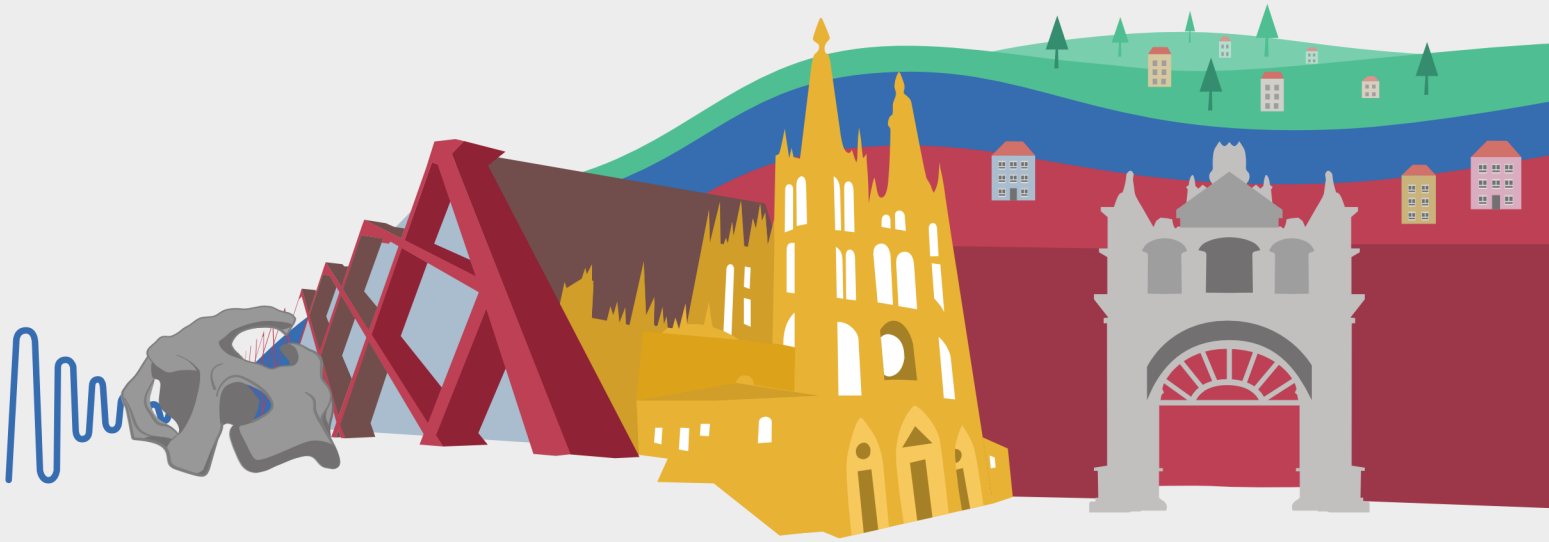
Hands-on Science

Rethinking STEAM education in times of uncertainty



Edited by:
Manuel Filipe P. C. Martins Costa
José Benito Vázquez Dorrío
Miguel Ángel Queiruga Dios
María Diez Ojeda

The Hand-on Science Network

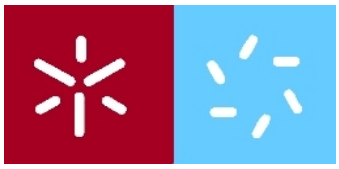
Hands-on Science

Rethinking STEAM education in times of uncertainty

ISBN 978-84-8158-937-5

Edited by

Manuel Filipe Pereira da Cunha Martins Costa, University of Minho, Portugal
José Benito Vázquez Dorrío, University of Vigo, Spain
Miguel Ángel Queiruga Dios, University of Burgos, Spain
María Diez Ojeda, University of Burgos, Spain

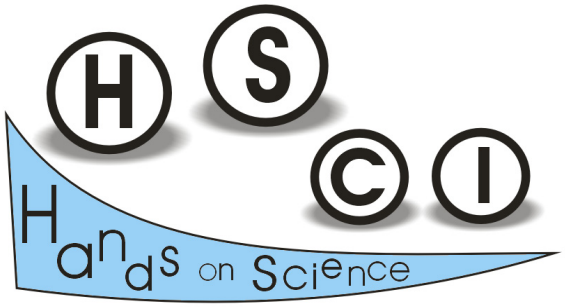


Universidade do Minho

Universidade Vigo

UNIVERSIDAD DE BURGOS

The Hands-on Science Network



ISBN: 978-84-8158-937-5
Legal deposit: VG 296-2022

Printed by: Copissaurio Repro – Centro Imp. Unip. Lda. Campus de Gualtar, Reprografia Complexo II, 4710-057 Braga, Portugal
Number of copies: 400
First printing: July 2022
Distributed worldwide by the *Associação Hands-on Science Network - contact@hsci.info*
Full text available online (open access) at *http://www.hsci.info*
The papers/chapters published in this book are exclusive responsibility of the authors.

Please use the following format to cite material from this book:

Author(s). Title of Chapter. Hands-on Science. Rethinking STEAM education in times of uncertainty. Costa MF, Dorrío BV, Queiruga-Dios MA, Diez Ojeda M (Eds.); Hands-on Science Network, 2022, Page numbers.

ISBN 978-84-8158-937-5

Foreword

Hands-on Science
Rethinking STEAM education in times of uncertainty

Sadly, the world is currently evolving in a rather distressing way.

After over two years of major constraints imposed by the COVID pandemic, the education world is still trying to find ways to adapt in order to keep providing, in an effective way, its crucial contribution to the world' development our societies need and expect.

War and destruction, widespread humanitarian crisis, systematic disrespect for human rights, regression of several civilizational advances humanity hardly conquered over many decades, recurring economic social and political crisis, all adds up to the uncertainty we all are felling today. The school, in the broader sense, must keep up with the difficulties and raise to the complex challenges it faces, finding ways to fulfil its goal supporting the students as learners and in their growth as integral human beings.

From July 25 to 29 at the 19th International Conference on Hands-on Science, hosted by the University of Burgos, in the open friendly informal environment that characterizes our conferences, these issues, from different perspectives, are discussed. To science education we add into this discussion technology, engineering, mathematics and arts education, STEAM, in an interconnected and holistic way.

The book herein aims to contribute to the improvement of Education and Science Education in particular, in our schools and to an effective implementation of a sound widespread scientific literacy at all levels of society. Its chapters reunite a variety of diverse works presented at the 19th International Conference on Hands-on Science held at the University of Burgos, Spain, July 25 to 29, 2022.

Vila Verde, Portugal, July 15, 2022.

Manuel Filipe Pereira da Cunha Martins Costa
Editor in chief

ISBN 978-84-8158-937-5

FOREWORD

CONTENTS

ISBN 978-84-8158-937-5

Nanoexplora (Nanoinventum): Kit of Nanotechnology for Education

J Díaz Marcos[1], *J Mendoza*[1], *JM Rebled*[1], *S Memminguer*[2], *N López*[2]
[1]*University of Barcelona (CCiTUB/IN2UB), Spain*
[2]*Centre de Recursos Pedagògics del Department d'Ensenyament de la Generalitat de Catalunya (CESIRE), Spain*
jdiaz@ub.edu

Abstract. Teaching and learning "nanotechnology" is not easy in primary school. Nevertheless, considering the importance of the studies that show students' alternative conceptions and learning difficulties, the project (Nanoexplora) proposes, for the first time, the idea of "nanotechnology learning progressions". This model is a useful tool for developing a science curriculum meant to teach these concepts and designing assessment processes to evaluate students' understanding. The learning progression for the big idea helps to predict students' learning in a classroom context and a "level-appropriate" instruction.

NanoExplora: A didactic toolbox that holds the materials to perform EIGHT different experiments that exemplify the key points of the NANOINVENTUM project

Keywords. Nanotechnology, Progression Map, Hands on Experiments, Materials, Nanoinventum, Nanoexplora, Primary School.

1. Introduction

Everyone 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?

Science is firstly introduced to kids during elementary school. Small doses of information are given through simple demonstrations done by the teacher and some theoretical subjects. These experiments are characterized by their spectacular nature but do not delve into their secrets. These experiences catch kids' attention and keep them wondering about the world for a little longer.

As they grow up, other questions arise, and new interests appear. The spectacularism of those experiments presented in elementary school alone is not enough to keep them interested in science. Basic courses in Biology, Chemistry and Physics are introduced during the first years of high school, willing to answer some of the questions asked a few years ago and keep them on the path of science. Unfortunately, all these subjects are based on theoretical knowledge. Hundreds of scientists' names, dates, theories, formulas, and abstract concepts are presented to students. A lot of information is given to them, and they feel overwhelmed by all the ideas they cannot relate to. The lack of real-life examples and experimentation makes understanding and learning more difficult, and students become disenchanted with science.

Experience-based learning (ExBL) [1] is a methodology based on first-person experimentation of the student and the assimilation of concepts from these. The NanoExplora Kit project proposes an experimental briefcase with various experiences related to the field of nanotechnology prepared to be developed by students autonomously.

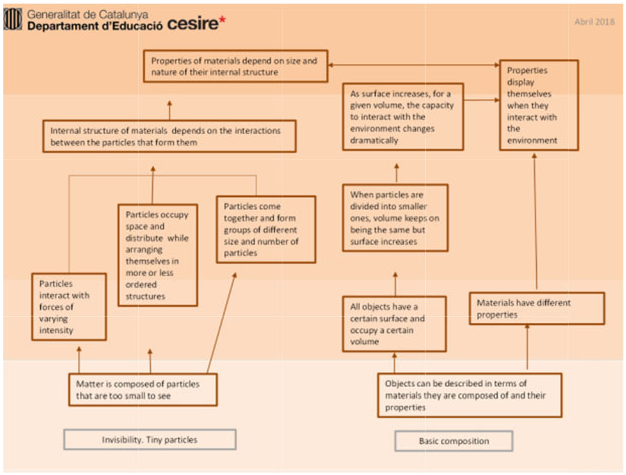


Figure 1. Learning progression map

NanoExplora is based on a Learning progression maps that can be defined as educational models of how students' ideas and ways of thinking about a given concept or topic are expected to evolve as they progress in their

ISBN 978-84-8158-937-5

studies [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.

Nanotechnology manipulates structures (mainly atoms and molecules) at a nanometric scale.

Science, engineering and technology at the nanoscale are leading to new knowledge and innovations that affect many aspects of our daily lives and are becoming a true revolution.

Nanoscience and nanotechnology are already part of our society and the immediate future of humanity, but they can also carry costs and risks that affect our lives in ways that we cannot always predict.

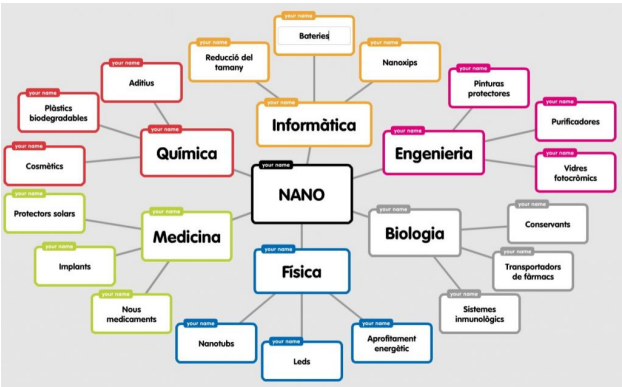


Figure 2. Nanotechnology is multidisciplinary

2. Nanoexplora Kit

NanoExplora is part of the project NanoInventum: NanoInventum is a scientific co-creation project that intends to introduce N&N in the primary school classrooms. By means of experimentation and progression maps an entire range of scientific concepts are introduced. After that, work teams are formed, and roles are chosen. Then, with the help of provided materials, the students create a model based on nanotechnological concepts designed to solve a future problem. The singularity of the present project lies in the fact that all this knowledge will be introduced and presented to very young students, that is, in primary school, a special moment of life where scientific vocations begin to build up. Besides, NANOINVENTUM offers new tools to approach STEAM disciplines, like the toolbox NANOEXPLORA with didactic experiences based on a progression map that sets a progressive and comprehensive way for students to apprehend the nanotechnological concepts. Finally, the experimental work is complemented by an artistic part that boosts creativity and breaks frontiers between disciplines, promoting a less intimidating regard on science.

NanoExplora is based on a concept map strategy, so that teachers can better explain concepts in nanoscience and nanotechnology, starting from basic concepts related to the atom, the molecule and the properties of matter up to nanomaterials' behavior and applications.

The progression map sets the steps in which the different concepts will be presented to the students:

- Phase 1: a) Structure of matter; b) Description of the objects in terms of materials.
- Phase 2: a1) How particles bind together; a2) Distribution of particles; b1) Surface and volume; b2) The properties.
- Phase 3: c1) Binding of particles and formation of compounds; c2) Specific surface.
- Phase 4: d1) Inner structure; d2) Relationship between specific surface, interaction and reactivity.
- Phase 5: e1) Properties of materials as a function of the structure; e2) Properties of materials as a function of the surface.

ISBN 978-84-8158-937-5

NanoExplora is divided in four parts:

- Invisible world
- Smaller but more…
- Amazing possibilities
- Take a decision

The NanoExplora kit is a material designed by CESIRE with the scientific advice of Dr. Jordi Díaz, from CCiTUB.

NanoExplora is part of NanoInventum. NanoExplora permits hands-on work in the schools: Kits and didactic charts will be sent to the educational centres so as to perform the practical part of the project. During the development of this phase (theory and practice imparted to students), team works will be arranged by the teachers. During the development of this phase, the teacher will collect questions and comments and will be assisted by an expert tutor (a researcher). At the same time, the organizers of the final contest will provide information about it and will detail the format and content of posters, presentations, as well as all the details about the final venue.

2.1. Invisible world

The properties of materials can be explained based on their structure, that is, how they are and how the particles that form them are arranged. These structures can only be seen with nanotechnology tools. In this activity you will be able to get an idea of what the nano scale is.

2.1.1. How long is it? In centimeters? In nanometers?

This ruler [4] helps children to make comparisons between their most used units of measurement and nanometers. At the same time, it makes them aware of the smallness of a nanometer.

They can begin to measure parts of the body (hand, finger, wrist, etc.) or objects in the classroom (pencil, table, eraser, etc.). They can play at guessing the size of an object by using nanometers instead of cm.

Figure 3. Materials of box "Invisible world"

2.1.2. Tidying up

The aim of this game is to arrange the cards according to the actual size of the pictures. The children should make a first attempt by just looking at the pictures, and then check if the distribution is correct from the measurement (in nanometers) on the back of each card.

An attempt has been made to present real images, but in the case of the sugar molecule, hemoglobin and red blood cells, they are representations. If appropriate, they can be removed from the game.

You can find the images here: [5].

2.1.3. What do you feel in the bag?

This activity aims to understand how a near-probe microscope (SPM) works.

The SPM allows to obtain images of objects in nanometers and angstroms (tenths of nanometers). It works in the same way as a blind person "feels" the objects, i.e., by probing the surface with a very sharp probe and generating a 3D image of the surface (Fig. 4).

To start the work with students, a question like this can be used: How could we know what is in the bag if we cannot look inside?

Based on the answers, the children are asked to put their hand in different bags and draw or model what they think is inside. Afterwards, the drawing or representation made is compared with the object once it is out of the bag.

ISBN 978-84-8158-937-5

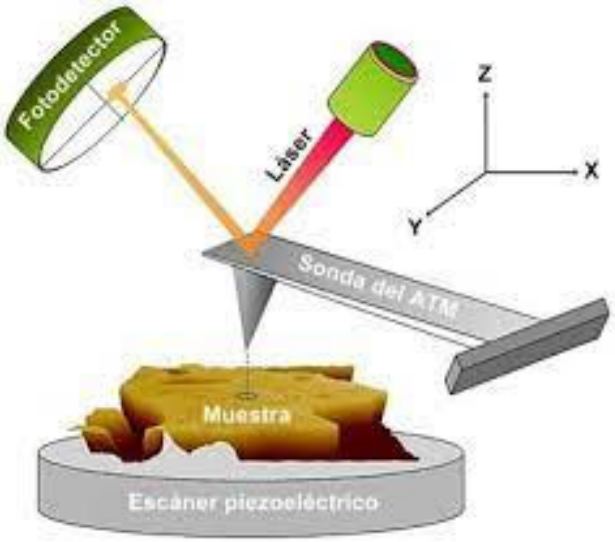


Figure 4 Scanning Probe Microscope scheme

To relate this activity to the near-probe microscope, we suggest reading a short text in English and interpreting the image linked in the text [5].

2.2. Smaller but more…

We tackle with the difference in properties that arise from the variation of particles size. Having in mind that the amount of surface incredibly increases as particles get smaller and smaller, the different interaction of light and the predominance of certain forces in front of gravity can be explained. This second activity provides the tools to simulate these effects and to observe the unusual colors that nanoparticles have in water according to their size.

2.2.1. Small things behave differently?

The aim of this activity is to observe how nanometric structures behave different from the same material or structure on the macroscale. In this case, the aim is to link the force of gravity to surface tension. A large and small cup ara compared. In the case of the small cup, the surface tension, which is related to the forces of interaction between particles, is biggerr than the gravity force and, therefore, the water inside doesn't fall.

You could start with the large cup, observing what happens, and then encourage students to make predictions about the small cup. Once the behaviour of the water in each of the situations has been checked, the children should come up with possible explanations.

2.2.2. How would you make the reaction faster?

Two effervescent tablet ara compared. The first one is crumbled, the other one, doesn't. Both effervescent tablets are solved in two glass of water. To answer the question "Why does it happen?", one would have to consider that the speed with which the reaction takes place increases as the contact surface increases, therefore the larger the contact surface the faster the reactions take place. In the case of the crumbled tablet, it is easier for it to dissolve in water, and in solution, it is easier for the interaction to take place. An analogy is proposed by comparing the surfaces of different solid cube. A material 1 cm on a side has 6 square centimeters of surface area, about equal to one side of half a stick of gum. But if that volume of 1 cubic centimeter were filled with cubes 1 mm on a side, that would be 1,000 millimeter-sized cubes (10 x 10 x 10), each one of which has a surface area of 6 square millimeters, for a total surface area of 60 square centimeters—about the same as one side of two-thirds of a 3" x 5" note card. When the 1 cubic centimeter is filled with micrometer-sized cubes—a trillion (1012) of them, each with a surface area of 6 square micrometers—the total surface area amounts to 6 square meters, or about the area of the main bathroom in an average house. And when that single cubic centimeter of volume is filled with 1-nanometer-sized cubes—1021 of them, each with an area of 6 square nanometers—their total surface area comes to 6,000 square meters. In other words, a single cubic centimeter of cubic nanoparticles has a total surface area one-third larger than a football field [7].

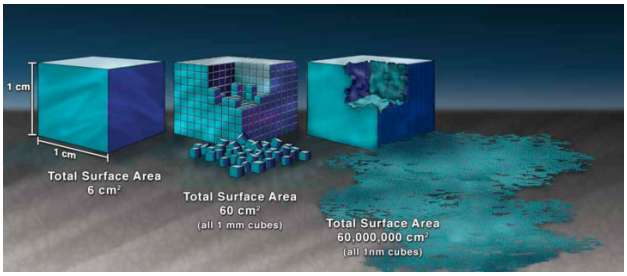


Figure 5. Change of specific surface area by miniaturization of a solid cube

2.3. Amazing possibilities

Nanotechnology opens the way to produce materials with incredible properties, so amazing applications open wide. The properties of matter at the nanoscale allow surprising products and applications to be obtained. Thus, for example, thanks to nano-particles such as TiO2 or SiO2 we can obtain self-cleaning surfaces or T shirts that never get wet, through the phenomenon of superhydrophobicity. We can also find applications in the cosmetic sector, with transparent and more efficient sun creams or nano-particles that release active ingredients on demand, as some anti-aging treatments do. Other applications are found in issues related to water treatment, where with a simple canteen we can obtain drinking water, or special filters to remove highly polluting metals. We are at the beginning of an unstoppable revolution.

2.3.1. Superhydrophobicity

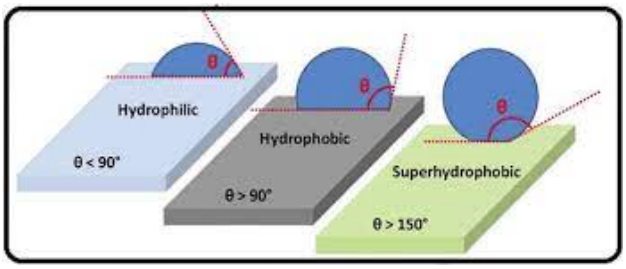


Figure 5. Sol-Gel Applications in Textile Finishing Processes - Scientific Figure on ResearchGate. Available from: https://www.researchgate.net/figure/Schematic-illustration-of-hydrophilicity-hydrophobicity-properties-of-substrate-as_fig6_318233418 [accessed 15 Jul, 2022]

This activity try to show a property as striking as superhydrophobicity, presenting an everyday material which is treated in such a way that its surface is covered with a thin nanometric layer that changes its properties. A hydrophobic substance is not miscible with water, this means that when a drop is deposited on a hydrophobic surface, the contact angle of the surface with water is greater than 90°. In the case of superhydrophobic material, this contact angle is greater than 150°. Superhydrophobity prevents the surface from getting wet, since the drop does not stick to the surface, but rolls on it. This property is also called the “lotus flower effect”, since the leaf of this plant has, on a nanometric scale, structures of nanometric-sized wax crystals that prevent the leaf from getting wet or stained.

2.3.2. "And if it doesn't get wet?"

After a day of rain, we go out into the woods and come back with dirty sneakers. How could we solve it? This activity aims to present an everyday material, which is treated in such a way that its surface is covered with a fine nanometric layer that changes its properties. The students have two pieces of cotton clothing, a dropper, a container with water and a spray of superhydrophobic liquid. It is important to carefully observe the two cutouts (how they are made, what material they are made of, how they react when wet, what happens when they get wet…). Regarding the spray, a prediction would also have to be made about its content and its usefulness. Finally, and focusing on the interaction between the fabric and the liquid, we will have to think about what would change if we treated one of the pieces of clothing with the superhydrophobic liquid. To finish, you can propose to the group that they design an experiment to test their predictions. To answer the question What is happening? the possibility of making a small video can be offered, since the effect is very spectacular.

2.3.3. Filtration

“How can we make it drinkable water?”

Every year, many people die in the world due to the ingestion of contaminated water. One of the solutions for this problem consists of filtration. Scientists are investigating the application of carbon nanotubes to improve the efficiency of filters. Nanofiltration is the process by which water is passed through a membrane so that a separation is produced based on the size of the particles. In the case of carbon nanotubes, the size of the pores is approximately one nanometer. Nanofilters can remove sediment, bacteria, viruses, toxic substances such as arsenic, and impurities.

ISBN 978-84-8158-937-5

Often, when we go on a school trip to the countryside, we sometimes find signs that warn us that the water from a fountain, for example, is not drinkable. The challenge proposed to the children is "How could we make this water drinkable?" To solve it they will need to answer some questions and look for information.

2.3.4. Sunscreen

Thanks to the development of nanoparticles new cosmetic compounds has been developed with improved capacity to absorb ultraviolet radiation. Sunscreens with nanoparticles of titanium dioxide and zinc oxide allow greater protection and, being transparent, are aesthetically more attractive.

To understand the operation of suncreens and the difference between those that have and do not have nanoparticles in their composition, the analysis of the following images (Fig. 6) is proposed.

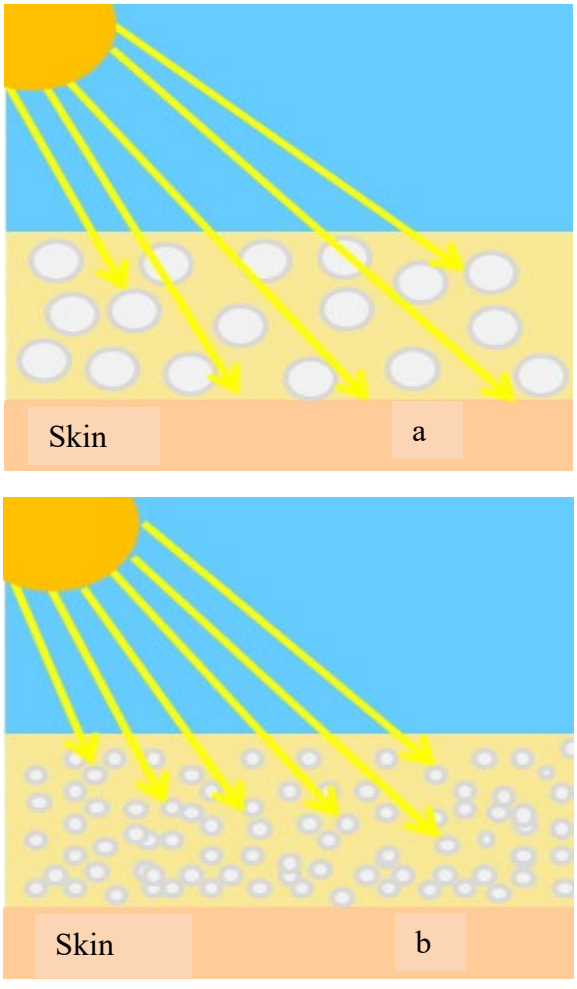


Figure 6. Sunscreens (a) without and (b) with nanoparticles

With the material of the NanoExplora (Fig. 7), an analogy can also be established between reality, images and models with expanded polystyrene balls.

Figure 7. Materials needed for the experiment

We made two different box with different polystyrene balls particle size. If we shine a flashlight through the top of the box, in the case of the larger balls we can see the light if we look below. By repeating the action, in the box of small balls, we will not see the light, which means that the rays do not pass through the material (Fig. 8).

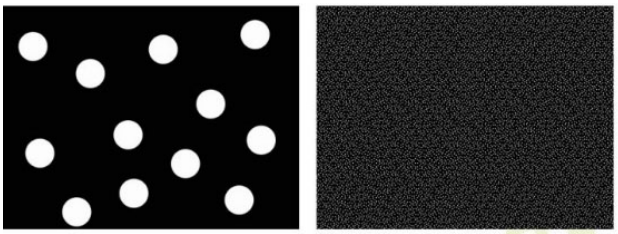


Figure 8. Depending on particles size, the light can pass through the box

2.4. Take a decision

It is time to take your decision. Nanomaterials are increasingly present in our daily life. They have obvious advantages, but it is necessary to use them responsibly and to consider the pros and cons (usually in the terms of potential dangers for human health and the environment). This research field and the associated technology is new and thus we still lack long-term risk studies to assess their potential harmfulness, as well as suitable legislation to deal with their use and commercialization.

In order to raise awareness on these subjects, different activities and didactic materials were created.

2.4.1. "You decide"

The goal of this activity, developed by the NISE network [8] is to help the schoolchildren to be aware about the new knowledge and useful innovations that the society can get thanks to the still growing fields on nanoscience and nanotechnology. However, nothing is for free and some risks and dangers may be present, but unknown. Scientists are human beings, with all the good but also with all the bad. They are active members of the social network and they are influenced by the values, fears and anxieties of their community. To take appropriate decisions, future scientists (and the whole community that directly or indirectly controls them) need to know the dangers, benefits, costs and utility of the research that they will do.

In this a hands-on activity the participants sort and prioritize cards with new nanotechnologies according to their own values and the values of others. Players explore how technologies and society influence each other and how people's values shape how nanotechnologies are developed and adopted. "Explore Science - Zoom info Nano You Decide!" (2016) version designed for groups and community outreach.

3. Conclusions

The resources and didactic proposals of NanoExplora aim to present the basic concepts of nanoscience and nanotechnology to students in the upper cycle of primary education or in the first cycle of secondary education.

The progression of learning through key concepts (big idea) of the activities designed in the NanoInventum Briefcase (NanoExplora), clearly help to assimilate the scientific bases so that primary school students can begin to understand how scientific knowledge works applied to everyday things that they can easily assimilate, to later be able to develop specific subjects, such as physics, biology or mathematics

NanoExplora is the first nanotechnology kit specifically designed for primary school and is intimately linked with the progression map that paves the way to a thoroughly learning of nanotechnology concepts. NanoExplra becomes an important educative complement deeply adapted to the development stage of the participants.

This material and the didactic proposal that accompanies it, are able to bring children closer to the advances of science and technology related to the study of materials at the nanoscale. The change of properties, the design of new products and the ethical aspects that are derived are the object of study, experimentation and debate in the classroom.

4. Acknowledgements

NanoInventum and NanoExplora are funded by Fundación Española para la Ciencia y la Tecnología, FECYT. We acknowledge BASF for their support.

5. References

[1] Kolb D. Experiential Learning: Experience As The Source Of Learning And Development.Prentice-Hall, 1984.

[2] Talanquer V. Progresiones de aprendizaje: promesa y potencial. Educación química. 24. 362-364, 2012.

[3] Díaz-Marcos J, Oncins G, López N. Nanoinventum: Approaching Nanotechnologies and Science to Primary School. Hands-on Science. Science Education. Discovering and understanding the wonders of Nature. Costa MF, Dorrío BV (Eds.), 115-124, Braga, Portugal, 2020.

[4] http://nanozone.org/nanoruler.pdf

[5] http://nanozone.org/stickers.pdf

[6] https://www.nisenet.org/catalog/diy-nano-book

[7] https://www.nano.gov/nanotech-101/special

[8] http://www.nisenet.org/catalog/programs/exploring_nano_society_-_you_decide

ISBN 978-84-8158-937-5

PBL at School: A Case Study µ-QUANT - Optimizing Microplastics Quantification through Image Analysis

B Machado, C Aguiar, C Coelho, C Gonçalves, I Ramos, M Mota, R Rocha
Colégio Luso-Francês in Porto, Portugal
rita.rocha@lusofrances.com.pt

Abstract. Six 12th grade students from Colégio Luso-Francês wanted to develop a project related with the improvement of methodologies to microplastics' quantification. The research was conducted in MIP [Research Project Methodologies], an extra-curricular discipline, which applies a Project-Based Learning [PBL] methodology to the formal curricula. In HSCI 2022 the authors will present µ-QUANT.

Keywords. Project-Based Learning Micro-plastics, Environmental Stress Factors, Riverine Systems, Computer Vision Systems.

1. Introduction

1.1. Background information

According to the Plastics Europe Report, EU produced more than 29 million tons of plastic post-consumer waste in 2021; only 34% of these were sent to recycling facilities, while the rest ended up in landfills and in energy recovery plants. The presence of plastic debris in the environment is a cause of concern due to several factors. Its low density and high buoyancy, leads to a great ability to spread; therefore, they can reach long distances far from their source. Plastic debris' high photo degradation rates induces its fragmentation into small-sized particles. These small particles, in return, may enter the food chains mainly via filter feeders. Beyond that, plastic debris present high persistent organic pollutants [POP] adsorption capacity, which, combined with its high dispersion capacity, turn them into excellent vectors for invasive species [1]. For all these, plastic waste is currently considered a planet boundary threat [10]. About 80% of the plastic enter the oceans via rivers and coastlines [5].

The rest comes from marine sources such as fishing nets, lines, ropes, and abandoned vessels [3]. As transitional ecosystems between the ocean and rivers, estuaries are recognized as playing an ecological essential role for food resources and temporary shelter for estuarine and marine organisms [8] but also as regulatory [climate, water, pest/disease control, carbon sinker] or as a buffering pollutants from a variety of terrestrial sources and riverine systems. Research estimates a 1–5% reduction in marine ecosystem service delivery because of the stock of marine plastic in the oceans representing, on a global scale, an annual loss of $500–$2500 billion in the value of benefits derived from marine ecosystem services. Despite this, estuarine areas are exposed to numerous anthropogenic perturbations, such as wastewater treatment plants [WWTP] effluents [11], laundry and personal care products discharge, sludge, runoff from urban, agricultural, touristic, as well as shipping activities.

This assumes particular relevance in urban areas with high population densities and a higher number of sources. Microplastics terminology first appeared in literature as any plastic particle smaller than 5 mm. These particles originate from the breakdown of larger plastic items – secondary microplastics – or, alternatively, they can be intentionally produced for use in industrial activities and, inadvertently, end up in the environment– primary microplastics. Household accounts for 77% of the global microplastics present in the ocean. Washing synthetic textiles, typically made of polyester, polyethylene, acrylic and elastane [2], represent one of the most common type of microplastics present in the water bodies, as their retention capacity in WWTP is narrow. As the end point of multiple environmental stress factors, estuaries become areas of great concern. In order to be sustainably managed, the impact of their environmental stressors have to be properly characterized. Currently, the main difficulty in the study of microplastics remains in assessing a reliable quantification method. The common practice relies on visual counting, thus exhibiting a high degree of misidentification [7]. µ-QUANT proposes an accuracy in particle counting down to an order of submillimeter magnitude, allowing overcoming some limitations in the study of plastic microparticles in environmental samples.

1.2. Objectives of the research

μ-QUANT research aimed at study the effectiveness of selective staining dying to detect microplastics in freshwater sediments and to test an automated counting open-source software for quantification of plastic particles.

2. Materials and Methods

2.1. Sampling area characterization

Figure 1. Location of the sampling area in the Douro estuary and wastewater treatment plants (W) along the estuary

Douro river extends along 930 km from Soria province, in Spain, to Porto city, in the northwest coast of Portugal, where it flows into the Atlantic Ocean. Douro estuary has highly dynamic funnel-shaped, with an average depth of 8 m, extending 21.6 km upstream of the river mouth until the Crestuma-Lever dam. According to salinity, the estuary is horizontally stratified [lower estuary – up to 3.5 km upstream the river mouth; middle estuary - from 3.5 km to 10.5 km upstream the river mouth; and upper estuary - from 10.5 km to 21.6 km upstream the river mouth] and vertically stratified, being considered a salt-wedged estuary [8]. The average monthly river flow in Douro's main course is 421 m^3s^{-1} with annual solid export values of sand transport of 2–3 × 10^5m^3/year [9]. The Douro estuary presents an irregular bathymetry where depths are generally under 10 m but can reach up to 28 m in narrower sections, outer bends, and former sites of sediment extraction [9]. In the lower estuary, corresponding to the sampling area, the sediments are essentially coarse and composed by small patches of gravel, sand, and muddy gravel in the deeper areas. This corresponds to 90% of the sediments greater than 63 μm, with mean values of 1.63 mm [9]. The sampling area is located in lower estuary [41.147073, -8.6565490] near Sobreiras WWTP and Granja stream (Fig.1). The area is often exposed at low tide and flooded at high tide.

2.2. Sampling and sample treatment

Sampling was conducted during winter [Feb'22] with low tide. According to the sediment zonation, three zones were established: A - the river edge, always in contact with water; B - the riverbank, where debris accumulate the most, and C - the top of the riverbank, where there is no contact with water. Along an 80 m line, parallel to the water body, twelve sampling points were established, along four transects perpendicular to the water line, using a random number generator. (Fig.2). At each sampling point, a 50 cm square quadrat was selected to delimit the area for sediment collection. The upper 2.5 cm of sand was collected to metal containers to prevent contamination and transported to the laboratory to be processed. The sediment samples were sieved with a 5 mm x 5 mm mesh size metal sieve in order to separate the microplastics from the sand [microplastics are considered all plastic particles in the range of 0.001mm - 5mm]. Polyethylene (PE), polypropylene (PP), and polystyrene (PS) are more likely to float in the water as their density is less than 1.00 gmL-1, while polyvinyl chloride (PVC), nylons, and polyethylene terephthalate (PET) are more likely to sink. In order to increase the buoyancy of plastic particles, the sieved sediment was inserted into a beaker with a hypersaline solution [140 gL^{-1} NaCl], stirred and mixed with a metal spoon and allowed to settle for one hour.

The supernatant was then filtered in 1.2 μm pore glass microfiber filters [Whatman GF/C, USA] in a glass filtration system previously washed with distilled water. After filtration, 1 mL of 0.01 $mg.mL^{-1}$ of Nile Red in ethanol [Sigma-Aldrich, Germany] was added to cover three filters of each sampling point. The filter was left

ISBN 978-84-8158-937-5

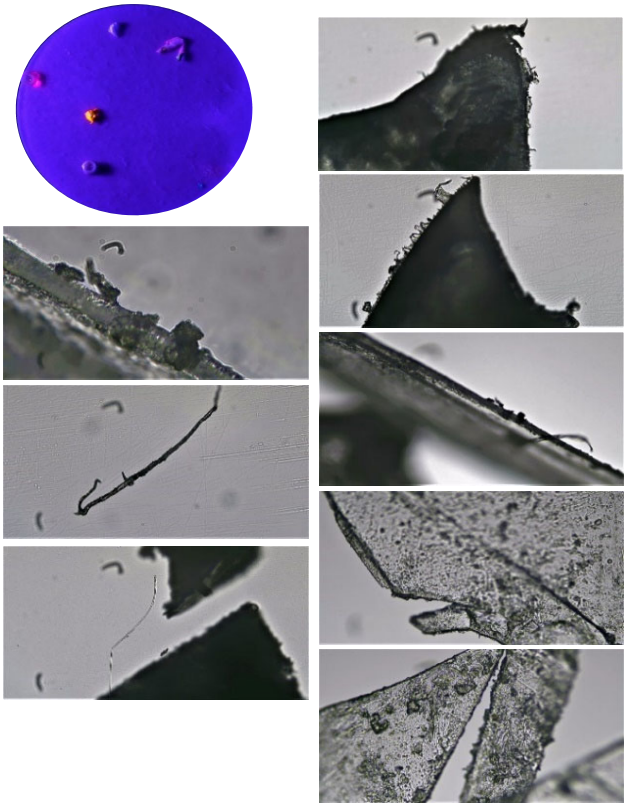
to react for 5 min. and then it was washed distilled water. Filters were kept in closed clean glass Petri dishes, covered with aluminium foil and dried in a laboratory oven for a week.

Figure 2. Riverbank sampling scheme in Douro lower estuary. Along 80 m, 12 sampling points were established, along four transects perpendicular to the water line, using www.random.org.[t1=1 m; t2=45 m; t3=69 m; t4=87 m]

2.2.1. Weathered polymers sample collection preparation

In order to test a way to avoid the biogenic organic matter removal pre-treatment in freshwater sediment samples, a second experiment was conducted.

A collection of six weathered polymers [synthetic rubber balloon; textile fibre; styrofoam; plastic cotton swab stick; plastic sheet, dolly rope] was collected in Ourigo beach, Porto a 1.5 km far from the research sampling area. The choice of the fragments type was based on frequency at the beach.



Figures 3a-i. (a) Weathered polymers in a glass fiber filter stained with Nile Red and photographed under UV-light; (b,g) - dolly rope releasing fibers; (c, d) fibers; (e,f) textile fibers; (h,j) – plastic sheet with biofilm. Phptpgraphs (b-i) captured with Bresser® TFM 301 trinocular microscope and Bresser® Mikrocam PRO HDMI; 10x magnification

The weathered polymers were handled cut into small fragments and kept in closed clean glass Petri dishes. A 1.2 µm pore glass microfiber filters [Whatman GF/C, USA] was subjected to 1 mL of 0.01 mg.mL^{-1} of Nile Red in ethanol [Sigma-Aldrich, Germany] and left to react for 5 min. and then was washed with distilled water. This blank filter was kept in a closed clean glass Petri dish, covered with aluminium foil and dried in a laboratory oven for a week. A second filter was stained, following the same procedure, but adding two fragments of each weathered polymer category. A third filter, with freshwater sediment, was stained and kept in the same conditions. Lastly, a set of 12 filters from the field, three per transect at each zonationarea, were subjected to the same procedure, i.e., two fragments of each weathered polymer category were added to each sandy filter and stained, following the same procedures described previously (Figs.3a-i).

2.3 Microplastics identification and quantification

Nile Red has affinity to lipophilic materials, producing fluorescence under UV-light. The filters were photographed in the dark under UV-light [Canon 250D, EF-S 18–55 mm, F-stop f/6.3, exposure time 6 sec., ISO 100]. Afterwards, the total area of the filter, corresponding to its full diameter [47 mm] was analysed in ImageJ software to identify fluorescent particles. A calibration for the filter diameter and for the conversion of pixels in mm was previously conducted.

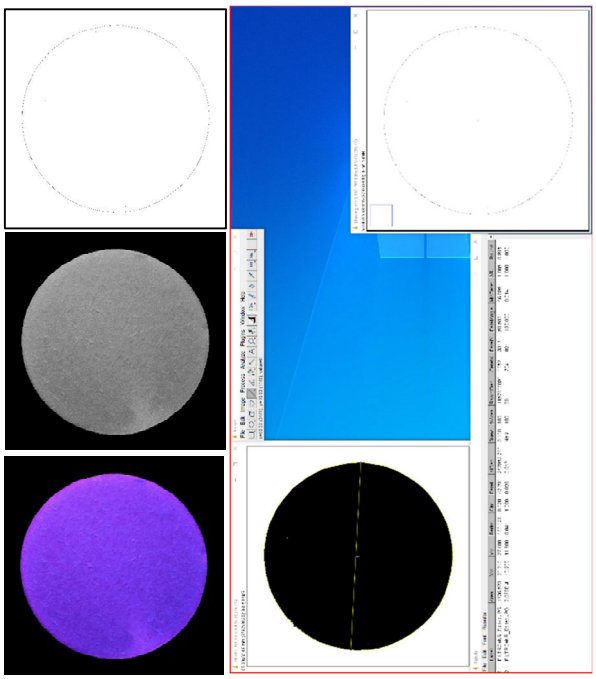
2.4. µ-QUANT SWOT analysis quantitative assessment

A SWOT analysis quantitative assessment was conducted to identify drivers and barriers for the adoption of alternative plastic source products, assuming that microplastics are an environmental global problem that need to be addressed. µ-QUANT applied a survey with 12 individuals [4 experts; 4 secondary students; 4 decision-makers] in four domains [Economic, Social, Political and Technological] to integrate a quantitative ranking and assessment [PEST analysis] to the SWOT attributes. In a first step, categories from previous research were systematized within each domain, according to previous research [4]. In a second step, the interviewers were asked to score the aspects according to their relevance. The Strengths and the Weaknesses are internal components of the project that give an advantage or a disadvantage, respectively, relative to others. The Opportunities and the Threats are external components of the project and correspond to the elements in the environment that the project could exploit to its advantage or, on the contrary, that could cause trouble for the project, respectively. PEST analysis classifies the aspects according to the Political, Economic, Social, Technological, Legal and, Environmental factors. A radar graph was made for each SWOT domain.

