk while we are speaking. The poster is empty at the beginning (excepting the notes) and we add the elements to the poster so that at the end of the talk (almost) all the information can be seen in the poster (see figure 1).

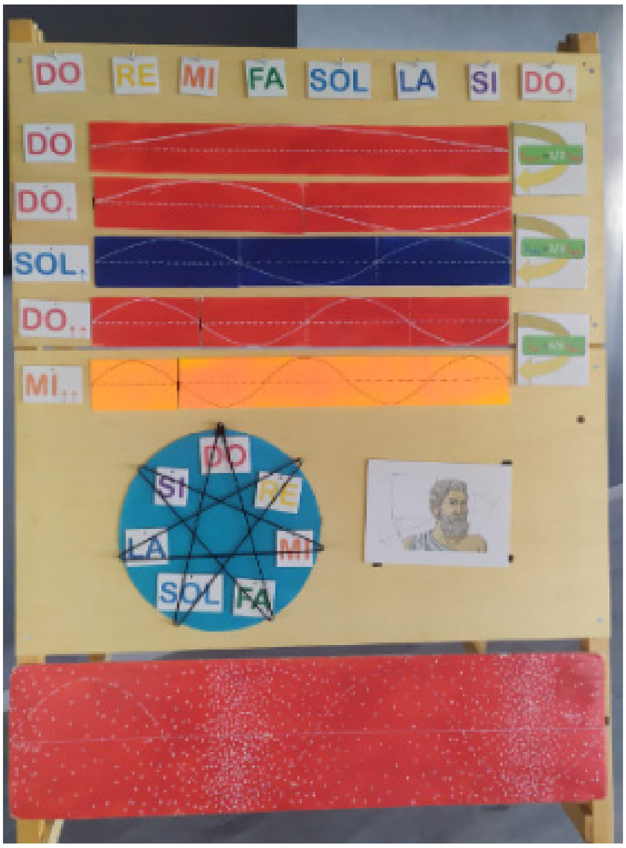

Figure 1. Final view of the poster summarizing all the concepts seen in the talk

We have found that the infographic support is key to make the take homw messages arrive to the audience. Indeed, an informal prove that this way of organizing the information is compact is that there is always somebody from the public asking for permission to do a photography of the final poster.

4.Conclusions

We have designed two shows to bring together amusement and knowledge by combining music and maths. The intention of the shows is to make people discover that maths can be found everywhere: also in music. This fact does not make music more mechanical… it makes people aware of the beauty of proportions (and maths in general).

We hope with the two shows to light a spark of curiosity that might awake the interest for maths to the general public, and most important: to young students.

7. Acknowledgements

The authors would like to acknowledge the company "Tico Musica" to support us with the tubes usd in the show, the Wak-a-tubes [6].

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Workshop Hands-on Blueprint: The Cyanotype

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Abstract. Cyanotype is a photographic printing process that produces a cyan-blue print. It was invented by Sir John Herschel in 1842 [1]. Shortly after Herschel developed the cyanotype process, his friend, photographer Anna Atkins, started exploring the process for book illustration by making cyanotypes of plants. She used the method to produce the first book that included photographic images, titled "*Cyanotypes of British and Foreign Flowering Plants and Ferns"* [2].

The Cyanotype process uses two iron salts, ferric ammonium citrate and potassium ferricyanide. Cyanotype is an excellent way to teach science because it is a simple process that produces a continuous tone image of Prussian Blue using a sensitizing solution of ferric ammonium citrate and potassium ferricyanide [3].

Figure 1. Printing students' cyanotype in the school playground

After the paper is coated with the chemical solution, any part of the surface that is exposed to direct UV light will react and change color. Cyanotype photographs can be made in two ways: by using a photo negative, or by placing an object directly on the paper that is being exposed to the sun. Wherever the object blocks out the light the paper will remain white, and wherever the light hits around that object will react and turn blue.

Figure 2. Washing the cyanotype in the Room 1 of the Learning support centre of the school

This method produces a print called a photogram. The prints are processed, and the material is stabilized by rinsing the paper in water. After the blue prints are dried, they will be rinsed and dried at the sun. This activity is weather-permitting, as photograms will not expose well if it is too cloudy or rainy.

Figure 3. Drying the cyanotype in the school playground

The Cyanotype method can be used to teach the principles of light-sensitive materials and the effects of UV light on chemical reactions [3]. Cyanotype can also be used to teach the principles of photography and the history of photography [2]. It is an excellent way to engage students in science and art [4].

After the short introduction to the Cyanotype, the participants will be invited to participate in a hands-on blueprint workshop in order for them to create their own cyanotype with every day objets. This workshop will engage the

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participants to experiment and to practice the Cyanotype photographic printing process and to discuss how it can be implemented in school' science classes.

Keywords. Hands-on Activities, Cyanotype, Photography, Interdisciplinary Learning, Creativity, Science Teaching, STEAM.

Acknowledgements

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FISIDABO Project: Bringing Science to TIBIDABO Amusement Park

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Abstract. An amusement park is a giant physics laboratory where Newton laws come to live in a very intense way. Taking advantage of this fact we have developed an educative project in Barcelona's amusement park TIBIDABO to bring science in general, and specifically physics, to young students and to the general public. Under the generic name FISIDABO we have developed a series of activities that are targeted to different publics:

- **FISIDABO 2K**: is dedicated to 15-18 years old students that perform a series of experiments in the amusement park.
- **FISIDABO formació**: teachers are taught how to use the sensors of the mobile phone to teach physics in the classroom… and also in the amusement park.

Figure 1. Performance in FISIDABO LabShow: physics and music

- **FISIDABO HIPATIA**: is dedicated to highly talented students, also 15-18 years old, that bring their own experiments to TIBIDABO.
- **FISIDABO LabShow**: are a series of scienticfic shows open to all the visitors of the amusement park.

  FISIDABO Experimenta!: has been created to reach little scientists that are visiting the amusement park.

FISIDABO 2K: TIBIDABO amusement park is closed one day to visitors and dedicated exclusively for two thousand students that will perform several physics experients in the amusement park during one morning. Most of the experiments are performed using the sensors of the mobile phone: students can record the acceleration of the rides or calculate velocities and trajectories analyzing the videos, using different mobile phone apps. All the experiments are designed to be performed in the amusement park, but data can be exported to perform a deepeer analysis of their results in the classroom. The experiments are clearly explained in a series of documents that can be downloaded for free from our web page [1].

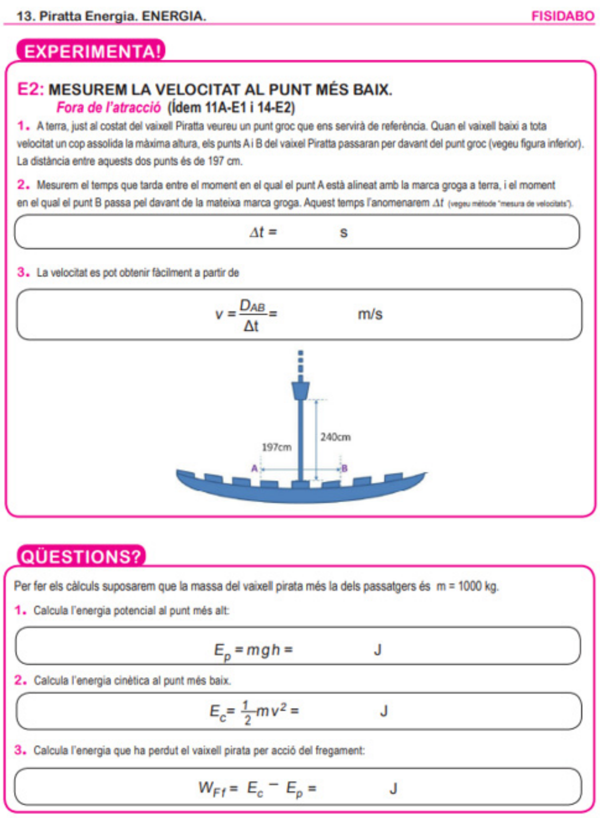

Figure 2. Example of experimental sheet

More invisible but also (even) more important is **FISIDABO formació** [2]. This is an open activity for teachers in which we explain how to perform physics experiments in the classroom

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with the help of the mobile phone. One objective is to teach teachers how to use the apps used in FISIDABO 2K. The main goal is, though, to provide them with a set of “stand alone” experiments that can be performed in the classroom, and that are freely accessible in our web page.

Figure 3. Teachers ready to measure acceleration

The activity **FISIDABO Hipàtia** [3] takes place the same day than FISIDABO 2K in the evening. In this case highly talented students bring *their own experiments* to the amusement park. We must point out that the experiments are designed and built by the students. The results of some of the experiments have been published in the peer reviewed journal European Journal of Physics [4-6].

Although engaging students in science is the main gol of our project, it must not be forgotten that the seed of the interest in the STEM areas must be planted well before the students have to choose their studies. For this reason, we have two activities dedicated to the general public, specifically to small boys and girls.