3. Results

3.1. Quantification of fluorescent particles in ImageJ

An automatic threshold was established in ImageJ, using an area range from 0.00 mm_2 to 0.08 mm^2 and circularity ranging from 0.0 to 0.8, being 1 a perfect circle. An approximation of the largest and smallest dimension of the particle was automatically generated, presented as Feret and MinFeret, respectively. Figs. 4a-d show the results of the image processing of the blank filter, stained with Nile-Red.



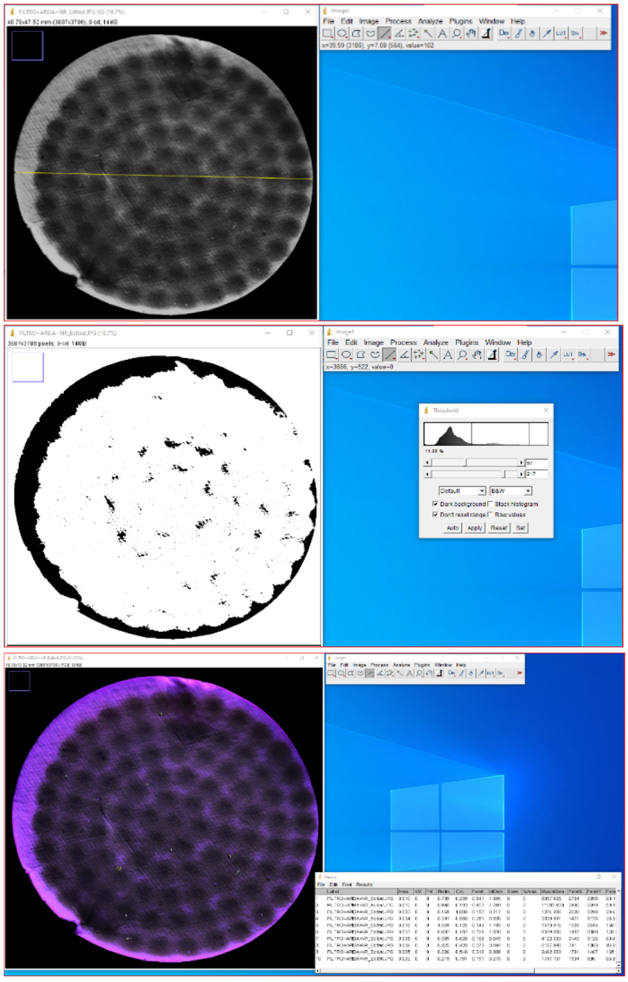
Figures 4a-d. Glass fiber filter [Blank] stained with Nile Red and photographed under UV-light (particles=2; 69.04 $pxmm^{-1}$)

The two particles detected had a dimension of 0.02 mm and 47.291 mm. Due to its size, this last particle represents, most probably, the axis outlined in the image to mark the filter diameter. Regarding the second particle identified, its circularity [=1] and small dimension, seems to indicate that it may be an artefact. There is no evidence of any change in the filter matrix after staining with Nile Red. Figs. 5a-d show the results of the image processing of the filter with freshwater sediment, stained with Nile Red.

Ten particles were detected. By the software characteristics [circularity, feret], these particles are consistent with microfibers. This microfibers presence are consistent with a cross contamination of the sample due to its colour [blue], fiber-shape [given by the circularity and feret parameters] and small quantity. The weathered polymers sample collection preparation was not conducted in a laminar flow hood in a clean room as it was not available in the school laboratory. One of the

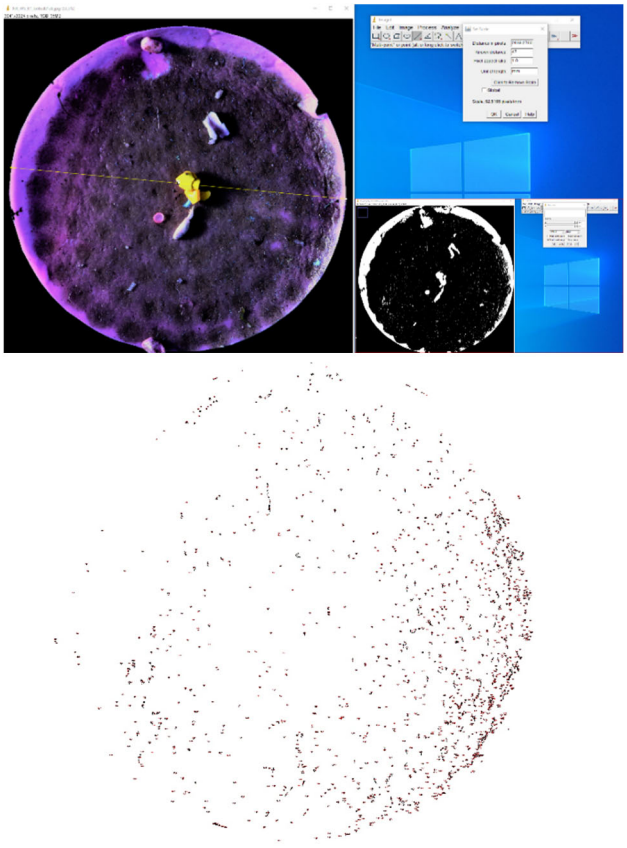
ISBN 978-84-8158-937-5

weathered polymer used is precisely textile fibers, consistent to those visualized in the filter. Filter analysis appears to show that the sample does not contain microplastics. The dark particles that cover the matrix are most likely organic material that was not digested in a sample pre-treatment. To confirm this suspicion, a spectroscopy analysis would have to be performed. Regarding the filter with the freshwater sediment and the weathered polymers, stained with Nile Red, the full area of the filter [1 734 mm2] was analysed and a total of 1 490 particles were identified (Fig. 6a-c).



Figures 5a-c. Glass fiber filter with freshwater sediment, stained with Nile Red and photographed under UV-light (particles=10; 79.68 pxmm^{-1})

A large amount of blue microfibers cover the filter surface. The origin of these blue microplastic particles is most likely due to the weathered polymers added to the sample, namely the textile fiber fragments, visible in the image, in a considerable degradation stage, thus releasing microfibers into the filter matrix. If we compare the behaviour of the textile fiber fragment in the filter with sand from the one without sand, but containing the same textile fiber fragment (Fig. 3a), it can be seen that the release of microfibers only occurs in the sandy filter. This fact reveals that a weathered plastic has an unpredictable behaviour, having points of structural fragility, when subjected to pressure, in this case caused by manual cutting and by the abrasion of the filter surface staining procedure. On the other hand, we can observe that the type of particles present in the filter sediment is not similar to the plastic particles added to its surface, neither in size nor in colour, which is consistent with the result observed in the stained filter, containing only sand (Fig. 5a-d]. The dark particles that cover the matrixare most likely organic material that was not digested in a sample pre-treatment.



Figures 6a-c. (a,b) Glass fiber filter with freshwater sediment and and weathered polymers, stained with Nile Red and photographed under UV-light (particles=1 490; 62.517 pxmm^{-1}); (c) –Microparticles counting in ImageJ [area range (mm^2) - 0.00 to 0.08; circularity range - 0.0 to 0.8]

In a first analysis, ImageJ counted 8 558 particles in the filter surface (Fig.7). After

ISBN 978-84-8158-937-5

careful analysis of the parameters of each particle, it was found that 25% corresponded to particles with an area approximately 2.56 E-04, which is too small to be considered valid as a potential particle. On the other hand, the particles had a circularity of 1, reinforcing the suspicion that they must be artefacts. In this way, the software was calibrated for an analysis of areas in an interval between 0.00 and 0.08 mm2 and a circularity between 0.0 and 0.8. With the new calibration a total of 1 490 particles were identified, with a size particle detection limit on the order of 23 µm.

µ-QUANT procedure allowed an extremely innovative refinement in the analysis of real samples, allowing to expand the potential of the software to a level that is not applied in academic studies.

Figure 7. Microparticles counting in ImageJ of a Glass fiber filter with freshwater sediment and weathered polymers, stained with Nile Red and photographed under UV-light (particles=8 558; 62.517 pxmm^{-1}; area range (mm^2)

3.2. µ-QUANT SWOT analysis quantitate-ve assessment

Figs. 8a-d represent spider graphs that resume the relevance of each factor [1- not relevant to 5 - very relevant] according to the answers of 12 stakeholders. They have diverse background, expertise or responsibilities related to the research topic: decision makers, students and researchers.

The strengths and weaknesses reflect the advantages and disadvantages of using alternative plastic sources compared to conventional plastic resources. The most relevant strengths are the environmental improvement and the climate change mitigation that new technologies could bring. Interviewers value the existence of legislation as a mean to regulate the implementation of new products and processes, which reveals a lack of trust in the individual, will for change.

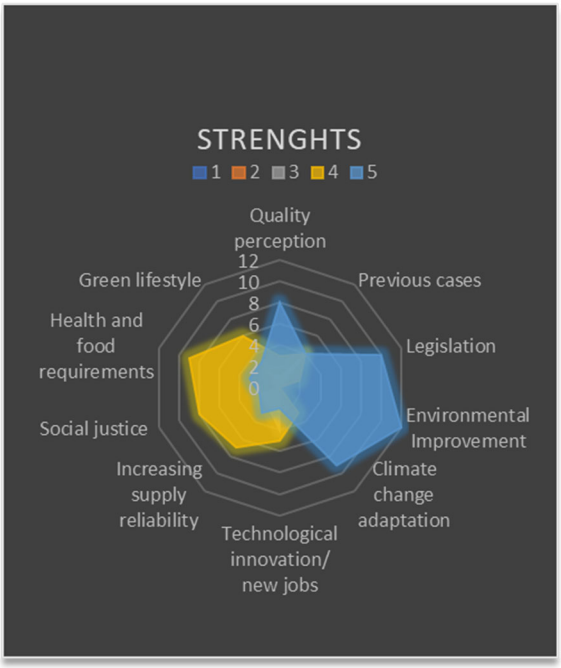


Figure 8a. Radar graph Strenghts relevance of several dimensions related to the adoption of alternative plastic sources. Graph combine a SWOT qualitative analysis with a PEST quantitative analysis

There is a generalized perception that the introduction of more friendly plastic products would increase quality and that would contribute to a more social justice and in ensuring a healthy way of life.

Regarding the Weaknesses chart, the cost of new products and the consumer incentive measures are the most valued items, for having a direct impact on people's lives. Regarding the more technical items [Impact of new plastic sources and Deficient WWTP], it appears that they are valued mainly by the specialist

ISBN 978-84-8158-937-5

respondents, which is understandable due to the lack of technical knowledge on the matter. This is corroborated by the response to the item Society disinformation. In the Opportunities chart, there is a tendency to value the most mediatic terms, such as Zero Waste strategy, Fossil fuel overuse, Tourism pressure and Climate change concern, even if they are not accompanied by a full understanding of their meaning. Pursuing the trend of the previous graphs, there is a special concern with the items related to the economy and health.

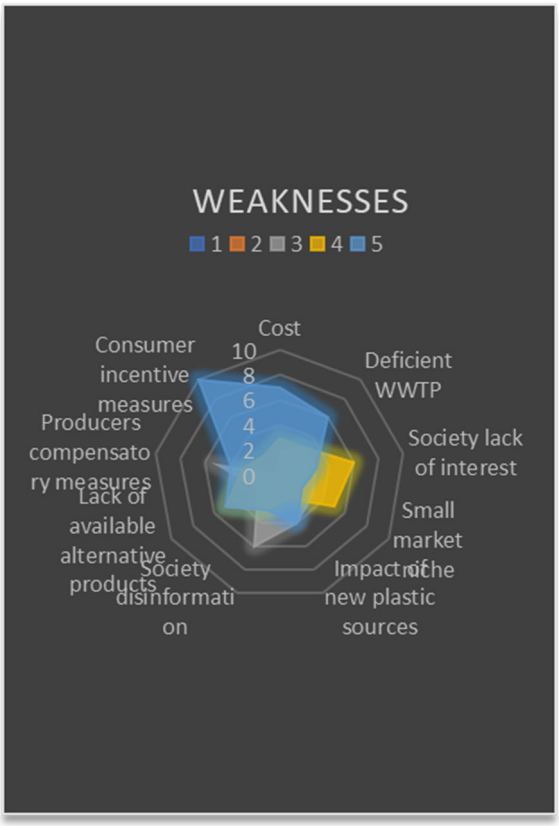


Figure 8b. Radar graph Weaknesses relevance of several dimensions related to the adoption of alternative plastic sources. Graph combine a SWOT qualitative analysis with a PEST quantitative analysis

By contrary, while in Strengths graph legislation was valued in a punitive perspective, in this case, when seen as an opportunity, respondents did not value it.

Lastly, regarding threats, there is a tendency to externalize the negative aspects, maybe as an attempt to provide individual exemption from the adoption of new paradigms.

Figure 8c. Radar graph Opportunities relevance of several dimensions related to the adoption of alternative plastic sources. Graph combine a SWOT qualitative analysis with a PEST quantitative analysis

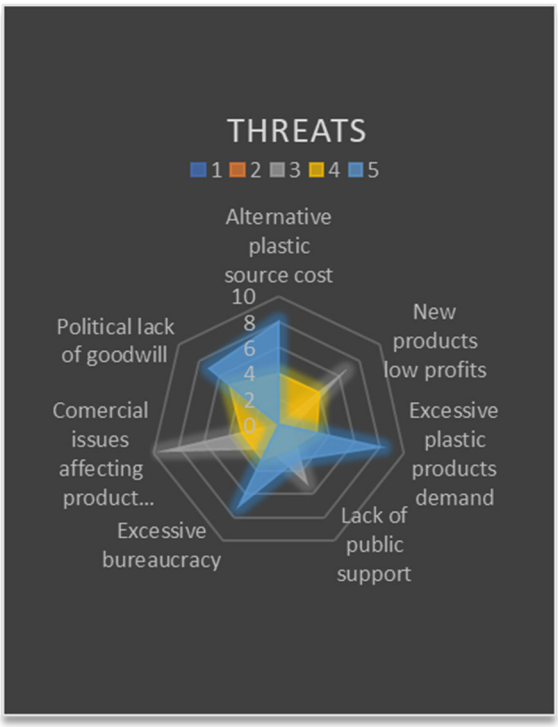


Figure 8d. Radar graph Threats relevance of several dimensions related to the adoption of alternative plastic sources. Graph combine a SWOT qualitative analysis with a PEST quantitative analysis

4. Discussion and Conclusion

The topic of microplastics has been worked on at school for the last nine years. The preliminary study aimed to clarify how relevant plastic debris were in marine beach near our school. The characterization was made by calculating the abundance of plastic waste per sampling unit, typifying it by type and size. The results revealed that microfibers were in vast majority among the microplastic fragments collected, which reinforced the need to conduct a second research, focused on wastewater treatment plants. The research consisted in the development of a nanopolymer capable of microfibres' retention in a household laundry machines, applying an electrospinning technique. Scaling from an individual sphere to a collective problem-solution, nothing seemed more pertinent than conducting a study on freshwater sediments, which are the most and primarily affected by terrestrial plastic debris sources.

µ-QUANT project arises. The estuarine area of the Douro River was chosen for several reasons. First, it is the terminal point of accumulation of all discharges from the various WWTPs; second, because it is highly sensitive in terms of ecological value, reinforced by the presence of Douro Estuary Local Natural Reserve and, a last, because it has suffered from silting in recent years due to the construction of the Douro breakwaters.

The results are surprising. There is no evidence of microplastics presence in the sediment sampled from the low estuary, which raises several questions: due to the hydrogeomorphological nature of the Douro River, there is no capacity for accumulation in the sediments of such small fragments, being washed away by the current. Interestingly, the studies carried out in the estuarine zone were carried out either in the biota or in the water column, which would be a line for further research. Another hypothesis is to assume that an adaptation has to be made to the guidelines for sampling in this estuarine zone, collecting sediment at greater depth. 10magnitude. The sampling was conducted in Douro's lower estuary.

According to the sediment zonation, twelve sampling points were established, along four transects, using a random number generator. At each sampling point, the upper 2.5 cm of sand was collected. In the lab, the sample was sieved, filtered and stained with Nile Red that, in the presence of lipophilic particles, produces fluorescence under UV-light. Filters were photographed and analysed in ImageJ software. A collection of six weathered polymers, of known typology, was collected and processed according to the same procedure. Regarding the results, a total of 1 490 particles were identified, with a size particle detection limit on the order of 23 µm. A SWOT analysis was conducted to identify drivers and barriers for the adoption of alternative plastic source products. The SWOT dimensions were then ranked in terms of relevance by 12 stakeholders through a survey focused on four domains: Economic, Social, Political and Technological. This way, µ-QUANT could integrate a quantitative assessment [PEST analysis] in a qualitative SWOT analysis. µ-QUANT procedure allowed an extremely innovative refinement in the analysis of real samples, allowing to expand the potential of the software to a level that is not applied in academic studies, using low-cost resources.

5. Acknowledgements

A Duarte - CESAM/ Centre for Environmental and Marine Studies, Department of Chemistry, University of Aveiro, Portugal.

6. References

[1] Arenas F, Bishop J, Carlton J, Dyrynda P, Farnham W, Gonzalez, D, ... Wood C.Alien species and other notable records from a rapid assessmentsurvey of marinas on the south coast of England. J. Mar. Biol. Ass., 86, 1329-1337, 2006.

[2] Essel R, Engel L, Carus M, Ahrens R. Sources of microplastics relevant to marine protection in Germany. Texte, 64, 656-660, 2015.

[3] Lebreton L, Slat B, Ferrari F. et al. Evidence that the Great Pacific Garbage Patch is rapidly accumulating plastic. Sci. Rep., 8, 4666, 2018.

[4] Lee J. Economic valuation of marine litter and microplastic pollution in the marine environment: An initial assessment of the case of the United

Kingdom, 2015. https://www.cefims.ac.uk/research/papers/DP126/dp126.pdf]

[5] Li W, Tse H, Fok L. Plastic waste in the marine environment: A review of sources, occurrence and effects. Sci Total Environ., 566-567:333-349, 2016.

[6] Plastics Europe. Plastics - the Facts 2021. An analysis of European plastics production, demand and waste data, 2021. https://plasticseurope.org/wp-content/uploads/2021/12/Plastics-the-Facts-2021-web-final.pdf

[7] Prata J, Reis V, Matos J, da Costa J, Duarte A, Rocha-Santos T. A new approach for routine quantification of microplastics using Nile Red and automated software (MP-VAT). Sci. Total Environ., 690, 1277–1283, 2019.

[8] Rodrigues S, Almeida C, Silva D, Cunha J, Antunes C, Freitas, V, Ramos S. Microplastic contamination in an urban estuary: Abundance and distribution of microplastics and fish larvae in the Douro estuary. Sci Total Environ, 659, 1071-1081, 2019.

[9] Santos A, Oliveira A, Pinto J, Freitas M. Hydrodynamic and Sediment Transport Patterns in the Minho and Douro Estuaries (NW Portugal) Based on ADCP Monitoring Data: Part 1-Tidal Sediment Exchanges. Coasts, 1, 31–55, 2021.

[10] Villarrubia-Gómez P, Cornell SE, Fabres J.Marine plastic pollution as a planet boundary threat – the drifting piece in the sustainability puzzle. Mar. Policy, 96, 213–220, 2018.

[11] Ziajahromi S, Neale P, Rintoul L, Leusch F. Wastewater treatment plants as a pathway for microplastics: development of a new approach to sample wastewater-based microplastics. Water Res., 112, 93–99, 2017.

ISBN 978-84-8158-937-5

Using Backyard Brains' Human-Human Interface to Perform a Milgram Experiment

D Duque, D Sánchez Bestué
Open Brains in Barcelona, Spain
dddbcn@gmail.com

Abstract. While visiting different schools in the Barcelona metropolitan area (Spain) to perform our Neuroscience outreach activities, we found teachers and high-school directors had an increasing concern to address common school problems such as respect, aggressivity and peer pressure. To address such issues we developed an hour and a half workshop where we tricked students during 20 minutes to think they were attending one of our Neuroscience practical workshops, when they were instead part of a Milgram-like obedience sociological experiment. Preliminary results show students are surprised by the trick and willing to talk openly about obedience, consent and peer pressure. Combined with other group activities it can also be used to talk about cognitive biases such as in-group bias or the bandwagon effect.

Keywords. Milgram, Obedience, Authority, Backyard Brains, Human-Human Interface, Responsability, Consent, Psychological Pain, Physical Pain, Threshold, Peer pressure, Bias.

1. Introduction

1 out of 3 Spanish students have suffered school bullying or cyberbullying recently [1]. On top of that, the COVID-19 pandemic has aggravated this situation [2]. Such increase may be responsible of the fact that, according to UNICEF, more than one over seven high-school students around the world have a diagnosed mental health issue [3] and, every year, around 46.000 adolescents commit suicide. And again, COVID-19 pandemic accentuated these problems [4,5]. To address this issue in high-schools we developed an hour and a half workshop where we tricked students during 20 minutes to think they were attending a Neuroscience practical workshop [6], when they were instead part of a sociological experiment inspired by the controversial Milgram study [7]. We found experiential learning [8] can promote a fruitful dialogue and create awareness about mental health by combining the emotional response generated by first-hand experience with the scientific rigour of reproducing classical studies.

2. Material and Methods

Two people are required to perform the Milgram-like experiment. The workshop as is actually designed requires little resources but highly specific.

3. Tools

At least one Human-Human Interface (HHI) kit by Backyard Brains [9] is required to perform the main awareness phase: the Milgram-like experiment. Actually, the TENS (transcutaneous electrical neurostimulation) unit [10] that comes with the HHI is the key tool. Several units of The Claw Backyard Brains kits [11] were used for the "Staging" phase, but other tools could be used instead.

4. Personnel

Two people are required for both the "Staging" and the "Experiment" phases. One experienced experimenter is required, the second one may be another course instructor or a sidekick student, but we have not yet tested that possibility. Decent theatrical skills are required for the "Experiment" phase.

5. Procedure

The workshop was divided into three different phases: “Staging”, “Experiment” and “Discu-ssion”.

5.1. Staging phase

The “Staging” was devoted to making students think they were in a Neuroscience & Robotics workshop, where they got to experience machines that read the neuromuscular activity to move a robotic prosthesis [11]. A classical workshop or practical session is perfect for the "Staging" phase, with a short theoretical part and a practical interactive section. During this first phase, it is critical to establish a clear hierarchy between the experimenter’s team, so one of us is very experienced (“boss”) while the other is merely supporting by passing the slides and making several questions and mistakes when setting up the prosthesis (“assistant”). A specific slide during the presentation showing

ISBN 978-84-8158-937-5

extremely different CV may help setting-up the hierarchy. A lab coat can be worn by the "boss" to accentuate the hierarchy of the set-up. Allow some time for the students to experience the tools and to get used to the workshop. Once the students were convinced of the false scenario, we started the “Experiment” phase.

5.2. Experiment phase

We showed the students the TENS unit [10], which allows us to send small electrical impulses and control the little finger movement of a participant if the electrodes are placed correctly. We ask them to line up, so we would measure one by one the mean threshold of the class by measuring at which level of stimulation they felt a tickling. The “boss” controlled the machine during the whole time and, when the students described tickling, the “boss” reported fake random levels between 25 and 35 arbitrary units (AU). The “assistant” annotated the number in the blackboard. After all the students tried the TENS unit, the mean threshold level was calculated, which was around 30 AU. Then, the “boss” said that the TENS unit would allow us to see how to move the whole wrist and that, to do so, the “assistant” would try the machine with higher impulses. We verbalise that the usual impulses that create a wrist move are around 90 AU. The critical part of the experiment lies here. The “boss” will slowly increase the intensity of the impulses and the reactions of the "assistant" should be constant:

1) At 20 AU, unexpectedly, and in a playful attitude, the “assistant” reports tickling (at a lower level than the students).

2) At 30 AU, the “assistant” begins to report an unpleasant feeling, verbalising the impulses are starting to bother him and that he/she is not comfortable.

3) At 40 AU, the “assistant” remains silent, but acts as if the impulses were hurting. As the wrist is still not moving, the “boss” keeps raising the impulses. During all this phase it is really important to keep an open dialogue with the students and to play down the individual experience of the "assistant".

4) At 50 AU, the “assistant” verbalises he is in pain and repeatedly says “stop”. At this moment, the “boss” says “but the wrist is not moving” and explicitly asks the class if they want to see it move.

If the "Staging" and "Experiment" phases were convincing, the class will be positive to increase the intensity. Before increasing the intensity of the impulses, the instructors have to stop the experiment and tell the students everything was fake, that the “assistant” was not feeling any pain and that everything was staged to start a discussion about human behaviour.

5.3. Discussion phase

The "Discussion" phase starts with the students describing what happened and explaining why they think they did not intervene and stopped the experiment. The typical responses will gravitate around five main topics: “authority figure”, “pain threshold”, "consent", "peer pressure" and "biases". The instructors should cover these topics addressing the historical and philosophical background [12,13], classical related experiments [14,15,16], the relevance of replications in scientific studies [17,18] and what is a cognitive bias [19].

Allow room for discussion between students and only moderate the debate with them so they can explain their thoughts and their perspectives on the subjects. We found crucial to finally verbalise the conclusions of the experiment, as it is a complex subject and some concepts are difficult to integrate by young students:

- We observed that *Ignorantia juris non excusat* ("ignorance of the law excuses not") is an elusive concept. It is important to reinforce the idea that we are always responsible for our actions.

- Empathy is generated by first-hand experimentation but it generally requires a discussion about biological thresholds.

- Consent is also an elusive concept. Many students claimed that the "assistant" originally accepted to be part of the experiment, thus should continue it until the end.

- Remind the students that they always have the power to choose and should

always speak up against anything that they feel is unfair.

6. Conclusion

Experiential learning [8] is an essential tool to explain concepts and it is a key resource to transmit scientific knowledge. When replicating classical sociological experiments [7] it can also help promote a fruitful dialogue and create awareness about mental health by combining the emotional response generated by first-hand experience with the scientific rigour of reproducing classical studies. We think that visibility actions such as this workshop can help start a discussion about otherwise difficult topics, especially when combined with other tools such as psychosocial support. These preliminary results are encouraging and could become a powerful resource for schools.

7. References

[1] UNESCO. (2019). Behind the numbers: ending school violence and bullying. UNESDOC Biblioteca Digital. https://unesdoc.unesco.org/ark:/48223/pf0000366483

[2] https://www.publico.es/sociedad/acoso-escolar-virtual-crece-pandemia.html

[3] https://www.unicef.es/sites/unicef.es/files/comunicacion/SOWC2021_ExecSum_SP_PRINT.pdf

[4] https://www.consaludmental.org/publicaciones/Salud-mental-covid-aniversario-pandemia.pdf

[5] https://www.revistapcna.com/sites/default/files/006_0.pdf

[6] https://www.open-brains.com/

[7] Milgram S. Behavioral Study of obedience. The Journal of Abnormal and Social Psychology, 67(4), 371–378, 1963.

[8] Kolb DA. Experiential learning: Experience as the source of learning and development. FT press, 2014.

[9] https://backyardbrains.com/products/HHI

[10] Ersek RA. Transcutaneous electrical neurostimulation: a new therapeutic modality for controlling pain. Clinical Orthopaedics and Related Research, (128), 314-324, 1977.

[11] https://backyardbrains.com/products/clawBundle

[12] Arendt H, Kroh J. Eichmann in Jerusalem (p. 240). New York: Viking Press, 1964.

[13] Onfray M. El sueño de Eichmann: Precedido de Un kantiano entre los nazis. Editorial Gedisa, 2021.

[14] Asch SE. Studies of independence and conformity: I. A minority of one against a unanimous majority. Psychological monographs: General and applied, 70(9), 1, 1956.

[15] Zimbardo PG, Haney C, Banks WC, Jaffe, D. The Stanford prison experiment. Zimbardo, Incorporated, 1971.

[16] University of Oklahoma. Institute of Group Relations, Sherif M. Intergroup conflict and cooperation: The Robbers Cave experiment, 10, 150-198. Norman, OK: University Book Exchange, 1961

[17] Burger JM. Replicating Milgram: Would people still obey today?. American Psychologist, 64(1), 1, 2009.

[18] Doliński D, Grzyb T, Folwarczny M, Grzybała P, Krzyszycha K, Martynowska K. Trojanowski J. Would you deliver an electric shock in 2015? Obedience in the experimental paradigm developed by Stanley Milgram in the 50 years following the original studies. Social psychological and personality science, 8(8), 927-933, 2017.

[19] Kahneman, D. Thinking, fast and slow. Farrar, Straus and Giroux, 2011.

ISBN 978-84-8158-937-5

Can You Make the Difference? SDGs Junior Summer School

M Ballatore, C Ricci
Association Apriti Scienza, Turin, Italy
manuel.ballatore@libero.it

Abstract. Is it possible to address complex topics, without excessive simplification, with young students? How to keep a view of the whole picture and try to deal with it by avoiding an item-by-item or environmental-centred program? The format of a summer school, tailored for 12-13 years old students, allowed us to work on the expectations for our inclusive and sustainable future and the awareness of the present time. The paper reports the key moments and outcomes of this experience.

Keywords. Education, Future, Science, Technology, Sustainable Development Goals.

1. Introduction

Education for sustainable development has received a considerable incentive in these last years, as a consequence of the launch of the well-known UN Agenda 2030. In the overabundance of educative proposals for students of different grades in Italy, we found a lack in the opportunity for middle school students to reach the whole framework of the sustainability issue at a glance. Moreover, we decided to focus on the core idea of sustainability as the intersection of three pillars - environment, society, and economy - and to not lapse into the common perspective by which science education only concerns environmental issues. Thus, we designed a summer school for young students, pointing out that the key point for the sustainable future is centred on people. In September 2021 we managed a junior summer school, addressed to students grade 6th and 7th, entirely devoted to the all 17 Sustainable Development Goals (SDGs). In an immersive and intensive learning environment, the kids were engaged on the theme of our sustainable future, the problems we are facing and the challenge of taking action for change. The summer school was organized along 4 days, each of which with a specific and interdisciplinary focus developed upon several activities in the morning time, whereas the afternoons were dedicated to a tinkering space, called “The factory of good ideas”, where the kids worked in groups to realize an original project.

2. Workshops and activities

During each day of the summer school, the students were involved in some structured activities in groups of 15-20 participants supported by two facilitators. The activities required both an individual and a team approach, sometimes they were based either on competitive or cooperative games, in other cases, we proposed scientific lab activities as well as creative and artistic tasks; physical and hands-on interaction was preferred instead of digital, but the use of some video or online quiz was included.

Here we give the overall structure of the program without in-depth details on the activities, many of which can be found in the references.

2.1. Day 1: imagining the future

We welcome the participants with a boarding pass, as they were leaving for a trip… our destination is the future! Obviously, everybody needs a passport to travel around the world, and also for time traveling: since this can sound unfamiliar to students of that age, we provide them with a blank fake passport.

- *Welcome to 2050*: they fill in their own document as they were in 2050 (they will be around 40 years old at that time) and then we ask them to imagine their life, focusing on food, transportation and holiday. They share their ideas by writing on different posters and we comment upon them.

- *In someone else’s shoes*: now, we provide everyone with a passport which shows the identity of other guys living in different countries around the world. How different would you plan your future if you were a different person? We ask the kids for a new story to be written around a wheel of inspiring (or mysterious) icons and then to share with the other participants (Fig.1).

- *What are the SDGs?* Someone already guesses the icons come from the SDGs and can explain the meaning, we add some information [1] and fun facts or propose short games or challenges to show how they matter in our everyday life.

ISBN 978-84-8158-937-5

The main goal of this first day is to make the students know each other and envisage themselves in the future, although also the importance of the socio-economic environment where we grow up and how it affects our life plans, gender issues and the education opportunities are spontaneously highlighted. The UN Agenda 2030 is therefore gently introduced as a tool that can help to bear in mind what really counts and not lose bearings.

Figure 1. In someone else's shoes

2.2. Day 2: plastic, waste, food and water

We start Day 2 with a well-known game about the story of thousands of rubber ducks.

- *Lost at sea* [2]: it is a game based on the ocean currents research carried on by Curtis Ebbesmeyer and James Ingram after a cargo ship lost at sea almost 30.000 friendly floatees [3]. The kids have to work in groups to draw on a planisphere the path of the floating ducks, using a bunch of advisory emails received by the research center within two years after the event, having the chance to see under no doubt the wide distribution of plastic due to ocean currents and thus estimating the impact of our action. So let's talk about plastic.

- *Plastic world:* the problem of plastic pollution relies on the huge amount of single-use plastic objects as exemplarily shown in Scarr & Hernandez's animation [4]. However, the activity provides an opportunity to reflect also on micro- and nano- plastic [5] and finally produce some bio-based plastic. We prepare with the students a type of "plastic" from expired milk and another from corn starch, this allowing us to introduce a debate on topics like the primary purpose of agriculture, the competition for soil exploitation, as far as waste reduction and circular economy. Despite feeling proud of our homemade bio-based plastic production, we provoke the students to consider whether bioplastic is always a solution or can raise a few issues, and to consider nonetheless the good properties of plastic materials: simply trying to drink some hot tea in a PLA cup!

Then, we abruptly move the focus to our diet and hand out to the students with a restaurant menu.

- *Healthy food:* divided into groups they firstly choose from the menu what to eat during a typical day and secondly select some activities from a list (i.e. running, swimming, reading, sleeping…). After planning the day, another group verifies if the decisions made are healthy and balanced counting out the calories provided and consumed. Based on the results, the students comment on the reasons behind our daily choices: processed food? Meat or veggie? Dessert and sugar? Fruit and vegetables? Furthermore, we should pay attention also to what we drink: a simple experiment shows the effective amount of sugar in a can of different types of soda. Drinking water does not add any calories, nontheless it is crucial for a healthy lifestyle. The body contains up to 70% of water, and what about the water hidden all around us?

- *Hidden water:* each group receives a bunch of objects (apple, coffee powder, chocolate, smartphone, milk, jeans trousers) to be ordered from the minimum to the maximum amount of water required for their production process. Then the groups compare their hypotheses, motivate each object's position and come to a common compromise. The facilitators finally give them the answers assigning to each object the amount of hidden water, expressed in liters, required for the production (Fig.2).

Figure 2. Hidden water

The focus of Day 2 is about water, starting from a sort of game following the floating ducks

ISBN 978-84-8158-937-5

(oceans currents and pollution), to the water in our body (health and food) and behind the common objects we use (production and consumption) the participants get the idea of interconnection among different SDGs and in the complex world we live in.

2.3. Day 3: cities, diversity, impact and responsibility

On the third day we go back to passports and travel, but this time the participants experience migration and living in countries with highly different cultures.

- *Happyland and Frigidtown:* the kids are assigned randomly to a fictional home country, whose they quickly learn the rules and habits: how people live, what is allowed and what is forbidden. After they have become familiar with their home country's lifestyle, they migrate to the other one, where they have to face the feeling of being a stranger in an unknown place, with no friends, a different language, and different rules. How do you feel? The game is inspired by a peace educational activity [6].

- *Sustainable cities and responsible citizens:* despite the cultural diversity of the world countries, the great majority of people live in cities: apart from some defined rules, we can decide how to act. Our behaviour can really make the difference and the kids share thoughts about this by playing a board game in the style of "snake and ladder" [7]. If you buy local products, you get ahead faster toward the finish, but if you go to school by car instead of riding your bike, then you must move back on the board game… the key is to be honest and listen to the opinions of others.

- *Ecological footprint:* can we measure our impact on the planet? Definitely yes, thanks to the footprint calculator [8] we can see how many planets would be needed if all the people in the world share the same lifestyle as us. It also helps to underline which aspect has the most remarkable impact: type of buildings, way of traveling, meat consumption, energy supply… In conclusion, everybody makes a commitment to change a little thing in his own life, writes it clearly on a piece of paper… and puts it below a footprint sign! (Fig.3)

As it clearly appears, Day 3 is centered on humans: migration, gender gap, jobs, relationships, cities, infrastructure, personal decisions, and lifestyle… although role play and games make it funny, these remain serious topics.

Figure 3. Footprints and personal commitments

2.4. Day 4: biodiversity, ecosystems, climate and partnership

Day 4 is for the Planet.

- Ecosystem structure: starting from the familiar terrestrial wood habitat, we propose a game where each kid is given a mysterious animal and should guess which is the animal only by asking "yes or no questions" to the other participants. Thus, they learn about the physical appearance of the animals, their diet and the habitat where they live. Then we move to the marine ecosystem of the Mediterranean and we build up together and learn about the food net connecting prey and predator. What's more, we add an exotic species… can you guess the impact on the whole ecosystem? The biodiversity is threatened particularly by human action and climate change, the latter requires proper investigation.

- Climate change: as scientists, the kids perform some experiments on the consequences of climate change: sea level rising, ice melting and ocean acidification [9]. Then, they share the results gained and the facilitators show the future flags of some counties according to the meltdown flag project [10] and give a historical overview of the last century's temperature rise with the Climate Stripes [11].

- Collective action: in conclusion, we propose a cooperative game to help the kids understand the importance of partnership toward a sustainable future. They look again at the 17 SDGs presented on Day 1 and need to work as a big team to collect some small objects (representing the SDGs) with a particular tool consisting of a hook that can be

ISBN 978-84-8158-937-5

actioned by several people by multiple strings… do you need a leader or can you work as a coordinated team? (Fig.4)

Figure 4. Learning how to cooperate

3. Tinkering space: the Factory of good ideas

Every day, during the afternoon, the participants get access to a creative maker space (Fig.5). They have plenty of inspiring materials available, many objects from the waste bin (wastes become resources!), some tools (scissors, tape, glue), and special devices (motors, LEDs, electric cables, buzzers…).

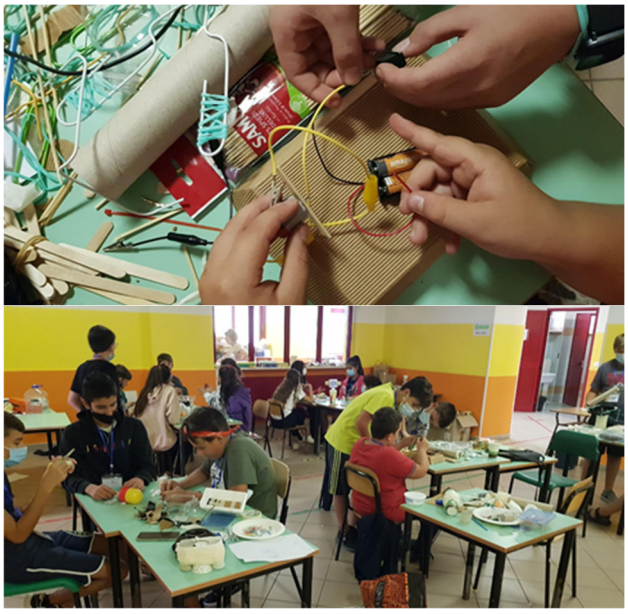


Figure 5. Tinkering space

They have some free time to explore the materials and then, working in groups, they have to design and build an object in order to solve a problem and help to achieve at least one SDG. Moreover, each group can upgrade the project with a programmable card BBC micro:bit [12]. All participants receive specific training on coding, necessary to move the first steps in robotic programming (Fig.6). This retraces the difference between an artisan, assembling components and creating“simple” mechanical objects, and an engineer, who works at a more advanced level of technology.

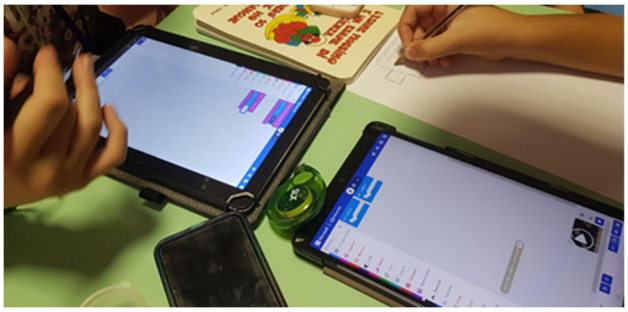


Figure 6. Coding with micro:bit

Figure 7. Wind turbine and food dispenser

To give a brief overview of the ideas collected by the kids,we must mention the following:

- a futuristic wind turbine (Fig.7);
- a special food dispenser to avoid waste (Fig.7);

- an airship for biodiversity monitoring;
- a portable basketball hoop intended for sports activities in poor countries' schools;
- an eco-friendly and cheap aircraft for climate migrants;
- a spaceship to explore Mars;
- a peace drone to supplymedicines in war zones.

4. Conclusion

The junior summer school was found to be an enriching experience for the 40 students that joined us. Some of them answered a short evaluation form and it came out that nobody had ever built an electric circuit or done coding before. This does not come as a surprise, since such tools and instruments are usually not available at school. In this regard, the need for STEM education programs has still to be strengthened in Italy and SDG 4 has a crucial role in the whole framework of sustainability in our country.

On the other hand, we ask the participants about the SDGs, and unexpectedly about half of them already knew about the UN Agenda 2030, meaning that school teachers had introduced some sustainability lessons along the year. This makes a point in favour of our school system, and confirms that formal and informal learning environments can find good overlapping spaces: therefore, as an association fostering science education, we wish to have further opportunities to work side-by-side with school teachers to plan innovative and effective programs.

FInally, theparticipants expressed great enjoyment and said they would recommend their friend to participate in a similar program. So we hope to replicate the summer school in the following years.

5. Acknowledgements

The project was founded by CRT Torino and hosted by I.C. Pinerolo V – Cumiana (TO).

6. References

[1] https://unstats.un.org/sdgs/report/2021/

[2] 2010 National Earth Science Teachers Association http://windows2universe.org

[3] Hohn D, Moby-Duck, Viking 2011

[4] https://graphics.reuters.com/ENVIRONMENT-PLASTIC/0100B275155/index.html

[5] https://youtu.be/KpVpJsDjWj8

[6] Ferracin L, Gioda P, Loos S. Giochi di simulazione per l'educazione allo sviluppo e alla mondialità, Rivoli: Elle Di Ci, 1990.

[7] https://www.thecrafttrain.com/printable-earth-day-game-for-kids/

[8] https://www.footprintcalculator.org/home/en

[9] Ocean Acidification: Eight experiments for students and teachers. Helmholtz Centre for Ocean Research Kiel, 2012 https://www.yumpu.com/en/document/view/37738683/eight-experiments-for-students-and-teachers-bioacid

[10] https://www.meltdownflags.org/

[11] https://showyourstripes.info/s/globe

[12] https://microbit.org/

ISBN 978-84-8158-937-5

CODELASTRO. A STEM Project for Code Learning with Astronomical Ideas

H Cachetas[1]*, VM Martins*[2]*,*
MFM Costa[3]*, JP Vieira*[4]
[1]*AE André Soares in Braga, Portugal*
[3]*Centro de Física das Universidades do Minho e do Porto, Portugal*
[1,2,4]*Casa da Ciência de Braga, Portugal*
henrique.cachetas@gmail.com

Abstract. Learning how to use and to be able to program computers and other computer based or artificial intelligence devices is becoming of high importance in today's modern societies. Micro:bit is a device that can be used to introduce children and students to this world. Micro:bit is a pocket programmable device that allows children and young people to learn how to program in a simple, playful and creative way. On the other hand, astronomy is an important science topic that appeals to the imagination and wonder of children, therefore contributing to their motivation and in promoting interest in science. Based on these two ideas, a STEM project named "Code Learning with Astronomical Ideas", codename CODELASTRO, was developed and is going to be presented herein. The core project idea was to create a code learning-program based on micro:bit and astronomical topics. The micro:bit integrated sensors allow the development of STEM projects, in which children and young people, almost autonomously and in groups, can learn by going through all phases of design, development, coding, testing and execution. Exploring the relationship of programming and astronomy gave us an opportunity to teach how science can be challenging and attractive to young people. The initial target audience of the CODELASTRO project was students and teachers from developing nations, Mozambique and East Timor in particular. It was proved that this project can be successfully implemented in such countries with limited resources and facing developmental challenges.

Keywords. STEM Projects, Astronomy, Coding.

1. Introduction

The CODELASTRO project is a code learning program based on micro:bit and astronomical topics. The project team, based at Braga Ciência Viva Center's (CCVB) in the north of Portugal, has partnered with schools in Mozambique and Timor-Leste to respond to a funding application of Office of Astronomy for Development (OAD), a joint project of the International Astronomical Union (IAU) and the South African National Research Foundation (NRF) with the support of the Department of Science and Innovation (DSI).[1] These funded projects use astronomy, space/related topics to tackle challenges in their communities and regions in order to promote sustainable development and create a better society. CODELASTRO implementation plan began by creating partnerships with schools that do not have access to this type of technological education, due to lack of means, which permitted a selection of children and young people in order to reduce inequalities. The chosen schools were Portuguese School of Mozambique and Portuguese School of East Timor, two Portuguese speaking countries. This kind of projets are an excellent way of exploring and investigate the metacognitive approach of science, Inquiry Based Science Education (IBSE). This approach gives students a metacognitive understanding of procedures leading to discussion, communication and argumentation among peers. The creation of ideas and solid cognitive structures gives to this project a way of linking science to society. [2] For young students and teachers, graphical coding is far easier and more adequate than dealing directly with coding languages. The use of the Makecode graphical programming tool appeals to the learners with its commands, simple or more advanced, represented by graphical blocks that the user will place on the programming board connected in a proper sequential way. Micro:bits were sent to schools in Mozambique and Timor-Leste (Fig.1). Then the team held online meetings with teachers in the partner schools to determine the structure and contents of a workshop for code learning based on astronomical ideas. This resulted in a learning guide to help teachers and students learn about the project.

ISBN 978-84-8158-937-5

Figure 1. Set of materials sent to East Timor and Mozambique

The replication of the project was made possible through online training of teachers in those schools through 7 webinars with hands-on activities for learning coding with astronomical ideas (Fig.2). Afterwards, those teachers implemented this learning guide with students of their own schools (Fig.3).

Figure 2. School teachers in Mozambique and East Timor (on screen) learning about Micro:bit and Astronomical Ideas

Figure 3. Children learning about Micro:bit and Astronomical Ideas

The resulting guide and training sessions aimed at the following:

A Mission to Mars was decomposed in several stages in order to be replicated in a simplified way through micro:bit coding and its sensors. Project based learning included the following projects:

- Stage 1 – Astronaut training, reflexes training and reaction time;
- Stage 2 – Rocket launch, acceleration measurement;
- Stage 3 – Space trip, cabinet pressure, monitoring temperature and radiation, sound warnings;
- Stage 4 – Landing, distance to ground, contact;
- Stage 5 – Robot in Mars, robot control, temperature in Mars, climate station.

We can synthetize the project results as follows:

- 7 online training sessions which included 12 professors of different disciplines.
- 10 presencial sessions at Braga Ciência Viva Center's in order to develop and test our methodology and create the learning roadmap, which involved 150 students.
- Sending electronic materials necessary for this project in East Timor and Mozambique.
- Elaboration of a guide for code learning with astronomical ideas, which is available online.
- 1 dissimination activity, both face-to-face and online, at our local University for a public of 20 international teachers from Greece, Estonia, Kenya, Malta and Portugal.

2. Educational Robotics

Educational Robotics is included in a comprehensive spectrum of activities of the so-called Physical Computing, defined as the creative development of interactive objects or systems using programmable hardware. [3]

With this type of teaching processes, it has been demonstrated that learning happens more effectively in a context in which the learner is consciously involved in the construction of a real, visible and tangible object. Likewise,

physical devices naturally support an exploratory diy approach, in which students learn to build on existing knowledge by following a step-by-step problem-solving pedagogy in a collaborative and active way [4]..

From the student's point of view, physical computing can become more positive than a more traditional approach in front of the screen. Students are naturally interested in building real devices with tangible physical functions and results, stimulating their creativity. It has also been reported that female children and young people, following this teaching method, are more interested in programming than traditionally. [5]

The benefits of educational robotics can be summarized as follows: [6]

- Motivation: the motivation of students increases, including those from adverse social contexts, because the learning experience and the result is tangible and not just virtual. This is especially true when programming tasks result in a practical and meaningful product.
- Tangibility: the physical nature of the devices helps to create connections in a natural way. Identifying and correcting physical system errors helps students to better understand the concepts of programming and the software development process. The fact that the result of the students' work can be seen and tested leads to a concrete understanding of the content transmitted.
- Collaboration: working with devices often leads to the need to work in groups, each student assuming a different role: design of functions, hardware interface, algorithm and user interaction. Students in each group can collaborate (or compete) due to the physical nature of challenges and tasks.
- Creativity: students relate in a practical way to devices and tasks, awakening their creativity and applying it to what they are building, thus promoting interest and autonomy in tasks.

3. About the Micro:bit

Micro:bit [7] was launched as part of the BBC's Make it Digital educational project [8], which Microsoft joined to create the programming environment, Makecode [9], which only requires a browser and internet access. The Micro:bit board is designed to be visually appealing, tangible, economically accessible, easy to use, interactive and extensible. Its integrated sensors allow the development of scientific, technological, engineering, artistic or mathematical (STEAM) projects, in which students can learn and lead all phases of design, development, programming and execution. Micro:bit's electronic expandability also allows the connection of external sensors, as well as connection to other devices and robots. The Micro:bit system includes: buttons A and B are binary sensors that only assume two possible states: pressed and not pressed. Buttons A, B and A+B can be programmed independently; the golden logo is a touch sensor that acts as the touch screen of a mobile phone, measuring small changes in electricity. It can be used to launch different actions such as when touching the sensor or when we take our finger off it; the accelerometer sensor values acceleration/inclination on the three axes x, y, and z (Fig.4), returning values between 0 and 1023 for accelerations between -2g and +2g. The x-axis values the lateral slope (left-right), the y-axis values the longitudinal slope (front-back), and the z-axis sees horizontal rotating movements. With these sensors (Fig.5) it is possible to detect movements such as shaking, shocks, measuring steps, etc; the magnetometer sensor measures the strength of the magnetic field on each of the three axes. It is useful for serving as a compass, metal detector or magnetic field generated by a magnet; the temperature sensor is that of the ARM processor itself, so the returned value is slightly above room temperature. For this reason, it is necessary to introduce a temperature correction in the code through a simple mathematical operation; the micro:bit light sensor is embedded in the LEDs themselves, which allows we to measure the light intensity in the surrounding environment, returning values between 0 (total darkness) and 255 (direct sunlight). The detectable light spectrum is wider than visible light, so it can also detect infrared light, for example from a television controller. By coupling the micro:bit to a robot, we can use this sensor to create a light tracking function. Projects can be made that take advantage of the fact that light is only a

ISBN 978-84-8158-937-5

small part of the light spectrum, creating analogies with other radiation; In addition to being possible a sound output through the pins, the micro:bit has incorporated a magnetic PCB speaker to make itself be heard. Likewise, the MEMs microphone provides a sound input, with an LED in front of the micro:bit to indicate when the microphone is turned on.

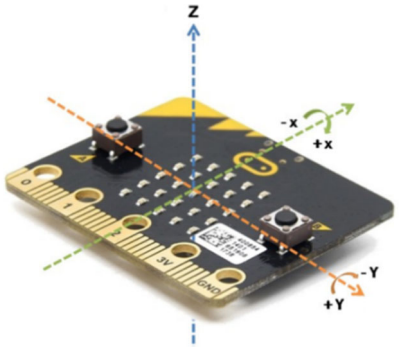


Figure 4. The axis of micro:bit gyroscope

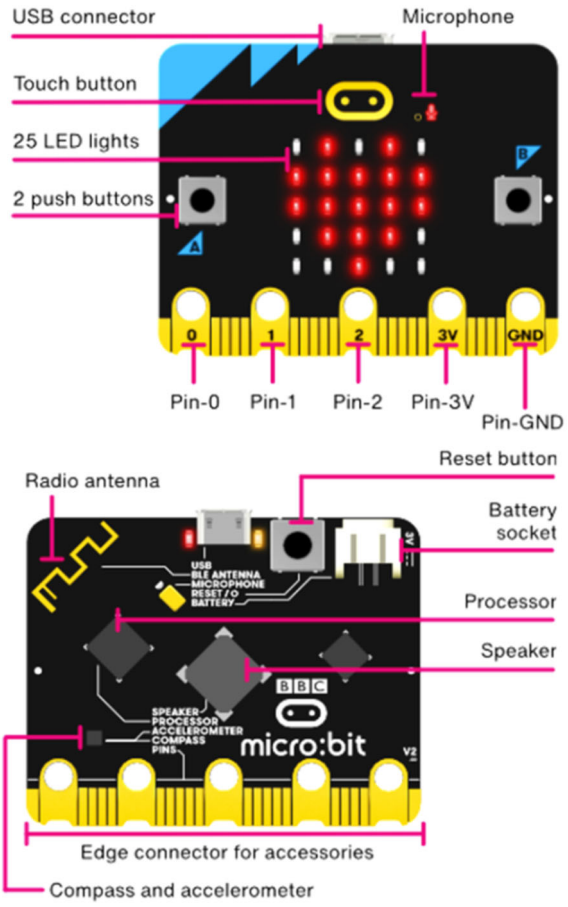


Figure 5. Features of the micro:bit

4. Learning roadmap

In this project, the most used pedagogical method to teach programming and micro:bit robotics with children and young people, as well as with teachers, was project-based learning. Instead of long theoretical exposures about the board and its programming resources, all explanations are transmitted throughout the implementation of practical projects, in which students are oriented to a concrete and attainable goal, applying the necessary tools. With the development of each project, doubts arise about how to solve the problems presented, before which space should be given to collaborative discussion and the creativity of each one to solve them. Achieving concrete and visible objectives quickly and easily, at least in the first projects, greatly increases enthusiasm and concentration on subsequent projects. An interesting strategy was to carry out a project that includes several subprojects. The project titled "Mission to Mars" includes smaller subprojects: launch (countdown and accelerometer), radiation exposure (luminosity sensor), communication (bluetooth messaging), and temperature difference between Earth and Mars (temperature sensor).

4.1. Stage 1 - Astronaut Training

Astronauts live in extreme conditions and their bodies experience many effects that can potentially diminish their normal abilities, so their training should include exposure to situations similar to those they will encounter in space. On a manned mission to Mars, astronauts should have diet changes, movement restrictions, changes in their sleep patterns, breathe artificial atmosphere and be subject to extreme pressure changes.

4.1.1. Electronic "badge"

With this project students can take a first contact with the micro:bit board and with the makecode programming environment. In order to create a badge through which they can show their names, various functions of the micro:bit can be explored, as is the case of the matrix of LEDs, the presentation of texts, icons or the use of buttons. This code (Fig.6) includes the function of "show LED´s", which can be activated one by one according to the desired drawing. This function has been added within the "forever" command, which indicates that the code will run indefinitely until other commands come to intervene. With the input function "On button A pressed", the student's name will be shown, after which the drawing will appear again on the LEDs.

ISBN 978-84-8158-937-5

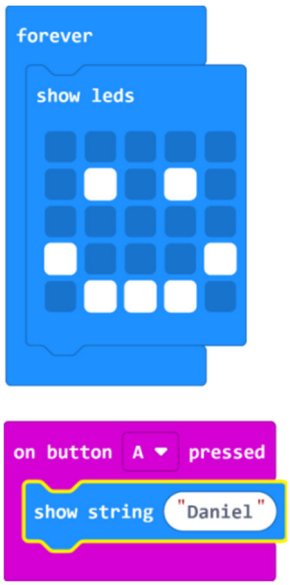


Figure 6. Code for LEDs and butons

4.1.2. Rock Paper Scissors

Here we introduce a playful aspect by creating a game well known to everyone that is the Rock Paper Scissors. This game can serve, for example, to decide which "astronaut" will go into space. We use a new input method, the "shake" function, which will trigger the game.

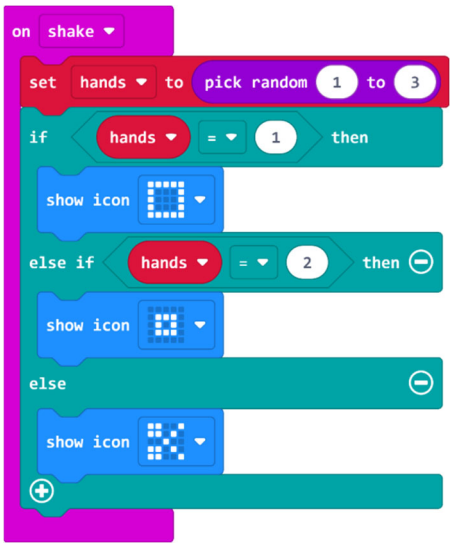


Figure 7. Code for "Rock Paper Scisors"

For this it is necessary to define a random variable between 1 and 3, here called "hand", followed by a conditional function. If the hand is equal to 1, the rock-shaped LED´s are shown. If 2, the paper form. And if 3, the form of scissors. In this way it is possible to explain what variables are (very important aspect in programming), random functions and conditional functions. It can also be explained how the "shake" function works, which uses the integrated accelerometer sensor (Fig.7).

4.1.3. Trainning reflexes

Having quick reflexes is vital for astronauts as they can deal with unpredictable incidents or projectiles at high speed. Astronaut reaction times can be improved through training, or they can get worse in case of distraction or by the effect of drugs or alcohol.

4.1.4. Catching the Ball

Continuing with a playful design, this is a simple code that uses basic game functions included in makecode to simulate the training of reflexes. The game consists of a ball that must be caught when it is in the center. An LED moves horizontally back and forth and the A button should be pressed when the LED is in the center of the matrix, adding up a point. Otherwise the game is over and the final score is shown.

With this simple game it is possible to resume the theme of variables and conditional functions (Fig.8).

In addition to these, the functions of games such as sprite (red dot), "move by", "if on the edge, jump", as well as scoring and "game over", are also used. Changing the pause number changes the sprite speed and the degree of difficulty according to the astronaut's reflexes.

4.1.5. Measure reaction time

By elaborating a slightly more complete project, we can measure the reaction time by taking a series of measurements and finding their average value. The effects of distraction on reaction times can also be explored.

Although not mandatory, we can use an outside LCD module to show the reaction time values. These values could, alternatively, be presented in the micro:bit LED matrix itself.

The LCD module must connect to a shield card or expansion card as shown in Fig. 9. In the case of the LCD, the red wire must be connected to the 5V connection of the shield card. Once the connections are made, a Makecode extension is added to control the

ISBN 978-84-8158-937-5

LCD, searching in the field of extensions for "LCD" or "LCD1602".

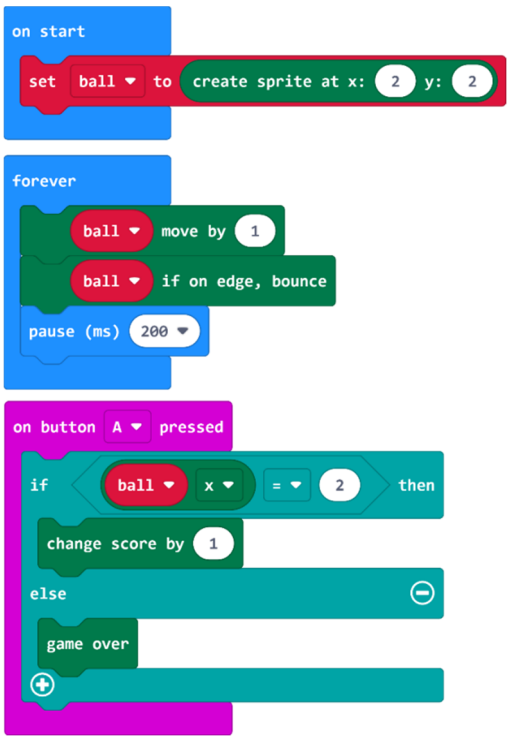


Figure 8. Code for "Catching the ball"

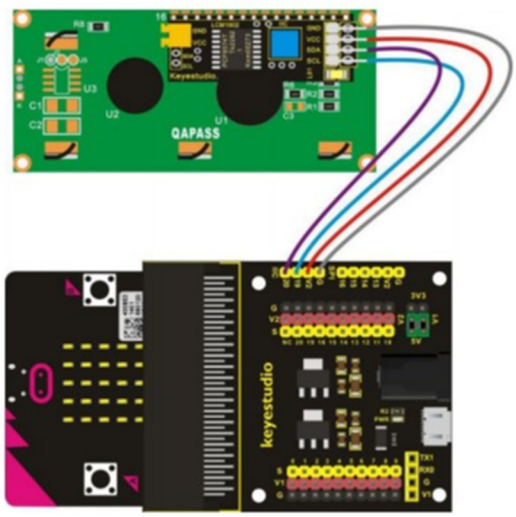


Figure 9. LCD connectiob to shield

A simple way to program the LCD in Makecode to measure reaction time is shown Fig.10.

To frame the use of this code, we can remember that reflexes are rapid responses of human beings to the environment. These reflexes involve the nerves that connect the spinal cord to the muscles, which give rise to the response. Some reflexes involve decision-making by the brain, which implies a reduction in response time. For this reason, reaction times can be improved with training, or else be impaired by distractions or mental changes caused by alcohol, for example.

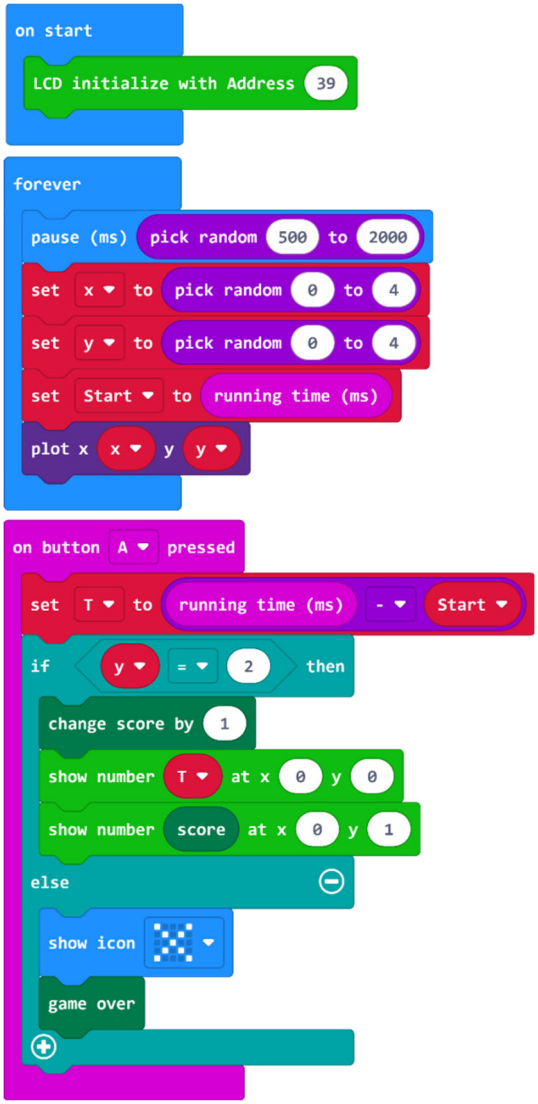


Figure 10. Code for "reaction time"

4.1.6. Step counting

Astronaut preparation requires numerous exercises to check their physical ability and train mobility in the harsh environment of space. We will train the astronaut to slow down his steps, which could jeopardize the success of his mission. This project aims to convey that the micro:bit can collect numerical data from acceleration, and apply a limit to sensor data to enable events when the number of steps is increased (Fig.11). We could resort to the "On shake" function that recognizes the typical movement of the human being when walking. However, this function may not return the most correct data, since it is possible that not all

ISBN 978-84-8158-937-5

steps are recognized. Thus, we used the numerical data of the accelerometer, accepting as steps all accelerations with a value greater than 1500. We may need to change this number to make the step count more accurate. This modification on the activation threshold is called "calibration".

Figure 11. Micro:bit attached to shoe [10]

It should be noted that when the micro:bit is not moving, it gives a reading of about 1000, which is caused by the earth's gravity exerting this force on the micro:bit. By placing the micro:bit into the shoes, astronauts can train walking very slowly, placing a limit on how many steps they can take, non-stop, in 20 seconds, for example (Fig.12). To this end, a second micro:bit may be programmed to count the seconds (Fig.13).

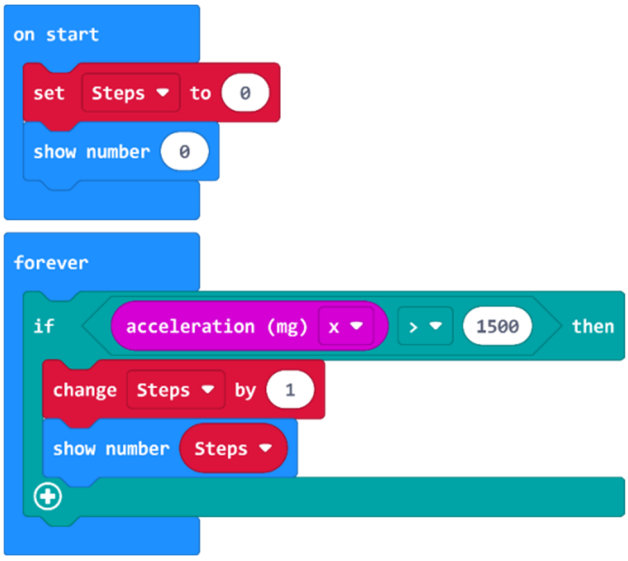


Figure 12. Code for step counting

As a design improvement, in order to save the micro:bit battery, we can prevent the LEDs from being permanently connected to show the steps already taken. Thus, we can program so that only when the A button is pressed appear the steps already taken. Alternatively to walking slowly, it can also be recorded the number of quick steps each astronaut can do in the same amount of time.

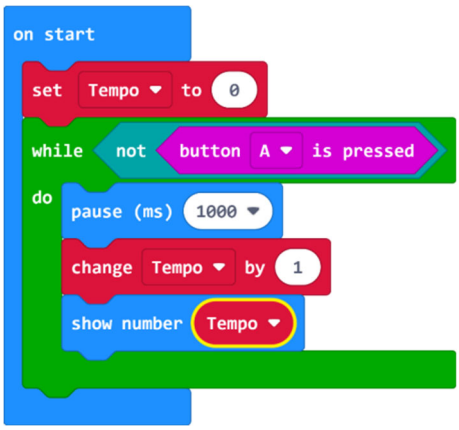


Figure 13. Code for timer

4.2. Stage 2 - Rocket launch

The launch phase requires extreme care and several series of tests to verify that everything is in a condition for the rocket to take off. The countdown, i.e. the decrescente count for NASA launches, typically begins two days before launch. It is necessary to carry out electronic checks on the systems, verify that there are no leaks in the fuel tanks, and ensure that the mechanical systems are working properly. [11]

4.2.1. Gas and pressure detection

We can simulate a gas detector to check for leaks using a smoke sensor or gas sensor. Similarly, we can use a pressure sensor to simulate checking the pressure inside the fuel tanks, or inside the chambers where the astronauts are. The various fuel tanks can contain liquid oxygen, liquid hydrogen and kerosene, among others, which once mixed or activated generate the combustion that will boost the rocket. A small leak can compromise the entire mission, so it's essential to detect them before launch. These gas leaks can also occur in our daily life as well as inside the astronaut cabin. If a toxic or flammable gas is released, a major risk to the health of the people occurs.

ISBN 978-84-8158-937-5

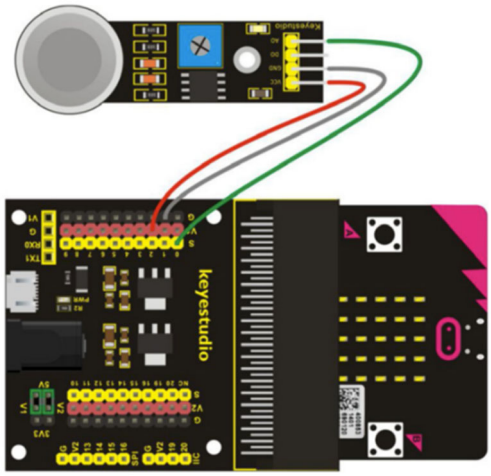


Figure 14. Analog gas sensor connection scheme

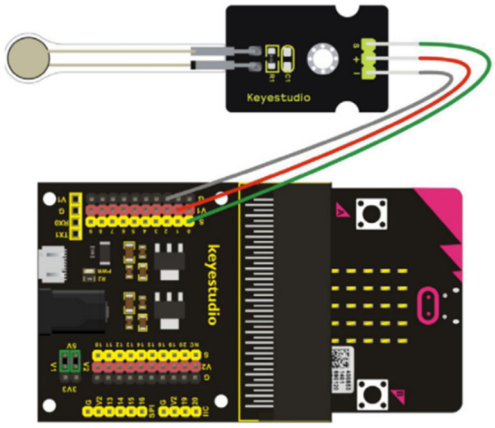


Figure 15. Analog pressure sensor connection scheme.

For this project we will use the analog gas and pressure sensors, whose connection to the micro:bit is carried out through the shield plate (Fig.14 and Fig.15). We display the connections of each sensor separately, although they can also be connected together, taking into account the programming for analog reading on the respective connection pin to each of the sensors. In order to be able to observe the evolution of sensor readings on the computer, the micro:bit with the makecode must be paired. After transferring the code to the micro:bit, the console can be opened to see the collected data (Fig.16). A file with data can also be downloaded to be analyzed later, or added to excel to make graphics.

If, in addition, we want to add a warning sound indicating the presence of flammable gases, we may use a passive buzzer module by programming as shown in Fig. 17. The code is programmed for the gas sensor to be read on pin 1 and the pressure on pin 2. Whenever the sensor signals the presence of gas (values less than 1000, in this case), a sound will be emitted through the buzzer, connected on pin 0.

Figure 16. Reading of sensors data

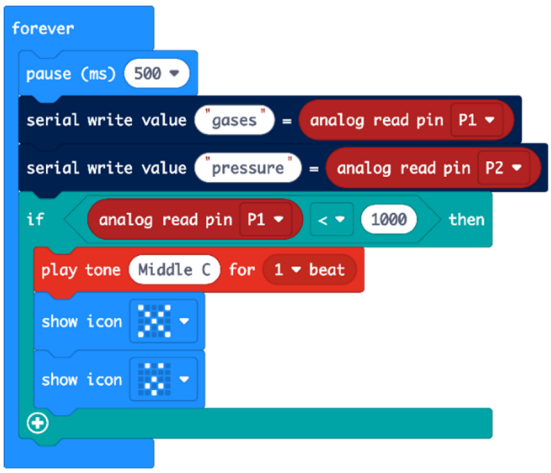


Figure 17. A code to read touch sensors

4.2.2. Acceleration

Understanding the difference between speed (measured in meters per second) and acceleration (measured in meters per second squared) is one of the essential learnings in physics curriculum. However, there is a common confusion between these two concepts, as to the terminology or units used.

One of the concepts to have in mind is that rockets require a large amount of fuel to reach the escape velocity of the Earth's gravitational field and be launched into space. However, they do not require fuel when they are traveling at a constant speed, as there are no forces of resistance to movement in space. In order to understand the difference between speed and acceleration, we can program the microbit to turn on the LEDs when it is accelerating, keeping them off when the speed is constant. With this code (Fig.18), students can be asked to move the micro:bit without the LEDs on,

ISBN 978-84-8158-937-5

since for this they can not apply too much force. If the LEDs light up, it means that the acceleration has passed the established limit.

We can also draw a code to show a graph of the acceleration obtained (during rocket launch), recording the maximum of the accelerometer sensor reading (Fig.19).

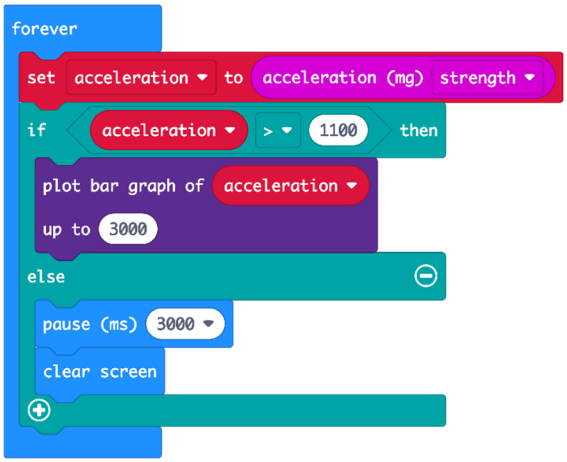


Figure 18. Code to light the LEDs when the acceleration is greater than the 1100 limit, turning off when it is lower

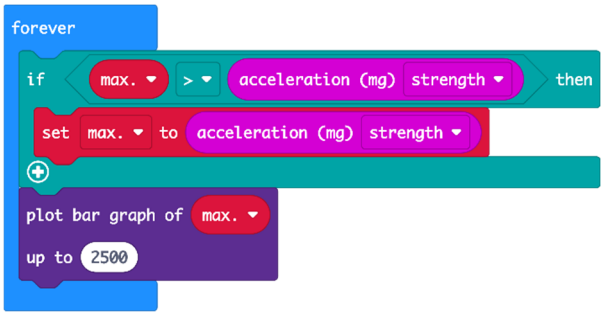


Figure 19. Code to show the graphics with the maximum acceleration value obtained by the micro: bit

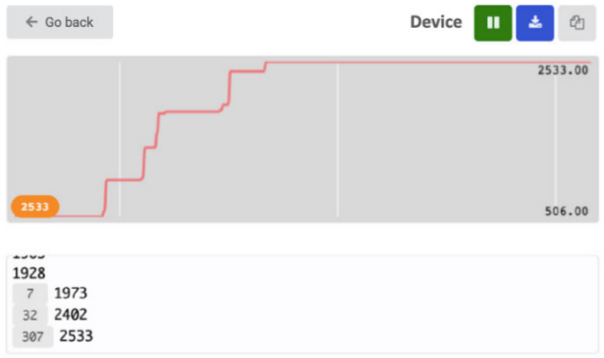


Figure 20. Console with graphics of real-time micro:bit accelerometer sensor values

In order to follow the concrete values of the sensor reading, we can open the console in Makecode to view, record or download the measured acceleration values (Fig.20).

If students move the micro:bit too fast, the LEDs will light up, but they won't be able to keep it that way for long. It is interesting to note that for LEDs to stay connected, a considerable amount of constant force is required. This may be related to the force required to launch a rocket into space, which must be maintained for as long as necessary until it reaches the required altitude and speed.

4.3. Stage 3 – Travel

During the trip some permanent care should be maintained for the safety of the rocket and astronauts. We will use three sensors to analyze important factors: radiation exposure, pressure and temperature inside the astronaut cabin.

4.3.1. Conditions in space

Even at relatively low altitudes on the Earth's atmosphere, conditions are hostile to the human body. The altitude at which atmospheric pressure equals the vapor pressure of water at the temperature of the human body is called the Armstrong Line. It is located at an altitude of about 19.14 km. Above this line, fluids in the human body, especially from the lungs, can begin to boil (evaporate). Therefore, above this altitude human survival requires a space suit or a pressurized capsule. There is also a thermodynamic relationship between pressure and temperature. Since temperature is the result of particle movement, the heat or cold senses will be the result of the interaction of these particles with our skin. When the pressure increases, it also increases the number of particles by volume quantity, and therefore increases the interaction between the particles. For this reason, the higher the air pressure around us, the higher the temperature. In space, however, there is no air, that is, there are no moving particles and therefore there is no temperature. We can not say that the temperature of the space is high or low, it simply does not exist. When exposed to the vacuum of space, the astronaut will not gain or lose temperature through convection or conduction (only existing in the presence of air), but will be exposed to radiation temperature transmission. Direct exposure to

ISBN 978-84-8158-937-5

sunlight, without the protection of the atmosphere or an appropriate suit can cause serious damage. Exposure to high-energy radiation and ionizing cosmic rays present in space can also have serious consequences on astronauts' health. On a mission to Mars, whose round trip can last three years, a large fraction of the astronaut's body cells can be traversed and potentially damaged by high-energy nuclei. The energy of such particles can be significantly decreased or blocked by a shield on the walls of the spacecraft.

4.3.2. Temperature

The micro:bit board has its own temperature sensor, associated with the processor temperature. However, for the same reason, the temperature obtained is not exact, since the temperature of the processor itself varies the reading, diverting it from the surrounding temperature value. To obtain a value closer to reality, we must calibrate the reading subtracting the difference, comparing with the temperature measured by a more rigorous thermometer. Despite this, the difference is only about 3 degrees, so it can be overlooked without affecting the purpose of the project.

4.3.3. Radiation

Likewise, the board also has a light sensor, which is measured through the LEDs themselves. By making the relation of visible light with electromagnetic radiation, this project can be explored to explain what radiation is, the existence of a visible and invisible spectrum, as well as the extreme radiations that can exist in space without the protection of the atmosphere (Fig.21). With this code, the temperature and brightness of the environment will be shown in real time.

Changes in this environment can be explored by increasing the temperature (approaching a heat source, or exposing it to the sun, for example), as well as changing the amount of light (representing radiation) in the environment. These changes can be logged over time and used to perform charts and tables with the recorded values. The connection to the LCD is performed in the same way as explained earlier (section 4.1.5.).

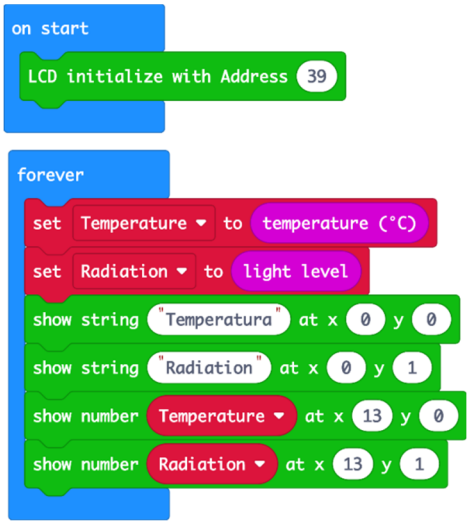


Figure 21. Code to show temperature and brightness readings on the external LCD

4.3.4. Cabin pressure

Pressure can only be measured through external sensors, since the micro:bit does not contain this built-in sensor (Fig.22).

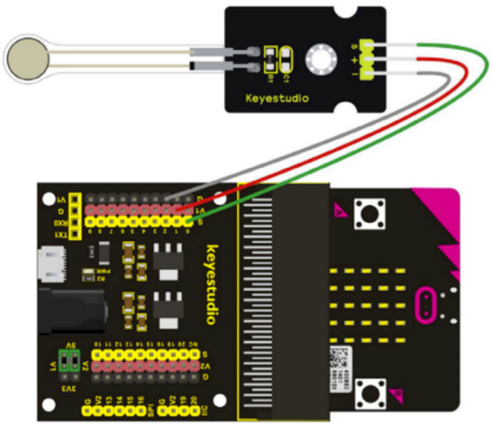


Figure 22. Pressure sensor connection scheme

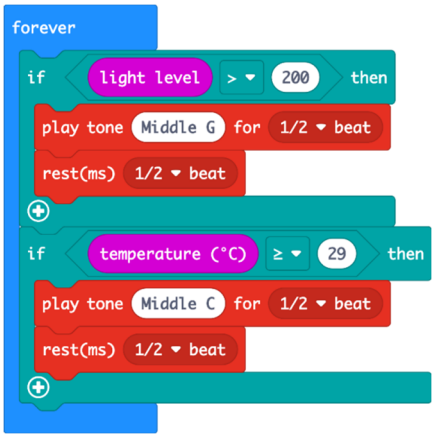


Figure 23. Code to beep when temperature and radiation limits are exceeded

If we want to connect multiple sensors at the same time, the connections must be made using different pins for each connection, with the consequent change in the makecode codes. The result of this programming can be tested by placing the sensor inside a balloon, which can be pressed to change the air pressure inside.

4.3.5. Audible warnings

To complete previous projects, we can set an audible warning whenever a temperature or radiation value is found above a previously established limit. With this code (Fig.23), the micro:bit (V2) will emit a warning sound whenever the radiation passes 200 and the temperature of 29ºC. In addition to an audible warning, an action could also be triggered through an external actuator. For example, an engine could be activated that would simulate the closing of an isolation gate of a section of the ship.

4.4. Stage 4 – Landing

The atmosphere entry, descent and landing is the shortest and most intense phase of a mission to Mars. On the Perseverance mission [12], the journey from the top of the atmosphere to the planet's surface lasted seven minutes, during which hundreds of critical events must be executed perfectly for a safe landing. To replicate the descent and landing, we can use several external sensors, including the distance and contact sensors.

4.4.1. Distance

As the rover descends through mars' atmosphere, it is necessary to know how far it is from the ground. The ultrasonic sensor can simulate the calculation of this distance, through a method in everything similar to that of a sonar. It includes an ultrasonic transmitter, a receiver and a control circuit. The module will emit ultrasound waves that will be reflected when finding an object, sended back to the receiver as an echo signal. By calculating the signal return time, we can determine the distance to the object.

In order to use this module, it is necessary to install an extension of the makecode, which can be found by searching "sonar" in the extensions. This link uses pin 1 for trigger and pin 2 for echo, but other pins could be used by making their code change. Using the "Sonar" (Fig.24) option of the added extension, we can configure the sensor to return the distance to the object as shown in Fig. 25.

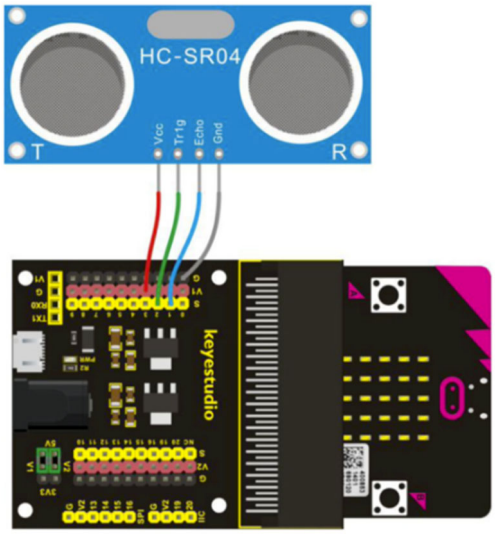


Figure 24. Ultrasonic sensor connection scheme

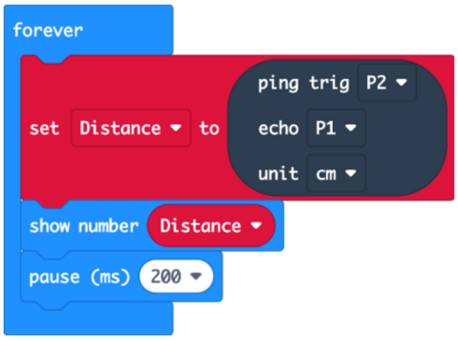


Figure 25. Code to get distance to ultrasonic sensor

This code will cause the distance to appear in centimeters on the micro:bit LEDs, but could also be programmed to show the distance value on an external screen, as previously programmed. This sensor could also be programmed together with a beep.

4.4.2. Contact

Contact with the ground on another planet is the most exciting moment of a space trip, as a good landing means the arrival at the ultimate goal of the journey. Contact is, after all, a controlled collision at a low speed, in order to avoid damaging the rover. That is why the sensor we're going to use is the collision sensor. The micro:bit, through its internal

ISBN 978-84-8158-937-5

accelerometer sensor, has the possibility to measure the force of a collision, however its sensitivity is too imprecise for it to be used reliably. The collision sensor, on the other hand, only allows we to understand whether or not there was contact, not measuring the force of that impact. This sensor, also known as an electronic switch, is a button-like module, which gives rise to an on-off digital signal. We will program this sensor in conjunction with an external buzzer so as to produce a contact signal as soon as the collision sensor is activated. We must note that in the connection diagram (Fig.26), the collision sensor is connected to pin 0, while the buzzer is activated via pin 7 (Fig.27). The collision sensor gives the value of 0 each time it is pressed, and 1 when it is not. We can also notice that the sensor has an LED that lights up whenever there is a collision.