Fisidabo LabShow [7] consists on a series of scientific shows peformed in the amusement area accessible to everybody (public does not have to pay to see the show). The shows want to be a true scientific performance leaving behind an increasing trend of designing scientific events in which experiments and spectacularity are ruling the script, instead of a scientific idea or concept. We have performed different shows but, as an example, we would like to highlight the one mixing physics and the music of a (live) Dixie Big Band and also the one about brain and perception performed by neuro-scientists.

Finally, we have just started a new project called **FISIDABO experimenta!** We would like that visitors that are queuing use their (otherwise wasted) time to perform some simple experiences by looking at the rides. This is done by scanning a QR that is found in the queues, that directs to a video in which the experiment is explained. The target audience for the video are children in primary school.

Once the experiment is done, measured data can be uploaded in a web-page from the university. This is important to convey the idea that science is a collective process. Data is also “open access” and can be downloaded from the same web page.

All in all, we think that, together with the proactive workers and administration of the amusement park, we have created a whole educative project accessing a whole range of public that (to the best of our knowledge) is unique. Although some amusement parks do allow students to make physics experiments and do have some educational activities, in our case we have created a whole project to be reached by students, teachers and the general public involving them in shows and experiments that can be performed by everybody.

Figure 4. FISIDABO Hipatia experiment: studying the effects of microgravity

Keywords. Mobile Phone, Digital Learning, Amusement Park, Physics, Maths.

Acknowledgements

The authors are deeply in debt with the TIBIDABO amusement Park of Barcelona.

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IoT and Safety with Scooters

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Abstract. In this communication is presented a project of the 7th "À Descoberta da Luz" Competition of the 11th "Hands-on-Science" Science Fair [1], promoted by the Hands-on-Science Network Association and the Portuguese Society of Optics and Photonics. This event welcomed the participation of students from all levels of education, as well as teachers, educators, and enthusiasts interested in any of the fields of science.

Micromobility solutions, such as electric scooters and electric bicycles, have become increasingly present in our daily lives, leaving their mark on our roads. While offering various conveniences for short-distance travel, these vehicles also present challenges and disadvantages, especially in terms of safety, due to their physical fragility compared to more common means of transportation, such as cars.

In this context, entrepreneurship emerges as a driving force in creating a prototype aimed at improving the safety of scooter users by addressing current concerns related to the safety of these vehicles. The development of this prototype was based on entrepreneurial efforts that combined knowledge and resources to create innovative solutions.

Our prototype aims to ensure the safety of both scooter users and those in their vicinity. To achieve this, it incorporates several features based on computer programming and Internet of Things (IoT) technology, resulting from an entrepreneurial process that involved research, creativity, and the application of technical knowledge.

The prototype includes a detection and alert system in case of a fall, which automatically detects when the scooter falls and sends an alert with emergency contact information. Additionally, it has a warning system for vehicles approaching the rear of the scooter, helping to prevent collisions. It also features signaling lights to indicate the intended direction of the user, increasing safety and awareness of other road users.

This project represents a clear example of the intersection between entrepreneurship, programming, and 3D modeling. The main objective was to improve the safety of scooter users by addressing current challenges related to the fragility and safety of these vehicles. Through the application of computer programming knowledge, it was possible to develop an innovative and technologically advanced prototype.

Computer programming, using BBC Micro:bits boards, played a fundamental role in creating this prototype, enabling the implementation of essential features to ensure user safety. The use of these boards is grounded in active learning methodologies such as Problem-Based Learning, Cognitive Development Theory, Project-Based Learning, and creative disobedience, providing students with fundamental skills such as motivation, commitment, creativity, and autonomy, while also contributing to the development of mathematical knowledge [2].

The result of this hands-on project was the creation of an innovative prototype aimed at improving the safety of scooter users, combining entrepreneurship, technology, and scientific knowledge. The project was developed using the STEAM (Science, Technology, Engineering, Arts, and Math) methodology, establishing connections between the skills present in the curriculum and promoting an interdisciplinary approach.

In summary, this work presents an entrepreneurial project that seeks to address the challenges related to the safety of electric scooters. The developed prototype incorporates features based on computer programming and IoT technology with the aim of providing increased safety for users and those around them.

The use of BBC Micro:bit boards and the application of active hands-on learning methodologies strengthened the development of the prototype, offering students essential skills and relating them to the educational curriculum.

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Keywords. 3D Modelling, Entrepreneurship, Programming, Internet of Things (IoT), Micro:bits, STEAM.

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Reproduction Teaching. True News Versus Fake Ones

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Abstract. Teaching of mammalian reproduction at secondary school and at the University is plagued by recurrent mistakes. These mistakes are caused by two main aspects, namely the utilization of humans as the model species to explain reproduction in the entire animal Kingdom and the use for teaching to investigation results that were obtained many years ago, without considering all advances added to our general knowledge in the last years. This work pretends to introduce the most recurrent mistakes propagated to start changes in criteria utilized to teach mammalian reproduction, optimizing thus the overall knowledge of this field by no specialized students.

Keywords. Animal Reproduction, Correcting Mistakes, Teaching.

1. Mammalian reproduction: a random phenomenon?

One of the most extended beliefs when teaching about mammalian reproduction is that fertilization is mainly a random phenomenon, in which an undetermined number of sperm are travelling through the female oviduct until they find an oocyte in an unspecific placement inside oviduct. Subsequently, all these great number of sperm try all together to penetrate oocyte, until one of them reach your goal. In fact, this image, which has been repeated *ad infinitum*, is not true. On the contrary, mammalian reproduction is a tightly controlled and totally protocolized phenomenon in which the only aspect of random is that linked to the precise sperm that will fertilize an oocyte. At this respect, it is noteworthy to remind the precise nature of mammalian reproduction. At first, practically all mammals require that the female was in the estrous phase of their ovarian cycle, since only in oestrus, these females will accept to be mounted by a male. This limits the possibility of fertilization to a very limited number of days, decreasing thus the chances of mountings without subsequent fertilization. This precision establishes that the mounting of a healthy female in oestrus by a healthy male implies in all cases the subsequent fertilization and, thus, gestation. Only a very few number of mammalian species allow the mounting of a female that was not in the oestrus phase, separating thus sex and reproduction. Among these species are bonobos, two or three dollphins and, of course, humans [1]. The common feature of these species is that the female has not a marked and specific oestrus period that implies the only one in which mounting is allowed by the female, although variations in the receptivity of males will vary during the entire ovarian cycle [1]. Unfortunately, since human is one of these exceptional species, an anthropocentric vision has led to the assumption that in the majority of mammals, sex can be separated from reproduction, introducing thus a random factor implied in the fact of the utilization of sex for questions other that induce a gestation. In other words, when teaching mammalian reproduction, human is not the rule, but the exception linked to the use of sex for matters other than pure reproduction.

Another aspect that causes a false appreciation of randomness linked to fertilization is the lack of knowledge about the precise fertilization process *per se*. The above-mentioned image of a fairly large of sperm looking for an oocyte in a long swimming race inside the oviduct only indicates the lack of knowledge about the process. At this respect, the phenomenon of sperm capacitation should be strongly highlighted by teachers. We have to remind that, in mammals, sperm collected immediately after ejaculation are not able to fertilize an oocyte. The ability to fertilize is reached by only sperm that reach oviduct. These sperm undergo a progressive process that starts immediately after ejaculation and ends only after oviduct colonization that, in a whole, is known under the term “capacitation” (See [2] as a review). The capacitation status is a very complex process involving molecular mechanisms launched by the interaction of sperm, seminal plasma and female genital tract fluids [2]. These processes culminate only in the very few sperm that reach oviduct, which are, in the best of cases, of a few thousands from those billions that were launched in the ejaculate inside the female genital tract [2]. The mechanism/s involved in the selection of the few sperm that will culminate the capacitation process are complex and not entirely understood at this moment, involving specific characteristics of sperm and the ability of sperm to interact with the female genital tract [2]. In any case, these selection processes achieve the result to select the best sperm to reach oviduct, avoiding the trap to select incorrect cells and, thus eliminating an important random effect, since not all sperm from an ejaculate will have chances to fertilize in *in vivo* conditions.

The basis for the misunderstanding of this phenomenon is linked to the appearance in human reproduction of *in vitro* reproductive techniques such as *in vitro* fertilization (IVF) or intracytoplasmic sperm injection (ICSI), in which there is not a strict selection of able sperm (even, death and abnormal ones are utilized in the ICSI technique), yielding thus the image that this selection process is not needed in *in vivo* conditions. This is a serious mistake, even if only considering the fertilization rates when compared *in vivo* mounting in species with marked oestrus cycle, which reaches values of nearly 100% with *in vitro* techniques in any species, which have in all cases much lower values.