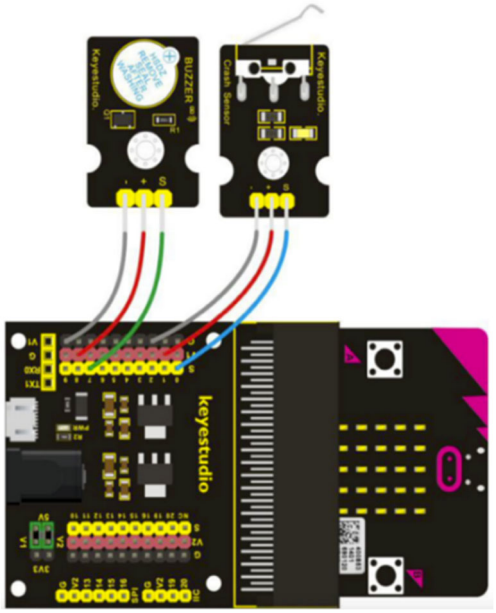


Figure 26. Conection schemes for buzzer and electronic switch

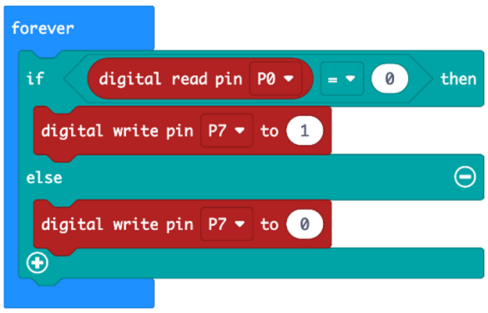


Figure 27. Code to get a beep when there is a collision

4.5. Stage 5 – Robot on Mars

After landing on Mars, the last phase of the mission begins, with a robot having to move and collect data from the Martian environment. Mars is being explored for eight missions currently: six in orbit — Mars Odyssey, Mars Express, Mars Reconnaissance Orbiter, Mars Atmosphere and Volatile Evolution Missile - MAVEN, Mars Orbiter Mission and ExoMars Trace Gas Orbiter — and three on the surface — Curiosity, Perseverance and the Chinese rover Zhurong. Among the deactivated missions that are on the Martian surface are the Spirit probe and several other probes and rovers, such as the Phoenix, which completed its mission in 2008, and Opportunity. Projects for simulating a rover on Mars may inspire students to research some of the missions mentioned above. This study may also include knowledge of the planet's physical characteristics, such as its atmosphere and climate, surface geology, soil and hydrology, craters, and volcanic activity.

4.5.1. Robot Control

We use Kitronik's "MOVE" robot [13] to replicate the rover on Mars. To do this, it is necessary to install the corresponding extension, searching for the word "move" (Fig.28). After installing the extension, new options will be available to control the lights, motors, sensors and actuators of the robot (Fig.29). In order to learn a basic method of controlling the engines, we will program a simple effect in which the robot moves in various directions.

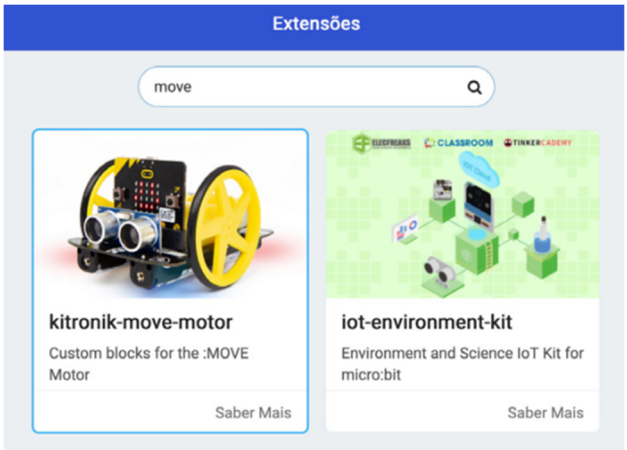


Figure 28. Adding :Move Motor extension

ISBN 978-84-8158-937-5

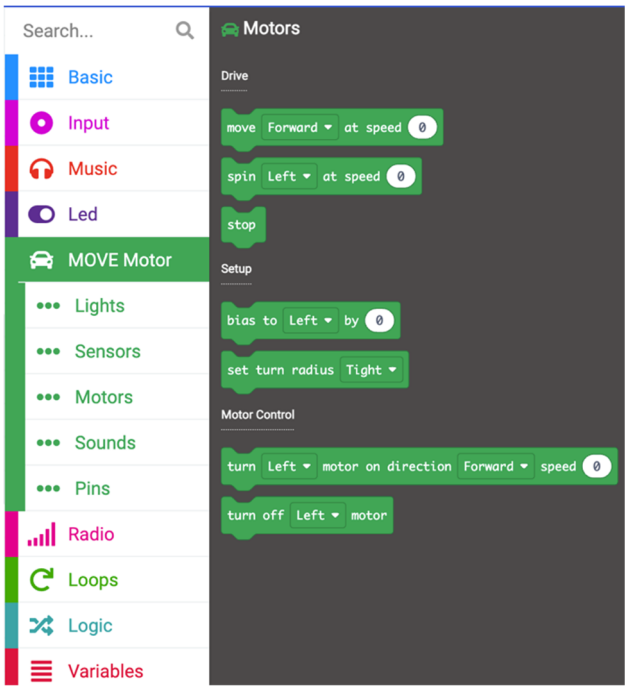


Figure 29. Move Motor functions

Engines can be programmed synchronized or with differentiated speeds. When one wheel is programmed to rotate at a slower speed than the other, the robot will move in the direction of the slower wheel. The pause between the engine instructions corresponds to the time the wheels will operate. Using a code with this type of commands, a route can be programmed between two points, bypassing obstacles, simulating the trajectory that a rover should make on Mars (Fig.30).

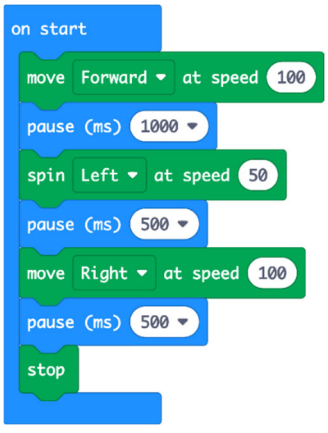


Figure 30. Code example for :Move Motor

4.5.2. Remote control

The robot, in addition to being programmed for predefined routes, can also be controlled remotely. However, it must be remembered that all communication between Earth and Mars must take into account the distance between the two planets.

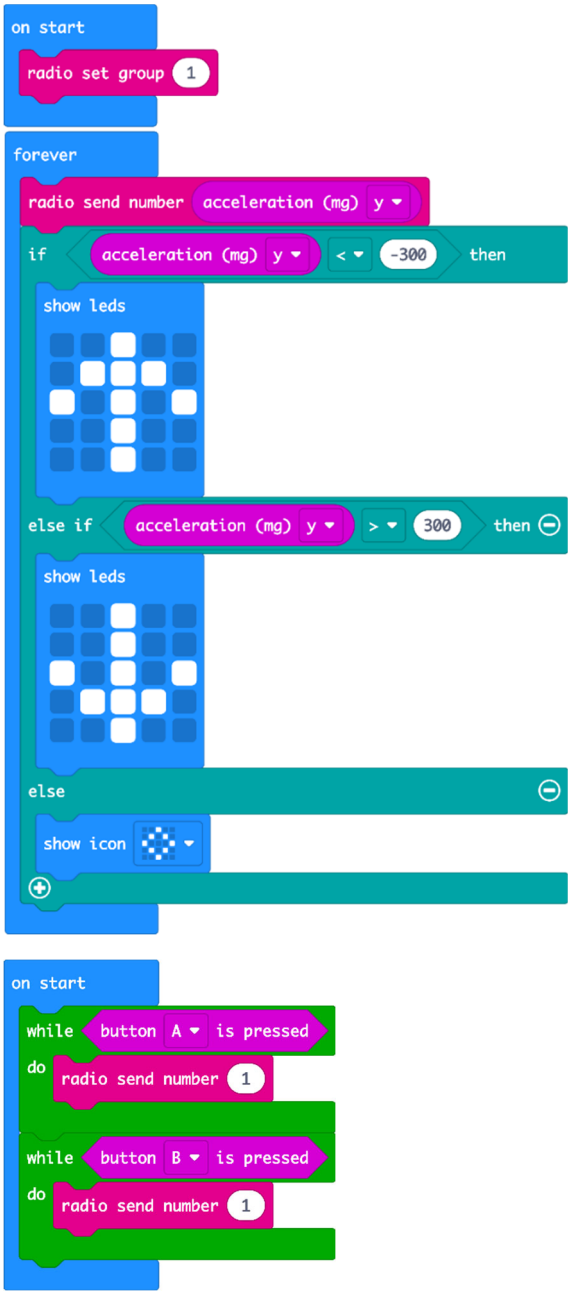


Figure 31. Command code for controlling the robot remotely

Depending on the relative position in their orbits, the signal sent from Earth may take 15 minutes to reach the red planet. In any case, for learning purposes, we can develop a distance control code. In the case of radio communication, after defining the radio group (the frequency), we will use the accelerometer sensor to control the robot by tilting the micro:bit (Fig.31). The acceleration on the Y axis is determined by the back and forth tilt of

ISBN 978-84-8158-937-5

the micro:bit, which is why we use this movement to move the robot in these directions. We want the robot to only move with a tilt value greater than 300, so that the controller is not too sensitive. For left and right shift, we use buttons A and B, sending a numeric signal for each direction. The micro:bit that will be coupled to the robot will make the movements depending on the data received. With a received number greater than 300 or lower than -300, the robot will walk back and forth respectively (negative Y values correspond to a forward slope). With the number 1 (sent by pressing button A) the robot moves to the left, and with the number 2 (pressing button B) to the right. With all the other numbers, the robot will stand still (Fig.32).

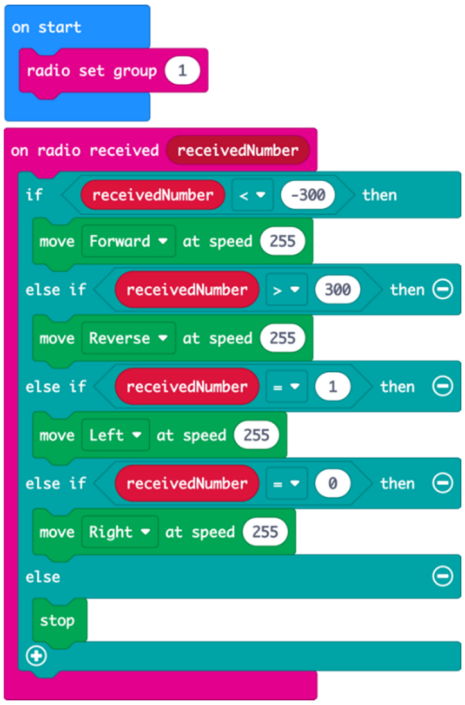


Figure 32. Code for Micro:bit attached to robot

4.5.3. Temperature on Mars

In order to simulate a temperature sensor installed on Mars that sends its value to Earth and vice versa, we should note that the average temperature on Mars is about -60ºC, while the average temperature of the Earth is about 15ºC.

This means that the temperature difference between the two planets is 75ºC. If we want the micro:bit corresponding to Earth to show the equivalent temperature of Mars, we can subtract 75 at the temperature received. For the use of the radio, it is necessary to define an equal radio group for the transmitter and receiver (groups can be defined between the values 0 and 255). The micro:bit temperature allocated on Earth is stored in a T-Earth variable, the value of which is sent by radio. When this micro:bit receives a numeric value (sent by the micro:bit allocated on Mars), that value is saved in the T-Mars variable. This value is continuously shown on a temperature chart through the LEDs. When the A button is pressed, the LEDs show the temperature value of Mars. The other micro:bit (equivalent to that on Mars) will have to have the variables reversed, as it will receive by radio the temperature of the Earth. This same code (Fig.33) can be used to continuously send the value of other variables, such as the inclination and orientation of the accelerometer and compass (simulating the position and direction of the rover), or luminosity (analogous to radiation).

Figure 33. Code sending Earth's and receiving Mars Temperature

4.5.4. Clima station

For the installation of a climacteric station for continuous data collection, we will use a Kitronic real time clock (RTC) & Klimate card (Fig.34). The environmental sensor of this plate

allows measuring temperature, barometric pressure and humidity, associating this data with the current date and time. This card already has a 3V battery holder to power a clock in real time while the micro:bit is not connected. The RTC card and micro:bit can be powered at the same time via a USB connection or through the terminal block.

Figure 34. RTC board

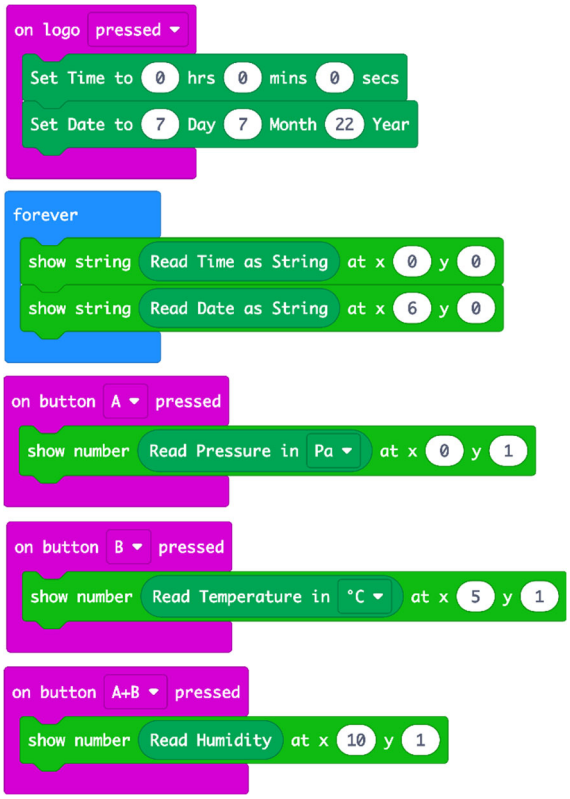


Figure 36. Code to show time, date, pressure, temperature and humidity

In order to define the beginning of time, we can create a code so that the time starts from scratch when we press the micro:bit Logo.

With this code, the micro:bit will permanently show the time and date until you press the A, B and A+B buttons to show atmospheric pressure, temperature and humidity, respectively (Fig.35).

For the use of this board, it is necessary to add the corresponding extension by searching for "kitronik klimate". To use the date and time functions, you must install the "kitronic-rtc" extension in Makecode.

In order to communicate this information to another micro:bit in real time, we just have to use the radio function (Fig.36), sending the name and values of each measurement.

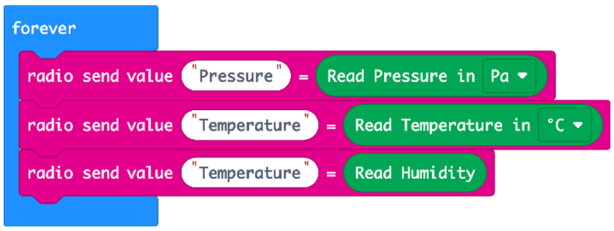


Figure 37. Code to send the measured values by radio

5. Conclusion

The CODESLASTRO project created coding competences and promoted the creation of opportunities, sensitising the school community to overcome the injustices imposed by geographical imposition, creating an enterprising and innovative project.

The authors concluded that in the initial phase of knowledge construction, autonomy and use of the programming language as a metacognitive tool and sharing, discussion, structuring, planning and interconnection with astronomy processes were predominant.

The CODESLASTRO project intended to be a contribution to alert to the importance of developing skills inherent to the concept of astronomy and programming and to demonstrate the need for its integration in the educational system, as it leads young people to relate and bring their learning closer to reality. On the other hand, it was intended to promote the formation of actors who are aware of the difficulties and opportunities associated to scientific and tecnological advances, capable of having an active and critical role on their own future, with a civic and intervening conscience

and a decisive role in the construction of a fairer society for all.

Regarding the use of programming as an educational resource to develop projects in collaborative work and with the project work methodology, this educational tool, with great potential, stimulates and develops collaborativism, and is also an excellent vehicle to develop the project work methodology.

Activities involving programming and robotics, in project-based learning, allow students to develop skills for the XXI century. They can also be used to stimulate the interest and skills in STEM (Science, Technology, Engineering and Mathematics). The use of these technological tools in the learning environment, particularly in interdisciplinary processes, can be very useful and should be taken into account also in teacher training. It would be an added value if these students and teachers had the opportunity to further explore these scientific approaches.

6. Acknowledgments

This work was supported by the Portuguese Foundation for Science and Technology (FCT) in the framework of the Strategic Funding UIDB/04650/2020.

7. References

[1] Office of Astronomy for Development website: https://www.astro4dev.org

[2] Martins V, Resende A, Mateus V, Costa MFM. Robotics and Entrepreneurship for a Better Society. Opening Doors to Mobility. Hands-on Science. Hands-on The Heart of Science Education, Costa MFM, Dorrío BV, Trna J, Trnova E (Eds.), 82-90, Masaryk University, Czech Republic, 2016.

[3] Przybylla M, Romeike R. Key Competences with Physical Computing. KEYCIT 2014: key competencies in informatics and ICT, 7:351, 2015.

[4] Horn MS, Crouser RJ, Bers MU. Tangible interaction and learning: the case for a hybrid approach. Personal and Ubiquitous Computing, 16 (4):379–389, Apr. 2012.

[5] Hodges S, Scott J, Sentence S, Miller C, Villar N, Schwiderski-Grosche S, Hammil K, Johnston S. .NET Gadgeteer: a new platform for K- 12 computer science education. In Proceedings of the 44th ACM technical symposium on Computer science education, pages 391–396. ACM, 2013.

[6] Sentance S, Waite J, Hodges S, MacLeod, E, Yeomans LE (2017). "Creating Cool Stuff" - Pupils' experience of the BBC micro:bit. In Proceedings of the 48th ACM Technical Symposium on Computer Science Education: SIGCSE 2017.

[7] https://microbit.org

[8] https://www.bbc.co.uk/programmes/p02kbpx4

[9] http://makecode.microbit.org

[10] https://microbit.org/pt-br/projects/make-it-code-it/step-counter/

[11] A summary of all phases of NASA's countdown for the Space Shuttle launch can be viewed on the page: https://en.wikipedia.org/wiki/Space_Shuttle_launch_countdown

[12] https://mars.nasa.gov/mars2020/

[13] https://kitronik.co.uk/products/5683-kitronik-move-motor-for-the-bbc-micro-bit

ISBN 978-84-8158-937-5

From the Magic of Chemistry (Science) to the Chemistry (Science) of Magic

JM Fernández Novell[1,2]*,*
C Zaragoza Domenech[3]
[1]*Professional College of Catalan Chemists, Spain*
[2]*University of Barcelona, Spain*
.[3]*Professor of Vocational Training in Barcelona, Spain*
jmfernandeznovell@ub.edu

Abstract. Chemistry is a fascinating field of study. We can find an amazing amount of phenomena that sometimes seems so incredible that we are talking about magic and science fiction than, actually, talking about chemistry. Mysteries at classroom intends to prepare students for enquiry learning by introducing them to challenging and fascinating phenomena. The perception of mystery will depend on the student's interests, experience and prior knowledge. In this context, The Professional and Official College of Catalan Chemists, has designed some theatrical meetings call "Mystery class". Each mystery presented covers a part of the science curriculum.

Keywords. Chemistry, Experiments, Theatre, Secondary School Level.

1. Introduction

Science education plays a key role in the transformation of education and it is crucial for a more informed society willing to be part of decision-making. Promoting the critical spirit of citizenship is essential to handle with the challenges of the future that we face as society, and non-formal science education will no doubt contribute to this goal [1, 2]. In recent decades, research centres, science museums and cultural institutions, among others [3-7], have developed a line of action linked to education, consolidating non-formal spaces for scientific dissemination –meaning out-of-school.

There is an amazing amount of phenomena that sometimes seems so incredible at our mind, we are talking more about magic and science fiction than, actually, talking about chemistry. Any magic phenomenon is closer or similar to "wow factor" used to show surprise and sometimes pleasure [8] As you can see, chemistry is a fascinating field of study.

Mysteries at classroom and "wow factor" [9] intends to prepare students for enquiry learning by introducing them to challenging and fascinating phenomena. The perception of mystery varies from one student to another because curiosity will depend on the student's interests, experience and prior knowledge.

In this context, the Professional and Official College of Catalan Chemists (*Col·legi Oficial de Químics de Catalunya*, COQC [10]) has designed some theatrical meetings call "Mystery class". Each mystery presented covers a part of the science curriculum in secondary school levels.

Initially, the aim of this activity was explain some magical chemical reactions with theatrical descriptions. They were developed into the secondary classroom to increase student science curiosity and also in a civic centre to bring this knowledge to society. Furthermore, after a few sessions and after consulting with secondary school teachers and students, we increased the topics of this theatrical idea with some mysteries of physics.

The aim of this work is to analyze the chemical background of two of the most spectacular reactions in the context of a magic show, heavy ice and iodine clock. Finally, the time travel is also analyzed. This phenomenon has never been studied at secondary school education. However the scientific basis on this mythic science-fiction topic and the main theories about time travel and the pros and cons of these ideas have been exposed.

2. Why should students rely on scientific explanations?

Scientists and scientific educators need to explain and justify how, when, and why you can trust science. For this reason, after the mystery presented in our theatrical meetings, the magical scientists must explain to the audience the scientific background which involve in the experiments and must answer all questions from the students (audience).

Currently, science education from elementary to undergraduate rarely, if ever, explains to its students how the sciences

ISBN 978-84-8158-937-5

ensure that the knowledge they produce can be trusted. This omission does science a disservice and enables misinformation to spread, providing a space for the purveyors of disinformation to undermine the authority and legitimacy of reliable scientific knowledge.

In addition, there is an increasing concern about the way the internet can be used to spread false information. The widespread acceptance of unfounded claims such as "vaccines cause autism, the Earth is flat, GMO are mortal for humans or that climate change is a hoax" are of grave concern. For, while true knowledge is a collective good, flawed or fake knowledge can be a danger.

Students and society must develop the competency to evaluate scientific information. That is why in our mysteries it is very important give an understandable scientific explanation.

3. Mysterious experiments

Two experiments done in a classroom or an Aula Magna from a secondary school or in a theater from a civic center will be explained.

Let's start as a play [11-13] :

*“Madame and monsieur... You’re welcome!!! I’m delighted to present the greatest magicians of our era... they have travelled around the world learning the art of controlling the matter... They have learned from the most brilliant magician of all cultures... They are...*drumroll* Zoenric brothers (invented name)”*

3.1. Heavy ice

“In the middle of the scenery, there’s one little table. On the table there are four glasses contain a liquid similar to water.

The magicians take the scenery. Everybody applaud. Both magicians without saying nothing, walks directly to the four glasses and put similar ice cubes into two glasses. Into the third one they put orange ice cubes and the fourth was drunk for the magicians.

Immediatly, the public observed that three glasses of clear, colorless liquids are displayed. An ice cube floats on top of the liquid in the first glass. An ice cube sits on the bottom of the secon one. An orange ice cube sits on the bottom of the third one, it’s magic.

Incredulous, the public applaud. The magicians give a knowing smile to the public."

3.1.1. Heavy ice explanation for primary and secondary school

Then, we have to give some explanations about this interesting phenomenon to primary or secondary students. Some questions were posed to the audience/students.

Which is heavier, ice or water?

Does ice weigh more than water?

"Water will expand while turning into ice so its volume will increase. So density will decrease. That is why ice floats on water." Notice that the word density has already appeared.

When water freezes does it get heavier?

"No. The mass doesn’t change, but the volume increases. As you will remember, density is measured in mass per unit volume. Since mass is constant, but volume increases, it means that the density of frozen water is lower than liquid water. The practical upshot is that the less dense ice floats on the more dense water."

Figure 1. Ice from Hubber glacier (Alaska) are floating on the sea

Four glasses of water are displayed. A transparent ice cube floats on top of the liquid in one glass. A transparent ice cube sits on the bottom of the second glass. And, finally, an

ISBN 978-84-8158-937-5

orange ice cube sits on the bottom of the third glass (Fig. 2) Why?. What is going on?

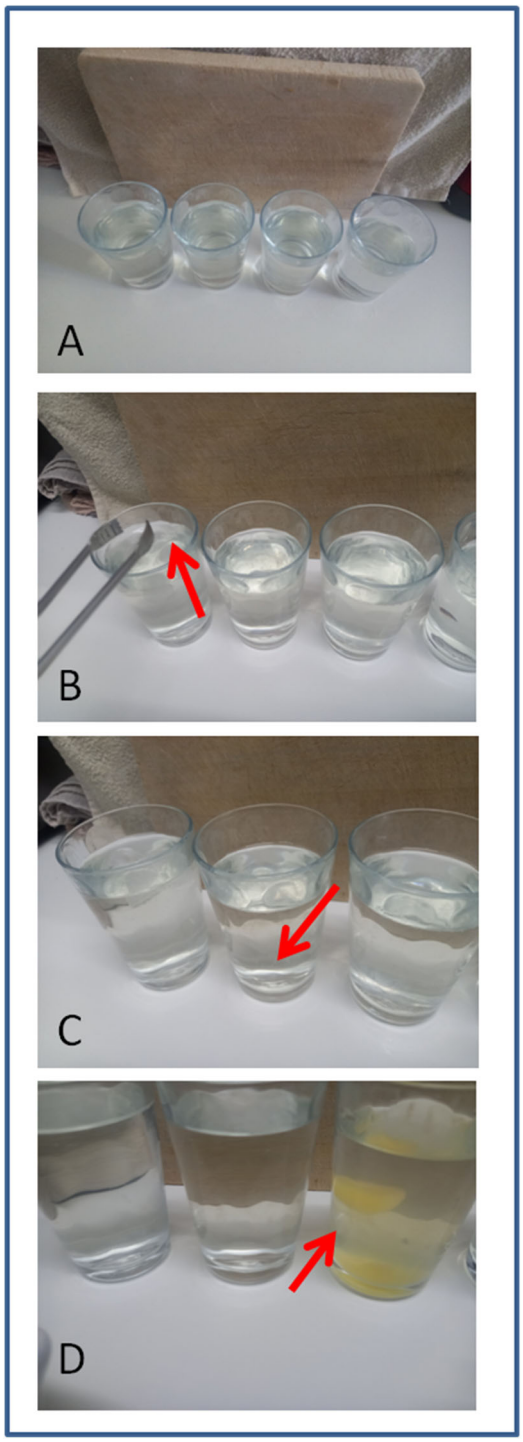


Figure 2. A) glasses filled with water or similar. B) Ice cubes float on the liquid. C) Ice cubes sit on the bottom. D) Orange ice cubes also sit on the botton of glass

The solution is related with density.

In the first glass, ice is floating, the same thing was supposed to.

In the second glass, the ice cube goes to the bottom, it has higher density than the liquid. If the liquid is water, the ice cube is not from water (explanation for high school), but if the liquid is not water, perhaps it is ethyl alcohol with a lesser density than the ice. In this experiment, the ice cube is from water and the liquid is ethanol. We have the same explanation for the third glass, liquid is water and ice cube is from orang juice with higher density than water.

Figure 3. After drinking water from the fourth glass, ice cubes are dissolving in water

At the end, students made some questions

Is vitamin C destroyed by freezing? question posed by an student 14 years old.

It is a well-known fact that during flash freezing (-20°C) vitamin C loses its properties by 5-10%. However, during preserving vegetables and fruits lose up to 40% of their vitamin C, and if they are dried – up to 70%.

Experiments to do at home:

Predict what other materials might float or sink in the water and in the ethyl alcohol.

Suggest other liquids (such as oil or salt water or honey or sparkling water) in which an ice cube might float or sink.

3.1.2. Heavy ice explanation for high school

The density of frozen water is lower than liquid water, why? (Fig. 4)

When water solidifies to form ice, the solid ice phase is less dense (as observed) than the

ISBN 978-84-8158-937-5

liquid water. This can be attributed to the hydrogen bonding that occurs in water in both the liquid and solid states. Hydrogen bonding is the strong intermolecular dipole–dipole force between the partially-positive hydrogen atom and the partially-negative oxygen atom of neighboring water molecules.

Figure 4. Image showing ice that floats in water and ice sinking into it. (Modified from the https://www.sciencephoto.com/media/92120/view/heavy-water)

When water freezes, hydrogen bonding holds molecules rigidly in a three-dimensional crystal. There are holes, or empty spaces, within the ice crystal. As a result, the density of ice is less than the density of liquid water, which explains why ice floats in water. Most substances are more dense in the solid state than in the liquid state. Water is the exception.

What does heavy water mean?

Like regular water, heavy water is composed of two hydrogen atoms bonded to one oxygen atom (H_2O).

Each hydrogen atom in ordinary water has a nucleus that contains one proton and zero neutrons. This isotope of hydrogen is called protium (^1H).

Heavy water [14], we can drink it, is also composed of two hydrogen atoms bonded to one oxygen atom, but the hydrogen atoms in heavy water are an isotope of hydrogen with a nucleus that contains one proton and one neutron called deuterium (^2H).

There is a third isotope of hydrogen with a nucleus that contains one proton and two neutrons called tritium (^3H). The three isotopes of Hydrogen are represented in Fig. 5.

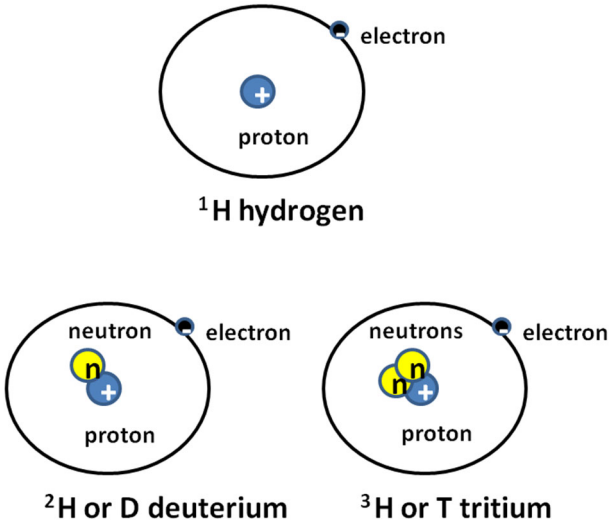


Figure 5. Forms of Hydrogen atoms

Ordinary water and heavy water are represented in Fig. 6.

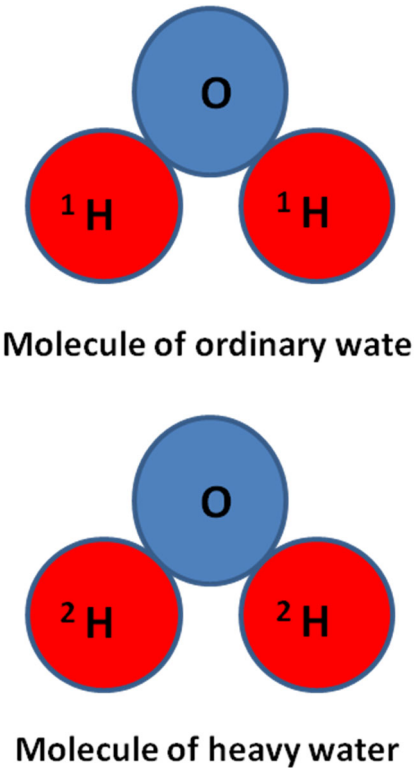


Figure 6. Illustrates the difference between these forms of water

Students could discuss why heavy water ice cubes sink in ordinary water. Heavy water

ISBN 978-84-8158-937-5

density must be higher than that of ordinary water. To estimate the density of heavy water, we can make some assumptions:

- Atoms of heavy water and ordinary water are the same size
- Heavy water ice and ordinary ice form exactly the same crystal structure.

Given these assumptions, students can estimate the density difference between heavy water and ordinary water by the percentage difference between the molecular mass of heavy water relative to ordinary water. Density of heavy water is 11 % higher than ordinary water at 25 °C.

3.2. Iodine clock

"The curtains are lift on; the magician appears again in the middle of the scenery. Everybody applauses enthusiastically.

Now, the four glasses have been removed by five elegant wineglasses. The magician carries with her a glassy recipient full with some transparent liquid. She carefully empties the liquid on the wineglasses and places the recipient on the table... Nothing happens... The public is puzzled. They look themselves worried. What should have happened? The magician is up there, looking to the shocked public with a big smile in her face... She snaps and suddenly the transparent liquid that filled the wineglasses turns into a dark-blue solution. Everybody is amazed. The public is crazy, it applauses loudly and strenuously."

As everything, magic has a scientific explanation. What has happened is a chemical reaction, named iodine clock. Fig 7 shows three moments of the oscillating reaction.

The iodine clock reaction [15] is an oscillating reaction with a really complex kinetics and mechanisim.

As oscillating reaction is a nonlinear chemical reaction, that temporally periodic or nearly periodic has a variation of the concentrations of one or more of the species on the reaction. These kind of reactions were first reported in 1828, and dismissed until fifty's, because it was thought to violate the Second Law of Thermodynamics.

The iodine clock was discovered by Landolt. The compounds and concentrations necessary to do the reaction are: 0.067 M potassium iodate, 1.2 M hydrogen peroxide, 0.053 M perchloric acid, 0.050 M malonic acid, 0.0067 M manganese (II) sulfate, and 0.01% starch. This mixture has been reported to give the best results.

Figure 7. The solution color change after a period of time called the Landolt's time, When the iodine is reaches the maximum it forms a iodine-starch complex responsible of the dark-blue colour of the solution

This reaction is highly dependent on the initial concentrations and the thiosulphate-iodine ratio. When the concentration of thisulphate is higher than iodine, the iodate will finally disappear of the reacting mixture and the solution will turn transparent again. In the most recent studies it has been proposed a 19-step kinetic model to describing this complex process [16].

4. Time travel

Now, the final trick!!...An absolute silence is made...Everybody is anxious...

Zoe the magician needs a volunteer and choses Enric.

In the scenery (classroom) there is a hidden door to a small room full of old things. Enric enter inside the room, but before he does, Zoe asks him to show his pocket watch. It is eleven in the morning.

Suddenly a strange sound comes from inside the small room. Enric is screaming. Zoe looks worried, she hurries to open the door, but she can. Enric is screaming...everybody is frightened... What is happening?...suddenly the screams stop.

Zoe tries again to open the door and now it opens smoothly. For the public surprise, Enric

ISBN 978-84-8158-937-5

is not inside... He appears on the opposite part of the classroom, looking puzzled and disoriented. He is wearing some strange clothes and some devises that noone has ever seen. Zoe smiles and asks Enric to show again his clock: it is now thirteen o'clock.

The public gets crazy, they applauses absolutely fascinated. Everybody stands up. The magician blows to the public and the last curtains drop marks the end of the spectacle.

The travel has never been demonstrated. However there are some scientific theories that argue that time travel is possible.

So, if it was possible, how could it happen? The theory of relativity [17] can give us some answers. Einstein proposed in his theory in 1907, the new idea of space-time, which implicates that the space and time are closely related. Since that the space could be deformed under to a big force, like gravidity, the time can also be altered [18].

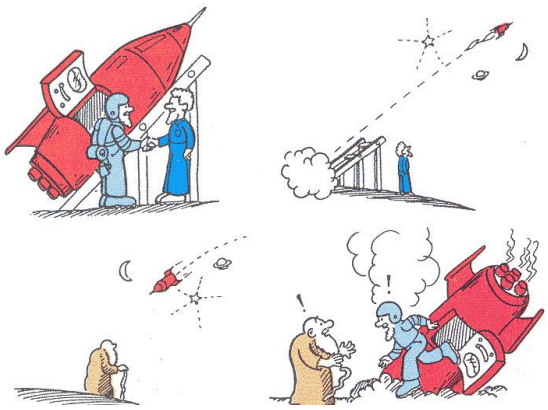


Figure 8. Paradox illustration from Alba Villaronga

The space-time could be deformed is such a way, that the past would be communicated with the present by a spatial-time path. Although this phenomenon has never been demonstrated, there are some paradoxes associated with the pass time travel. One of the most famous is the Grandfather's paradox: for a moment, imagine you have created a time machine and travelled thought the pass and meet my grandfather before he knew my grandmother and kill him. If that happened and it was real...then, the question is: how can I've been born, travelled to the pass, killed my grandfather and prevent myself to be born? That is the paradox (Fig. 8).

So how we can solve this paradox? students asked.

There are 2 options: one, the time travel is impossible, so it will never be possible to travel thought the past moment; two, the travel it is possible but we cannot change the past.

However, could be a way to instantly travel forward to the future? During the eighty's some physicist made some theoretical hypothesis of the instantly time travels. These works inspired Carl Sagan (1934-1996), american astronomer and science novelist, to write his novel *Contact* (Fig. 9).

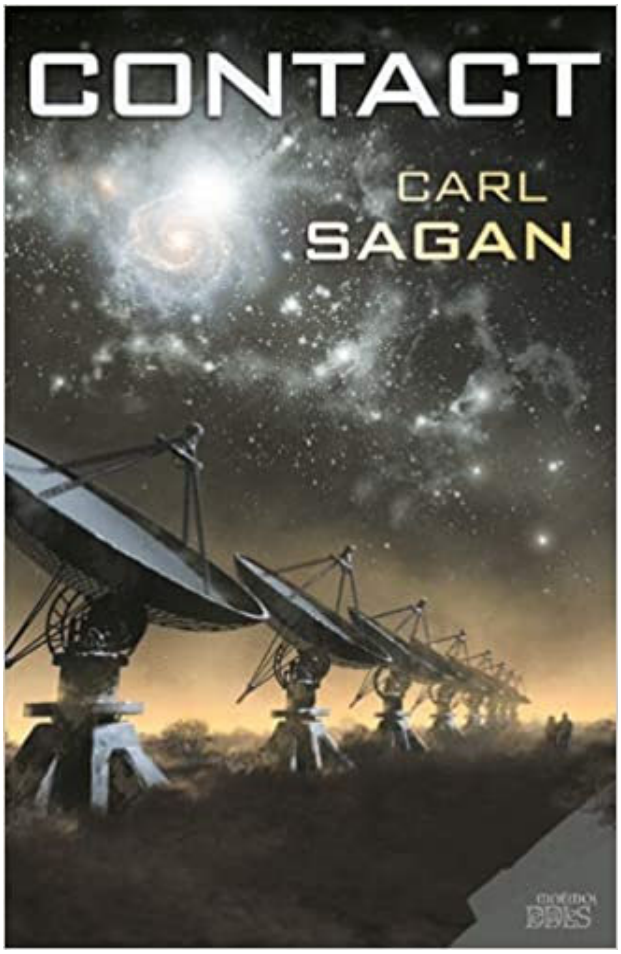


Figure 9. Cover of the Contact book

He first describes a wormhole. A wormhole is a tunnel that communicates two different ends of the space time. This space-time path could allow us to travel to other parts and times on the universe. These tunnels are a recurrent topic in science fiction "Star trek" or "Back to the future".

The time travel is something theoretically possible but with our knowledge and

technology is practically impossible. The answer is still in the air.

5. Conclusions

Scientists, science teachers and science disseminators could explain the magical experiments developed in this article. In addition, they can expose more magical reactions on glucose, sodium acetate tri hydrated, alginate balls filled with an indicator solution and many more. These magical and interesting phenomena motivate students to learn about science in general and chemistry in particular.

Mysteries at classroom generate curiosity, lead to questions and provide affective engagement to the students.

This activity shows that even traditional phenomena and concepts from the curriculum can be transformed into a mystery if they are presented differently. True knowledge is a collective good.

After each theatrical session, students and science secondary school teachers were asked about the activity acceptance. The results indicated that teachers appreciated this non-formal proposal and students welcomed a theatrical activity which serve to increase the students' interest towards the sciences.

6. Acknowledgements

We thank all participants, secondary school students and their science teachers for their significant inputs. We also thank our university students for their fundamental cooperation. An special thanks to Alba Villaronga who realized part of these magical reactions and drawing as an university work.

7. References

[1] Fernández-Novell JM, Zaragoza C. Strategies for Educationn in a New Context. Universitat Politècnica de València Editorial. 677-686, Universitat Politècnica de València. Spain, 2014.

[2] Fernández-Novell JM, Zaragoza C. The Periodic Table as a Didactic Resource for Understanding "Bioelements". Hands-on Science. Innovative Education in Science and Technology. Costa MF, Dorrío BV, Minakova K (Eds.), 5-10, National Technical University "Kharkiv Polytechnic Institute", Ukraine, 2019.

[3] Fernández Novell JM, Zaragoza C. Divulgación de las ciencias: Richard Feynman, Stephen Hawking y Jorge Wagensberg. In INNODOCT/18. International Conference on Innovation, Documentation and Education. Editorial Universitat Politècnica de València. 861-871. València. Spain, 2019.

[4] Fernández-Novell JM, Zaragoza C. Broadcasting Science: a New bridge between Science and Society. M. Kalogiannakis, D. Stavrou, P. Michaelides (Eds.), Proceedings of the 7th International Conference on Hands on science, Rethymno-Crete, 57-62, 2010.

[5] Zaragoza C, Fernández-Novell JM. Teaching science with toys: Toys and Physics. M. Kalogiannakis, D. Stavrou, P. Michaelides (Eds.), Proceedings of the 7th International Conference on Hands on science. Rethymno-Crete, 63-68, 2010

[6] Fernández-Novell JM, Blajé J, Zaragoza C. Visiting Science Museums. Hands-on Science. Science Education with and for Society. Costa MFM, Pombo P, Dorrio BV (Eds.), 358-364, Universidade de Aveiro, Portugal, 2014.

[7] Torrent P, Fernández-Novell JM, Magical and Chemical Summer Camp. Hands-on-the Heart of Science Education, Costa MF, Dorrío BV, Trna J, Trnova E (Eds.), 91-96, Masaryk University, Brno, Czech Republic, 2016.

[8] http://dictionary.cambridge.org/es/

[9] Fernández-Novell JM, Zaragoza C. Bringing the "WOW" factors in Science Classroom to Increase students' interest. 12th International Technology, Education and Development Conference. IATED Academy. Valencia. Spain. 5841-5848, 2018.

[10] http://www.quimics.cat/

[11] Zaragoza C, Fernández-Novell JM. Young students turn the History of Science into an educational theatre. The Global and the Local: The History of Science and the

Cultural Integration of Europe. M. Kokowski Ed. 143-148, 2007.

[12] http://www.creativedrama.com/2019/08/31/integrating-drama-into-other-subjects/

[13] http://www.artslynx.org/theatre/thed.htm

[14] Waltham C. (2011) An Early History of Heavy Water. arXiv.physics/0206076v2.

[15] Briggs TS, Rauscher WC. An oscillating iodine clock. J. Chem. Educ. 50, 496-499, 1973.

[16] Limpanuparb T, Ruchawapol C, Sathaintthammanee D. Clock reaction Revisited: Catalyzed Redox Substrate-Depletive Reactions. J. Chem. Educ. 96, 812-818, 2019.

[17] Einstein A. Einstein's Essays in Science. Translated by Alan Harris (Dover Ed.) Mineola, NY. Dover Publications, 2009.

[18] Lobo F. Time, Closed Timelike Curves and Causality. In NATO Science Series II. 95, 289-296, 2003.

[19] https://www.britannica.com/biography/Carl-Sagan

Hands-on STEAM and Inclusive Education in Primary School

[1]M Marques, [2]MFM Costa
[1]EB1/JI N. Sra. Da Conceição, A. E. Fernando Távora in Guimarães, Portugal
[2]Centro de Física das Universidades do Minho e do Porto, Portugal
mfcosta@fisica.uminho.pt

Abstract. Education policies increasingly 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. Students with Autism Spectrum Disorders (ASD) present particular further and challenges to the implementation of STEAM education approaches aiming to improve their basic scientific literacy. An individualized instruction approach is needed. Hands-on activities proved to be capable to decisively help the education process of this group of students. The study herein present was implemented at a TEACCH classroom. Five students, four boys (one of the first grade, two of the third grade and one of the fourth grade), and one girl (of the first grade) participated during the group work area of the TEACCH Program. Only two students are verbal (one boy of the third grade and one boy of the fourth grade). Several examples of the practical hands-on implementation of STEAM activities are given, carried out with elementary school students with Autism Spectrum Disorders (ASD). The children showed entusiasm and joy during the experimental activities being much more focus and committed than usual.

Keywords. Autism Spectrum Disorders (ASD), Hands-on Activities, Inclusive Education, Primary Science Teaching, STEAM.

1. Introduction

Every child has the right to a quality education [1]. Dawson & Scott (2013) explain that inclusion has been shown to lead to academic gains, including better performance on standardized assessments, classroom grades, behaviors, and motivation for learning for students with disabilities.[2]

To ensure success for students with autism in general education classrooms, teachers must plan collaboratively, create structured classrooms, and teach lessons in meaningful and engaging ways. [3]

The TEACCH® Autism Program is a clinical, training, and research program based at the University of North Carolina – Chapel Hill. TEACCH was developed by Dr. Eric Schopler and Dr. Robert Reichler in the 1960s. It was established as a statewide program in 1972 and has become a model for other programs around the world.

TEACCH uses a method called “Structured TEACCHing.” This is based on the unique learning needs of people with ASD, including strengths in visual information processing, difficulties with social communication, attention and executive function.

Structured TEACCHing uses organization and supports in the classroom environment to help students learn best. This includes physical organization individualized schedules work (Activity) systems and visual structure of materials in tasks and activities. [4]

Inclusive education involves teachers and schools making a commitment to build and keep a sense of belonging for all students. Inclusive education involves teachers and schools making a commitment to build and maintain a sense of belonging for all students. Like all children, students with autism grow and develop when they are in environments where they feel valued and where they feel they belong.

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 prosper and be active members of the society.

Inclusive education means all children in the same classrooms, in the same schools.

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. [5]

Incorporating science experiments into

ISBN 978-84-8158-937-5

learning is a great way to involve children and make lessons more hands-on and fun. While autistic students may have different needs in the classroom, they 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. 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 input (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. [6]

These activities were realized in a structured teaching room with children with autism spectrum disorders (ASD). This article contains five activities, documenting examples of science through the lens of creativity with autistic students. In this study, the activities and photographies will illustrate creativity in science and / or arts in the early years. These were based from selected observations and supported by information gathered through several types of data, non verbal comunication, communication tables and pictograms. This study was realized in a structured teaching room with children with autism spectrum disorders (ASD). The findings of this qualitative study aim to reveal the potential for creativity and STEAM in the classroom realities of primary science education for students with ASD.

2. Instruments and methodology

2.1. Instruments

The instruments used to record and to analyse the data were, in this case we report, the field notes and photographs taken by the teacher and reflections of the teacher and inputs collected with children.

2.2. Methodology

The objective of the observation during this activity is to spot and to characterize children performance through non verbal comunication, communication tables and pictograms. The notes taken include the children's interventions, observation of facial expressions, the emotions, the actions and the events occurred.

3. Characterization of the class

The school, located in Guimarães, in northern Portugal, is a public educational institution covering two levels of education: preschool and primary school; the students in a total of sixty students, are aged between three to ten years old. The structured teaching room is wide with perfectly identified functional areas endowed with suitable materials, and obeys to TEACCH program [7], that uses a method called Structered Teacching. 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. Five early school students four boys (one of the first grade, two of the third grade and one of the fourth grade), and one girl (of the first grade) participated during the work groups area of the TEACCH Program. Only two students are verbal (one boy of the third grade and one boy of the fourth grade).

4. STEAM activities

Teaching strategies are practices used by adults (e.g., family members, practitioners) or, in some instances, by other children 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. [8]

Global skill shortages in STEAM-related fields are redefining educational priorities. Schools are starting STEAM-based learning programmes to equip students with the skills and knowledge needed to thrive in the 21st century.

The benefits of STEAM learning are think outside the box, feel safe to express innovative and creative ideas, feel comfortable doing hands-on learning, take ownership over their learning, work collaboratively with others, understand the ways that science, maths, the arts, and technology work together, become increasingly curious about the world around them and feel empowered to change it for the

better [9].

For our article, we have picked five “clean” science experiments that are quiet and don’t require children to get their hands messy, since these can be typical triggers for autistic children**.**

4.1. European Maritime Day (20th May). Sink or float experiment, egg-box boats, sensory painting and boat draw on tablet

The sink or float experiment is one of the favourite of the children. Students remain engaged in an inquiry-based learning project, full of surprises and sensory experiences that they will talk about all year long. Predicting is an exciting skill that comes with practice. The teacher promotes the pupils to think like an inquiring person which is looking for an answer to the identified question (what kind of objects can sink or float. The teacher asks the pupils to point the pictogram √ (yes) or X (no) to an object considering what they think about behaviour (making prediction).

Figure 1.1. Sink or float experiment

Figure 1.2. Child DA. and child N. egg-box boats

Figure 1.3. Child D. egg-box boat

Figure 1.4. Child D. sea sensory painting

ISBN 978-84-8158-937-5

Figure 1.5. Child N. sea sensory painting

Further the teacher offered the pupils objects for verification of their predictions. They also constructed egg-box boats and observed they floating, in the European Maritime Day, made sensory painting of the sea with salt and sand and used the tablet to join numbers in order to obtain the figure of a boat.

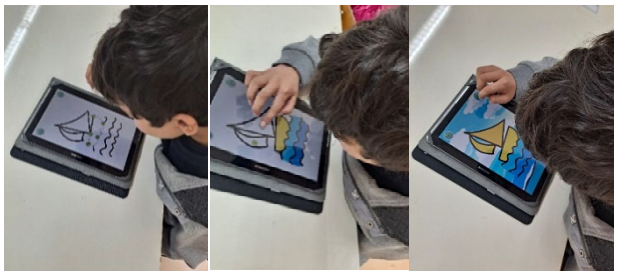


Figure 1.6. Child DA. using a tablet to join numbers in order to obtain the figure of a boat

4.2. Ocean Sensory bottles

About the comemoration of the European Maritime Day, they still made ocean sensory bottles. Sensory bottles are a fun and easy activity that is suitable for children with ASD. Not only are they fun to build they are also a great calming activity. Making an ocean sensory bottle can be a great way to add some creativity to an ocean learning unit at school. They used plastic bottles, water, blue food colouring, sand and baby oil.

Figure 2.1. Sensory sea bottle

Figure 2.2. Child D. sensory sea bottle

Figure 2.3. Child DA. sensory sea bottle

Figure 2.4. Child N. adding sand to sensory sea bottle

Figure 2.5. Child D. playing with sensory sea bottle

4.3. Crazy Magnetic Hair Styles

Demonstrating how magnets attract metal, were used the magnets to start gathering up all the little pieces of pipe cleaners. Students loved to look at the strands of hair (pipe cleaner pieces lines) that it suddenly was attracting to its 'head'. Children started using the coloured strands to make various styles. It was so much fun.

Figure 3.1. Child L. "atracting" crazy hairs made of pipe cleaners

Figure 3.2. Child D. observing "crazy hairs" atracted made of pipe cleaners

Figure 3.3. Child D. cuting pipe cleaners

ISBN 978-84-8158-937-5

Figure 3.4. Child N. "atracting" crazy hairs made of pipe cleaners of another child

Figure 3.5. Child DA. observing "crazy hairs" made of pipe cleaners, now without paper envolving, atracted by the magnet that was hide

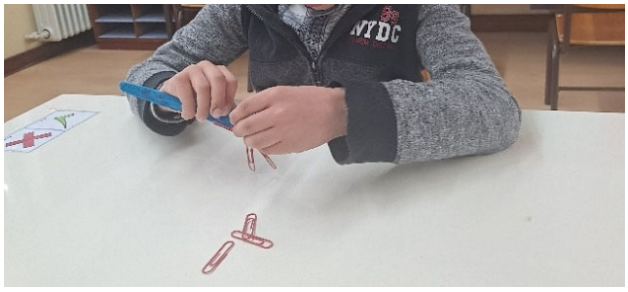


Figure 3.6. Child DA. making magnetic experiments now with paper clips

4.4. Suncatchers

Suncatchers are translucent, colored that hang in a window or other sunny location and that transform light as it passes through them. Suncatchers are decorative objects and add a bit of color or playfulness in a window.

There are so many ways to make suncatchers. The main materials for making suncatchers are those that are translucent and colorful. The students used tissue paper and transparent Adhesive film. Teacher explained children that transparent describes a material in which light passes through and an image behind it can be distinctly seen. Explained too that translucent describes a material which light can pass through but which the image behind it cannot be distinctly seen. Most of suncatchers are translucent as well the suncatchers made by the children. The theme was the spring, and so they made a bee, a sun, a tree, a butterfly and a ladybug.

Figure 4.1. Child D. making the sun suncatcher

Figure 4.2. Child DA. making the flower suncatcher

Figure 4.3. Child N. making the bee suncatcher

Figure 4.4. Child M. making the ladybug suncatcher

Figure 4.5. Working group. Making the leafs of the tree with for the tree suncatcher

Figure 4.6. The final result: the suncatchers decorating the school windows

4.5. Static electricity

The objective of these activities is to mention and recognize that objects are made of different materials and the materials differ in surface, shape, color, size, etc.; to develop science process skills, mainly observation and categorization skills in simple inquiry activities; to develop ability to construct simple, but objective conclusion to realized inquiry activity; to develop preconceptions about static electricity.

Figure 5.1 Child DA. "whisperering" the snake with static electricity

Figure 5.2. Rubbed Ballon with orange flannel cleaning duster

The used materials were balloon; confetti ; ball of wool; plastic spoon; ruler, tissue paper; colored styrofoam and orange flannel cleaning duster and a dish.

ISBN 978-84-8158-937-5

Figure 5.3. Child D. rubbed ballon attracting small pieces of paper

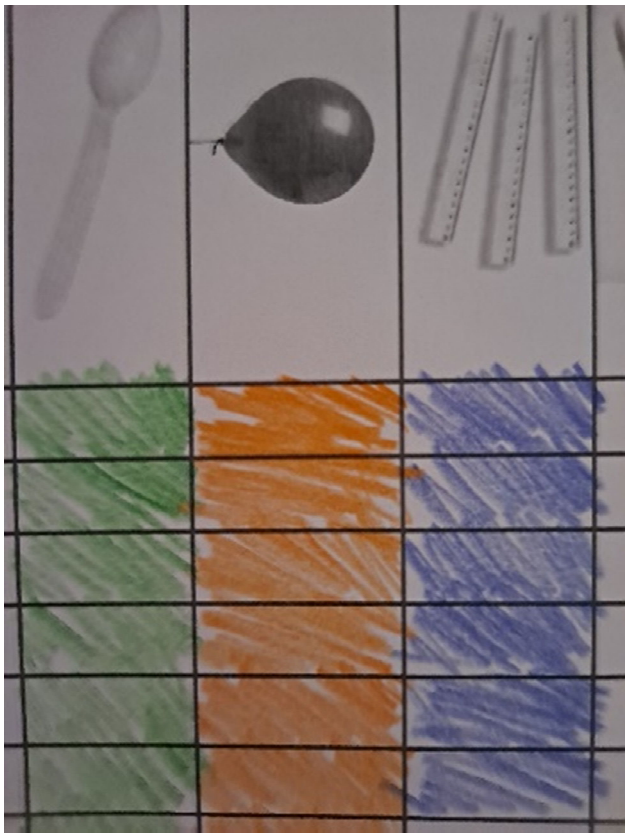


Figure 5.4. Worksheet with colour as many squares in the table as many pieces of styrofoam the rubbed object attached

The teacher asks the students to cut a snake in tissue paper. Then asks the students to rubber the plastic spoon with a orange flannel cleaning duster and “whisperer” the snake.

Figure 5.5. Child N. with a rubbed plastic spoon attracting styrofoam

Figure 5.6. Child D. with a rubbed plastic spoon attracting styrofoam

Further the teacher offered the pupils balloons to rub and atract small pieces of tissue paper. She explained that it is important to rub all the inquired material against the orange flannel cleaning duster the same way to get the comparable results.

At least pupils rubbed a plastic spoon in a orange flannel cleaning duster and put it near to small pieces of colored styrofoam. They have to colour as many squares in the table as many balls of colored styrofoam the rubbed object attached.

5. Discussion

The activities herein presented were about learning experiences in the fields of sciences, arts and technology at primary school. The role of the teacher in guiding learning activities in order to achieve the desired effectiveness in learning was important. All the students made the activities after the explanation and demonstration of the teacher. Only one child had to be helped by the operational assistant during the execution of the activities. The others revealed autonomy for doing all the proposed activities. Children showed enthusiam and motivation in the execution of the activities.

6. Conclusion

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

Incorporating science experiments into learning is a great way to engage children and make lessons more hands-on and fun. The teacher initiated activities explaining and making demonstrations to the students. Observation, encouraging students in simple science ativities was fostered.These five activities showed creativity through children's agency, curiosity, engagement and entusiasm. Rich motivating contexts for play and exploration were fostered.Collaboration, promoted by use of group work of TEACCH program, played important role in involving children specially in children with autism spectrum disorders. The children showed entusiasm and joy during the experimental activities being much more focus and committed than usual.

7. Acknowledgements

This work was supported by the Portuguese Foundation for Science and Technology (FCT) in the framework of the Strategic Funding UIDB/04650/2020. The authors thank all children and operational assistants for their active participation in this work and also thank specially school coordinator, Special Education department coordinator, vice principal and school principal.

8. References

[1] Spring J. The Universal Right to Education: Justification, Definition, and Guidelines. New York: Routledge, 2000.

[2] Dawson H, LaRon, S. Teaching students with disabilities efficacy scale: development and validation. Inclusion, 1(3), 181-196, 2013.

[3] https://www.kennedykrieger.org/stories/linking-research-classrooms-blog/supporting-inclusive-education-students-autism-spectrum-disorder-part-i

[4] https://www.autismspeaks.org/teacch-0

[5] https://www.unicef.org/education/inclusive-education

[6] https://ourfamilycode.com/clean-science-experiments-for-autistic-children/

[7] Hume K, Steinbrenner JR, Odom SL, Morin KL, Nowell SW, Tomaszewski B, Szendrey S, McIntyre NS, Yücesoy-Özkan S, Savage M N. Evidence-based practices for children, youth, and young adults with autism: Third generation review. Journal of Autism and Developmental Disorders, 1(11), 4013-4032, 2021.

[8] Waters V, West T, Lim CI, Campbell P, Pedonti S. A guide to teaching practices. Chapel Hill, NC: STEM Innovation for Inclusion in Early Education Center, 2021. https://stemie.fpg.unc.edu/guide-teaching-practices

[9] http://elearning.tki.org.nz/Teaching/Future-focused-learning/STEM-STEAM

ISBN 978-84-8158-937-5

Chemistry of Food, Essential to Promote Science Education

JM Fernández Novell[1]*, E Blanco Ferran*[2]*, X Hernández Alias*[3]*, C Zaragoza Domenech*[4]
[1]*Professional College of Catalan Chemists, Spain*
[2]*University of Barcelona, Spain*
[3]*Centre for Genomic Regulation (CRG). The Barcelona Institute of Science and Technology, Spain*
[4]*Professor of Vocational Training in Barcelona, Spain*
jmfernandeznovell@ub.edu

Abstract. Chemistry is everywhere in our everyday and cooking is a paradigmatic context for the hands-on learning of science. The Professional and Official College of Catalan Chemists (*Col·legi Oficial de Químics de Catalunya*, COQC) has developed the practical seminar "Molecular cuisine" with lectures and practical classes. The main objective is to motivate young students, fifteen to seventeen years old, towards chemistry studies by introducing them to molecular gastronomy. Some notions about emulsions, colloids, fermentations, spherifications and liquid nitrogen were treated in the classroom and in the laboratory.

Keywords. Molecular Cuisine, Chemistry, Experiments, Food, Secondary School Level.

1. Introduction

Molecular gastronomy is a new scientific discipline born as a combination of chemistry, biochemistry and culinary techniques. Alice Foundation (*Fundació Alícia*) [1] at Món Sant Benet, was founded by the molecular cuisine chef Ferran Adrià [2] who has pioneered in the scientific study of cooking.

Chemistry is specially present in our nutrition, in the foods (water, ions, minerals and other chemical elements) that we eat and cook. We obtain different biomolecules, such as proteins, sugars or carbohydrates and lipids [3]. After digestion, our bodies, our cells, obtain energy and monomers, to create new and necessary molecules.

When food is cooked, proteins unfold, and most of them lose their properties and functions. This might seem like a disadvantage, but it's actually helping our own proteins to act faster and efficiently. It can be accomplished by applying heat, changing the salt content, or changing the pH.

Furthermore, when we cook a piece of meat at a barbecue, many chemical reactions have been produced, for example the Maillard reactions happening between amino acids from proteins and sugars from carbohydrates.

In addition, milk, mayonnaise and butter are all forms of emulsions, stable dispersions between immiscible aqueous and fatty phases. Knowing that a suitable emulsifying agent can help mix water with fat also allows us to clean our fatty dirty dishes with water plus a detergent with emulsifier.

As such, chemistry (elements and molecules) and physics (heat and pressure) are in our everyday cooked food, but also biology is commonly used in cooking. For instance, yeasts and bacteria make all the difference in the bread, beer, wine, or yoghurt production by fermentation.

In this context, the Professional and Official College of Catalan Chemists (*Col·legi Oficial de Químics de Catalunya*, COQC [4]) has designed the practical seminar "Molecular cuisine" developed into secondary scool classroom and also in a civic centre with lectures and practical classes.

This practical seminar tries to apply a non-formal learning methodology [5] for presenting all these chemical reactions and activities. The main objective is to motivate young students, fifteen to seventeen years old, towards chemistry studies by introducing them to molecular gastronomy.

The main objective is to motivate young students, fifteen to seventeen years old, towards chemistry studies by introducing them to molecular gastronomy.

Finally, after each seminar, science secondary school students were asked about the activity acceptance. Results pointed out that they appreciated this non-formal proposal and, significally said that the activity has served to increase the students' interest towards the

sciences in general and chemistry or molecular gastronomy in particular.

2. Chemistry of food programme

Through the COQC we make available to the secondary school students, fifteen to seventeen years old, scientific experiments related to chemistry of food.

Usually, this practical seminar occupies four sessions of three hours each one, two theoretical sessions and two practical sessions. The total time to do this can be one day, morning and afternoon (practice sessions only), two days, morning and afternoon or four days with four mornings.

The places where it has been done are: In secondary schools the seminar has been done in the school laboratory of physics and chemistry and with the format of one day. In the civic centers and Foundations, the seminar was held in the respective kitchens and in the format of two or four days.

In this article, the authors only presented the two practical sessions, in two different sections, with a bit of theory to understand the obtained results by students.

3. First day of practice

3.1. Tyndall effect

Colloids are stable mixtures of two or more immiscible substances, in which one (the dispersed phase) is suspended in particles within the other (the dispersion phase). Colloidal dispersions are characterized by the scattering of light by the particles of the colloid, which is defined as “Tyndall effect”. As shown in Fig. 1, UV light is scattered when it traverses a sample of milk (colloid), while it is not visible in water alone or in a sucrose solution.

The scattering of light by colloids is named after the Irish physicist John Tyndall (1820–1893) [6], who studied the diffusion of light by large molecules and dust. In addition, he performed experiments demonstrating that the sky’s blue colour results from the scattering of the Sun's rays by molecules in the atmosphere.

The Tyndall effect**,** also called Tyndall phenomenon**,** describes the scattering of a beam of light by a medium containing small suspended particles—e.g., smoke or dust in a room, which makes visible a light beam entering a window. As in Rayleigh scattering, short-wavelength blue light is scattered more strongly than long-wavelength red light. However, Rayleigh scattering occurs from particles much smaller than the wavelength of light, while the Tyndall effect occurs from particles roughly the same size as the wavelength of light. [7]

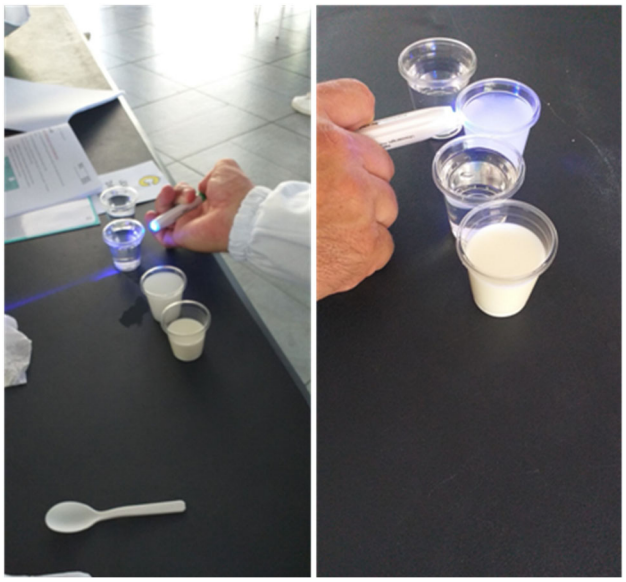


Figure 1. Tyndall effect in a sample of sucrose solution (left) and milk (right). The UV laser light is scattered only in the latter, which indicates the colloid nature of milk

3.2. Emulsions

An emulsion is a stable dispersion of two or more immiscible liquids held in suspension by small percentages of substances called emulsifiers. [8]

Emulsions are types of colloids formed by a liquid dispersed phase and a liquid dispersion phase, which are typically formed by a hydrophobic and an aqueous phase (e.g., milk is an emulsion of lipidic particles within an aqueous medium).

The stability of an emulsion is provided by the presence of amphiphilic molecules, such as surfactants or proteins. For instance, in the elaboration of mayonnaise, the egg provides an aqueous phase with amphiphilic proteins that can emulsify with olive oil if the proper mechanical dispersion is applied. In lactonase, eggs are replaced by the aqueous phase and proteins of milk.

ISBN 978-84-8158-937-5

Figure 2. Elaboration of mayonnaise (left) and lactonase (right). In the first, oil is beig added and dispersed into eggs. In the second, milk is emulsified with oil

3.3. Cheese

We must give thanks to nature and, of course, the development of humanity for giving us dairy products. For 3200 years, since ancient civilizations, we have consumed cheese with pleasure. With the development of humanity, cheese, and other dairy products, have been developed and grown in variety. Along the way, lots of methods have been applied, many of which are still being used to this day.

Casein is the most abundant protein in milk, and its precipitation constitutes the basis of cheese preparation. To that extent, casein molecules minimize their intermolecular repulsion when their global charge state is neutral, which is called the isoelectric point of a protein and depends on its aminoacidic composition. In the case of casein, this happens at pH 4.6. Therefore, casein precipitation is achieved by acidifying milk either by directly adding an acid (e.g., lemon juice) or by adding microorganisms that perform lactic fermentation. Finally, the precipitate is separated from the remaining serum. This precipitate would then be salted and matured for the cheese product of interest.

There are also many new methods being developed. This differs for each country, according to geological and cultural influences, each region has created its own way of producing. The production process includes three main parts: preparation, salt bathing and maturation. [9]

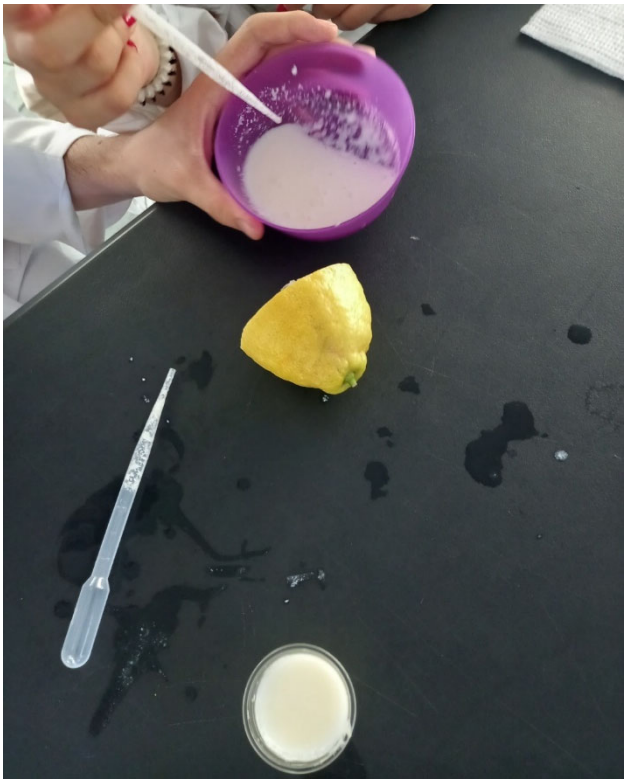


Figure 3. Precipitation of casein by addition of lemon juice. At pH 4.6 casein starts to precipitate and separates from the rest of serum, as observed in the bowl

3.4. Butter

Milk or cream is an emulsion of lipidic particles within an aqueous medium. If a mechanical force is applied, it will at first incorporate oxygen and produce whipped cream. However, if we continue shaking the mixture, it will in the end reverse the state of the initial emulsion: the aqueous phase will get dispersed within a lipidic medium and separate for the rest of the serum. This constitutes the elaboration of butter.

Butter therefore is essentially the fat of the milk. It is usually made from sweet cream and is sometimes salted. Butter is produced by agitating cream, which damages the fat membranes and allows the milk fats to conjoin, separating from the other parts of the cream. Variations in the production method will create butters with different consistencies, mostly due to the butterfat composition in the finished product.

Milk fat is comprised mostly of triglycerides, with small amounts of mono- and diglycerides, phospholipids, glycolipids, and lipo-proteins.

The trigylcerides (98% of milkfat) are of diverse composition with respect to their component fatty acids, approximately 40% of which are unsaturated. Fat firmness varies with chain length, degree of unsaturation, and position of the fatty acids on the glycerol. Fat globules vary from 0.1–10 μm in diameter. The fat globule membrane is comprised of phospholipids and lipoproteins.

Figure 4. Elaboration of butter by agitation. In the left, cream is agitated until fat particles conjoin forming butter (right). This milk fat emulsion if finally separated from the serum

3.5. Yoghurt

Since centuries ago, human beings learnt how to use microorganisms (yeast, bacteria) in the cuisine, which can perform extremely efficient (and tasty) biochemical reactions: fermentations.

Figure 5. Yoghurt elaboration by incubation of bacteria cultures at 42 °C. After mixing one liter of milk with one yoghurt, which serves as the starter culture, fermentation takes around 10 hours at 42 °C

Yoghurt is a fermented slightly acid often flavored semisolid food made of milk and milk solids to which cultures of two bacteria (Lactobacillus bulgaricus and Streptococcus thermophilus) have been added. [10]

In the elaboration of yoghurt, bacteria these two bacteria species metabolize the lactose molecules of milk to produce lactic acid, in a process called lactic fermentation. These bacteria grow optimally at 42 °C, and within some hours milk is acidified and accumulates the flavorful metabolites of yoghurt.

4. Second day of practice

4.1. Fermentations

Fermentation**,** chemical process by which molecules such as glucose are broken down anaerobically. More broadly, fermentation is the foaming that occurs during the manufacture of wine and beer, a process at least 10,000 years old. The frothing results from the evolution of carbon dioxide gas, though this was not recognized until the 17th century. French chemist Louis Pasteur (1822-1895) [11] in the 19th century used the term *fermentation* in a narrow sense to describe the changes brought about by yeasts and other microorganisms growing in the absence of air (anaerobically); he also recognized that ethyl alcohol and carbon dioxide are not the only products of fermentation. [12]

Glycolysis, the breakdown of sugar, was originally defined about 1930 as the metabolism of sugar into lactate. The six-carbon sugar glucose is broken down into two molecules of pyruvic acid (three-carbon. The pyruvate may then be oxidized, in the absence of oxygen, to lactic acid (yoghurt), ethyl alcohol (beer), acetic acid (vinegar) or other products.

Alcohòlic fermentacion. To visually observe the alcoholic fermentation reaction made by yeast, we look for the CO2 produced, trapped in the balloon. We compared two different conditions, in the sun (30°C), and in the fridge (4°C). The results were better in the sun, this means the reaction is quicker.

To reproduce this experiment you need yeast (to make bread), sugar, water, tubes and a balloon. You mix sugar with water and prepare a control tube. Then you mix the solution with some yeast, and prepare other tubes. Seal the tubes with a balloon. Put half of the tubes in each condition and wait 1-2 hours.

ISBN 978-84-8158-937-5

To analyze the results, search for bubbles in the tube walls and the air inside the balloon.

Figure 6. Reaction tubes and solution for the alcoholic fermentation experiment. Solution preparation (left), incubation tubes at RT (middle) and incubation tubes at 4ºC (right)

4.2. Espherifications (*Sferificacions*)

Spherification is a culinary process that employs sodium alginate and either calcium chloride or calcium glucate lactate to shape a liquid into squishy spheres, which visually and texturally resemble roe.

Figure 7. Direct spherification performed with a pasteur pipette

Direct spherification. To produce direct spherification of an edible liquid, you have to mix it with alginate and let it fall in a solution with calcium. The calcium solution can be made with calcium chloride, or with glucanolactate. The second one produces spheres with better taste.

The spherification [13] is caused for the interaction of calcium ions with alginate and then, it polimerizes.

Indirect spherification. Indirect spherification is used when the food you want to produce spheres of, contains calcium. You need to change the compound of the solution, and dissolve alginate. When the liquid with calcium falls into the solution, it produces an sphere, exactly the same as the direct spherification. In this case the food is yogurt, dissolved in a little bit of water

Figure 8. Direct spherification performed with a spoon. This allows to form bigger spheres

Figure 9. Indirect spherification

4.3. Liquid nitrogen

Liquid nitrogen is produced by compressing and cooling nitrogen gas to a point below its evaporation point of about − 196 °C. Liquid nitrogen is used for a variety of things, such as a coolant for computers, in medicine to remove unwanted skin, warts and pre-cancerous cells,

ISBN 978-84-8158-937-5

and in cryogenics, where scientists study the effect of very cold temperatures.

It is also used as a source of refrigerations on materials in such applications as food freezing and cooking. [14]. You can freeze food with liquid nitrogen. In fact, it's the only way to do it “properly,” if you want to avoid any nutritional degradation. Using liquid nitrogen, food can freeze quickly

4.3.1. Ice cream

Figure 10. Ice cream freezed with liquid nitrogen

We produced ice cream with liquid nitrogen. The liquid nitrogen in very cold (-170°C), and the temperature is constant, because in contact with air (25°C aprox.), it boils. The base of the ice cream is milk, cream and mashed fluit. To that you add some liquid nitrogen and mix gently, to correctly distribute the cold and produce a creamy ice cream.

If we don’t mix correctly, the parts that contact the mixture freeze compleatly, but the other parts keep liquid.

4.3.2. Liquid nitrogen some applications

Liquid nitrogen can also be used to produce “cooked eggs”. They are not edible, because they are too cold, and would burn you. Another difference with eggs cooked with heat, is that when the temperature raises, eggs go back to how they were before adding the liquid nitrogen. The difference is that with liquid nitrogen, water freezes, and with heat, proteins denaturalizates.

Figure 11. Performing different liquid nitrogen applications, ice cream (left) and drinking a fruit juice mix with liquid nitrogen (right)

A liquid nitrogen cocktail is any mixed drink whose preparation involves the use of liquid nitrogen. Popularized as a novelty because of the smoky and bubbling effects. Using liquid nitrogen is controversial as a cocktail ingredient because it boils at −196 °C and its consumption is thus potentially dangerous [15]. However, it is not a regulated substance in most countries and there is little control of its use. It will be better to let all the liquid nitrogen boil into a drink and it will be no longer be harmful.

5. Conclusions

This activity is an opportunity to discover foods and culinary processes from the vantage point of chemistry discipline, and to learn how it can provide answers and solutions to the current challenges around sustainable, healthy food. Chemistry of food promotes teaching and dissemination activities, lectures and laboratory sessions, in a playful way. Furthermore, it communicates chemistry in order to bring society, particularly secondary school students, closer to this knowledge.

At the end of the seminar the results are discussed and related to diets, meals and more. Our objectives are to promote healthy habits to ensure that everyone eats better, transfer this knowledge and share it with the whole society, the families of the participants.

Cooking is not only the perfect staging for learning scientific principles from our daily life, but also an interesting source for hands-on practices in scientific education. Students and teachers appreciated our activity and teachers

said that this activity could be also performed in Primary school level.

6. Acknowledgements

We thank all participants, secondary school students and their science teachers for their significant contributions.

7. References

[1] https://www. alicia.cat/es/

[2] https://elbullifoundation.com/biografia-ferran-adria/

[3] Fernández-Novell JM, Zaragoza C. The Periodic Table as a didactic resource for Understanding "Bioelements". Hands-on-Science. Innovative Education Science and Technology. Costa MF, Dorrio BV, Minakova K (Eds.), 5-10, National Technical University "Kharkiv Polytechnic Institute", Kharkiv, Ukraine, 2019.

[4] http://www.quimics.cat/

[5] Fernández-Novell JM, Zaragoza C. Strategies for Education in a New Context. Universitat Politècnica de València Ed., 677-686, Universitat Politècnica de València, Spain, 2014.

[6] https://www.britannica.com/biography/John-Tyndall

[7] https://www.britannica.com/science/Tyndall-effect

[8] https://www.sciencedirect.com/topics/chemistry/emulsion

[9] https://fisair.com/applications/cheese-production-and-maturation/

[10] https://www.merriam-webster.com/dictionary/yogurt

[11] https://www.biography.com/scientist/louis-pasteur

[12] https://www.britannica.com/science/fermentation

[13] Mans C. *Sferificacions i macarrons*, Spherifications and macaroni. Editorial Ariel, Grupo Planeta, Barcelona, Spain 2014.

[14] https://www.sciencedirect.com/topics/chemical-engineering/liquid-nitrogen

[15] Nordqvist C. Are liquid nitrogen cocktails dangerous? October 10, Medical News Today, 2012. https://www.medicalnewstoday.com/]

ISBN 978-84-8158-937-5

PBL at School: A Case Study E-DRONE - Assessing Cargo Ship Exhaust Emissions using Low-Cost Multicopter Unmanned Aerial Vehicles

J Cunha, M Gonçalves, M Noites, P Dinis, R Rocha
Colégio Luso-Francês in Porto, Portugal
rita.rocha@lusofrances.com.pt

Abstract. Four 12th grade students from Colégio Luso-Francês wanted to develop a project related with particulate matter sampling using low cost devices. The research was conducted in MIP [Research Project Methodologies], an extra-curricular discipline, which applies a Project-Based Learning [PBL] methodology to the formal curricula. In HSCI 2022 the authors will present E-Drone.

Keywords. Project-Based Learning Environmental Drone, Aerosol Particulates, Atmospheric Boundary Layer, PM2.5.

1. Introduction

1.1. Background information

According to the Review of Maritime Transport 2021 Report of the United Nations Conference on Trade and Development [UNCTAD], over 80% of the volume of international trade in goods is carried by sea. The majority of the ships still run on fossil fuels, causing high levels of pollutant exhaust emissions such as sulfur dioxide, nitrogen oxide and particulate matter, in addition to carbon monoxide, carbon dioxide, and hydrocarbons, which again leads to the formation of aerosols through secondary chemicals reactions, recognized by EPA as responsible for adverse human health effects. Despite this, shipping remains one of the less regulated anthropogenic emissions [7].

Research estimates that 12% of the total relative external costs of international ship traffic in Europe are due to air pollution [10]. For the Iberian Peninsula, studies are still scarce. Being the region the most western point of the European continent and the only natural opening by sea between the Mediterranean Sea and the Atlantic Ocean, data is needed for the full understanding of air pollution scenarios. A study conducted in 2021 estimated that all-cause premature deaths attributable to PM2.5 ship-related emissions represented an average increase of 7.7% for the Iberian Peninsula when compared to the scenario without shipping contribution [10]. The authors estimated costs of around 9 100 million € yr-1 [for a VSL approach, meaning how much society is willing to pay to avoid an anonymous death] and 1 825 million € yr-1 [for a VOLY approach, i.e., value of a life year] were estimated for PM and NO2 all-cause burden of disease.

Portugal is a country with 942 km of coastline, densely populated in coastal areas. According to the Statistical National Institute [12], maritime transportation represented 51,5% of the total exported goods for the period of 2020, and 58,1% of all imported goods at a national level. Recent studies revealed that ships' emissions can be transferred up to hundred kilometers towards the mainland [2,4], depending on the meteorological conditions and the influence of wind directions /sea breeze [13].

Particular concern is related to PM [Particulate Matter], VOC [Organic Volatile Compounds], CO [Carbon Monoxide], due to their potential public health impacts, NOx [Nitrogen Oxides] and SOx [Sulfur Oxides] due to their contribution for rain acidification, and CO2 [Carbon Dioxide] due to its role on greenhouse effect [9]. Particulate Matter is a mixture of heavy metals, black carbon, polycyclic aromatic hydrocarbons, and other organic and inorganic substances suspended in the atmosphere, differing in diameter and, consequently, in the ability to penetrate the respiratory system. Below 10 micrometers [PM10] particles can be inhaled, and, selectively, be retained by bronchioles [PM 2.5] and villi along the airways. The Portuguese National Maritime Authority ensures compliance with several international agreements related to shipping pollution regulations, such as the International Convention for the Prevention of Pollution from Ships [MARPOL], the International Convention on Oil Pollution Preparedness, Response and Co-operation 1990 [OPRC 90], the Protocol on Preparedness, Response and Co-operation to Pollution Incidents by Hazardous and Noxious Substances, 2000 [OPRC-HNS], the Convention for the Protection of the Marine

ISBN 978-84-8158-937-5

Environment of the North-East Atlantic [OSPAR] and the Lisbon Agreement. The 2018 amendment to the EU Emissions Trading System [ETS] Directive emphasizes the need to act on shipping emissions in order to ensure a climate neutrality in Europe by 2050. Boosting the uptake of alternative fuels, increasing the efficiency across the whole transport system and implementing monitoring and control of air pollution schemes to minimize the impacts of port activities. One of the priorities is to improve data acquisition methods, in order to have more detailed input information and better estimations of the ecological and health impacts. Commercially available low-cost Multicopter Unmanned Aerial Vehicles [UAV] can be attached to a Particulate collection system [PCS], operated on board, for in situ measurement of Aerosol Particulates in the atmospheric boundary layer [ABL], thus allowing to reduce sampling costs and the inability to operate in difficult circumstances, that have resulted in a lack of information for shipping emissions for decades.

1.2. Objectives of the research

E-Drone research aimed at study the effectiveness of using commercially available low-cost Multicopter Unmanned Aerial Vehicles [UAV] as shipping exhaust monitoring devices in urban stressful hotspots in coastal areas.

The authors established the following specific objectives:

- developing a PCS to couple to a commercially available UAV that allows air particles sampling and characterization in Ports;
- assessing the effectiveness of E-Drones in monitoring cargo ships exhaust, comparing with conventional sampling methods;
- developing a cost-benefit analysis regarding the E-Drone prototype developed by the authors when compared to conventional methods.

2. Materials and methods

2.1. Sampling area characterization

Leixões Port is located in the North of Portugal, northwest of the Iberian Peninsula, about 2.5 miles north of the mouth of the River Douro and near the city of Porto [41.18685,-8.70240]. This Port is the largest port infrastructure in the Northern Region of Portugal and one of the most important in the country, handling around 20 million tons of goods per year and representing 25% of Portuguese foreign trade by sea. Around 2 700 ships pass through here a year, more than 670 thousand TEU's and all types of cargo. It also receives passengers from cruise ships. Leixões Port is surrounded by a densely territory that comprises the Porto Metropolitan Area, which is under the influence of the air coastal dynamics of the Atlantic Ocean (Fig.1).

Figure 1. General overview of E-Drone sampling site including sampling points

Regarding the air quality characterization, the surrounding urban area is influenced by several emission sources. Besides the shipping emissions, there used to be a refinery, recently closed, and there is a network of roads inside and outside the Port and a railway, that may affect air quality at the sampling site.