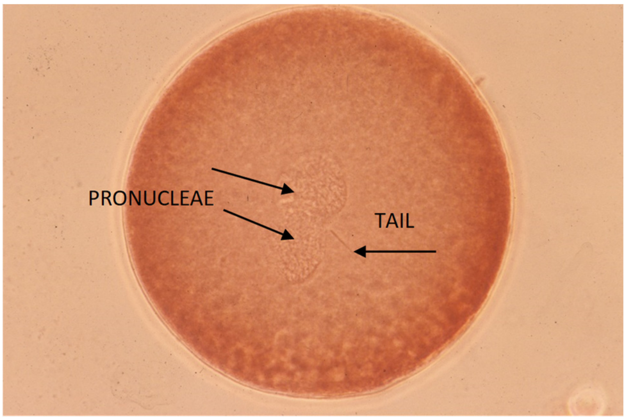

Figure 1. Presence of sperm tails inside an oocyte after fertilization. Microscope image of an ovine oocyte showing the presence of a sperm tail (TAIL) inside the oocyte after an in vitro fertilization procedure. PRONUCLEAE: Pronucleae from both sperm and oocyte. Image donated by Dr. Dolors Izquierdo, Autonomous University of Barcelona

Another question that is often erroneously taught is that the number of sperm that are needed to fertilize an oocyte is high, about hundreds. In fact, *in vivo* studies utilizing nanocamerae introduced inside the oocyte have found that a very small number of sperm surrounds an oocyte during the fertilization process, between 5 and 10 [3]. This low number of sperm is the natural consequence of the strict selection process launched to yield the most able cells, in contrast of the random selection usually exposed. The basis of this mistake, of course, is the utilization of images obtained in *in vitro* conditions, since any successful IVF procedure, in any species, requires an elevated number of sperm [4], precisely why there has not been a strict sperm selection similar to that launched in *in vivo* conditions. Likewise, this mistake is often associated with the idea that sperm only introduces the head inside the oocyte. This is false, at least in most mammalian species, in which the entire sperm is introduced into the oocyte (Figure 1).

Figure 2. Image showing the presence of the centriole inside the neck of a mammalian sperm. Black arrow: connecting pieces. Black head arrow and a: axoneme. White arrow: centriole. From [5]

The origin of this mistake is, probably, the perpetuation of this idea starting from microscope images obtained many decades ago, in which the resolution was not enough to detect other structures inside the oocytes than sperm heads. In fact, the introduction of other sperm structures are essential. Thus, the first mitotic division after fertilization will by based in the centriole that is introduced by the sperm, which is placed in the neck of the cell, not in the head ([5] and Figure 2). Otherwise, structures such as midpiece are needed to introduce the phospholipase C ζ that will launch the initial Ca^{2+} surge needed for the activation of embryo function after fertilization [6]. Thus, a more

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actualized teaching corpus is needed to address these important questions, minimizing in this manner the random effect on the fertilization process.

2. Towards an evolutionary perspective of mammalian reproduction teaching

The usual knowledge utilized to teach mammalian reproduction is based on data obtained from only two species, namely human and mouse. This is a very important mistake, not only because the implicit anthropocentric trap that leads to the mistake to use human as the norm, but also because this strategy ignores the species-specificity of reproductive function. Thus, each species has specific and different reproductive strategies, which are based not only on phylogenetic aspects, but also on ethologic and ecologic ones.

Thus, the precise reproductive function of each species will depend on several aspects such as the duration of the oestrus, the volume of the ejaculate, the deposition placement of sperm inside the female genital tract during ejaculation, the number of oocytes ovulated in a cycle, the type of ovulation, either spontaneous or induced or the number of males that mounts a female during an oestrus period. As an example, Table 1 compares several mammalian species to highlight these differences.

Table 1. Comparison of factors influencing reproductive function among separate mammalian species. SP: spontaneous ovulation. IND: induced ovulation. SP-IND: spontaneous ovulation, but with strong inductive characteristics. Values are the mean calculated from more than 10 separate sources

	Human	Bull	Dog	Boar	Cat	Mouse	Horse
Volume of ejaculate	1.5mL-5mL	3 mL-10mL	0.5mL-10mL	200mL-700mL	0.05mL-0.5mL	0.01mL-0.1 mL	10mL-200mL
Deposition placement	Vaginal vestibule	Cervix	Vagina	Cervix-uterus	Vaginal vestibule	Vaginal vestibule	Cervix-uterus
Number of oocytes	1-2	1-2	2-20	30-60	2-10	5-20	1
Type of ovulation	SP	SP	SP	SP/IND	IND	SP	SP
Mounting males	≥1	1	≥1	1	2-12	1	1

As can be observed, differences among species are very high, which the result that these differences will cause separate, species-specific reproductive characteristics, that often are completely different to that associated to human.

Thus, a special emphasis should be placed in introducing and evolutionary, species-specific point of view when teach animal reproduction avoiding the anthropocentric trap.

3. Conclusions

At this moment, the teaching of animal reproduction is marred by several incorrect ideas that avoid a good understanding of this point to students of both Secondary Cycle and University.

The most important idea that might be discarded involving mammalian reproduction teaching is the excessive weight of randomness in the fertilization process. In fact, fertilization is a completely organized process in all its extension, in which random is ever kept of a minimum.

Anthropocentrism is a very serious mistake when teaching mammalian reproduction, since human reproduction is not a model for other species, but only an exception.

An evolutionary point of view should be introduced when teaching animal, and, hence, mammalian, reproduction, since each species has a very precise, species-specific reproductive function mechanism.

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Hands-on Spectroscopy: Linking Research and Schools

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Abstract. Spectroscopy is an analytical technique that uses the interaction of an electromagnetic wave with matter by means of refraction in a prism or diffraction in a grating. It is used in many fields of science and engineering. For example, X-ray diffraction spectroscopy allowed us to know the structure of DNA 70 years ago or is the technique used currently to know the composition of stars. It is an important tool related with fundamental concepts of Physics and Chemistry and linked to historical scientific controversies such as the nature of light or the atomic model.

It is therefore connected to curricula in secondary education, baccalaureate, and first university courses. The difficulty in learning these concepts often lies in the non-obvious relationship between the mathematical formulation describing the phenomenon and its practical experimental realisation. Moreover, in these curricula, spectroscopy is presented in textbooks in a very theoretical and simplified way and, in the best of cases, with an experimental part that most of the time is carried out with complex and expensive laboratory instruments, but proper hands-on activities can be lead to meaningful learning if the necessary conditions are in place.

In this paper we present a set of manipulative activities that have been used inside and outside the classroom during the academic year 2022-2023. The protocols and learning outcomes in several schools are shown.

Keywords. Hands-on, Research, Schools Luminous Efficacy, Spectroscopy.

1. Introduction

It should be borne in mind that the development of knowledge and understanding of scientific concepts takes place in a variety of settings, both in and out of school. Thus, the usual hands-on activities that take place in informal teaching-learning contexts allow for inquiry-related learning experiences in which the student can observe, test, explore, predict and question the physical phenomena that are taking place [1,2]. Thus, learning scientific-technological content in non-formal contexts represents an important educational support in generating young people's interest in these disciplines, preventing drop-outs and improving student retention in them [3, 4].

This work presents the design, development, construction, and use of a hands-on paper spectroscope with a diffraction grating for mobile phones that can be employed in and out of school for formal and informal learning [5]. This simple spectroscope can be built and used by students at a cost of approximately 14 euro cents [6]. This spectroscope was used in this case in a sustainable education project with several secondary schools in Galicia, Spain [7]. Through a guided investigation, the luminous efficiency and energy efficiency class of public and private lamps [8] in the school, in the streets, and at home have been identified. A comparison with natural illumination and other light sources has been provided and important links to daily life, UE regulations and the dangers of artificial light emission with high blue spectral content for our health and the environment.

2. Diffraction inside and outside the classroom

Diffraction is an everyday natural phenomenon which occurs every time a wave encounters an obstacle similar to its wavelength: for visible light of the order of microns, for radio waves of the order of metres, for microwaves from kitchen of the order of centimetres, and so on. This is why this phenomenon sometimes goes unnoticed for ordinary people and is difficult to learn in school. In this case, it is as if the wave breaks and splits at the obstacle, reaching areas where the wave should not be. For example, we found unexpected illuminated areas in shaded areas in the case of light (Figure 1).

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This phenomenon has been known for a long time in research centers but also we can observe it every day if we pay attention. For example in a CD, a DVD or a Blu-Ray Disc when the visible light diffracts in their micrometric grooves [9] and we see striking colours (Figure 2), maybe better if we illuminate these storage devices in a certain angle and look at the colours reflected on the wall [10] (Figure 3).

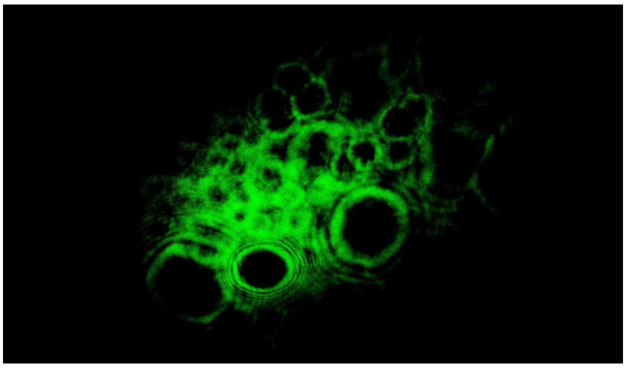

Figure 1. Diffraction with monochromatic light during school lessons

Figure 2. Direct diffraction with polychromatic light at home

Figure 3. Projected diffraction with polychromatic light during school lessons

We also observe the diffraction phenomenon when, for example, on a foggy day we see colours surrounding the moon at night, in this case small water droplets are the obstacles. Or we see these colours (from blue to red) on a television, monitor or mobile phone screen (Figure 4). There, the obstacles are the small pixel grids on the screens. By observing how light is separated by diffraction, we can analyse the structure of very small obstacles and also the structure of light itself, its colours, its wavelength, its spectrum. The technique that makes use of this phenomenon for these analyses is called spectroscopy.

Figure 4. Diffraction on a monitor

3. *Spectrumbusters* inside and outside the classroom

In schools there are often expensive and complex spectroscopes used to explain atomic structure, in an educative process similar to that which took place in the early 20th century when in order to explain the colour lines of the spectrum of gases slip by refraction it was necessary to understand what atoms looked like. The effort to interpret these results led to the birth, in part, of Modern Physics. In this project we proposed to bring this important analysis technology to the students' home in paper format [11], in order to identify the lamps that surround the pupils and to turn students into "*spectrumbusters*".

Figure 5. Paper spectroscopes

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Each school received material to build 60 spectroscopes with a unit cost of 14 euro cents and the students We thus distributed around 2400 spectroscopes all over Galicia, Spain. 22 schools completed the project (Figure 5). For school teachers, a variety of support material was prepared and assistance was provided on request. Several masterclasses [12] were also held in different schools (Figure 6).

Figure 6. Masterclass in schools

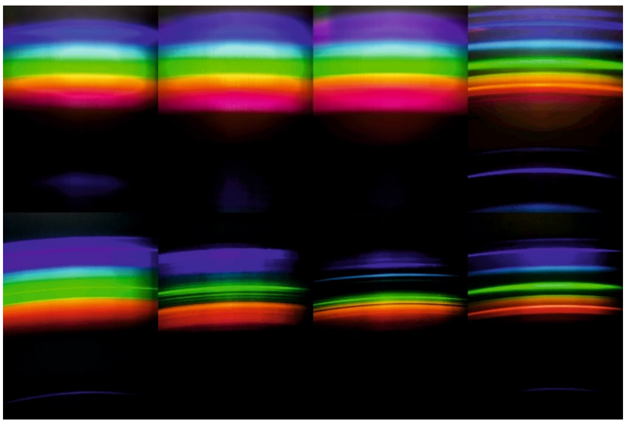

Figure 7. Spectral photographs obtained from different lamps

There are other similar devices for direct visual observation or for coupling to a mobile phone which typically use a piece of CD [13-17]. In our case, a small plastic diffraction grating, with a frequency of 1000 lines per mm, is employed. So quality spectra can be obtained on students´ mobiles with our paper spectroscope (Figure 7). If needed, the Tracker program can be employed [18] in order to obtain more precise numerical information on the spectral content of the analyzed lamp.

In order to identify the energy class of different light sources, students have to proceed as in a research project:

- consult information, in principle, from the project website, if necessary, look for more information or contact with an expert [6-7];
- build the paper spectroscope with the help of a template (Figure 8);
- make a field campaign, in the houses, in the schools, in the streets, taking pictures of the spectra of different lamps;
- identify the lamp technology by comparing it with a collection of spectra [16];
- and assign it an efficiency/effectiveness and an energy class.

This is a generous estimate, which also allows students to note, for example, that there are currently no class A lamps, and few class B or C lamps. European regulations [19] foresee that these lamps will be developed in the future.

4. Results and conclusions

The results from the schools were similar. The different lighting technologies that produce a similar white visual perception can be clearly distinguished with our spectroscope. Different percentage tables of energy classes of the different lamps were compiled. Some of the identified lamps are already obsolete and have to be replaced, either because they are dangerous or because they are of very low energy class. Other more efficient technologies should be used with caution, such as the popular LED light, which, with a high blue light component, does not favour our rest in our homes and can be harmful to our health, and in the streets increases light pollution and causes damage to the environment. In this way, we can better understand and appreciate artificial lighting, one of the most important technological achievements of Mankind. Various learning and satisfaction surveys were carried out.The results show significant learning, confidence and motivation for the involved students.

In conclusion, the project was successful as a simple and low-cost hands-on activity. The students were able to build their own spectroscopes and use them to make practical observations of continuous and discrete spectra of luminaires of different technologies in an informal learning activity that also empowers students in terms of confidence and self-esteem.

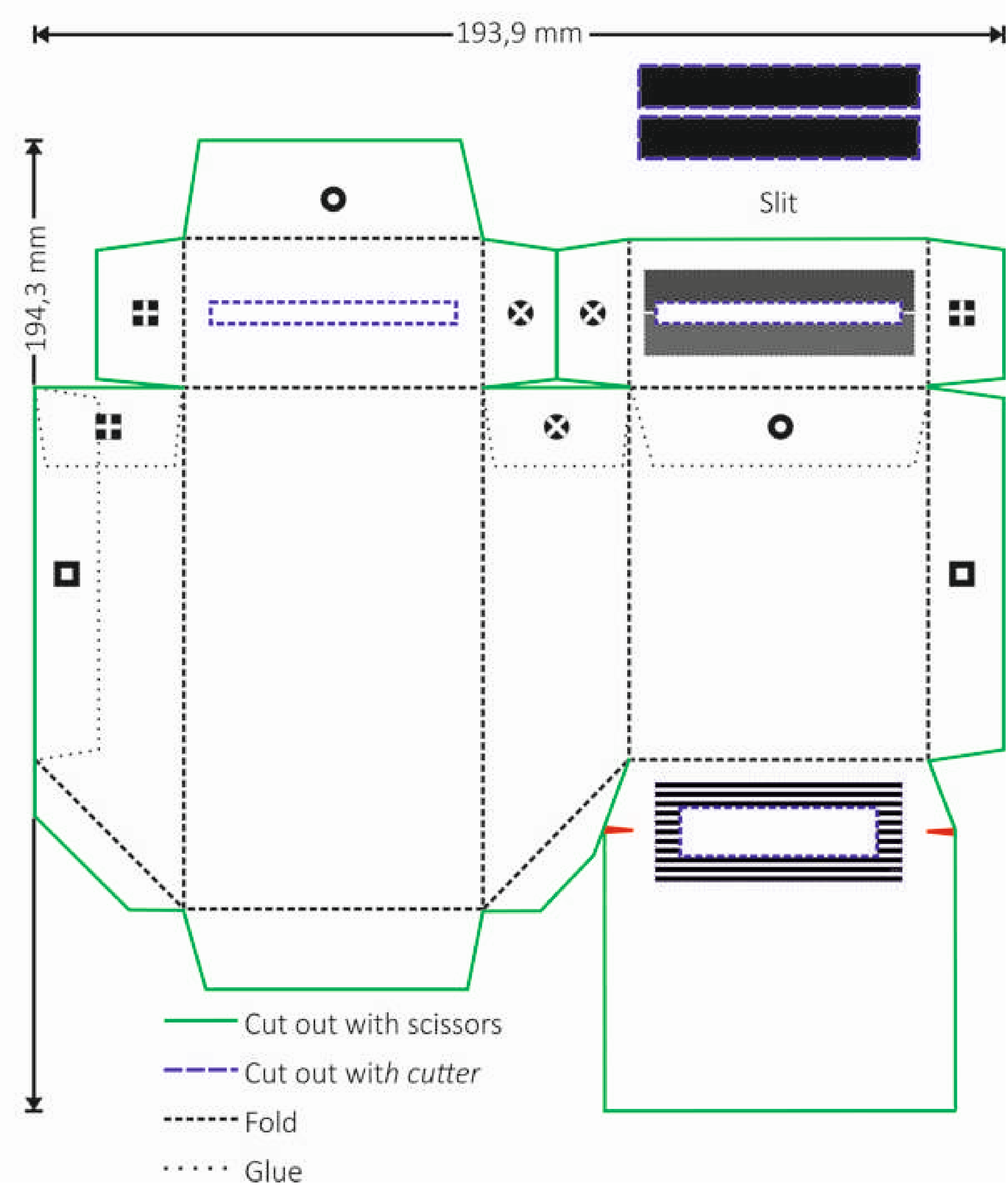

Figure 8. Our paper spectroscope template [6-7], adapted from [11]. Real size: 194,3 mm x 193,9 mm

5. Acknowledgements

We would thank all participants, students and teachers, involved in the Project "La Caja Sostenible". This project is co-funded by the School of Mining and Energy Engineering and the Social Council of the University of Vigo and the Official Association of Mining Engineers of Northwest, Spain (COIMNE). It has the collaboration of the Spanish Foundation for Science and Technology of the Ministry of Science and Innovation of Spain (FECYT Project- FCT-21-16592).