The local air quality is monitored by three stations, located nearby [Seara, João Gomes Laranjo and Custóias]. These stations are a part of the monitoring network of the Portuguese Environmental Agency and continuously measure hourly data for the main atmospheric pollutants PM10, SO_2, NO_X and CO.

The latest available data in QualAr database refer to 2016. The scarcity of measurement data is related to the complex measuring methods, which reinforces the importance of E-Drone application for systematic collection of data. Regarding the wind patterns, the wind blows from ocean to land (West–Southwest quadrant) during the daytime and from land to ocean (Northeast wind) during the nighttime, which suggests a pollutant dispersion over the urban area close to the Leixões Port during the

day and a dispersion over the sea during night-time (Fig.2).

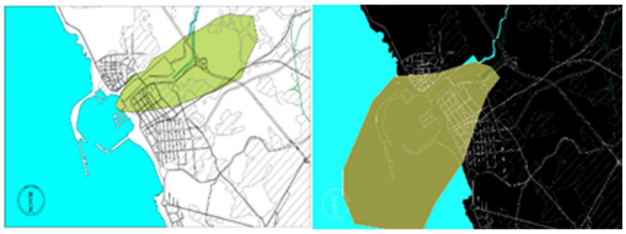


Figure 2. Air pollutants dispersion in surrounding are of Leixões Port during daytime (left) and night-time (right)

The study area extends for 5 km of quay, 55 ha of embankments and 120 ha of wet area. Two sampling points were selected, one at the cruise terminal [41.177565472062, -8.702010973610108] and one at the cargo ship terminal [41.18939621822624, 8.694503518526705] (Fig.1), having as a criteria the access to the highest possible point and closer to the ships. The coastal area is strongly restricted for any flight operation. For this research, several authorizations had to be requested [Leixões Port Captainship; National Civil Aviation Authority, National Aeronautical Authority and the Administration of the Ports of Douro, Leixões and Viana do Castelo, APDL] and the E-Drone flight operation was obliged to fly at a maximum height of 30 meters above the ground in a maximum perimeter of 50 meters. The sampling days [14 February '22; 28 February '22] corresponded to the presence of cruise and cargo ships at the terminals and the sampling time [06:30] occurred at dawn, when the wind is less strong in order to guarantee the UAV stability.

2.2. Particle Collection System [PCS] prototyping

The E-Drone Particulate Collection System [PCS] research was conducted along the last three years and was developed to operate on board a commercially available unmanned aerial vehicle [UAV] for *in situ* collection of Particulate Matter in the Atmospheric Boundary Layer [ABL]. The Phantom 4 Advanced UAV selected for the research comes with a 5-hour battery life remote controller, a built-in screen and a camera [1-in 20 MP sensor], allowing aerial videos and photos with a maximum video transmission range of 7 km. This UAV have a dual-band satellite positioning [GPS and GLONASS]. The Phantom's battery for regular flight operations has a durability of 30 minutes. However, the experimental flights revealed that the maximum duration of each flight is approximately 15 minutes due to meteorological conditions and to the introduction of the PCS, which changed the weight of the equipment. For the research purposes, five batteries were acquired. A mass flow sensor, a battery, a blower, an ESP32 microcontroller, an air inlet, and a Particulate extraction unit, composes the PCS (Fig.3).

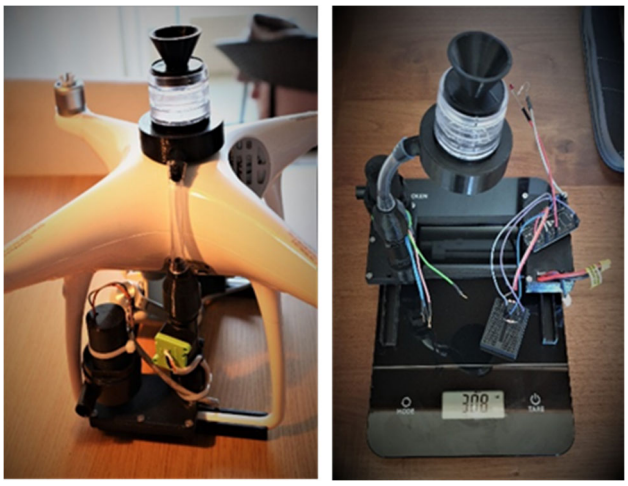


Figure 3. E-Drone PCS

2.2.1. Mass flow sensor

A reliable determination of air Particulates concentration requires the precise determination of the sampled air volume. This was achieved by installing a mass flow sensor that permanently remains in the airflow path of the PCS, irrespective of whether data from the flow sensor is collected or not. The SFM3000/ CMOSens® sensor is a digital flow meter operating from a 5 Volt supply voltage and features a digital 2-wire C interface. The sensor combines signal processing and digital calibration on a single microchip. This sensor can mesure up to 200 lpm.

2.2.2. Batteries

The PCS prototype will make use of Li-Po Turnigy Nano-tech batteries [950mAh; 7,4V] that allows the UAV to operate with a safety margin of one hour. The battery provides power to the blower.

2.2.3. Blower

The blower, powered by the batteries, is responsible for the extraction of the air. The E-

ISBN 978-84-8158-937-5

Drone blower option was limited by the weight capacity of the drone. For a Phantom 4 Advanced UAV, weighting 1368 g., the maximum load should not exceed 300 g. A more powerful blower would be naturally bigger and heavier, which could disturb the drone and require larger and heavier batteries. Given the charge limit admitted for this UAV, it was not viable for the research. The blower used in the prototype was taken from a mini vacuum cleaner, commercially available. In a first stage, the particle extraction unit made use of quartz filters, increasing the air resistance, thus resulting in a 5 lpm of airflow. In a second stage, the filters were substituted by a sampling cassette used to capture bioaerosols. This way, we could increase the airflow by 15 lpm, which reduced substantially the time flight.

2.2.4. ESP32 microcontroller

The ESP32 microcontroller selected for this research was responsible for reading the sensor, generating the engine control signal and communicating via Wi-Fi with a mobile phone. In this way, air extraction could be controlled at each altitude, allowing a vertical profile Particulate matter characterization. The ESP32 board has Wi-Fi wireless communication that allows you to talk to the cell phone through a web page and thus view the flow and turn the engine on/off (Fig. 4). In addition to this board, there are transistors that are controlled by an ESP32 output signal and work like a switch that turns the motor on or off. The flow sensor is also connected to the ESP32 board via an I2C communication port.

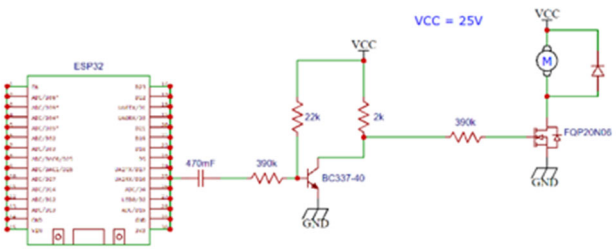


Figure 4. E-Drone PCS circuit with the ESP32 microcontroller

2.2.5. Air inlet

The geometry and orientation of the air inlet had to guarantee that the sampled air was representative in terms of its particle load. This could be achieved by isokinetic sampling [7], meaning that the flow velocity of the air entering the inlet is identical, by magnitude and direction, to the flow velocity of the surrounding air approaching the inlet. If isokinetic sampling is not ensured, aerodynamic effects, such as particle mass inertia and coefficient of drag, could result in a no representative surrounding air uptake and biased particle concentration value. The larger the particle, the higher the mass and thus inertia, the more important isokinetic sampling becomes [7]. In order to provide omnidirectional air intake under isokinetic or at least near-isokinetic conditions, a bell-mouth shape air inlet was designed and prototyped through a 3D printer (Fig. 5).

2.2.6. Particle Extraction Unit

In order to achieve a lean workflow from sampling to visual particle identification and counting, the extracted particles should be easily accessible for visual analysis without complex and time-consuming sample preparation steps. An impactor has the potential to meet all these demands.

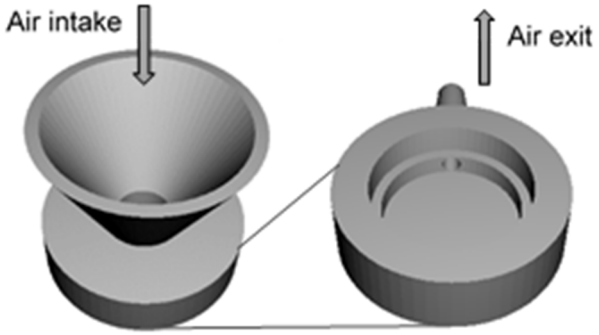


Figure 5. E-Drone Air inlet prototyping

The functional principle of an impactor is based on the deflection of a Particle-loaded free-flow gas stream by means of an impaction plate [7]. In the first stage, the impactor made use of a filter in the open jet at a small distance from the nozzle. This forced the Particulate-loaded gas stream to deflect. Due to their mass inertia, the Particulates in the gas stream were able to follow this deflection only to a limited extent. Therefore, particles with a sufficiently high mass inertia impinge on the surface of the impaction plate and could be retained in the filter (Fig. 6).

In the research we used 35 mm diameter quartz filters [QM-A, Whatman], previously burned at 500ºC for 12 hours. The filters were

ISBN 978-84-8158-937-5

weighed before and after sampling, and after conditioning for 24 hours, at room temperature and 50% relative humidity. The concentration of total suspended particles was determined gravimetrically, based on the mass of Particulates deposited on the filters and the volume of air that passed through the filter during the sampling period. The particle extraction unit evolved along the project and, as previously mentioned, in a second stage, the E-Drone made use of Air-O-Cell® Sampling Cassettes. Particles in the air stream are accelerated as they approach the tapered inlet opening and drawn through a small slit aimed directly at a glass slide. This glass slide contains a sticky and optically clear sampling media, which can permanently collect particles, and allow direct staining and examination by bright field, dark field, and phase contrast microscopy. As the particles come through the slit, the air velocity forces the particles to impact into the sampling media, while the air stream makes a sharp 90º turn and proceeds around the slide and out of the cassette (Fig.7). This feature allowed increasing the airflow from 5 lpm to 15 lpm.

Figure 6. E-Drone Air inlet prototyping using filter filled sampling cassettes

2.3. Portable Total Particle Suspended Sampler

In order to compare data with a conventional sampler, a low-volume digital sampler was used. The sampler automatically recorded the temperature and pressure, as well as the sampling time [1h14'], the air volume [2,78m^3] and the flow rate [38,03 lpm]. The sampler used quartz filters [QM-A, Whatman], previously burned at 500ºC for 12 hours and the collection of atmospheric particles followed the procedure described in 2.2.6.

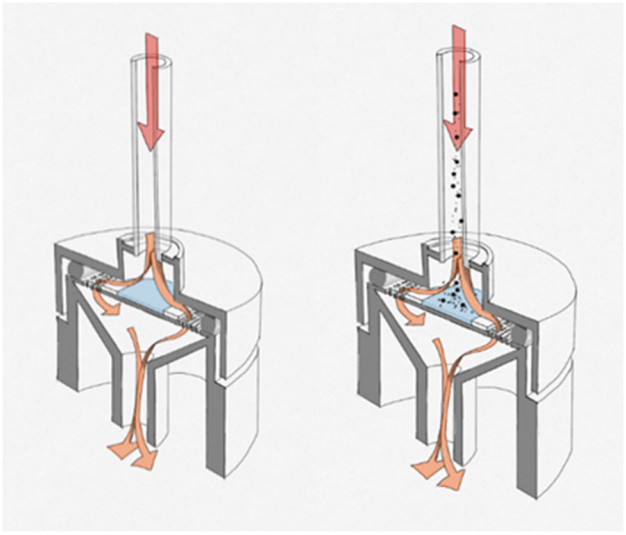


Figure 7. Air-O-Cell® Sampling scheme

2.4. Particulate matter [PM] processing and characterization

2.4.1. PM gravimetric analysis

Gravimetric analysis was performed with the samples collected at the cruise terminal site, ensuring a minimum rainless period of 15 days. Three filters were collected, using the same cassette, in order to avoid any mass difference between devices. The filters were placed in labelled aluminium foil to be safely transported to the laboratory, where they remained stored until processing. The quartz filters were then weighted with a 1/10 balance (OHAUS Adventurer™). A clean quartz filters' mass was used to compare the weight of filter blanks with weight of filters post-sampling, and then to calculate the mass of PM fraction in each sample. As for the Portable Total Particle Suspended Sampler, a continuous airflow was maintained during the time of the E-Drone sampling scheme, using the same quartz filter. The sampler was then transported to the laboratory where the filter was removed and processed.

2.4.2. PM optical analysis through microscopy

The adoption of Air-O-Cell® Sampling Cassettes implied a change in the way the sample was collected and processed. The cassette was placed in the same position as the filter-filled ones without the need of adding or replacing any filter. After sampling, each cassette was placed in labelled aluminium foil

to be safely transported to the laboratory, where they remained stored until processing. As this technique is completely innovative for the purpose of the research, several pre-tests were conducted prior to Leixões Port collection. The devices were firstly validated in an industrial area of Estarreja city, in the centre of Portugal, and in a car garage. After ensuring that the devices worked properly coupled to the E-Drone PCS, a final sampling in cargo ship area at Leixões Port was conducted. Once at the laboratory, the Air-O-Cell® Sampling Cassettes were opened and the slide with the particles was removed and placed in Bresser® TFM 301 trinocular microscope. A Bresser® Mikrocam PRO HDMI captured images from the samples in order to process under ImageJ software.

The Air-O-Cell® particle deposition area at a flow rate of 15 lpm is approximately 1.1 mm wide by 14.5 mm long yielding an approximate area of 15.95 mm^2. To calculate the number of particles in the deposition area, the slide could be divided in 10 transverse sections if the sample was concentrated along the line and if the deposition pattern was homogeneous (Fig. 8).

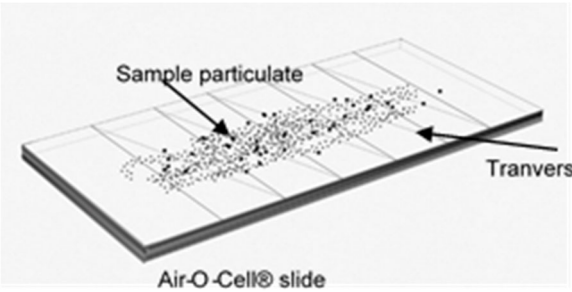


Figure 8. Air-O-Cell® counting method

As it was not the case in Leixões Port samples, area unit was used for calculation. The particle concentration per cubic meter of air was performed applying the following equations:

EQUATION 1

Air volume (m^3) = [Flow rate (lpm) / 1000] x Nr. of minutes

EQUATION 2

Total Area counted (mm^2) = Area unit counted (mm^2) x Nr. of Area units

*For the measurement of Area unit in mm^2, a calibration slide must be previously applied

EQUATION 3

Number of Particles/ m^3 = [Air-O-Cell® particle deposition area (15,95 mm^2) / Total Area counted (mm^2)] x [1/ Air volume (m^3)] x Nr. of Particle counts

Visual analysis was supported by the freely available Image J (https://imagej.nih.gov/), leveraging thresholding and analysis tools. Since users need to set a scale for each picture, it was necessary to calibrate the Bresser® Mikrocam PRO HDMI software using a calibration slide [200µm].

2.4.3. Economic value of E-Drones implementation for environmenttal monitoring

In order to proceed with a comparative analysis regarding the implementation of E-Drones for environmental monitoring instead of conventional sampling methodologies, a Canvas chart and a SWOT graph was designed.

3. Results

3.1. PM gravimetric analysis

Table1 shows the mass of PM deposited in the quartz filters in LOW-VOLUME sampler. In the case of the DRONE, it is not possible to quantify the mass of particles eventually deposited on the filters. There are several reasons that can be pointed out for this result: i) the low airflow passing through the filter [4 lpm] can be a result of the small diameter air outlet hole; ii) the difficulty in removing the filter from the support used in the Drone, without damaging it because it was too tight to the support; iii) after sampling, the DRONE filters were placed in the weighing box [controlled humidity] but this procedure was not possible before sampling, which may explain having values for the final masses of the same order of magnitude (or less) as the initial masses. In the case of Low-Volume filters, the processing was done according to the guidelines. Nevertheless, the result is surprising for the atmospheric concentration of PM2.5 is [288 µg/m^3] during such a short sampling period, being more than 10x higher than the value of the limit value not to be exceeded [25 µg/m^3]. The accounts and records were double-checked, the equipment

ISBN 978-84-8158-937-5

was working well, and the sensors clearly marked the volume of air sampled. One possible explanation may be due to the anchored cruise ship. This result opens up a range of possibilities for future work on air quality in that area of Leixões Port.

Table 1. Mass of PM in quartz filters for Drone sampler and LOW-VOLUME sampler (Mass values already corrected for blank filter mass). In the case of the DRONE sampler, it is not possible to quantify the mass of particles deposited on the filters

Filters DRONE

Filter code	Initial (g) F1 (Blank)	Initial (g) F2	Final (g) F1 (Blank)	Final (g) F2	PM mass (g) F1 (Blank)	PM mass (g) F2
Initial mass (g)	0,0924	0,0922	0,0922	0,0920		
	0,0923	0,0922	0,0921	0,0920		
	0,0932	0,0923	0,0923	0,0922		
	0,0932	0,0925	0,0922	0,0921		
	0,0923	0,0922	0,0923	0,0921		
average	0,0927	0,0923	0,0922	0,0921		
s.d.	0,0005	0,0001	0,0001	0,0001		

NOTE: After sampling, DRONE filters remained 24 hours in the weighing box at room temperature and a RH aprox. 50%.
It was not possible to follow the same procedure bofero sampling (no access to the filters at Aveiro University laboratory the day before sampling).

Filters LOW-VOLUME ($PM_{2.5}$)

Filter code	Initial (g) DR1 (Blank)	Initial (g) DR2	Final (g) DR1 (Blank)	Final (g) DR2	$PM_{2.5}$ mass (µg) DR1 (Blank)	$PM_{2.5}$ mass (µg) DR2 (corrected f/ Blank)	$PM_{2.5}$ (µg/m³)
Initial mass (g)	0,1479	0,1480	0,1483	0,1490			
	0,1481	0,1482	0,1484	0,1491			
	0,1480	0,1479	0,1484	0,1496	340,0	800,0	288
	0,1482	0,1480	0,1485	0,1499			
	0,1482	0,1483	0,1485	0,1487			
average	0,1481	0,1481	0,1484	0,1492			
s.d.	0,0001	0,0001	0,0001	0,0004			

NOTE:Before and after sampling, LOW-VOLUME filters remained 24 hours in the weighing box at room temperature and a RH aprox. 50%.
Sampling conditions in the Low-Volume sampler:
Beginning: 10h32 | End: 11h46
Flow rate: 38.03 L/ min
Sampled air volume: 2,78 m³

Filter codes	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15
Initial mass (g)	0,0924	0,0922	0,0926	0,0934	0,0935	0,0940	0,0929	0,0925	0,0929	0,0949	0,0932	0,0947	0,0928	0,0945	0,0930
	0,0923	0,0922	0,0925	0,0931	0,0937	0,0941	0,0928	0,0925	0,0929	0,0947	0,0935	0,0949	0,0929	0,0945	0,0290
	0,0932	0,0923	0,0928	0,0932	0,0935	0,0941	0,0929	0,0924	0,0928	0,0948	0,0934	0,0947	0,0928	0,0945	0,0932
	0,0932	0,0925	0,0928	0,0933	0,0935	0,0939	0,0930	0,0924	0,0929	0,0949	0,0934	0,0946	0,0929	0,0946	0,0931
	0,0923	0,0922	0,0925	0,0931	0,0937	0,0941	0,0928	0,0925	0,0929	0,0947	0,0935	0,0949	0,0929	0,0945	0,0290
average	0,0927	0,0923	0,0926	0,0932	0,0936	0,0940	0,0929	0,0925	0,0929	0,0948	0,0934	0,0948	0,0929	0,0945	0,0675
s.d.	0,0005	0,0001	0,0002	0,0001	0,0001	0,0001	0,0001	0,0001	0,0000	0,0001	0,0001	0,0001	0,0001	0,0000	0,0351

3.2. PM optical analysis through microscopy + ImageJ software

As PM calculation was not possible in Drone samples, a filterless collecting methodology was adopted in order to increase the flow rate in the system. The Air-O-Cell® Sampling Cassettes are based on visual analysis under microscope, allowing a quantification and a visual identification of the sampled particles. Table 2 presents the concentration of particles per m^3 for 6 area units sampled in cargo ship Leixões terminal.

Table 2. Particles counting with Drone sampler using microscopy and ImageJ software

MIKROS image	Nr. of Particle counts	Flow rate (lpm)	Time sampled (minutes)	Air volume (m^3)	Area unit counted* (mm^2)	Nr. of Area units	Total Area counted (mm^2)	Number of Particles/ m^3 ($part/m^3$)
1	134	14,84	17	0,25	0,55	6	3,30	8642
							Total Area (mm^2)	Number of Particles/ m^3 ($part/m^3$)
2	48							
3	91						15,95	2160
4	85							
5	41							
6	48							
	447							

Air volume (m^3) = [Flow rate (lpm) / 1000] x Nr. of minutes
Total Area counted (mm^2) = Area unit counted (mm^2) x Nr. of Area units
Concentration of Particles/ m^3 = [Air-O-Cell® particle deposition area (15,95 mm^2) / Total Area counted (mm^2)] x [1/ Air volume (m^3)] x Nr. of Particle counts

* Calibration
02,mm=386,48 pixel

Pixel		mm
width	1920	0,99
height	1080	0,56

For a total area counted of 3,30 mm^2 the Air-O-Cell® Sampling Cassettes collected 8 642 particles. For the total Air-O-Cell® particle deposition area, corresponding to 15,95 mm^2 the concentration of particles is estimated in 2160. The particles were counted using ImageJ software (Fig. 9).

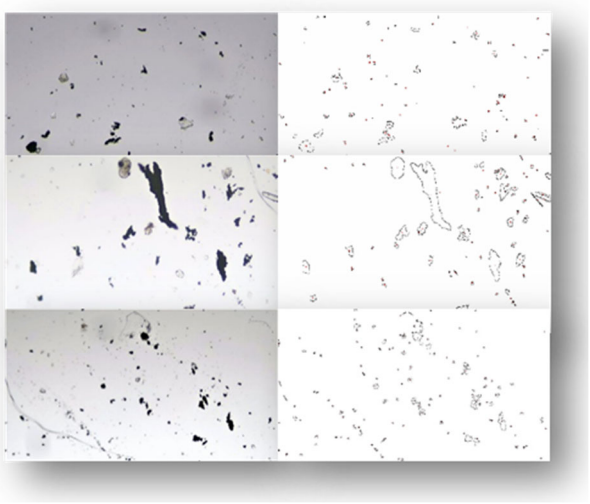


Figure 9. E-Drone sample particles counting using ImageJ software

Figure 10. E-Drone SWOT analysis

3.3. Economic value of E-Drones implementation for environ-menttal monitoring

In order to proceed with a comparative analysis based on cost-benefit of using commercially available low-cost Multicopter Unmanned Aerial Vehicles [UAV] for air quality monitoring in coastal areas, a SWOT analysis (Fig.10) was conducted.

ISBN 978-84-8158-937-5

4. Discussion and conclusion

E-Drone research was conducted during 3 years in which challenges were overcome in the different subjects involving the project. Regarding the mechanicals of the prototype, the big challenge was to guarantee the stability, not exceeding the weight this kind of commercial drone could carry. This implied printing pieces in 3D, instead of using available materials, and to assume some limitations regarding the blower, namely the flow rate capacity. The electronics was another challenge. The authors wanted to acquire data in a specific height of the atmosphere, which implied the use of a mechanism that triggered the engine, remotely controlled, at a specific altitude. The PCS attached to the E-Drone naturally generated some electromagnetism, which is a problem for UAVs. Some strategies were implemented to minimize the conflict, namely the creation of a Faraday cage to isolate the system. Regarding the particles collecting device, the position of the inlet was crucial to guarantee that the sample was representative of the inner atmosphere of the drone when operating. Several studies were conducted and some air dynamics using colourful smoke were made to understand the effect of the drone paddles. Once these challenges were overcome and decisions were taken regarding prototyping, the fieldwork in Leixões cruise terminal revealed that the filtering system blocked the airflow. This conducted the team to a new research on alternative sampling devices. Air-O-Cell® Sampling Cassettes are used in biotechnology and, as it is a filterless system, it allowed an increase in airflow of 3x. The challenge became the data treatment, as it was focused on microscopic visualization and counting. ImageJ software seemed to fit the purposes of the research. The objectives were accomplished in terms of testing whether drones are capable of capturing particles, identifying and counting them. Further steps include working on a method that allows comparing the output dimensions of the Drone sampling (number of particles per area unit) with that of the conventional samplers, and that appears in the legislation [mass of particles per area unit]. This fact is precisely the main advantage of E-Drones usage in air quality monitoring: it allows collecting extremely small particles – that tend to be those that are more easily inhaled – that, in a conventional sampling, are irrelevant in a mass analysis perspective. Another advantage is that E-Drone sampling method allows the visualization and identification of individual particles, which could be very interesting from a Human health point of view. Several tests were conducted prior to Leixões filed work, namely in Estarreja where a substantial amount of pollen and microplastics were collected in the slide of the Air-O-Cell® Sampling Cassettes. This opens an all-new field of research in the frontier of health studies and toxicology and atmospheric chemistry. E-Drone monitoring is a smart alternative methodology that allows intensive data acquisition because its sampling is easily conducted with relatively cheap analysis.

5. Acknowledgements

P Moreira - Department of Electrical and Computer Engineering, Faculty of Engineering of the University of Porto, Portugal and INESC TEC - Institute for Systems and Computer Engineering, Technology and Science, Portugal;

J Lima - Department of Electrical and Computer Engineering, Faculty of Engineering of the University of Porto, Portugal and Research Centre in Digitalization and Intelligent Robotics, Polytechnic Institute of Bragança, Portugal;

R Duarte – CESAM/ Centre for Environmental and Marine Studies, Department of Chemistry, University of Aveiro, Portugal.

6. References

[1] Bell ML, Morgenstern RD, Harrington W. Quantifying the human health benefits of air pollution policies: review of recent studies and new directions in accountability research. Environ. Sci. Policy, 14, 357–368, 2011.

[2] Corbett, James J, Winebrake, James J, Green, Erin H, Kasibhatla, Prasad, Eyring, Veronika, Lauer, Axel. Mortality from ship emissions: a global assessment. Environ. Sci. Technol., 41 (24), 8512–8518, 2007.

[3] Crazzolara C, Ebner M, Platis A, Miranda, T, Bange J, Junginger A. A new multicopter-based unmanned aerial system for pollen and spores collection in

the atmospheric boundary layer. Atmos. Meas. Tech., 12 (3), 1581–1598, 2019.

[4] Eyring V, Köhler HW, Lauer A, Lemoer B. Emissions from international shipping: 2. Impact of future technologies on scenarios until 2050. J. Geophys. Res.: Atmos., 110 (17), 2005.

[5] European Environment Agency. Air quality in Europe – 2020 Report. Office of the European Union, Luxembourg, 2020.

[6] Kuittinen N, Jalkanen JP, Alanen J, Ntziachristos L, Hannuniemi H, Johansson L, Karjalainen P, Saukko E, Isotalo M, Aakko-Saksa P, Lehtoranta K, Keskinen J, Simonen P, Saarikoski S, Asmi E, Laurila T, Hillamo R, Mylläri F, Lihavainen H,... Rönkkö T. Shipping Remains a Globally Significant Source of Anthropogenic PN Emissions Even after 2020 Sulfur Regulation. Environmental Science & Technology, 55(1), 129–138, 2021.

[7] Kulkarni P, Baron P, Willeke K. Aerosol Measurement: Principles, Techniques, and Applications. 3rd Edition. Wiley Online, 2011.

[8] Li X, Peng Z, Lu Q, Wang D, Hu X, Wang D, Li B, Fu Q, Xiu Q, He H. Evaluation of unmanned aerial system in measuring lower tropospheric ozone and fine aerosol particles using portable monitors. Atmospheric Environment, 222, 117134, 2020.

[9] Matthias V, Bewersdorff I, Aulinger A, Quante M. The contribution of ship emissions to air pollution in the North Sea regions. Environmental Pollution, 158: 2241- 2250, 2010.

[10] Nunes R, Alvim-Ferraz M, Martins F, Sousa S. Assessment of shipping emissions on four ports of Portugal. Environmental Pollution, 231 (2), 1370-1379, 2017.

[11] Nunes R, Alvim-Ferraz M, Martins F, Peñuelas L, Durán-Grados V, Moreno-Gutiérrez J, Jalkanen JP, Hannuniemi H, Sousa S. Estimating the health and economic burden of shipping related air pollution in the Iberian Peninsula. Environment International,156: 106763, 2021.

[12] Rodrigues S, Inácio A, Proença M, Chainho, L, Vieira S. Relatório do Estado do Ambiente 2020/21. Agência Portuguesa do Ambiente, 2021.

[13] Sorte S, Arunachalam S, Naess B, Seppanen C, Rodrigues V, Valencia A, Borrego C, Monteiro A. Assessment of source contribution to air quality in an urban area close to a harbor: Case-study in Porto, Portugal. Science of The Total Environment, 662, 347-360, 2019.

[14] UNCTAD. Review of Maritime Transport 2021. United Nations Conference on Trade and Development, 2021. https://unctad.org/system/files/official-document/rmt2021summary_en.pdf.

7. Note

E-Drone has a strong link to research projects, being an outreach activity of AMBIEnCE [projectambience.wordpress.com/], a a National collaborative research developed at the University of Aveiro, focused on assessing the impact of atmospheric organic aerosols deposition on the molecular composition and reactivity of dissolved organic matter in different coastal marine systems, as well as exploring how the intrinsic chemical features of organic aerosols drive the solubility and bioavailability of atmospheric-derived trace metals in seawater.

ISBN 978-84-8158-937-5

Interdisciplinary Didactic Scenario in Technology Education and Information Technology

L Golikidou, D Fasouras
3rd Gymnasium of Elefsina in Attica, Greece
lgolikidou@sch.gr

Abstract. This paper presents an interdisciplinary teaching approach to the subjects of Technology Education and Information Technology in secondary education, according to the Framework Curriculum of the second Grade of the Greek Gymnasium for those students that are 14 years old.

This good practice aims to be an interdisciplinary activity that enrols and combines several topics in both subjects. In the subject of Technology Education students study the structure of a processing industry or a line production industry; they design its logo, decide what its website should look like, and simulate its organizational structure, the roles, and responsibilities of every department.

At the same time-usually a semester- in the subject of Information Technology the students learn and practice using spreadsheet software (i.e. Ms Excel or LibreOffice Calc) to support accounting functions of the same industry they have studied in the subject of Technology such as budgeting, financial statements, and balance sheets. Also, they learn to create multimedia content (Video, Animation, Presentation, etc.) in order to advertise and promote the products of their industry and to design and print a 3D model of these products

The methodology to follow is the Project Based Learning (PBL) in which students learn by actively being engaged in real-world and personally meaningful projects.

The scenario aims to be an original activity that can be at the same time a holistic approach to many topics according to the official Curricula of the two subjects and also according to the 21st-century skills that require the involvement of students in "real-world problems".

Through this project, students are able to acquire knowledge by working in cross-learning environments, combining different skills, and being creative in activities that are relevant to the real world and at the same time gain pedagogical and cognitive benefits.

Keywords. Didactic of Information Technology, Interdisciplinary Approaches Technology Education.

1. Introduction

One of the demands of modern teaching is the interdisciplinary approach to cognitive subjects with the simultaneous engagement of teachers and students. The Partnership for 21st Century Learning has designated “Learning and Innovation Skills,” including critical thinking and problem-solving, communication, collaboration, and creativity, as core skills in that students need to be successful in today’s world (“Partnership for 21st century skills: Framework for 21st century learning,” 2014).

In this paper we briefly present the basics of an interdisciplinary didactic scenario which it is implemented in the Greek Gymnasium within the framework curriculum of the subject of Technology Education and the subject of Information Technology.

According to the research literature (Rautopuro et al., 2006; Webb, 2002), one of the three separate aspects of Information and Communication Technology (ICT) in school education is using ICT as a tool to support teaching and learning processes, for example using a wordprocessor, spreadsheet or database in other subject areas such as mathematics or science. Learning ICT is more than the ability to operate and use a computer system.

At the same time, the main purpose of Technology Education in High School is the familiarization of students with their technological and productive environment that affects every dimension of modern life and modern culture before the end of compulsory education and regardless of future career choices. To function in modern society, the citizen must have basic technological knowledge and skills.

2. Methodology

The methodology followed in this scenario

was Project-Based Learning (PBL) which is defined as a "model for a classroom activity that shifts away from the classroom practices of short, isolated teacher-centered lessons and instead emphasizes learning activities that are long-term, interdisciplinary, student-centered, and integrated with real-world issues and practices" (Holbrook, 2007). The basic idea is for students to simulate the roles of the departments of industry and collaborate in order to work on several tasks and be creative accordingly to both subjects of Information Technology and Technology Education.

3. Implementation

In the subject of Technology Education according to the Framework Curriculum, the second-graders students have to collaborate in groups and build the template of industry and at the same time take on and perform roles that are related to industry management. They are choosing an industry and they assume roles as industry executives. In their first meeting, as industry executives, they decide on the name and the industry logo.

Figure 1. Floor Plan of the Industry

In the next meeting, the marketing manager after a discussion with the general manager and the managers of production, design, quality control, and finance presents the products of their industry.

The design manager designs the floor plan of the virtual industry. In collaboration with the Manager of Human Resources and the production, the Manager distributes the tasks among their team in order for the template of the industry to be constructed. The managers of production, quality control, and supplies select the materials for the construction (wood, paper etc).

Assignments related to the IT course:

- The Design manager undertakes the design of the logo using designing software such as Gimp https://www.gimp.org/
- The Financial Director prepares the price list of the products (using a Spreadsheet i.e. Ms Excel or LibreOffice Calc).
- The Design manager designs the product packaging and manufactures the template which later is printed in the 3d printer.

Figure 2. Students working in the IT Lab

- The Quality control manager presents the raw materials used presentation software as Ms PowerPoint or Google Slides
- They also create the QR code using https://gr.qr-code-generator.com/ with product information.
- The Production Manager presents the production stages of the industry's products using a presentation tool using www.Prezi.com

Other activities:

- The Financial Manager creates a spreadsheet that reflects the budget, the income, the expenses, and the profit of the industry.

ISBN 978-84-8158-937-5

- The Safety manager makes a poster with the safety and hygiene rules and a poster with some safety or hygiene message using the www.canvas.com.
- The Director of the Public Relations of the industry creates a poster and a letterhead using software as Ms Word or LibreOffice Writer.
- The Information Systems manager creates decides the content of the industry website after having visited several websites of real industries of a similar product and assembling information from each director of the departments of the industry.
- The Procurement manager works on the barcodes of the products as well as in the spreadsheet save the date of the suppliers of materials (information: address, telephone, products, prices etc)
- The Director of education organises the seminar programs and the invitations using a word template.
- The Marketing manager advertises and promotes the product (s) and the sales budget by creating a banner and a short video.
- The Manager of personnel creates the organization chart of the industry using https://www.popplet.com/ or https://bubbl.us/ .

Finally, all managers have to present their role in the industry by creating a presentation using one of the Web 2.0 tools in order their presentations to be embedded into the industry's website. All the students work on a financial statement and budgeting using the spreadsheet of the LibreOffice suite. They have created Graphs and they analyze the results and the data proposing strategic solutions for marketing.

3. Results

3.1. Create a logo

After it is made clear what the significance of logos in companies and how to create recognizable logos, students create their own using a free tool as https://www.canva.com/ .

Among the logos is decided on the one that will represent their industry. It is obvious that technology is not a "stand-alone" entity but rather intertwined with nearly every aspect of our lives.

Figure 3. Create a logo for the Industry

3.2. Create a Web Site

After reviewing web sites of the structure and the contents of websites of similar product industries in the Greek or European market the web design manager has created the website of the industry using a web designing platform such as Weebly or Wix.

3.3. Designing a 3d model

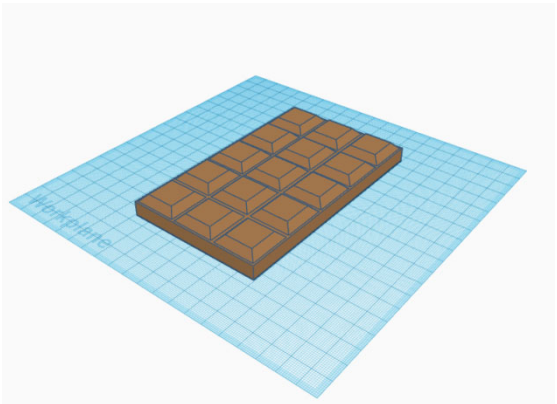


Figure 4. Designing a product using Tinkercad

3d printing is a technology that creates excitement in the classroom and a better understanding of the design process as they

gain hands-on experience from conception to creation.

3d printing works by starting with a digital model and then creating a physical three-dimensional object.

A user-friendly easy to use tool is the https://www.tinkercad.com/ which gives also the way to review student designs and monitor their progress in your dashboard.

3.4. Printing the 3d model of the product

Students learn how to use the 3d printer, bringing the touchable final product out of the computer screen and into the real, physical world. Through this process is gained self-directed construction and capacity for independent and introverted work, as well as improving physical tactility and the observability of the physical artifacts created (Eisenberg, 2013).

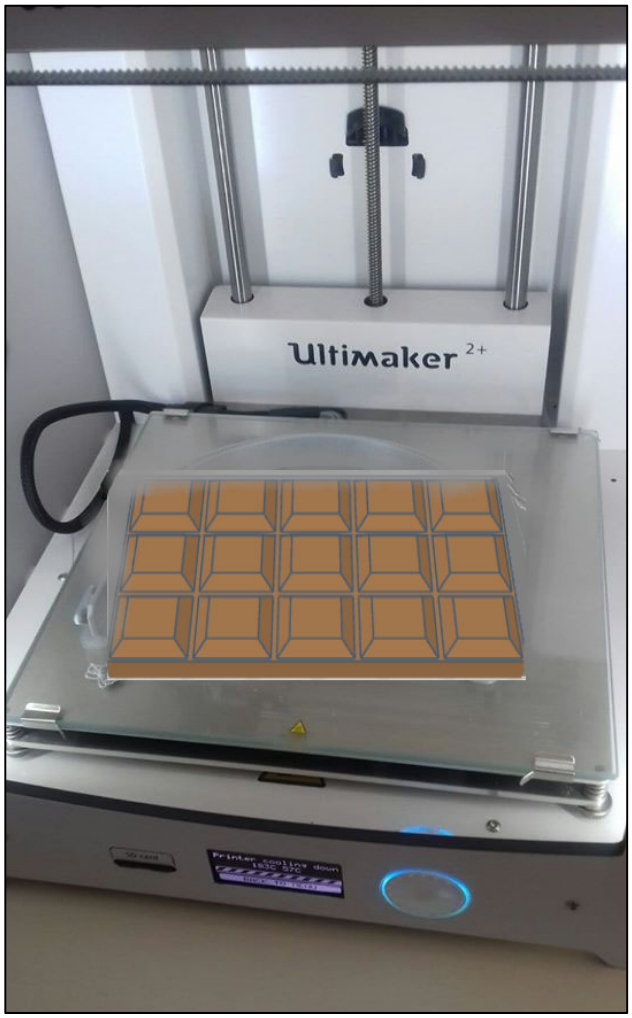


Figure 5. Printing the product

3.5. Create a Video

The marketing department is responsible for promoting and advertising the products and a fine way to do so is through multimedia such as a video or a banner which can easily be embedded in the website of the industry. The students use the https://www.canva.com/ platform and its high-quality templates in order to enhance their creativity and create the promo video for their industry.

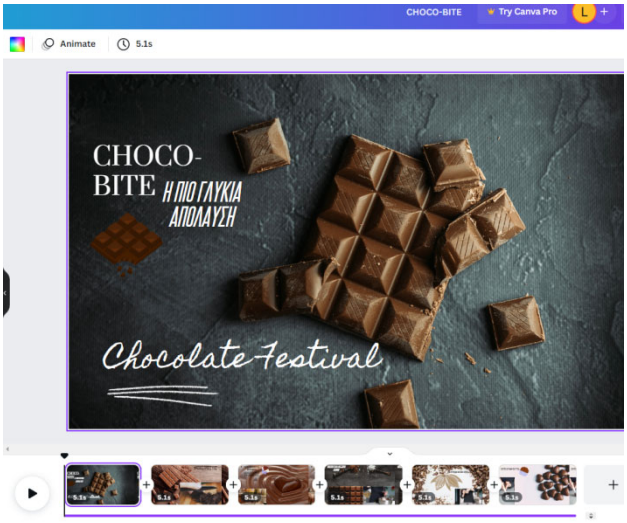


Figure 6. Creating a video promoting the product

3.6. Visualize and interpret data

One of the main aims of the Framework Curriculum in the subject of ICT is for students to learn basic data processing tasks with spreadsheets such as Ms Excel or Calc LibreOffice.

In the specific educational scenario, the connection between the two didactic areas is what provides students with the possibility to expand their creativity and build knowledge that is meaningful to them. The spreadsheet gain meaning within the functions of the industry and students learn to use it in order to process the financial and budgeting statements of their industry and visualize through graphics the main statistic measures.

The content of the graph is crucial to the delivery of information. Through the graphs students can have a clear image of their industry and see the trends over time, such as sales or profit per quarter. Based on the graphs the students were asked to make a plan and take decisions that have to do with their

ISBN 978-84-8158-937-5

industry, from different points of view regarding their sector and specialization.