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In-Service Teacher Training Mentoring Model for Scientific Inquiry Teaching

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Abstract. Teacher actions are promoting student learning. Successful teachers are constantly inquiring into how their practice influences students learning. Mentoring is one of the tool facilitating teachers' job in this field. Therefore, this is a good time to get your mentor to observe you and help you reflect on the effect your teaching is having on students' learning. Future teaching profession; in addition to conveying information and measuring how much of the information is understood by students with classical and alternative methods, it is included as mentoring that support students' mental activities and the process of context-based skill development. While the discussions about the disappearance of the teaching profession due to the rapid integration of the digital world into our lives continue, experts predict that the teaching profession will not disappear due to human nature; on the contrary, it will evolve into mentoring.

Mentoring can be defined as the directing of experienced and expert individuals in terms of professional and personal development, in a planned process, to guide and support less experienced individuals. Mentoring practices is a tool to realize this vision and to have all these equipment and competencies [1].

Mentoring is an accepted term in many different disciplines such as education, medicine, law, and commerce [2]. Since the mid-1970s, it has also attracted great attention in the fields of education, management and psychology [3]. When it comes to teacher training in mentoring, its rise has been evident since the 1980s [4]. It has been used especially when encouraging teachers to prepare for pre-service, initiation and early professional development [5].

Mentoring models vary from researcher to researcher in the literature. Although different mentoring practices are encountered in the literature on mentoring models, the types of mentoring in general can be listed as follows [6]: One-on-one mentoring, team mentoring, reverse mentoring, peer mentoring and self-mentoring.

One-on-one mentoring is defined as the relationship between an older and experienced mentor who is at the top level in his career and a less experienced individual (learner) [7]. Team mentoring is expressed as the process in which individuals with different characteristics interact and share in small groups. Team mentoring is mostly used in mentoring studies with teachers [8]. In this type of mentoring, it is important that the characteristics of the learners are similar to each other or that they come from the same study disciplines [9]. Although traditional mentoring is predominantly applied in mentoring programs, reverse mentoring programs have become widespread with the advancement of technology [10]. In the reverse mentoring model, unlike the one-on-one mentoring, the learner is older than the mentor. Managers are matched with individuals younger than themselves to learn about new technological trends [11]. In the process, individuals who are learners pass on their experience and advice to their younger colleagues. In this way, young people will be able to understand the job better [12]. The basic element in peer mentoring is that interaction is easy. The fact that communication with peers is easier than others makes learners feel safe. Supporting each other with peers with similar characteristics is one of the preferred types of mentoring in the field of education. Self-mentoring is the process of advancing the process in line with the goals that the individual has determined. The process begins with well-structured and clear goals [13].

The most widely used mentoring models in the literature are one-to-one (traditional) mentoring, team (group) mentoring, and peer mentoring [14]. Mentoring, which has an important place in revealing the potential of person's experiences from daily life, supports the professional development of individuals in many different contexts. Individuals receive support from career development programs in order to meet and develop their needs during the career development process.

In-service trainings for the professional development of teachers are carried out with a central planning, and the compulsory participation of teachers is generally expected from one day to one week. The effectiveness of these programs is limited due to the fact that they are organized in a standard content suitable for everyone, and that teachers are trained in the role of students. Each teacher has different expectations and needs in their classroom environment. Therefore, the aim of the current study is to develop an in-service teacher training mentoring model that includes inquiry-based team mentoring, peer mentoring and self-mentoring processes. The program, supported by in-class scientific inquiry, includes a four-stage mentoring process (Figure 1).

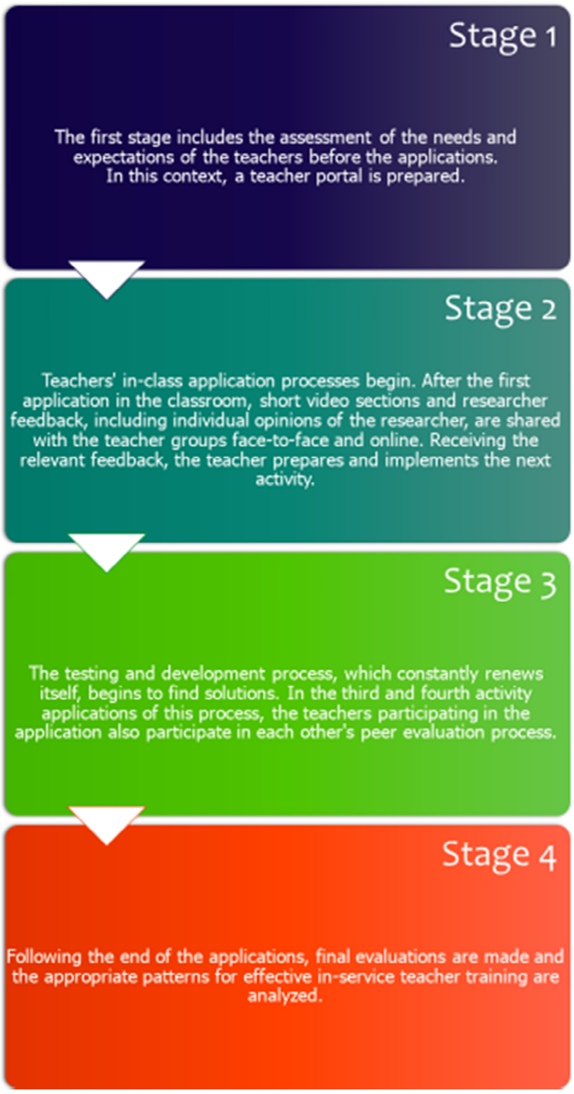

Figure 1. In-service teacher training mentoring model for scientific inquiry teaching

The model includes the feedback process in which teachers record the lessons they teach at schools by video recording, and where they are presented to the evaluation of academics working at universities as their mentors, and the feedback provided by the academicians to the video recordings at every stage. The mentors evaluated each course within the framework of the Scientific Inquiry-Supported Classroom Observation Protocol [15]. The protocol includes the stages of scientific inquiry. The current in-service program has been designed with more solidarity, more awareness, more courage, empathy and sharing, taking into account the climate and nature of this universe, by listening to teachers' ideas, dreams, future plans and expectations. Inquiry-based teaching encourages students and emphasizes crucial components of science such as curiosity, openness, and skepticism.

As mentoring grows in popularity as a tool to support teachers, there is an increase in the number of studies on teacher mentoring [16]. (Fraser, Tobin & McRobbie, 2012). In this respect, it is thought that the mentoring model proposed in this study is an effective model in in-service teacher training that will meet the expectations and needs of the teacher in their classroom environment.

Keywords. In-Servive Teacher, Mentoring Model, Scientific Inquiry, Training.

Acknowledgements

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Lively and Exciting Hand-Made Experiments – Electromagnetic Wave

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Abstract. We have been presenting hand-made experiments in various areas of physics at HSCI international conferences since 2017 and discussing the role they have in physics education. [1-4] This time, we would like to introduce hand-made experiments focusing on electromagnetic waves and discuss how they can make Physics classes fun and meaningful.

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

The reason why electromagnetic waves become more difficult is that products and experimental equipment that we use in daily life or in the laboratory are black-boxed. First, it is necessary to solve that black box. One solution is to go back to the experiments when they were first discovered. For example, the Hertz's experiment is the most principled and easy-to-understand experiment to uncover the true nature of electromagnetic waves. [5] Students can create an image of a changing electric and magnetic fields that are induced each other and transmitted in the space.

The second perspective is to create an image of the changing electric and magnetic fields. Recognition of electric and magnetic fields as electrical and magnetic properties of space can be done through experiments such as experiments of static electricity or observation of the magnetic field around a magnet. However, in view of the connection with electromagnetic waves, it is desirable to conduct ingenious experiments on how changes in electric and magnetic fields convey information and how they are detected. What we have devised are experiments on communication using electric fields and magnetic fields. The experiments of using voice current to change the electric and magnetic fields are effective. By detecting electric and magnetic fields and extracting the original information from them, we can strongly impress students with the existence of electric and magnetic fields, and also explain the principle of radio wave detection in a simple way. [6-7]

The final perspective is to give students the fact that how they themselves are surrounded by and live with radio waves. The simpler the experiment, the stronger the impression on them. For example, a primitive experiment like a germanium radio. Students are surprised, "How easy!" but they are even more surprised that it includes physics such as resonant circuits. Radio wave detection experiments using Schottky diodes are also useful to understand how they live surrounded by electromagnetic waves. [8]

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

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An Escape-Room about Electronic Transport and Oxidative Phosphorylation for Chemical Students

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Abstract. Gamification is the process of using games to engage and motivate people to achieve their goals and solve problems easily. Students playing a game enjoy themselves and at the same time learn basic and important concepts. In our consolidated teaching innovation group (GINDOC-UB/180), we prepared various games including crossword puzzles, word search puzzles, knight's tour games, connecting dots, mazes or labyrinths, matching two sets, amidakuji, and logic games. Since these games were very successful, we decided to combine all of them and construct a new teaching activity, that would help our students to study one essential metabolic pathway: electronic transport and oxidative phosphorylation. An Escape-room is an adventure game in which players solve a series of puzzles, using clues, to complete objectives and therefore this kind of game was very useful, as we could observed in a previous Escape-room prepared by our group for Krebs cycle [1].

To perform the Escape-Room, the Google Drive Form online program was used. Google Forms collects information from students via personalized quizzes [2]. Forms are distributed in Sections and several question types can be used: short answer, paragraph, multiple choice, checkboxes, drop-down, file upload, linear scale, multiple choice grid, checkbox grid, date, and time. Questions used as code were ticked as mandatory, to be answered by students in order that they could move to the next section. Usually, short answers were used (either numeric or alphanumeric).

The Escape-room prepared for electronic transport and oxidative phosphorylation was divided in 8 section containing information about various aspects of the electron transport and the oxidative phosphorylation:

Section 1.- Electron transport. This section contained an explanation and a video about electron transport chain [3]. In order that students look the video, we asked a question regarding at what time (in seconds) the explanation of electronic transport begins. A time value between 180 and 210 seconds was accepted as an answer for this Section. We also present a game with a maze, and students should get the letters from the maze (idiot monarch) to obtain an anagram (mitochondria) related to electronic transport.

Section 2.- Standard potentials of semireactions. The section contained an introduction with the semireactions. Students should order the intermediate of electron transport and understand that electrons should flow spontaneously following a thermodynamic order. A labyrinth with labels, i.e., labels connected with letters, where students should order those labels, and letters connecting the correct labels will form a key word to change section. The word (Mitchell) was also related to connection between electronic transport and oxidative phosphorylation. In fact, Peter Mitchell was awarded with the Nobel Prize for Chemistry in 1978 for his chemiosmotic hypothesis relating both pathways [4].

Section 3.- Complex I. After a short introduction about Peter Mitchell, a list of enzymes generating NADH or $FADH_2$ was added. These enzymes were numbered, and students should write the numbers of the enzymes that are related to NADH (or to Complex I). The list contained:

1. α-Ketoglutarate dehydrogenase (Krebs cycle)
2. 3-Hydroxyacyl-CoA dehydrogenase (lipid metabolism)
3. Acyl-CoA dehydrogenase (lipid metabolism)
4. Glyceraldehyde-3-phosphate dehydrogenase (sugar metabolism)
5. Glycerol-3-phosphate dehydrogenase (sugar metabolism)
6. Isocitrate dehydrogenase (Krebs cycle)
7. Malate dehydrogenase (Krebs cycle)
8. Pyruvate dehydrogenase (Krebs cycle)
9. Succinate dehydrogenase (Krebs cycle)

Key answer, related to Complex I. was: 124678.

Section 4.- Complex II. To pass this section, students should answer the enzymes related to $FADH_2$ (or to Complex II). Key answer for this Section related to Complex II was: 359.

Section 5.- Complex III. This section includes an introduction about the effect of inhibitors of complex I, II and III, explaining how some inhibitors are more potent than others. Students should identify the name of the inhibitors, using a code translation. Inhibitors were written with Morse code and with Braille code. Inhibitors for complex I are written in Morse code, whereas inhibitors from complex II are written in Braille code. Students should classify these inhibitors names, and the key answer is the name that is repeated in both codes (an inhibitor of Complex III): antimycin A.

Section 6.-. Complex IV. In this section a knight tour's game is shown, that contains the sentence: "Cyanide is an inhibitor of the electron transport chain's complex IV, and it is a poison". The sentence will be the key answer of this section.

Section 7.- Complex V (ATPase). This section contained a video about F0,F1-ATPase [5]. In order that students look the video, we asked a question regarding at what time (in seconds) the explanation of F0 domain of ATPase begins. A time value between 180 and 200 seconds was accepted as an answer for this Section. A short introduction also shows the P/O plots. A second question for this Section is regarding the P/O plots, and the compounds that could be used for these graphs are listed:

1. Complex I inhibitors.
2. Complex II inhibitors.
3. Complex III inhibitors.
4. Complex IV inhibitors.
5. Complex V (ATPase) inhibitors.
6. Uncoupling agents.
7. Ionophores.

A P/O plot is shown, and after looking it, the students should recognize which compounds have been used in the P/O plot. The answer key is: 56.

Section 8. Congratulations. In this section there are some sentences regarding the general game and celebrating the achievement of the end of the game by the student. There are also some questions about the student's satisfaction on this Escape-room and if they think if other innovation questions should be added and also if they disagree on other questions.

We ask to the Biochemistry's students of the Chemical degree to solve this Escape-room as a self-learning. The game was solved by 44 students, and the answers were evaluated. In general, students considered that this Escape-room was very useful for self-learning Biochemistry. They didn't have suggestions for an improvement of this Escape-room, and they ask a better explanation of the games to be performed, and better resolution of the figures. Some asked that it would be great if they could download a copy of the introductions of each section, although these introductions could be easily copied from the questionary.

Regarding the Likert test [6, 7], we asked at the last Section to evaluate from 0 to 7 the following points: if they found difficult the game (6.2 ± 0.3), if they liked it (5.7 ± 0.3), if they found it useful (6.3 ± 0.3), if they enjoy it (5.8 ± 0.3), if they found interesting (6.1 ± 0.3). It seems that students liked this Escape-room and that they learnt very much from introductions in each page and enjoy playing the games and finding the key answers.

Keywords. Biochemistry, Electronic Transport, Escape-Room, Oxidative Phosphorylation.

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Database Course in Higher Education: Goals, Methodology, Approaches, Assessment

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Abstract. Database course is a very important subject in higher education. Teaching databases is a demanding, and challenging procedure. The current presentation suggests an approach for teaching database design and implementation course for no-engineer students in higher education [7,8]. The introduction of the current presentation specifies the teaching goals and the challenges in a database course. It also presents the difficulties which can be treated with different practices. The main part of the paper suggests the teaching procedure in a database course which covers all the stages of a relational database life cycle.

Specifically, during the semester lectures are used to teach students introductory concepts about data and information, storage units, data files, data structures, databases, and data models. They also get an architectural overview of database systems. An important part of the theory lectures is about database design and entity relationship diagrams, the relational model, the transformation of an entity relationship diagram (conceptual schema) to a relational database (logical schema). Students are introduced to relational algebra and the relational database design principles and normal forms (Normalization). Lectures also cover methodologies and query languages and teach students the Structured Query Language (SQL) commands. Finally, NoSQL databases, trends in data management and information retrieval are also presented with lectures. [1,5,6,9]

Laboratory courses: Students also attend laboratory courses which help them implement what they have learnt from lectures and acquire skills in different Database Management Systems. Laboratory courses start with the Microsoft Access Database Management System. Students create databases in Microsoft Access and use queries, forms, and reports to build complete database applications. In the last 5 lab lessons students work in the Oracle Apex Server environment to familiarize themselves with SQL commands starting with DDL commands to create the database and then DML commands to manage the data. Students can also build a complete web application with Oracle Apex Server low code application builder. Experienced students can also include logic to their databases by writing triggers, functions, procedures, and packages with PL/SQL.

Project assignment: During the semester, students work to create a complete database project [2,3,4]. The project is divided into steps and starts the second week of the semester. The first step is the definition of database requirements. Next steps are the conceptual database design and the implementation in MS-Access or Oracle APEX Server environment [10,11]. The project is gradually developed, and each step is completed during the semester after the relevant theoretical lecture.

Course assessment is achieved with oral project defense, exercises in laboratory courses, and the final written examination. Students' projects and comments are very useful and are always taken into consideration to make improvements.

The experience gained from teaching the specific course in higher education and the gradual improvements led to the combination of all the abovementioned practices. Finally the limitations of the specific approach concludes the paper.

Keywords. Databases, Hiher Education, Project Based Learning, Database Models, Relational Databases.

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Exploring CO_2 Properties. A Learning Situation to Promote the SDG 13 Climate Action

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Abstract. This communication, to be presented in faire and poster format, describes a learning resource implemented in classroom with high school students. The proposal is related to the Sustainable Development Goal SDG13 Climate Change, and asks students to propose ideas to mitigate the increase in atmospheric CO_2. To learn about CO_2 and be able to make its proposals, students perform experiments to investigate CO_2 properties. The experiments show that CO_2 is denser than the air, that it is soluble in water, more soluble in cold water than in hot water; that when it disolves in water the pH decrease, and that a precipite is formed when CO_2 goes through a solution of calcium oxide. To deep learn about CO_2 properties students explore the best way to create CO_2 bubbles and how to drop air bubbles onto a CO_2-rich atmosphere. They implote or explote?

Keywords. CO_2 Emissions, CO_2 Properties, CO_2 Bubbles, Bubbles Sorrounded by CO_2

In this communication is presented a teaching-learning resource in the format of a “Learning Situation”, the way of programming required by the new curricula. It has been implemented in “Chemistry and Physics Challenges”, a new subject that students in the first year of High School can choose as an optative subject [1].

The context of the “Learning Situation” is related to the Sustainable Development Goal SDG13 Climate Change, and the challenge asks students to reflect on the problem of carbon dioxide (CO_2) and its causes, and elaborate and communicate proposals to mitigate the increase in atmospheric CO_2, that include arguments based on the investigated properties of CO_2 allong the experiments.