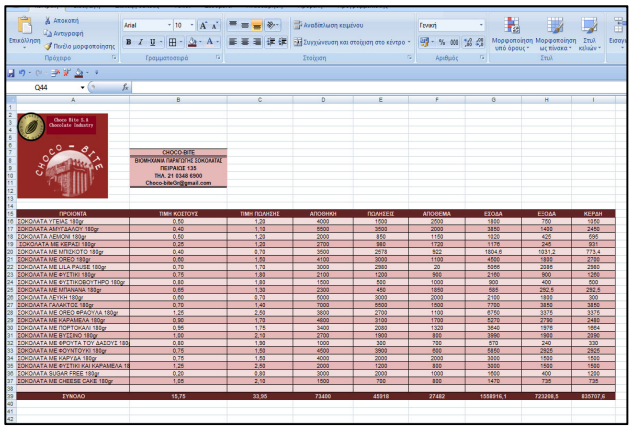


Figure 7. Learn to use Calc Libreoffice

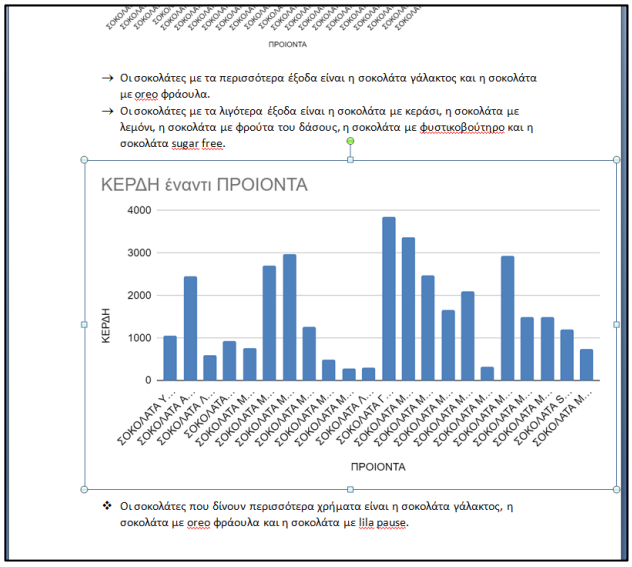


Figure 8. Analyse the graphs

4. Conclusions

Through this interdisciplinary scenario, the students have managed to acquire the main core of the topics of both subjects through this real-life-based learning activity. The teaching scenario facilitates students to understand how an industry functions as an entity enhancing at the same time their digital and collaborative skills.

In the framework of Technology Information, they managed to conceive a clearer idea of how an industrial company is structured, what is the main activity of each department, to choose their role corresponding to the executives of a real industry such as General Director, etc. They were able to acquire knowledge by working in cross-learning environments, combining different skills, and being creative in activities that are relevant to the real world, and at the same time gain pedagogical and cognitive benefits.

In the framework of Information Technology got in contact with different platforms and Web 2.0 tools, suites, software, and new technologies p.e 3d printing. They managed to combine decision-making, innovation, and creativity skills.

In addition, students come in contact with open-source software and they learn how important open-source thinking is to innovation.

This teaching scenario can be implemented in both distance and face-to-face learning, giving the opportunity for every teacher to enrol several topics and modify them according to the needs or interests of his/her class.

5. References

[1] Chen CH, Yang YC. Revisiting the effects of project-based learning on students' academic achievement: A meta-analysis investigating moderators, Educational Research Review, 26, 71-81, 2019.

[2] Eisenberg M, 3D printing for children: What to build next?, Int. J. Child-Computer Interact., 1, 7–13, 2013.

[3] Nilson LB. Teaching at its best: A research-based resource for college instructors, San Francisco, CA: Jossey-Bass, 2010.

[4] Papadopoulos I, Dagdilelis V. Didactic Scenarios and ICT: A Good Practice Guide, 2010.

[5] Prasad R, Wicklow B, Traynor C. "Practical problem-based learning: An interdisciplinary approach," 2018 EEE Integrated STEM Education Conference (ISEC), 258-261, 2018.

[6] Rizos I. Teaching scenarios and their role in the interdisciplinary approach Case study: The Minkowskian Metric https://arxiv.org/ftp/arxiv/papers/2204/2204.00627.pdf

[7] Sanders ME. Interdisciplinary approaches to teaching technology education. In K. Helguson and A. Schwaller. (Eds.).

Selecting instructional strategies for technology education: Yearbook #52 of the Council on Technology Teacher Education. Peoria, IL: Glencoe/McGraw-Hill, 65-86, 2003.

[8] Tsami A. Anastasopoulou A. International Journal of New Technology and Research (IJNTR) 2 (12), 01-06, 2016.

[9] UNESCO. Information and communication technology in education: A curriculum for schools and programme of teacher development, 2002. http://www.ifip-tc3.net/IMG/pdf/unesco-ifip_wg3.1-129538e.pdf

[10] Virtue EE, Hinnant-Crawford BN. “We’re doing things that are meaningful”: Student Perspectives of Project-based Learning Across the Disciplines. Interdisciplinary Journal of Problem-Based Learning, 13(2), 2019.

ISBN 978-84-8158-937-5

Introducing Science to Primary School Students with Autism Spectrum Disorders

[1]*M Marques,* [2]*MFM Costa*
[1]*EB1/JI N. Sra. Da Conceição, A. E. Fernando Távora in Guimarães, Portugal*
[2]*Centro de Física das Universidades do Minho e do Porto, Portugal*
marques.mib@gmail.com

Abstract. Education policy over the past years has pointing the need for scientific literacy as evidenced by the rise of the awareness of the importance of science, technology, engineering, arts and mathematics (STEAM) education. Many programs have begun to target the need for STEAM education for all students from kindergarten through high school. For students with Autism Spectrum Disorders (ASD), the need to increase their scientific literacy is further difficult to achive by the need of an individualized instruction necessary when approaching new skills. This study was implemented at a structured teaching room with ASD early primary school students. The results of this qualitative study aim to reveal the potential for creativity and the role of inclusion and STEAM in early primary education with this group of ASD students. The way the education for students with ASD is approached is changing. The principle of inclusion has become strongly supported and recognized by national educational authorities in Portugal. However, barriers prevent students with autism from being genuinely engaged in school STEAM activities, especially at the early age levels. We need to do more to improve these students' access to STEAM studies. The present paper presents the analysis of data in relation to one case study that involved one teacher and children working in classroom context. The case study reported addresses simple science hands-on activities on static electricity, through the lens of creativity.

Keywords. Autism Spectrum Disorders (ASD), Creativity, Inclusive Education, Primary Science Teaching, Static Electricity, STEAM.

1. Introduction

Teaching strategies are practices used by adults (e.g., family members, practitioners) or, in some instances, by other children 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 [1].The early years provide an exceptional opportunity to introduce STEAM, but that this potential is often left unrealized, especially for young vulnerable children, who live in poverty, are members of linguistic and ethnic minority groups [2].

Incorporating science experiments into learning is a great way to involve children and make lessons more hands-on and fun. While autistic students may have different needs in the classroom, they 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. 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 input (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. [3].

Since the discovery of autism as a human condition by Kanner (1943) and Asperger (1944) in the 1940s, individuals responsible for education and care of children and youth with autism spectrum disorder (ASD) have striven to provide effective practices and programs. Such efforts continue today. The increased prevalence of ASD has intensified the demand for effective educational and therapeutic services, and intervention science is now providing evidence about which practices are effective [4]. This study was realized in a structured teaching room with children with autism spectrum disorders (ASD). Creativity is not confined to special people or to particular arts based activities, nor is it undisciplined play, it is however, notoriously difficult to define. It has been described as "a state of mind in which all our intelligences are working together "…involving", seeing, thinking and innovating" [5]. In the context of the classroom, developing opportunities for children to "possibility think"

their way forwards is therefore critical. This will involve you in immersing the class in an issue or subject and helping them be playfully and explore options [6].Creative teaching is a collaborative enterprise which capitalises on the unexpected and variously involves engagement, reflection and transformation, patterned at such a rate as to invite and encourage a questioning stance and motivate self directed learning. [7].The case study contains three activities, documenting examples of science through the lens of creativity with autistic students. In this study, the activities and photographies will illustrate creativity in science and / or arts in the early years. These were based from selected observations and supported by information gathered through several types of data, non verbal comunication, communication tables and pictograms. This study was realized in a structured teaching room with children with autism spectrum disorders (ASD). The findings of this qualitative study aim to reveal the potential for creativity in the classroom realities of primary science education for students with ASD. For our article, we have picked three “clean” science experiments that are quiet and don’t require children 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, in this case we report only on the field notes [8] and photographs [9] taken by the teacher and reflections of the teacher [10] and inputs collected with children [11].

2.2. Methodology

The objective of the observation during this activity is to spot and to characterize children creativity [12] through non verbal comunication, communication tables and pictograms.The notes taken include the children’s 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 Guimarães, in northern Portugal, is a public educational institution covering two levels of education: preschool and primary school; the students in a total of 60, are aged between three to ten years old, The structured teaching room is wide with perfectly identified functional areas endowed with suitable materials, and obeys to TEACCH program [4], that uses a method called Structered Teacching. 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. Five early school students (four boys (one of the first grade, two of the third grade and one of the fourth grade, and one girl of the first grade) participated during the work groups area of the TEACCH Program. Only two students are verbal (one boy of the third grade and one boy of the fourth grade).

4. STEAM activities

The objective of these activities is to mention and recognize that objects are made of different materials and the materials differ in surface, shape, color, size, etc.; to develop science process skills, mainly observation and categorization skills in simple inquiry activities; to develop ability to construct simple, but objective conclusion to realized inquiry activity; to develop preconceptions about static electricity. The used materials were balloon; confetti; ball of wool; plastic spoon; ruler, tissue paper; colored styrofoam and orange flannel cleaning duster and a dish.

4.1. Static electricity - Snake

This first activity is mainly focus on teacher scaffolding, involvement, during the presentation of the main themes of the activities that the children will develop. Main general science aspects are focused in the scientific contents that are going to be part of this activity. Obviously teacher is very concerned about this aspect; and teacher as the ability to guide the group through the “static electricity” concept. One student have already knowledge about the theme, others haven’t so. In this learning activity creativity was present when teacher encourages children to make connections between previous ideas and cross curriculum concepts and ideas. In particular one student that we might consider that recognizes one situation from out of the school learning “that gives shock”, referring to plastic

ISBN 978-84-8158-937-5

bench: *"The plastic bench outside sometimes gives shock in our hands."* After this, the teacher asks the students to cut a snake in tissue paper. Then asks the students to rubber the plastic spoon with a orange flannel cleaning duster and "whisperer" the snake.

Figure 1.1. Child D "whisperering" the snake with static electricity

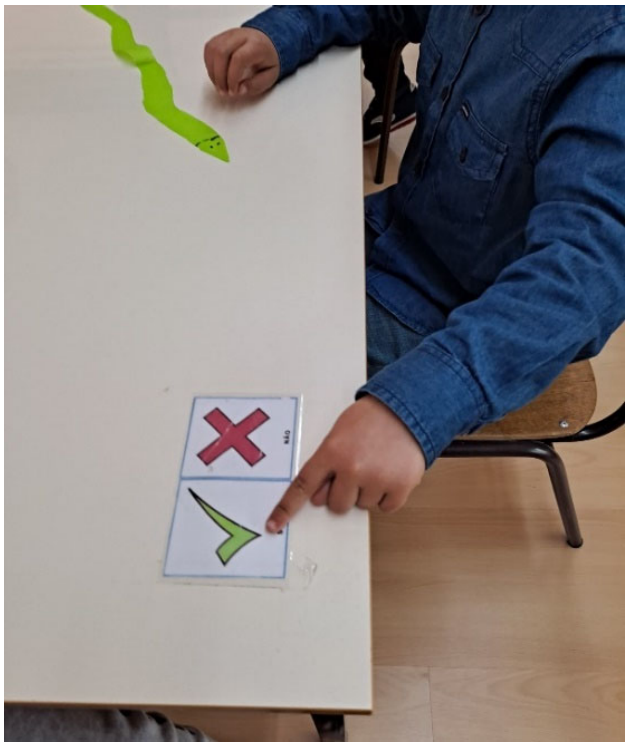


Figure 1.2. Child D pointing to the yes pictogram when asked if he enjoyed the activity

Figure 1.3. Child DA "whisperering" the snake with static electricity

Figure 1.4. Child M "whisperering" the snake with static electricity

Figure 1.5. Child N “whisperering” the snake with static electricity

Figure 2.2. Child DA rubbed ballon attracting small pieces of paper

4.2. Static electricity experiments- Balloon

Figure 2.1. Rubbed Ballon with orange flannel cleaning duster

Figure 2.3. Child D. rubbed ballon attracting small pieces of paper

ISBN 978-84-8158-937-5

The teacher promotes the pupils to think like an inquiring person which is looking for an answer to the identified question (what kind of objects can cause rising up static electricity, in what kind of cases we can experience effect of static electricity). The teacher asks the pupils to point the pictogram √ (yes) or X (no) to an object considering what they think about behaviour of the balloon when it will be rubbed against orange flannel cleaning duster (making prediction).

Further the teacher offered the pupils balloons for verification of their predictions. She explained that it is important to rub all the inquired material against the orange flannel cleaning duster the same way to get the comparable results.

Figure 2.4. Child D. trying to fix more papers by hand

Figure 2.5. Child L. rubbed ballon attracting small pieces of paper

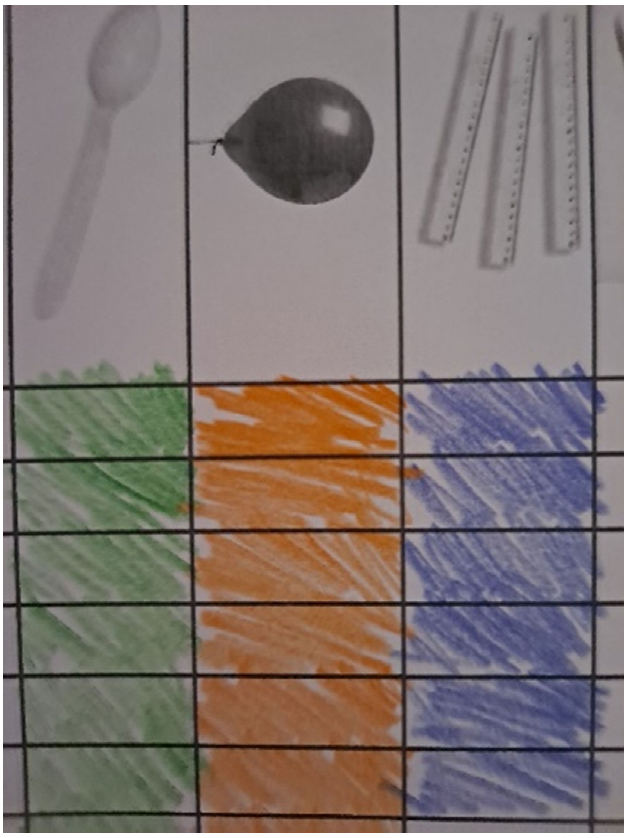


Figure 2.6. Worksheet with colour as many squares in the table as many pieces of paper the rubbed object attached

4.3. Static electricity – plastic spoon and styrofoam

Pupils should rub a plastic spoon in a orange flannel cleaning duster and put it near to small pieces of colored Styrofoam. They have to colour as many squares in the table as many balls of colored styrofoam the rubbed object attached.This activity was supposed to measure the “power of attracting” between the object and the tiny objects like confetti and/or Styrofoam and they have to colour as many squares in the table as many pieces of styrofoam the rubbed object attached.

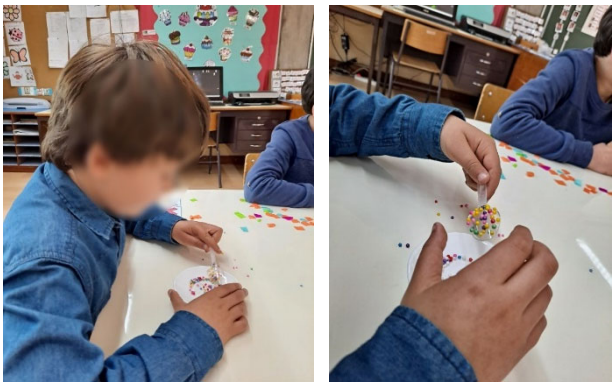


Figure 3.1. Child D with a rubbed plastic spoon attracting styrofoam

Figure 3.2. Child DA touching colored styrofoam.

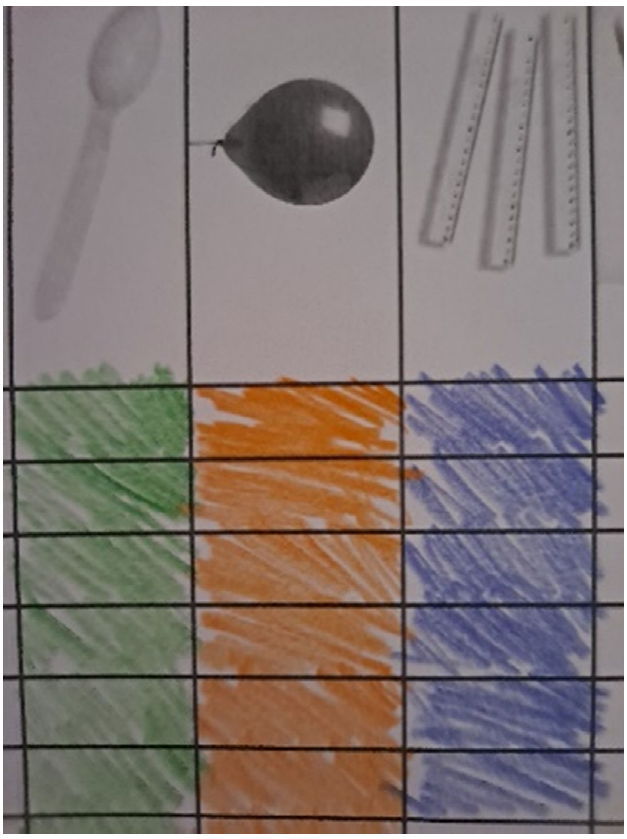


Figure 3.3. Worksheet with colour as many squares in the table as many pieces of styrofoam the rubbed object attached

Figure 3.4. Child N with a rubbed plastic spoon attracting styrofoam.

ISBN 978-84-8158-937-5

Figure 3.5. Child N with a rubbed plastic spoon attracting styrofoam.

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 activities promoting the interest and curiosity of students.During the activities, the teacher was always careful to guide students in their learning and guiding them to a way forward. The teacher has many years of experience, that means she is very sensitive as to when to guide. She fosters observation, encouraging students in simple science activities. These three activities showed creativity through children's agency, curiosity, engagement and entusiasm. Teacher prepares her lessons depending on students' interests, not forgetting the national curriculum and student achievement, looking to find activities that promote students' interest in mathematics, science, arts and creativity. Teaching approaches appear to provide children with a "starting point" from which they can experiment, observe phenomenon and so on, mainly teacher provides guidance so the students can achieve the purpose of the activities proposed and building their knowledge. As noted, teacher has the ability to foster creativity.Teacher fostered rich motivating contexts for play and exploration. Collaboration, promoted by use of group work, played important roles in involving children specially in childrem with autism spectrum disorders. The potential of sensitive and responsive teacher scaffolding both to support autonomy was emphasized, particularly in relation to when to mediate and when to stand back. Across the episodes there were many examples of children *observing.* The teacher made reference to the importance of encouraging and supporting children's engagement in early years science and mathematics as an important starting point for learning. Also emphasised the need to foster motivation and collaboration and provide a rich environment with space and time for exploration and, underlining key role for teacher in encouraging making connections to promote children's conceptual understanding.

6. Acknowledgements

This work was supported by the Portuguese Foundation for Science and Technology (FCT) in the framework of the Strategic Funding UIDB/04650/2020. The authors thank all children and operational assistants for their active participation in this work and also thank specially school coordinator, Special Education department coordinator, vice principal and school principal.

7. References

[1] Waters V, West T, Lim CI, Campbell P, Pedonti S. A guide to teaching practices. Chapel Hill, NC: STEM Innovation for Inclusion in Early Education Center, 2021. https://stemie.fpg.unc.edu/guide-teaching-practices

[2] Clements DH, Vinh M, Li, CI, Sarama J. STEM for inclusive excellence and equity. Early Education and Development, 32(1), 148-171, 2021

[3] Clean science experiments for autistic children**.** https://ourfamilycode.com/clean-science-experiments-for-autistic-children

[4] Hume K, Steinbrenner JR, Odom SL, Morin KL, Nowell SW, Tomaszewski B, Szendrey S, McIntyre NS, Yücesoy-Özkan S, Savage MN. Evidence-based practices

for children, youth, and young adults with autism: Third generation review. Journal of Autism and Developmental Disorders. Advance online publication, 51(11), 4013-4032, 2021

[5] Craft A. Creativity Across the Primary Curriculum: Framing and Developing Practice, London: Routledge Falmer, 2000.

[6] Craft A.'Little c: creativity in craft'. In Craft A, Jeffrey B, Liebling M (Eds.) Creativity in Education, London: Continuum, 2001.

[7] Grainger T, Barnes J. Creativity in the primary curriculum. In Arthur J, Grainger T, Wray (Eds.). Learning to Teach in the Primary School. London, UK: Routledge, 209–225, 2006.

[8] Newbury D, Diaries and fieldnotes in the research process, Research Issues in Art Design & Media. Birmingham: the research training initiative, 2001.

[9] Einarsdottir I. Playschool in pictures: Children's photographs as a research method, Early Child Development and Care, 175(6): 523-541, 2005.

[10] Brenner ME, Interviewing in educational research. In: Green JL, Camilli G, Elmore PB (Eds.), Handbook of complementary methods in education research. Mahwah, NJ: Erlbaum, 357–370, 2006.

[11] Danby SJ, Ewing L, Thorpe KJ, The novice researcher: Interviewing young children, Qualitative Enquiry, 17(1), 74-84, 2011.

[12] Siraj-Blatchford I, Sylva K, Muttock S, Gilden R, Bell D. Researching Effective Pedagogy in the Early Years. Department of Education and Skills Research Report RR 356. Norwich: DfES, 2002.

ISBN 978-84-8158-937-5

Creating of STEM – Equipment: Mini Solar Plant

K Minakova, R Zaitsev,
M Kirichenko
National Technical University «Kharkiv Polytechnic Institute», Ukraine
friday.marjory.johnes@gmail.com

Abstract. The history of modern solar energy dates back to 1839, when the French physicist Alexandre Edmond Becquerel, at the age of 19, discovered the photoelectric effect. He found that some materials, when exposed to sunlight, produce an electric current. More than 100 years passed before technology could catch up with the young scientist's discovery. The real leap in innovation came in 1954, when Daryl Chapin, Calvin Souther Fuller, and Gerald Pearson came to Bell Labs with a silicon photovoltaic cell. The cell of this solar cell was capable of converting solar energy with an efficiency that made its use practical. From the 1980s to the 2000s, scientists continued to make solar panels more energy efficient and cheaper. This has enabled businesses and individuals to use solar systems to meet their energy needs at an affordable cost. The residential solar panel market continues to grow and is already making alternative solar energy an affordable choice for many. In this regard, the basic familiarization of schoolchildren with the principles of operation of such systems is very relevant. As part of the work carried out, a simple and budget solution was proposed for a miniature solar plant containing all the key elements: a solar panel, an energy storage and conversion system. Especially interesting for schoolchildren is the practical application of the proposed mini solar power plant for charging modern mobile devices. Several STEM workshops on the creation of the proposed solar plant will allow the children to gain currently relevant technical competencies in the design, creation and operation of solar power plants.

Keywords. PVT Systems, Solar Plant, Engineering Problem, Solar Energy, STEM Equipment.

1. Introduction

Acquaintance of schoolchildren and students with the modern basics of renewable energy should be a mandatory educational component [1-2]. At present, the development of world energy is aimed at significantly reducing dependence on fossil fuels and reducing economic dependence on its supply. Current European trends are aimed at achieving a share of energy generation from renewable sources of 50% or more. Therefore, it is necessary to form in students a correct understanding of this issue, to create the necessary teaching and demonstration devices [3-5] and to form a correct view of the issue.

In order to achieve this goal, we have proposed to develop and create a small mobile device that allows you to demonstrate all the necessary processes that are implemented in the creation and operation of a solar power plant. In particular, the processes of generation, selection, conversion and accumulation of electricity.

Schematically, such a device is quite decent and is implemented according to the scheme shown on Fig. 1.

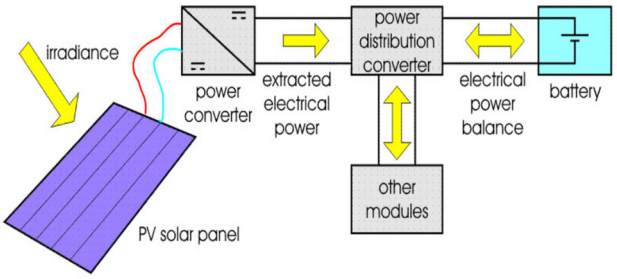


Figure 1. General scheme of using solar energy

In order to be able to offer such devices as closely as possible, a device with a low cost was offered. The following modules are offered in the basis of devices:

- PWM controller as the basis of the device, which combines low cost and optimal efficiency at low voltages;
- Electric energy storage based on lead-acid AGM battery;
- Control and measuring devices required for visual demonstration of electrical processes occurring.

ISBN 978-84-8158-937-5

2. PWM- controller

The classic simplest and most common PWM controller was chosen for the development and implementation of the device (Fig. 2).

Figure 2. PWM- controller

The selected controller performs the functions of control and conversion of energy from the solar battery and from the battery to the load. The voltage from the solar panel on the two conductors (plus and minus) comes to the stabilizing element and the dividing resistor circuit. Due to this part of the circuit, the equalization of the input voltage potentials is obtained and to some extent the protection of the controller input from exceeding the input voltage limit is organized (Fig. 3). It should be emphasized here: each individual model of the device has a specific limit on the input voltage (specified in the documentation).

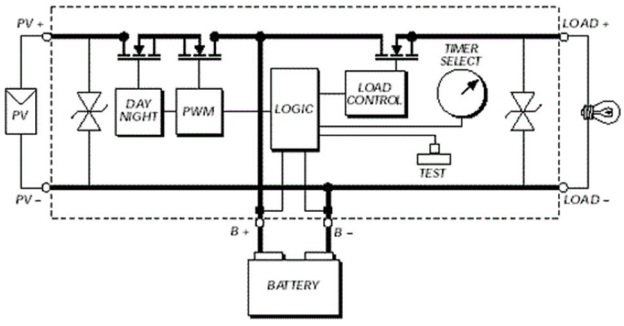


Figure 3. Schematic diagram of PWM-controller

Then the voltage and current are limited to the required value by power transistors. These circuit components, in turn, are controlled by the microcontroller through the driver chip. As a result, the nominal value of the voltage and current of the battery is set at the output of a pair of power transistors.

Also in the circuit there is a temperature sensor and a driver that controls the power transistor, which regulates the load power (protection against deep discharge of the battery). The temperature sensor monitors the heating status of important elements of the PWM controller. Usually the level of temperature inside the housing or radiators of power transistors. If the temperature exceeds the set in the settings, the appliance switches off all active power lines.

Almost all manufacturers of PWM-controllers require adherence to the exact sequence of connection of devices.

The technique of connecting PWM controllers to peripherals is not particularly difficult. Each board is equipped with marked terminals. Here you just need to follow the sequence of actions. Peripheral devices must be connected in full accordance with the designations of the contact terminals:

- Connect the battery wires to the terminals of the battery pack according to the specified polarity.
- Switch on the protective fuse directly at the contact point of the positive wire (if not provided in the solar panel)..
- Attach the wires from the solar panel to the controller contacts for the solar panel. Adhere to polarity.
- Connect to load terminals (usually 12/24V).

This sequence must not be violated. For example, it is strictly forbidden to connect solar panels first when the battery is not connected. By doing so, the user risks disabling the device. It is also unacceptable for PWM controllers to connect a voltage inverter to the controller's load terminals. The inverter should be connected directly to the battery terminals.

ISBN 978-84-8158-937-5

3. Energy storage

A rather simple and inexpensive 12 V AGM battery with a capacity of 2.3 A·h was also chosen as the energy storage device (Fig. 4). Particular attention was paid to the small size to ensure the small size of the device as a whole.

Figure 4. Selected AGM battery

The capacity of the selected battery is enough to demonstrate the principles of operation of the device and charge the usual mobile devices.

4. Control and measuring devices

Typically, industrial solutions for solar power systems do not have devices for visual demonstration of voltages and currents of generation and supply, they are limited to remote monitoring.

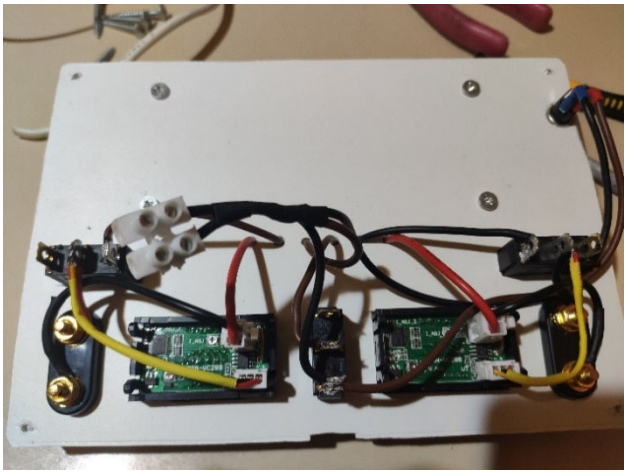
However, for a visual demonstration during the classes, it was decided to equip the device with control devices. Universal built-in volt-ammeters were chosen (Fig. 5).

Figure 5. Volt ammeters

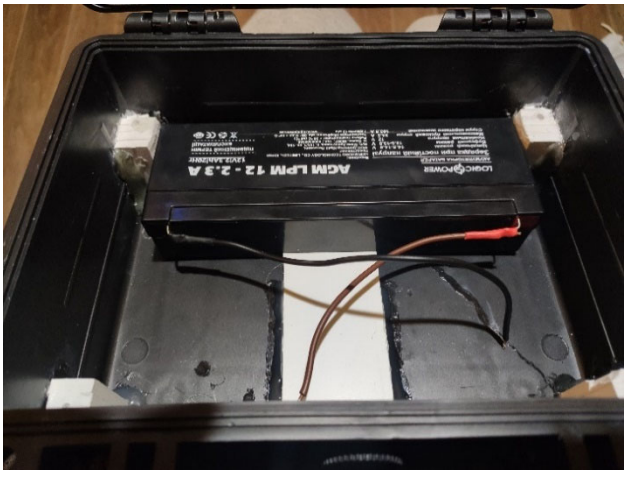
5. Implementation of the device

A small case with protection from dust to drops of liquid was chosen to collect the device. All the above components were mounted inside the case (Fig. 6).

a)



b)



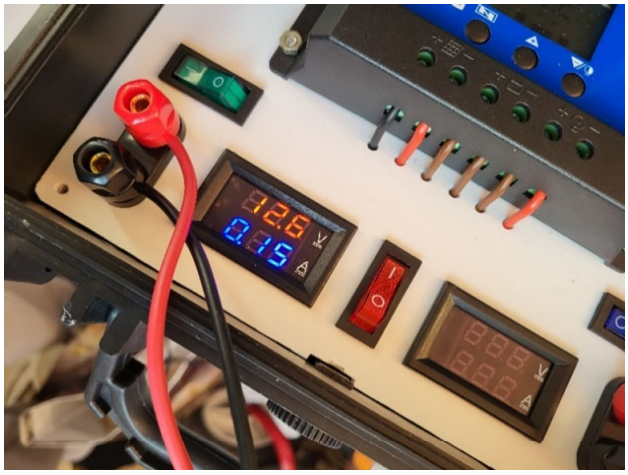
c)

Figure 6. Installation of the device

ISBN 978-84-8158-937-5

Based on the installation results, a compact device for a miniature autonomous solar power plant was obtained (Fig. 7).

a)



b)

Figure 7. Appearance of the device

6. Conclusions

As part of the work, a compact device was implemented to demonstrate the operation of autonomous solar power plants. With its use, several master classes were held with students. Testing of the device with different types of solar panels and load showed its reliability and uninterrupted operation. According to the results of implementation, the device was presented at an educational exhibition as part of a demonstration complex (Fig. 8).

Figure 8. The device was developed at an educational exhibition

7. References

[1] Minakova K, Petrov S, Radoguz S, Tomashevskyi R. Inquiry Based Science Education in National Technical University "Kharkiv Polytechnic Institute" as a Way to Increase the Popularity of Natural and Technical Sciences. Hands-on Science. Advancing Science. Improving Education. Costa MF, Dorrío BV, Fernández-Novell JM (Eds.), 72-74, University of Barcelona, Barcelona, Spain, 2018.

[2] Minakova K, Petrov S, Radoguz S. How "Street Chemistry" and "Street Physics" settled at the National Technical University "Kharkiv Polytechnic Institute". Hands-on Science. Advancing Science. Improving Education. Costa MF, Dorrío BV, Fernández-Novell JM (Eds.), 354, University of Barcelona, Barcelona, Spain, 2018.

[3] Minakova K, Zaitsev R, Chiaverina C. Creating of STEM – Equipment: Transmission Information on Distance Using Laser Beam. Hands-on Science. Innovative Education in Science and Technology. Costa MF, Dorrío BV, Minakova K (Eds.), 84-89, National Technical University "Kharkiv Polytechnic Institute", Ukraine, 2019.

[4] Minakova K, Zaitsev R, Kirichenko M. Creating of STEM – Equipment: MagLev Train. Hands-on Science. Innovative Education in Science and Technology. Costa MF, Dorrío BV, Minakova K (Eds.), 104-111, National Technical University "Kharkiv Polytechnic Institute", Ukraine, 2019.

[5] Minakova K, Kirichenko M, Zaitsev R, Danylchenko D, Fedorchuk S. Science Tech Weekend School “Welcome to photovoltaic universe!” Hands-on Science. Science Education. Challenges and Opportunities of Distant and Online Teaching and Learning. Costa MF, Dorrío BV (Eds.), 57-65, Braga, Portugal, 2021.

Prosody and Hands-On Science: The Results of AMPER in Madeira for Learning and Research

MH Dias Rebelo
Universidade da Madeira
(FAH-DLLC e CIERL), Portugal
CLLC da Universidade de Aveiro, Portugal
mhrebelo@staff.uma.pt

Abstract. T As far as we know, Madeira Archipelago did not have any scientific study about Prosody before 2007. Until then we can only find some references to the way the islanders talk. Porto Santo island is generally well known for the slow rhythm and special pronunciation of its local population. At the University of Madeira, many students of Linguistic courses have this perception. Nevertheless, no one will have scientific experiments to prove it unless the subject is investigated. At school, Madeira prosody subjects are not studied. It is why the AMPER Project wants to present results for regional oral variety.

Keywords. Prosody, Learning Orality, AMPER, Madeira, Linguistic Students.

1. Introduction

The AMPER (Atlas Multimédia Prosódico do Espaço Românico [Prosodic and Multimedia Atlas of Romanic Space]) [1] is an international project created by Michel Contini at the University of Grenoble (France), who had the idea, but who needs a team to accomplish it. At the moment, the general coordinator is Antonio Romano of the University of Torino (Italy) [2], who has played an important part in the project as it has its origins in his thesis and has developed thanks to the work developed by Lurdes de Castro Moutinho. Now, universities from the Latin countries in Europe and in Latina-America are involved as the project extended to all the Romanic languages and also to their dialectal varieties. At the end, the purpose is to have prosodic data to compare all these languages. For Portuguese AMPER (AMPER-POR: Portugal and Archipelagos + Brazil), the coordination is at the University of Aveiro [3], where Lurdes de Castro Moutinho is in charge of this Romanic language. At the same time, Moutinho is responsible for the other official language in Portugal, the Mirandês.

As for the Portuguese variety of Madeira, the research began in 2007. Until now, fifteen years later, the work has been intensive to improve prosodic knowledge of Madeira and Porto Santo islands. One of goals was to give the students the possibility to test some common suppositions about regional oral speech, getting them involved in the project. Having contact with scientific materials, like the results of AMPER for Madeira Archipelago, they can learn more about the Portuguese linguistic system and understand some specificities of Prosody better. For instance, they learned how to distinguish an interrogative and a declarative sentence when both have the same words. Once they get participate on the AMPER Project, they understand why so many inconsistent affirmations about local or regional speech are normally unfounded. Some of them are just perception feelings [4], for speech melody, then, at the same plan, for music melody [5]. All the general ideas about insular speech are just suppositions, based on the ear.

With STEAM (Science, Technology, Engineering, Arts and Mathematics) used in the study of the language, linguistic material, everything changed. This is what happens when students understand a project like AMPER and the importance it can have if we need to teach, to learn and to speak Portuguese, even in Madeira archipelago. So, the general ideas of regional speech are not repeated by the students who collaborate in this research. To prove a supposition is more difficult than to say it. Then, they can test if some islanders speak more slowly than others.

2. Madeira Archipelago and Prosody

Situated not far from The Canary Islands and Africa (Fig. 1), the Madeira archipelago has many islands (Fig. 2), but only two of them are inhabited. Madeira is the biggest and Porto Santo the smallest (Fig. 3). These Atlantic insular territories were the first ones to be discovered during Portuguese sea exploration and discoveries (“Descobrimentos”).

Discovered in the 14th century by Portuguese navigators João Gonçalves Zarco and Tristão Vaz, and in the beginning, the Madeira archipelago had most of the Portuguese population [6] from south and north

ISBN 978-84-8158-937-5

of Portugal, specially from Minho. About its history [7] [8], in 1440-1450, D. Henrique, named The Navigator, was one brother of the king and the new territory belonged to him. He wanted to divide the Madeira Island in two areas. The line boundary was from Ponta da Oliveira until Ponta do Tristão. The south part, with the capital at Funchal, was for João Gonçalves Zarco and the north, with Machico as the most important city, for Tristão Vaz. Porto Santo, belonging also to D. Henrique, was for Bartolomeu Perestrelo, the father-in-law of Christopher Columbus. This history of Madeira and Porto Santo for the land property is consensual. At that time, Portuguese was the language spoken in the community; however, Latin had some importance. Until now, the linguists continue to study the specificities of this Roanic language, including its Prosody.

What is “Prosody”? It corresponds to the suprasegmental elements of speech like “intonation”, “tone”, “pitch”, “stress”, “frequency”, “intensity”, “loudness”, “duration”, “tempo” and “rhythm”. Prosody is relative to utterances like a statement with declarative sentence’s type, a question with interrogative type or command present in an imperative sentence. It is about grammar or vocabulary meaning.

Figure 1. Espaço Geo. À Descoberta da Madeira. Guia de Aprendizagem, Porto, Asa, 2006

To learn Prosody with scientific experiments explains how there is more than one meaning for sentences where the same words occur in the discourse. The sentence prosody makes changes and the occurrences of the same words take other meanings. Because of that, for instance, “Não!” [No!] could assume some different meanings. It is more than a simple negative answer to a question. It can be pronounced with evident surprise “Não!?”; like a question or a doubt “Não?”. The emphasis can also express a negative order or a prohibition “Não!”. So, in the linguistic significant nothing changes, because the segmental is constant (“Não” [No]) and there is just one word, but the prosody gave to this word changing aspects with different meanings. For David Crystal [9], “prosody” is defined like “a term used in suprasegmental phonetics and phonology to refer collectively to variations in pitch, loudness, tempo and rhythm”.

Figure 2. *Espaço Geo. À Descoberta da* Madeira. Guia de Aprendizagem, Porto, Asa, 2006

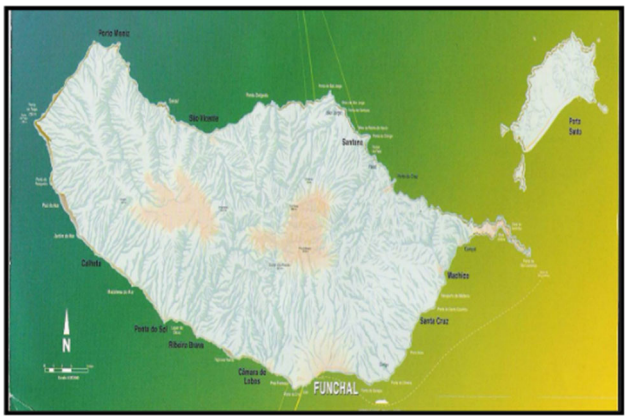


Figure 3. Guia Madeira e Porto Santo, BODY.MIND.MADEIRA, Direcção Regional de Turismo

Today, no one really knows what kind of Portuguese was spoken in 14th century and some research presume it was a koiné, but it is

ISBN 978-84-8158-937-5

difficult to have a scientific vision of it, almost for its prosody. The first Portuguese grammar appeared in 1536, written by Fernão de Oliveira and it was a description of the Portuguese spoken in the 15th Century, when Latin was still the official language. Before that, we know nothing about the Portuguese language spoken by the population in general, specially the ones living in Madeira and Porto Santo. For these territories, it is clear that the first academic study was presented to the University of Lisbon in 1939 [10]. Then for more than five hundred years, the opinions and intuitions multiplied until the first scientific publication about a phonetic phenomenon was written by Andrade Pardal [11]. This author studied the characteristic palatalization of [l] in certain contexts. Nevertheless, suprasegmental topics were not described. The AMPER research in 2007 brought a new approach to this subject for prosody.

2.1. Madeira Archipelago in AMPER Project

Motivated by Lurdes de Castro Moutinho, Madeira Archipelago integrates the project. To build a Romanic Prosodic Atlas is a collective work, but the essential elements need to be established by the coordinators. That has happened and the methodology was defined at the birth of AMPER, some years before, by the central committee composed, among others, by Michel Contini, Antonio Romano and Lurdes de Castro Moutinho. The structure of the corpus was the same for all the teams (each one with a unique Romanic language). They decided methodology and it was explained by the AMPER-POR, for the corpora. All the recording work needs to be done on field, the better way is at the informants' place, assuring to have good data for the analysis. In the case of the regional informants' productions, the same process had to be used. The signal quality needs to be uniform, to guarantee fidelity. A same group of sentences defined a priori was collected and it was oriented by similar criteria. Because the vowels are the most important part of speech, they have the relevant information for the prosodic curve and they count for the stress structure of Portuguese. Some representative words were chosen for oxytone, paroxytone and proparoxytone in different positions in the sentences of the corpus. The objective was to maintain as far as possible the same phonetic context for all languages, with almost unvoiced consonants. They intended to reduce the problems with coarticulation phenomena to guarantee an easier and precise segmentation of the acoustic signal. The structure chosen for the sentences was SVO (subject-verb-object) neutral and positive for the declarative sentences and the interrogatives ones. The corpus established for the continental Portuguese would be the model for the others AMPER teams. But some changes were made specially with lexical units for a better adaptation to each variety and its involving reality. The same occurred with the images (Fig. 4 and 5) used to motivate the speech informant to produce the sentences planned. All the sentences have a code (Table 1), which is the same for all the teams and, of course, languages and dialects. Words and images are different because of variation.