Students perform a set of experiments to generate CO_2 in the lab and to investigate properties if CO_2 [2].

In the experiments, they use CO_2 generated with an acid, such as cictric acid, and the sodium hydrogen carbonate; or they also use CO_2 from cartridges to inflate bicycle wheels. Students investigate if CO_2 is more or less dense than aire observing how CO_2 can put out a candle. But fortunately when it is forming part of the mixture of gases in the air it does not accumulate in the lower part of the atmosphere.

In another experiment, students catch CO_2 into a syringe an submerge it into a recipient with water to investigate if it is water soluble. They compare the results by using room temperature water or cold water. Students also explore the pH changes produced when CO_2 is dissolved in water, and differences among different waters, such as tap water or sea water. They relate the results with ocean acidification.

Another experiment shows how CO_2 can be trapped in calcium oxide solutions. The solution, that at the beginning looks transparent, turns cloudy when CO_2 is bubbled through it. This is a method used in some CO_2 filters and maybe can be useful to get CO_2 out of the air

One of the most exciting thing for the students is to generate air bubbles and release them into a CO_2 atmosphere and observe their behavior. This phenomenon is compared to the behavior of bubbles generated with CO_2 inside. Students make hypotheses, elaborate explanations that allow them to delve into the properties of this gas, get excited about the bubbles and imagine creative solutions.At the end of the course, students present their conclusions and the performed experiments in a science fair of their city, in which they have the opportunity of communicate their proposals and show the experiments. This opportunity allows them to share their experiences with younger students and general public, and to consolidate their learning while enjoying.

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

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

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

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

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

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Arduino in the Physics Classroom: Sensors and Prototypes

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Abstract. Arduino is an electronics prototyping platform designed so that people without any knowledge of electronics can program interactive devices. Since Arduino applies the open-source model not only to software but also to hardware, the Arduino board and the sensors and actuators necessary to work with it can be purchased at a very low price. This democratization of electronics has opened up a broad range of possibilities in the world of education, especially in STEM disciplines.

Sensors can be used in the physics classroom to show relationships between magnitudes and to make measurements in laboratory work. But Arduino's educational use may go beyond its mere use as a measuring device. This microcontroller allows us to propose activities in which students design, program, and build devices or prototypes to simulate phenomena, explain physical laws, or show concepts that have been studied theoretically in the classroom. Using an Inquiry-based methodology, students not only learn Physics topics in an entirely practical way, but also develop other essential skills, like problem-solving, digital literacy, critical thinking, communication and collaboration with their peers, or time management. This approach also adds a factor of motivation since it allows them to face problems from a more realistic perspective and close to how scientists work. And when students build their own devices, they become creators of technology, not only consumers.

In this presentation, we want to show how to use Arduino as an educational tool in Physics in Secondary School. We will present several practical activities that can be used as a complement to the traditional teaching of physics. Some are simple and immediate, such as measuring temperature or pressure with a sensor. Others involve the manufacture of devices –with different levels of complexity– to carry out experiments with light and sound, address energy-saving measures, or study climate change.

The activities shown are just a sample of the enormous potential of Arduino as a tool in STEM subjects, not only Physics. We hope they will serve as inspiration so that more and more teachers are encouraged to introduce this excellent tool in their classes.

Keywords. Arduino, Inquiry-Based Learning, Open-Source, Physics, Sensors.

STEM to STEAM Revolution in 21st Century Education: Rational, Practices, Progress, and Considerations for the Future

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Abstract. STEM (Science, Technology, Engineering, and Mathematics) education has been a dominant approach in education since 1990's. However, in the last two decades, there has been a growing emphasis on incorporating the arts (A) into STEM education, resulting in the STEAM (Science, Technology, Engineering, Arts, and Mathematics) education approach. This scoping review paper explored the STEM to STEAM revolution in 21st century education by examining the rationale, practices, progress, and prospects of this paradigm shift. The paper draws from a wide range of sources, including academic research, policy documents, and practitioner reports, to provide a thorough understanding of the STEM to STEAM revolution in 21st century education.

The findings of the review indicates that the rapid transitioning from STEM to STEAM is due to the potential of STEAM to harness the holistic education of workforce with the skills require for the 21st century economy. This is because the integration of art and design into traditional STEM subjects creates a learning environment that sustains students interests in STEM and hands-on learning experience that fosters creativity, innovation, critical thinking and problem-solving skills.

Despite the emergence of STEAM education in the United States of America, a significant number of countries across the globe have adopted policy initiatives for the implementation of STEAM. It was found that, whilst most countries implement STEAM as national policy framework, STEAM education initiatives in countries such as United states, Canada, Australia are state-based, provincial-based or regional-based and sometimes district-level. Also, policy development for STEAM in most contexts are harnessed through cross-sector collaboration between education departments or ministries and departments concerned with scientific and technological advancement.

Aside governmental initiatives, several organizations that promote STEAM education have been formed. These organizations are established with the aim of increasing public awareness and training teachers teach STEAM. In addition, some higher education institutions in have reviewed their teacher education curricula to adopt STEAM methods to train teachers. Also, other higher institutions have designed STEAM teacher certificate, diploma as well as bachelors, masters, and doctoral degree programs due to the growing need of teachers with STEAM teaching competency.

STEAM has been implemented in two approaches: in-school approach and out-of-school approach. Thus, STEAM education maybe initiated as a reform of regular school curriculum or extra-curricular initiative depending on the implementation plan in a particular context. In the teaching STEAM, arts, and STEM teachers' collaboration to design and co-teach lessons is one of the best practices in STEAM teaching form both theoretical and empirical literature.

The paper concludes with a discussion of the challenges associated with the implementation of STEAM education and the future directions of this paradigm shift which includes adequate initial teacher training, continual in-service teacher professional development, funding and provision of resources and the need for more research into effective STEAM teaching practices to ensure that all students to have access to high-quality STEAM education.

Keywords. STEAM Education, STEM Education, 21st Century Education.

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Milestones in the Information Technology History

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Abstract. Traditionally a syllabus of many subjects begins with a lecture on the history of this particular subject. Obviously it is a good approach to provide students with a view of the progress in the field, and a choice of a starting point is very important. Very often it can be seen that the history of information technology is started from very old times. The authors of such chronics consider that each tool and each method used to carry out calculation and storing data can be considered as related to information technology. This is a definitely questionable opinion if we consider the term "information technology" itself to clarify what is typical of information technology, who and when implemented these specific features.

The term includes two words. "Technology" is defined as "the application of scientific knowledge for practical purposes" in Oxford Reference [1]. The second word "information" means "data as processed, stored, or transmitted by a computer" [2], then Oxford Reference describes the whole term "Information Technology" as "The study or use of computers, telecommunication systems, and other devices for storing, retrieving, and transmitting information" [1]. The last definition introduces one more term - "computer". Many reference resources explain that computer is "an electronic device for storing and processing data, typically in binary form, according to instructions given to it in a variable program".

Thus, the key concepts related to information technology are the binary number system, a stored program and an electronic computing device. Inception of information technology became possible only when these concepts had been implemented in devices and tools of practical use. The following events are true milestones in the information technology history.

Claude Shannon, a mathematician at Bell Telephone Laboratories, identified promising characteristics of binary. In 1938 he showed that calculations could be performed much faster in binary using electromagnetic relays than they could be performed with mechanical decimal calculators. Also he applied Boolean algebra. His 1948 paper "A Mathematical Theory of Communication" is the foundation of information theory and much of computer science.

A 1946 paper by Arthur Burks, Herman Goldstine, and John von Neumann titled "Preliminary Discussion of the Logical Design of an Electronic Computing Instrument" is frequently cited as the birth certificate of the modern computer. With the proposal of the stored-program computer, the processing paradigm changed. A stored-program computer includes, by design, an instruction set, and can store in memory a set of instructions (a program) that details the computation. A stored-program design also allows for self-modifying code. Subsequently, computers with stored programs would be known as von Neumann machines. Intel engineer Ted Hoff is one of the inventors of technological basis for their implementation. In 1971, he developed a single-chip circuit to execute commands that were accessed from memory. In particular, he came up with the idea of a universal central processing module, "universal processor". Before that, processors were focused on performing only specific tasks. He designed the processor architecture and core functions. This is how the central processor was created.

Modern-day information technology spectrum is the result of more than six decades of evolution of early computers which are binary, electronic and programmable.

Keywords. Information Technology, History, Binary, Processor, Stored-Program Computer.

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Technology-Supported Sequential Astronomy Activities to Foster Spatial Thinking

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Abstract. Understanding the night and day cycles, the phases of the Moon, and solar and lunar eclipses, which arise as a result of the rotation and revolution of the Earth and/or the Moon, requires spatial thinking skills. Furthermore, students' Earth-bound observations in their daily lives make it more challenging to understand these phenomena. In this case, it is important for students to transition to a space-based perspective and actively engage with the subject through the learning activities.

Considering this situation, we have developed technology-supported sequential activities that facilitate the transition between Earth-based observations and space-based observations. These activities utilize a specialized Sun, Earth, Moon model for teaching the concepts of the night and day cycle, phases of the Moon, and solar and lunar eclipses. The activity materials include a model that represents the relative sizes of the Moon and Earth, as well as the inclination between the Moon's axis of rotation and the ecliptic plane. Additionally, it involves a light source, a smartphone, a computer, a projector, a screen mirroring application, Stellerium software, and Celestia software.

The activity begins by setting up the model. Then, the screen mirroring program on a smartphone is used to project the image onto a screen. By opening the smartphone's camera, the intention is for students to observe the simulated phenomena in the model from various angles and perspectives. In the activity, the night and day cycles, phases of the Moon, and solar and lunar eclipses are presented to the students sequentially on the model. Using a smartphone, the transition between Earth-based observations and space-based observations is facilitated. Stellerium software and Celestia software are then used to observe the phenomena simulated from various celestial bodies, such as the Moon and the Sun.

Keywords. Night and Day Cycles, Phases of the Moon, Solar and Lunar Eclipses, Technology-Supported Sequential Activities, Spatial Thinking.

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The Beauty of Mathematics – Explaining Abstractness

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Abstract. Why do some people like mathematics? A usual answer to this question is because they are beautiful. Mathematicians claim proofs are an art; some are simple or disruptive enough to be considered stunning. Nevertheless, a lot of people do not like mathematics at all. They find them too complex or feel that mathematics are just dull. We could think this beauty is only accessible to those dedicated to studying science.

However, many people like to understand complicated mathematical concepts even in their free time: YouTube channels dedicated to mathematical dissemination have thousands and millions of viewers [1,4]. What is the key to their exit?

At this conference, we will follow a proof considered one of the most straightforward but more powerful in the whole mathematical world as an excuse to talk about the beauty of mathematics and why some people love studying them. We are talking about the diagonalization argument of Georg Cantor [3].

Cantor proved that some infinities were bigger than others, achieving a remarkable thing: with a finite mind, he could arrive at comprehending infinity. Hopefully, by the end of the talk, we will be able to understand his arguments and, by following his steps, contemplate one breathtaking idea in this science.

We will explore the mathematical world with Cantor's eyes and with some great mathematical communicators that have explained these and other results [2,5,6]; to try to solve the questions that arise to us about why people enjoy mathematics.

Keywords. Beauty, Cantor, Mathematics, Proofs.

Acknowledgments

I want to thank the people in Ciència Oberta for all the help and valuable comments on my work as a science communicator. I also want to thank Josep Maria Fernandez Novell for convincing me to prepare a presentation for this congress.

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Can Linguistics Be a Scientific Subject in Portuguese Classes, at High School? Analysing Some Teachers' Opinions

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Abstract. In Portugal, at High School, Portuguese is a subject where Literature is teaching, but where Linguistics has not a (real) place. This area of knowledge is essential to the language's studies, especially for students when they learn native tongue. However, the High School notebooks confirm it, because the tables of contents have just some few grammar topics (and not linguistic one) and, even then, they occur mixt with all literature references. The students need to read texts like novels and some poetry, knowing authors and historical contexts, etc.). This all need to be studied during all the years before incoming the university, as far the Humanities courses. At the end of High School, for the examinations, including at the national level, the most important was Literature. For the Universities courses, just Literature contents are request. There is not any linguistic subject in them. At the Humanities, the students had no contact with research in areas like Phonetic, Syntax, Morphology, Semantic, History of the Language or another linguistics one. That seems a nonsense. Literature can be kept, but Linguistics needs to be taught in high school.

When the students arrived at the Humanities courses, they haven't any idea about Linguistics and the scientific study can be done with the native tongue, or also with foreign languages. They did not had contact with scientific research at the language classes, also at Portuguese classes, even if the name of the subject and the notebooks matter have this name: Portuguese or Portuguese Language.

The question is why this situation is accepted by all, including by teachers? Is Linguistics a scientific subject can be teach in Portuguese Classes, at High School? At a Seminar, spending some time with a group at teachers who must teach Portuguese as a subject in a high school this topic was discussed. They answered a questionnaire about it. Their opinion is important. Analyzing teachers' point of view can bring some understanding about the separation of areas at school for the knowledge. Can Linguistics be a scientific subject teach in Portuguese Classes, at High School? Can Humanities and Sciences be reconciled? What some teachers of Portuguese think about these? Looking at teachers' opinions can be the begging of political changes at school. Put hands-on science at languages classes is indispensable.

Keywords. Humanities, Science, Linguistics, Portuguese, High School, Teachers.

An Entrepreneurial Approach to Electric Scooter Safety

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Abstract. Micromobility solutions, such as electric scooters and electric bicycles, have become increasingly prevalent in our daily lives, leaving their mark on our streets. While they offer various conveniences for short-distance travel, these vehicles also pose challenges and disadvantages, particularly in terms of safety, due to their physical fragility compared to more common means of transportation, such as cars.

This presentation showcases a project developed within the framework of the 7th "*À Descoberta da Luz*" Contest of the 11th "Hands-on-Science" Science Fair, organized by the Hands-on-Science Network Association and the Portuguese Society of Optics and Photonics [1]. The focus is on highlighting the importance of safety in micromobility, specifically addressing the challenges faced by electric scooter users.

The prototype developed in this project is based on an entrepreneurial approach that combines technical expertise, research, and creativity [2]. It incorporates several innovative functionalities, including a fall detection and alert system, a vehicle alert system, and signaling lights, all aimed at improving user safety and raising awareness among other road users. The integration of computer programming and IoT technology played a pivotal role in the development of this prototype.

This project exemplifies the intersection of entrepreneurship, programming, and 3D modeling, offering a groundbreaking solution to enhance safety in micromobility. By addressing the pressing concerns of user safety, it contributes to the ongoing efforts in making micromobility a safer and more sustainable mode of transportation.

This particular project offers a chance to disseminate its results and valuable insights, promote the exchange of knowledge, and encourage further progress in enhancing micromobility safety. It stands as evidence of the potential of entrepreneurship, innovation, and collaboration in addressing real-world issues and catalyzing beneficial transformations [2].

Keywords. 3D Modelling, Entrepreneurship, Programming, Internet of Things (IoT), Micro:bits, STEAM.

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The Water Cycle in Your Classroom! Or Where Does your Tap Water Come from?

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Abstract. Getting water to a tap is a complicated process linked to the water cycle – which itself is a complexity of earth science processes. But many of these can be quite easily and cheaply demonstrated in a classroom. This session will offer a range of practical ideas that can be used or upgraded for use at any level. These include: make your own rain, water storage, cleaning water, make your own aquifer, evaporation, percolation and infiltration, rock water storage, a lysimeter, and condensation. A water cycle game is included too for younger pupils. All resources are provided. Come and try them out – and bring your own ideas as well.

Keywords. Practical, Classroom Based, Water Cycle Processes, All Levels.

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A Scoping Review of inclusive Teaching Practice in Science Education

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Abstract. This rapid review looks into the research on inclusive science education instructional strategies. The purpose of inclusive teaching practices is to foster a learning environment that meets the needs of all students, including those from different backgrounds; lower-socio-economic backgrounds, and with exceptionalities; disabilities, gifted and talented students. The research will focus on numerous research articles published between 2015 and 2022 on inclusive science teaching strategies using search engines such as google scholar, Scopus, and Web of Science. The search engines will employ the keyword ‘inclusive science teaching practices’ to identify the various articles. The research highlights sources that offer insight into effective ways for encouraging inclusivity in the science classroom, such as constructivist approaches, student-staff partnerships, and reciprocal teaching. In addition, the sources emphasize the significance of engaging students and offering chances for active learning and the relevance of focusing on fundamental concepts and transdisciplinary ideas in science education. For educators and researchers interested in creating and implementing inclusive teaching approaches in science education, this rapid review offers a place to start.

Keywords: Inclusive Education, Inclusive Science Education, Teaching Strategies.

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GFP in Genetic Engineering

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Abstract. Genetic engineering has revolutionized some scientific disciplines, enabling precise modifications of organisms for diverse applications. GMO is the abbreviation for Genetically Modified Organisms, a plant or animal whose genes have been scientifically changed. This article explains the modification of Escherichia Coli bacteria using Green Fluorescent Protein (GFP), a widely used marker in molecular biology and cell imaging. The process involved the design and construction of a plasmid vector containing the GFP gene, followed by its transformation into the bacterial cells using established molecular biology techniques. Upon successful transformation, the modified bacteria exhibited a noticeable green fluorescence under appropriate excitation, confirming the expression of GFP. This visual marker enabled easy detection and tracking of the transformed cells, facilitating further analysis and experimentation. The implications of this experiment extend to various fields of research, such as environmental monitoring, biotechnology, and medical diagnostics. The ability to manipulate bacteria and confer them with fluorescent properties offers valuable insights into microbial behavior, gene expression, and cell-cell interactions. Finally, the article highlights the power of genetic engineering tools like GFP in understanding and manipulating biological systems. It serves as a stepping stone for future studies, opening up new avenues for investigating complex cellular processes, developing biosensors, and designing novel therapeutic strategies.

Keywords. Genetic Engineering, GFP.

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