Figure 4. TWPA **O fadista gosta da música**

Figure 5. TWPI **O fadista gosta da música?**

Clara Rolão Bernardo decided the words of the sentences to be used for Azores (Table 1) as she develops research about this archipelago [12]. Azores were in AMPER before Madeira Archipelago. Then, because this archipelago came later, it was decided it would keep the same of the Azores. Both territories are Portuguese Atlantic archipelagos and it was presumed the two realities were similar.

Watching images (sequencies of them, like figures 4 and 5), the informants have to say the declarative and interrogative sentences of table 1. They have to produce more or less natural sentences. For example, for the structure TWP they should say two sequencies: TWPA (O fadista gosta da música. [The "fadista" likes the music.]) (Fig.4) and TWPI (O fadista gosta da música? [The "fadista" likes the music?]) (Fig. 5).

ISBN 978-84-8158-937-5

AMPER wants to understand what change happens between a declarative and an interrogative sentence when they have the same words. The Project wishes to compare the prosodic differences that occur in all Romanic languages and their dialects. For the interrogative, at the sentence code, it was added an "i" and for the declarative an "a" (Table 1). For example, for the structure TWP (o fadista gosta da música [the "fadista" likes the music]), there are two sentences: TWPA (O fadista gosta da música. [The "fadista" likes the music.]) and TWPI (O fadista gosta da música? [The "fadista" likes the music?]). So, the same words do not mean the same information and the research intent is to understand how it happens.

Table 1. The *corpus*

N.º	Code	*Corpus* (sentences structures)
01	**BWT**	a música popular fala do fadista
02	**DWP**	o fadista popular gosta da música
03	**DYP**	o fadista do Canadá gosta da música
04	**FWT**	a música castiça fala do fadista
05	**GWP**	o capataz popular gosta da música
06	**JWP**	o capataz típico gosta da música
07	**KWK**	o capataz gosta do capataz
08	**KWP**	o capataz gosta da música
09	**KWT**	o capataz gosta do fadista
10	**PWD**	a música fala do fadista popular
11	**PWG**	a música fala do capataz popular
12	**PWJ**	a música fala do capataz típico
13	**PWK**	a música fala do capataz
14	**PWP**	a música fala da música
15	**PWS**	a música fala do fadista castiço
16	**PWT**	a música fala do fadista
17	**PWX**	a música fala do capataz castiço
18	**PWZ**	a música fala do fadista típico
19	**PYD**	a música fala do fadista do Canadá
20	**PYS**	a música fala do fadista das Capelas
21	**PYZ**	a música fala do fadista do México
22	**SWP**	o fadista castiço gosta da música
23	**SYP**	o fadista das capelas gosta da música
24	**TWB**	o fadista gosta da música popular
25	**TWF**	o fadista gosta da música castiça
26	**TWK**	o fadista gosta do capataz
27	**TWP**	o fadista gosta da música
28	**TWT**	o fadista gosta do fadista
29	**TWV**	o fadista gosta da música típica
30	**VWT**	a música típica fala do fadista
31	**XWP**	o capataz castiço gosta da música
32	**ZWP**	o fadista típico gosta da música
33	**ZYP**	o fadista do méxico gosta da música
x2 = 66	**x2**	**-a + -i**

It is important to explain that the corpus was composed attending stress words, a fundamental prosodic parameter. Normally, no one pays attention to it, but it seems to make the difference for speech. This is one of the principal hypothesis AMPER studies.

However, as the corpus and the project methodology are the same for all the languages and dialects, the researcher needs to decide the most representative points for the inquiry. Because of their history, for the islands Madeira and Porto Santo, six points have been defined: four for Madeira (Fig. 6) and two for Porto Santo (Fig. 7). Funchal, with about 125 thousand inhabitants has more than half of the population of Madeira. It is why there are two points (Santa Maria Maior, the oldest zone at the littoral, and São Martinho, on the top of the mountain). It seemed important to have more points: one in the north coast and east side (São Jorge) and another one at the south coast and west side (Calheta). Therefore, and because there are no dialectal areas, a possibility would be to divide Madeira islands in the two historical parts (south and north), excluding Funchal. For Porto Santo, having near 5 thousand inhabitants, the same criteria would be kept: Camacha was chosen for the north coast and east side and for the opposite localization Campo de Baixo was indicated for the south coast and west side of the little island.

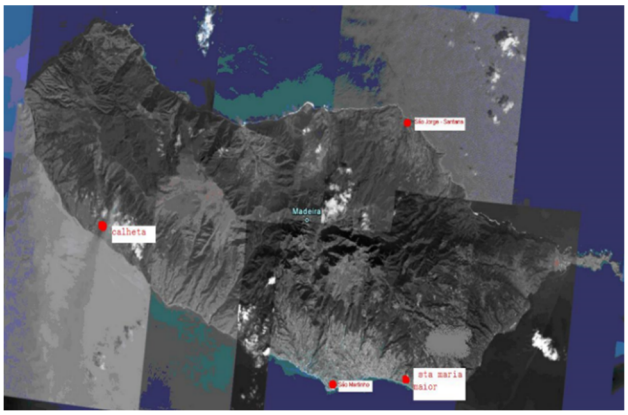


Figure 6. Madeira http://www.varialing.eu/

For each point, almost two persons would be recorded (Table 2): one woman (with 1 at the code) and one man (2 at the code). To collect all the speech, each informant was a middle-aged person, analphabet or without studies. All would be informants without studies or with few years of school because they would be more authentic speakers. The speech was taped in mono WAV format, at 16 000 Hz.

ISBN 978-84-8158-937-5

Figure 7. Porto S.to http://www.varialing.eu/

Table 2. 7 Inquiry Points

Island	Informants code	Points of inquiry
Madeira	01k1 01k2	Funchal (Santa Maria Maior)
	01l1 01l2	Funchal (S. Martinho)
	01m1 01m2	Calheta
	01n1 01n2	São Jorge
Porto Santo	01o1 01o2	Campo de Baixo
	01p1 01p2	Camacha
= 2	**= 12**	**= 6**

At the total, for now, it means to count for the corpus research: 6 points x 12 informants x 66 sentences, but it is not enough. The 66 sentences (Table 1) were produced in 6 series. The intention was to have more material than what the researcher needs. After that, for any sentence, three productions (with the same number of vowels because they are the key for prosody and sometimes the speakers do not pronounce them) for interrogatives and declaratives sentences. At the end, the analysis was for 6 points x 12 informants x 66 sentences x 6 series. The linguistic material totalizes 28 512 sentences, but just 14 256 (3 interrogatives and 3 declaratives for 33 structures) were chosen for the project. As it was explained, any sentence produced by an informant needs to have a unique code (fig. 8, an example) to identify it when it is compared with the others. The code contemplates the point, the gender, the structure, the sentence type and its number. These are the elements of the identification. This phase of the research – the codification – is extremely important and really thorough.

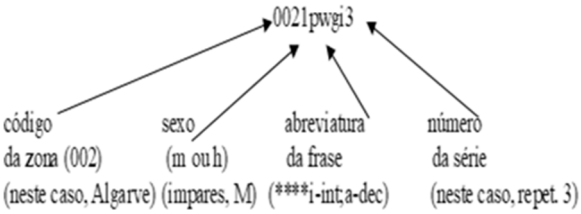


Figure 8. The code, http://www.varialing.eu/

The informants must be representatives of the inquiry point. Their collaboration is precious, without it AMPER cannot exist. Humanities Science work with persons productions like it is in Linguistic. The researcher had to meet each informant to explain well what the project was about. If they accepted to participate, they had to formalize the process. All the informants had to sign an authorization because the project uses and works with their voice: the waves were compacted at the international plan, in the AMPER Web page. With the methodology just like it was proposed by Michel Contini [13] for AMPER research, the three types of words stress have to count for the corpus analysis. The author explained it very well: « il faut rappeler que sont pris en considération les trois types accentuels dominants dans les parlers romans avec l'accent placé sur l'une des trois dernières syllabes, l'objectif étant aussi d'évaluer la relation entre accent et intonation ». It is why the sentences structure count different types : « La phrase simple a été par la suite élargie en introduisant des expansions dans les syntagmes par l'adjonction d'un adjectif et d'un syntagme prépositionnel représenté par un toponyme (…). » It means that words stress are fundamental for the sentence prosody and it is what the research has to test: « Il faut enfin préciser que, le questionnaire doit permettre de tester, dans les deux syntagmes, les éventuelles modifications prosodiques dans la succession de types accentuels différents (….).»

ISBN 978-84-8158-937-5

Before the codification, the segmentation of the records were done with COOLEDIT program. The waves were segmented by the 6 series tapped and keep in a file. Inside each series, any sentence produced by the informants was segmentate and codified. After that, 3 sentences with the same number of vowels articulated were chosen and, one by one, all the 14 256 sentences (3 interrogatives and 3 declaratives for 33 structures) were described (Figures 10-16: an example of the initial laboratory work). Once concluded the segmentation and the nominated phases, the prosodic analysis itself began with MATLAB program. In it Antonio Romano [14] developed a script for the AMPER to present results for the frequency of the informant (F0), intensity and duration. The project chose these three parameters as essential to compare the results for Romanic languages Prosody. With all the sentences for each informant, the media of F0 was calculated (Fig. 8, F0 of informant 01o2).

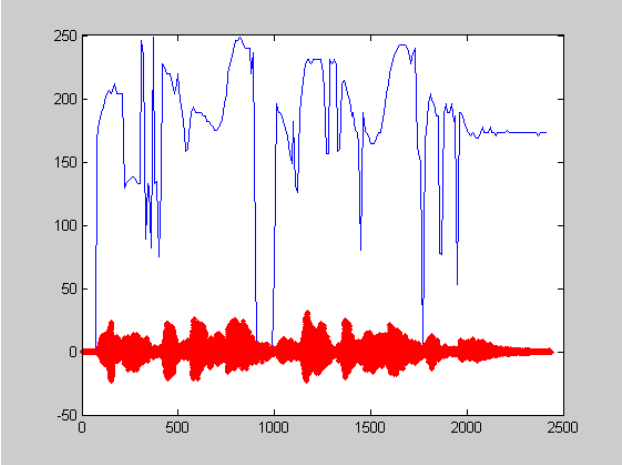


Figure 9. 01o2, media of F0 = 168 Hz

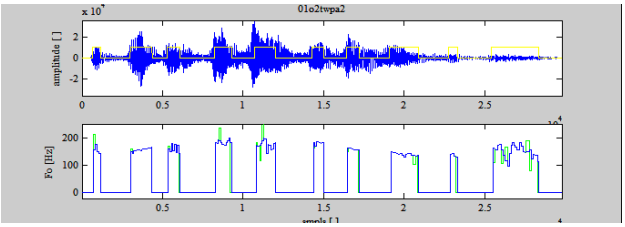


Figure 10. 01o2, TWPA2: measuring vowels

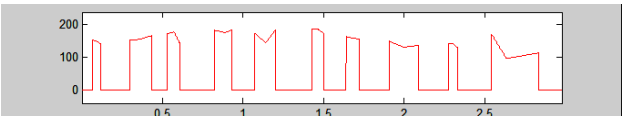


Figure 11. 01o2, TWPA2 modelized

The corpus composed by the 66 sentences with 66 WAV files were described. The selection of the 3 sentences with the same vowels of 33 declaratives + 33 interrogatives were measured and modelized (for example TWPA by the man of Campo de Baixo in Porto Santo island: Figures 9-16). The vowels were counted and their limits signalized for the same three sentences and the media appears for the declaratives (Fig. 11) and for the interrogatives (Fig. 12). At the end, the MATLAB script gives automatically figures with comparison of the media (Fig. 14: red declaratives and blue interrogatives) and it is possible to understand the differences for F0 curves. Then, the pitch (TON) file still keeps the sound – the melody of the media of declarative (-a) or interrogatives (-i) – without words (Fig. 15-16).

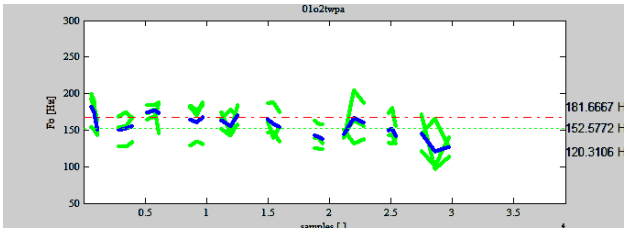


Figure 12. 01o2, TWPA curves 1, 2, 3 and media

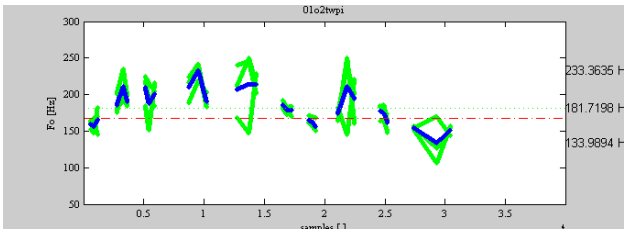


Figure 13. 01o2, TWPI curves 1, 2, 3 and media

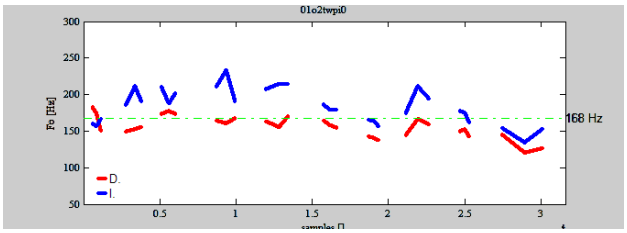


Figure 14. 01o2, TWPA and TWPI curves media

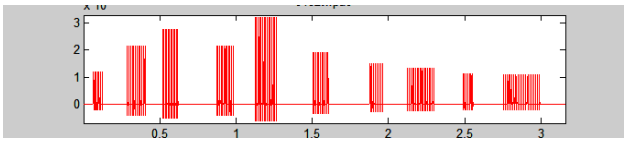


Figure 15. 01o2, TWPA media for file TON

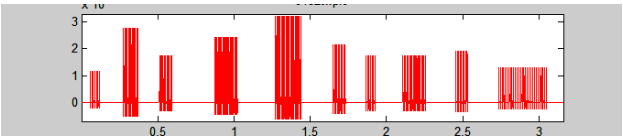


Figure 16. **01o2, TWPI media for file TON**

Then, after this analysis, the *corpus* was constituted with all the data (66 WAV files x 12 informants x 3 productions x 66 media x 66 TON files). Because of some particular circumstances, the record of 01n2 (the man of São Jorge) was not included in the results until 2011.

3. The Results for AMPER at Madeira and Porto Santo

For Madeira and Porto Santo, the first data prosodic studies began to be collected in 2007 as it was explained before. The end of the first recordings was in 2011. The project with all the work (in field and in the laboratory) motivated a pos-doctorate concluded in that year. But, for sure, the research continues because it is fundamental to explore all the linguistic material, analysing different topics about various questions. Until the end of the pos-doctorate, in 2011, the most important work was to record the *corpus* with the informants of all point of inquiry defined before. It is the basis of all this research. With this linguistic material, the prosodic studies in a scientific way began for Madeira and Porto Santo. With the organization of Paolo Mairano [15], AMPER Project had all data published in 2011, by University of Grenoble (France). This was also the final year of the pos-doctorate, presented at the University of Aveiro (Portugal). It is why the papers and the articles written until then just introduce some of all the material collected for the *corpus*.

3.1. 2007-2011

The purpose of this text is to present what was done in these years. It is to give the results of AMPER in Madeira for research and learning until 2022, what it was done from 2007 until 2011. In five years (Table 3), some participations in conferences can be counted [16-20]: 2 national (Aveiro and Faro) and 2 international (Romania and Spain). A total of 6 publications were made since 2011: 2 national (Aveiro and Funchal) and 4 international (Romania, Spain – 2 – and France). For the French publication, it is necessary to count 11 chapters prepared for Géolinguistique. Having all the corpus constituted, the intention was to compare the data. The comparison could be made in many ways. The start was to put side by side some sentences, i.e., some structures. For example, to know the prosody of both islands, some sentences of some informants were studied. It is or it is not the same the prosody of these islands' population? What kind of prosodic differences there is for both? Can we find similarities between the men of north and south and the same for the women for the two islands? Asking questions creates the opportunity to find answers with the AMPER corpus of Madeira and Porto Santo.

Table 3. Results until 2011

Year	Title	Oral	Publication
2007	"O Arquipélago da Madeira no Projecto AMPER-POR".	I Jornadas Científicas AMPER-POR de 29 a 30-10-2007	in Actas: I Jornadas Científicas AMPER-POR
2008	"Alguns Dados Prosódicos para o Funchal no Âmbito do Projecto AMPER-POR"		in revista Margem. Viver n(o) Funchal, n.º 25
2008 Oral 2009 publication	"O Arquipélago da Madeira e o Projecto AMPER-POR: Primeiros Resultados da Análise Prosódica para o Funchal"	simpósio La variation diatopique de l'intonation dans le domaine roumain et roman, na Universitatii Alexandru Ioan Cuza, em Iasi, na Roménia, 21 e 22-10-2008	in La variation diathopique de l'intonation dans le domaine roumain et roman
2011 Oral 2012 publication	"O Arquipélago da Madeira no Projecto AMPER: Comparação de Dados Prosódicos de Duas Informantes do Funchal (Santa Maria Maior e São Martinho)"	X Congresso Internacional da Associação Internacional de Lusitanistas, Universidade de Faro, de 18 a 23-07-2011	in *Avanços em Ciências da Linguagem*
2011 Oral 2014 publication	"O Arquipélago da Madeira no Projecto AMPER: Comparação de Alguns Dados Prosódicos de Duas Informantes da Ilha da Madeira (Calheta e São Jorge)"	V Congreso Internacional de Fonética Experimental, Cáceres (Espanha), realizado na Universidade de Cáceres, Espanha, de 25 a 28-10-2011	in Fonética Experimental, Educación Superior e Investigación, Vol. III. Prosódia,
2011	Relatório Pós-Doutoramento (com projecto de 2007) entregue à Universidade de Aveiro, em Julho de 2011		
2011	Capítulos "Santa Maria Maior 01k1, "Santa Maria Maior 01k2, "São Martinho 01l1", "São Martinho 01l2", "Calheta 01m1", "Calheta 01m2", "São Jorge 01n1", "Campo de Baixo 01o1", "Campo de Baixo 01o2", "Camacha 01p1", "Camacha 01p2"		in Intonations Romanes (DVD). In: Géolinguistique

3.2. 2012-2022

Using the data (Table 4), an important issue appears: the feminine and the masculine prosody. It was one of the subjects explored but much more needs to be described. The linguistic material is too much to compare all at one time. This is why it is not finished and

many other–studies can be prepared. In ten years, more publications were added [21-26]. There were 2 national works presented in Aveiro, 2 (waiting for the third one) at an international level (France and Brazil), 1 poster and 6 oral presentations.

Table 4. Results until 2022

Year	Title	Oral/ Poster	Publication
2012	"O Arquipélago da Madeira, Região Europeia, e o AMPER, Projecto Transeuropeu. Uma Amostra da Prosódia Feminina Madeirense"	I Jornadas de Ciências da Linguagem, evento organizado por João Manuel Nunes Torrão e Maria Teresa Roberto, Universidade de Aveiro, 20-06-2012	in *Revista da Universidade de Aveiro-Letras*, RUA-L, Revista da Universidade de Aveiro-Letras
2013	"A Madeira e o Porto Santo: A Prosódia das Ilhas"	**POSTER:** II Jornadas de Ciências da Linguagem, realizadas no Departamento de Línguas e Culturas da Universidade de Aveiro, 12-06-2013	
2015	"Acerca da Prosódia nas Ilhas Madeirenses",	Colóquio Internacional de Geoprosódia do Português e do Galego, no Departamento de Línguas e Culturas da Universidade de Aveiro, Portugal, de 17 a 19- 06-2015	in *Estudos em Variação Geoprosódica*
2016 Oral 2018 Publication	"À Propos de la Prosodie des Îles de l'Archipel de Madère. Résultats d'un Test"	IVème Congrès International de Dialectologie et de Sociolinguistique (CIDS 2016), Paris-Sorbonne, de 07 a 09-09-2016.	in *Variations, Phraséologie et Ressources*
2018 Oral 2019 Publication	"A Prosódia Madeirense e Porto-Santense: Comparação de Curvas Melódicas de Frases Interrogativas"	Congresso Internacional em Variação Linguística nas Línguas Românicas, na Universidade de Aveiro, Portugal, de 02-05-2018 a 04-05-2018.	in *A prosódia das línguas românicas*. Número temático da Revista *Intercâmbio*, v
2021 Oral 2022 Waiting for the publication	"O AMPER e a prosódia masculina na ilha do Porto Santo: Observação e descrição das curvas entoacionais de frases declarativas e interrogativas com final oxítono"	II Congresso Internacional em Variação Linguística nas Línguas Românicas, Universidade de Aveiro (formato misto presencial e por Zoom), de 22 a 24-06-2021.	

These results cannot be considered definitive because the analysis is not finished. The 14 256 sentences (33 interrogatives and 33 declaratives for all the informants) need to be more explored from different points of view. In the same way, inside the group AMPER-POR a new project for Dialectometric interconnected with AMPER has begun. Lurdes Moutinho leads it [27]. The corpora are used to make maps for the comparison of all AMPER-POR and with it and others, like AMPER-GAL for Gallaecian. It is a work that requires careful attention. AMPER is an atlas and maps are really important to visualize the linguistics parameters and for Prosody the suprasegmental ones.

By the way, the informant 01n2, the man of São Jorge, is still missing and this work is being done by two students in 2022. They have analyzed the recording of two men of São Jorge. In 2019, six master student were also introduced to AMPER methodology and they have brought new points of inquiry for Madeira Island (Table 5). These two students, like the others six in 2018-2019, were students of Phonetics and Prosody at the Master of Linguística: Sociedades e Culturas at the University of Madeira.

The students have collaborated on the project, learning in hands-on science context. Until then, they thought the language studies were just Literature and some kind of counting analysis to answer questions like: How many x words exist in this text? What is the syntactic function of this word? What is the classification of this grammatical element? They never thought we can measure vowels and describe an acoustic signal. Studying a language becomes a scientific matter and they learn to use some speech programs. Now, for varied reasons, MATLAB was substituted by Praat and the vowels were measured in this speech program, but the goal is still the same: to understand what makes the difference between declarative and interrogative types of sentences when they have the same words. Until this moment, the research proves that vowels duration (Fig. 17) can be important, although their intensity (Fig. 18) does not make real difference. Another conclusion is that the F0 curves depend on the position of the stress, a property of words (Fig. 19 and 20). That means the accent of sentences changes when the position of stress also changes. But many times, the informant options are not the same for the curves. Sometimes, in the corpus differences are found.

Here, with some figures aleatory chosen for TWPI (Fig. 4-5 and Table 1) [O fadista gosta da música?], we have almost identical sentence end. The comparison showed it, with the man 01o2 (Fig. 13-14) and the women of the both islands (Fig. 19-20): they have the end sentence movement ^ for the proparoxytone "música". Each type of sentence produced by all informants has the same acoustic curves when stress is the same? This is a question without an answer for now. So, the research has to continue. The analysis of all the linguistic material of the corpus has to be compared. With this research presented to students, they could understand how the regional Portuguese is and also why the research in languages is so

ISBN 978-84-8158-937-5

fundamental. The scientific language studies are really important at different levels.

Table 5. Students Research

Year	Students	Contribution
2018-2019	Marlene Ascensão de Macedo	Ribeira Brava 01q1 01q2
2018-2019	Fátima Marília Góis de Sousa	Santo António (Funchal) 01r1 01r2
2018-2019	António Costa de Ornelas Gonçalves	Santa (Porto Moniz) 01s1 01s2
2018-2019	Yessyka Andreina Marques Oliveira	Caniçal 01t1 01t2
2018-2019	Alexandra José Cabral Sá Nunes	São Gonçalo (Funchal) 01u1 01u2
2018-2019	Tânia Carina Viveiros Martins	Santa Cruz 01v1 01v2
2021-2022	**Inês Machado Vilhena Andrade**	**São Jorge** **01n2** **Informant A**
2021-2022	**Mariana Luísa Gouveia de Sousa**	**São Jorge** **01n2** **Informant B**

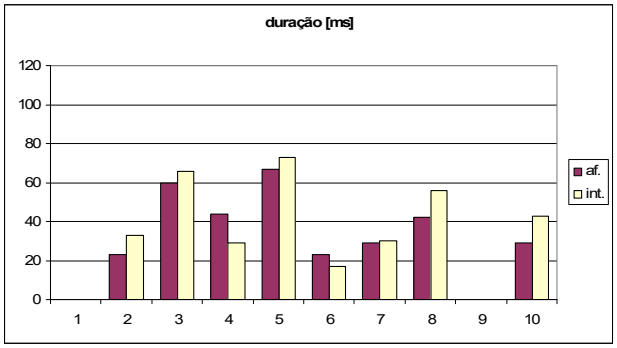


Figure 17. 01k2, TWPA and TWPI vowels duration

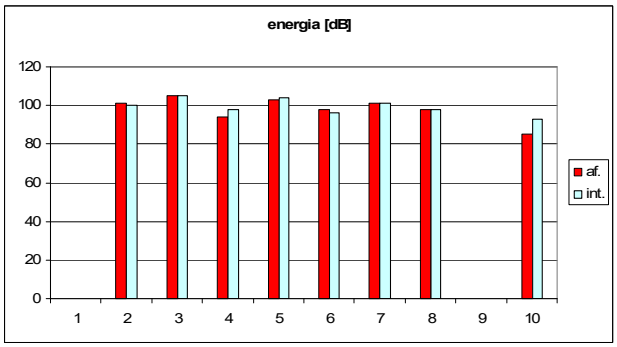


Figure 18. 01k2, TWPA and TWPI vowels intensity

The results of AMPER in Madeira can give materials for the Portuguese lessons both at High School and at University in Linguistics Course. The experimentation was done with some students and they discover their own language and also how the prosody knowledge can change their own perspective when the access to some scientific research is given. They discover how they can be interpreted.

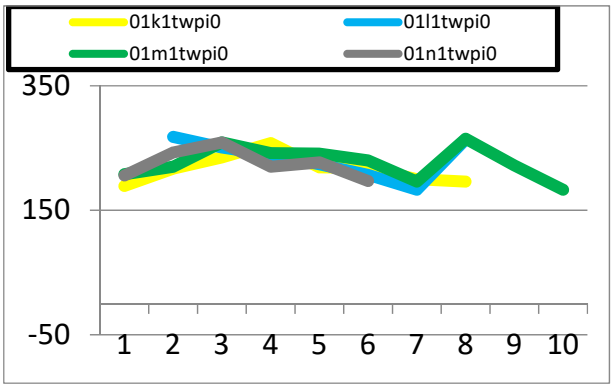


Figure 19. Madeira women TWPI F0

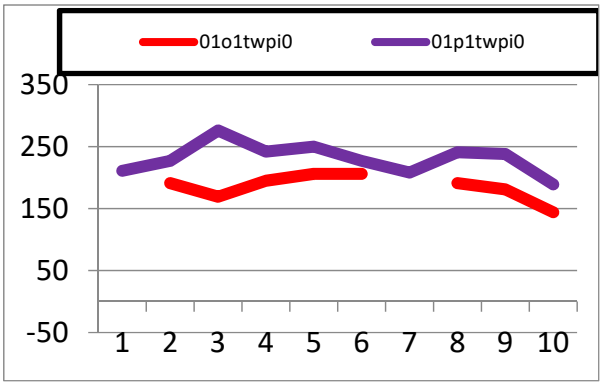


Figure 20. Porto Santo women TWPI F0

4. Conclusion

Madeira Archipelago is considered an outermost region from the mainland. Regional prosody can be observed in loco with research. AMPER focuses on some sentence structures for declarative and interrogative types, produced by informants from both islands: Madeira and Porto Santo. They have been recorded in the region two informants in each of the following points of inquiry: Santa Maria Maior, São Martinho, Calheta, São Jorge, Campo de Baixo and Camacha (at Porto Santo). Various data were compared, including the evolution of the curve essentially melodic sentences in simple declarative type with corresponding direct interrogative. Both have the same segmental part (the same words), but the prosody makes the difference. With several years, the AMPER methodology wants to compare how the speakers of Romanic languages make the difference. For the languages, orality and intonation [28] are

essential and to have a perspective of the linguistic variation is a necessity for the life in the community. Then, there is not just one way to teach languages and their varieties. Using a book with texts can be a possibility just like to put hands on science and to study prosody with the AMPER methodology. This is a real challenge presented to the university students at different Linguistic courses works in prosody and its history. Between 2007 and 2022, Madeira Archipelago had given materials to AMPER and it has begun to have a corpus for prosodic studies. For this international project, in these years, 13 participations were made, most of them oral in congress. In total, there were 10 publications and 6 of them were international. So, the results of AMPER in Madeira Archipelago for Learning and Research are kindly positive. But much research work still needs to be done.

For the students, it is an opportunity. On the one hand, learning native or foreign languages at the Educational System in Portugal follows the same approach, and this situation happens in other countries: more attention has been given to the writing skill. The orality has not so much relevance. On the other hand, normally, at school, from primary to university level, the students do not learn how to analyze scientific results of linguistic research. They intensively study texts, more Literature type than any other one. They work with a book and they usually spend time writing, reading or doing exercises about what they read which seems contradictory. A language is spoken in a community and needs to be listened to until it comes natural to understand it, if it is a foreign language and, for the native speakers it is the same. The students need to learn how it is inside the structures and the functions. On Master classes of Phonetics, there is an opportunity to understand how Prosody is important in communication as there are multiple prosodic ways to say things. Of course, the learners have to write and to read texts, but before that it is indispensable to listen and to speak. But the purpose needs to be another one, for the research that is done at University. So, they have to make experiments. The Prosody and AMPER Project can definitely contribute to that purpose.

5. References

[1] http://www.varialing.eu/

[2] https://www.lfsag.unito.it/amper/amper.html

[3] Moutinho L, Coimbra RL. Para a Construção de um Atlas prosódico multimédia das variedades românicas, Revista da Universidade de Aveiro – Letras, 17, 111-118, 2001.

[4] Monteiro dos Santos Costa MLO. Porto Santo. Monografia linguística, etnográfica e folclórica, Revista Portuguesa de Filologia, I (II), II (I), III, Separata, Revista Portuguesa de Filologia, Coimbra: Editora Casa do Castelo, 1950.

[5] Santos, C. Tocares e cantares da ilha. Estudo do folclore da Madeira, Empresa Madeirense Editora Lda. Madeira, 1937-1938.

[6] Melo LS. O problema da origem geográfica do povoamento, Islenha, 3, Funchal: DRAC, 19-34, 1988.

[7] Vieira A. (Coord.) História da Madeira, Funchal: Secretaria Regional de Educação, 2001.

[8] Carita R. Curso de história e cultura da Madeira, Universidade da Madeira, 2008.

[9] Crystal D A. dictionary of Linguistics and Phonetics, Cambridge: Mass. Blackwell, 1994.

[10] Macedo DB. Subsídios para o estudo do dialecto madeirense, Dissertação policopiada, Lisboa: Faculdade de Letras de Lisboa, 1939.

[11] Andrade Pardal E. Algumas particularidades do português falado no Funchal, Actas do IX Encontro da Associação Portuguesa de Linguística/ Coimbra, Lisboa: Colibri, 17-29, 1994.

[12] Bernardo MCR. Estudo preliminar da variação prosódica nos Açores, Géolinguistique, hors série n.º 3. Grenoble. Université Stendhal-Grenoble 3.Centre de Dialectologie, 2005.

[13] Contini M. Le Projet AMPER: passé, présent et avenir, Moutinho LC, Coimbra RL (Org.), I jornadas científicas AMPER-POR – Actas, Universidade de Aveiro, 9-19, 2007

[14] Romano A. Développement d'un Environnement de Travail pour l'Etude des Structures sonores et intonatives de la Parole, Mémoire de DEA en Sciences du Langage, Grenoble, Univ. Stendhal, 1995.

[15] Mairano P (Org.). Intonations romanes (DVD). In: Géolinguistique (ISSN 0761 9081), hors-série n.° 4, Centre de Dialectologie / GIPSA-lab, Grenoble: Ellug, Université de Grenoble, 2011.

[16] Rebelo H. O Arquipélago da Madeira no Projecto AMPER-POR, Actas das I Jornadas Científicas AMPER-POR de 29 a 30-10-2007, (org. Moutinho LC, Coimbra RL), Universidade de Aveiro, Centro de Línguas e Culturas e FCT, 39-54, 2007.

[17] Rebelo H. Alguns dados prosódicos para o Funchal no âmbito do Projecto AMPER-POR, Margem. Viver n(o) Funchal, n.º 25, Santos TP (coord.), Funchal, Câmara Municipal do Funchal, 106-112, 2008.

[18] Rebelo H. O Arquipélago da Madeira e o Projecto AMPER-POR: Primeiros Resultados da Análise Prosódica para o Funchal, Turculet A (Ed.), La variation diathopique de l'intonation dans le domaine roumain et roman, Iasi (Roménia): Editura Universitatii Alexandru Ioan Cuza, 167-183, 2009.

[19] Rebelo H. Relatório do Pós-Doutoramento Universidade de Aveiro, 2011.

[20] Rebelo H. 11 Capítulos "Santa Maria Maior 01k1, "Santa Maria Maior 01k2, "São Martinho 01l1", "São Martinho 01l2", "Calheta 01m1", "Calheta 01m2", "São Jorge 01n1", "Campo de Baixo 01o1", "Campo de Baixo 01o2", "Camacha 01p1", "Camacha 01p2", in Mairano P. (org.). Intonations Romanes (DVD). In: Géolinguistique, hors-série n.° 4, Centre de Dialectologie / GIPSA-lab, Grenoble: Ellug, Université de Grenoble, 2011.

[21] Rebelo H. O Arquipélago da Madeira, região europeia, e o AMPER, projecto transeuropeu. Uma amostra da prosódia feminina madeirense, RUA-L, Revista da Univ. Aveiro-Letras, 1.º número, II.ª série, Ramalheira AM, 321-347, 2012.

[22] Rebelo H. O Arquipélago da Madeira no projecto AMPER. Comparação de dados prosódicos de duas informantes do Funchal (Santa Maria Maior e São Martinho), Avanços em Ciências da Linguagem, Petrov, P. Sousa, P. Q. de, Samartim, R. L.-I., Torres Feijó, Elias J. (Eds.), Santiago de Compostela-Faro, AIL-Através Editora, 429-444, 2012.

[23] Rebelo H. O Arquipélago da Madeira no projecto AMPER. Comparação de alguns dados prosódicos de duas informantes da ilha da Madeira (Calheta e São Jorge), Fonética Experimental, Educación Superior e Investigación, Vol. III. Prosódia, Congosto Martín Y, Montero Curiel ML, Plans AS (Eds), Madrid: Arco-Libros - La Muralla, 309-322, 2014.

[24] Rebelo H. Acerca da prosódia nas ilhas madeirenses, Estudos em variação geoprosódica, Moutinho LC, Coimbra RL, Fernández Rei E (Coord.), Aveiro, UA Editora Universidade de Aveiro, 53-78, 2015.

[25] Rebelo H. À propos de la prosodie des îles de l'Archipel de Madère : Résultats d'un test, Variations, Phraséologie et Ressources, ISBN: 978-855294628-1, 2016-2018, 179-189, 2019.

[26] Rebelo H. A prosódia madeirense e Porto-Santense: Comparação de curvas melódicas de frases interrogativas, Moutinho L, Sandra Madureira S (Eds.). A prosódia das línguas românicas. Intercâmbio, v. XXXIX, São Paulo: LAEL/PUCSP, 119-143, 2019.

[27] Moutinho LC, Vieira A, Gómez Bautista A, Fernández Rei E, Rebelo H, Salema LFP, Coimbra RL, Sousa X. Análise dialectométrica e cartográfica da variação linguística, Moutinho LC, Coimbra RL, Fernández Rei E, Sousa X, Gómez Bautista A (Eds.) Estudos em variação linguística nas línguas românicas, Aveiro: UA Editora, 248-258, 2019.

[28] Hirst D, Di Cristo A (Eds.), Intonation systems: A survey of twenty languages, Cambridge University Press, 1998.

ISBN 978-84-8158-937-5

Approaching Science to School Children

R Arroyo Sanz, A Alonso Diez,
V Calderón Carpintero, L Cuenca-Romero,
S Gutiérrez González
Universidad de Burgos, Spain
rasanz@ubu.es

Abstract. With the aim of bringing science closer to children, the University of Burgos organizes educational activities to help them understand the work carried out in the Department of Architectural Constructions and I.C.T. and to familiarize them with the environment of construction materials and construction methods.

For this purpose, visits are made to the University, to the research laboratories and to the laboratories where they participate in the design of new construction materials, initiating them from an early age in the knowledge of the construction processes and the mathematical bases necessary for it, as well as valuing the importance of recycling industrial waste such as polyurethane, glass, slate, silestone or black slag from electric arc furnaces, by incorporating them into these new construction materials, obtaining a great saving of natural resources.

With these participative workshops, the children are able to make contact with the laboratory, the construction materials and the construction methods, generating great benefits when learning the work that is done at the university, as well as helping to develop their creativity in different areas.

Keywords. Science, Recycling, New Construction Materials, Dissemination Workshops.

1. Introduction

During the last few years, the University has tried to carry out dissemination activities beyond its usual activities, in order to bring the knowledge it transmits to university students closer to pre-school and primary school children, with the aim of bringing science to children in a simple way, but in which they can actively participate and get involved.

The importance of the role of laboratories in the teaching of science has been demonstrated for years [1-2], both by psychologists, educators and scientists, since it helps to visualize everything that they want to teach, and makes students act in a participatory way in the development of various activities. It has been shown that performing laboratory work brings great benefits to learning [3], giving it a central and distinctive role in science education.

For all these reasons, bringing science closer to children so that they can experience the observation and manipulation of the different elements with which we work at the university is a very useful tool to develop understanding and to be able to appreciate everything that is done in the Department of Architectural Constructions and I.C.T. of the University of Burgos.

2. Organization of the workshops

In order to familiarize the students with the University, they are taken on a tour of the entire Polytechnic School, the research laboratories and the workshops in which they will later participate in various activities, so that they can get to know everything that the university involves and get an idea of the activities that are carried out there.

Several workshops are carried out for students of both pre-school and primary education, in which activities have been carried out according to their ages so that they can participate in them actively through play and come to understand the different construction materials that are used today, as well as the different construction processes used, always adapted to the needs that each age group requires.

2.1. Design of new construction materials

One of the workshops consists of the design of new construction materials in the workshop. Thanks to this workshop, students learn the importance of recycling and reusing materials, and it promotes creativity, since they themselves design materials that can later be used in construction.

To do this, they make small-scale plasterboards in which they replace part of the gypsum used in their manufacture with

industrial waste such as polyurethane, glass, slate, silestone, or black slag from electric arc furnaces. All this is done by making them take part in a game, in which they develop a recipe with the different ingredients and then they themselves manufacture their own ceiling tiles on a small scale. In this way, they reduce the use of natural resources, generating an environmental benefit, and recycle industrial waste at the same time, eliminating it from the landfill.

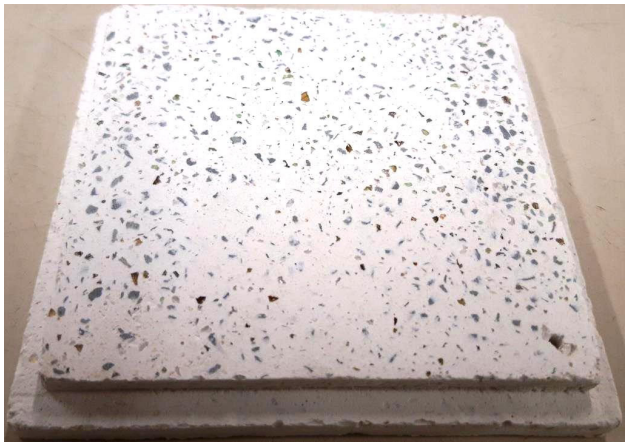


Figure 1. Ceiling tile made with recycled materials

Diseño de nuevos materiales de yeso con residuos de poliuretano

Nombre del investigador:

Fecha del ensayo: 10 de diciembre de 2019
Temperatura del laboratorio:
Humedad del laboratorio:

Nombre de la Mezcla:
Mezcla reciclada

Material	Cantidad
Yeso	20
Agua	
Poliuretano	12
Otros residuos	8
Silestone	
Vidrio	
Escoria	
Pizarra	

Figure 2. Recipe to make the ceiling tile

Figure 3. School children making the ceiling tile

2.2. Design of a little house with recycled materials

Another workshop is the design of a little house made from recycled materials. Thanks to this workshop, students understand the importance of recycling and see its usefulness, thus giving them an added value. It also helps to familiarize them with the environment of construction materials, thus initiating them in the knowledge of the construction process.

Figure 4. School children making the recycled houses

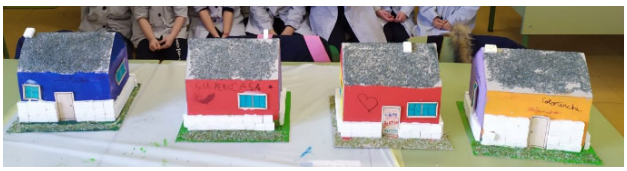


Figure 5. Houses made with recycled materials

The residues used for its elaboration are industrial wastes such as polyurethane, glass, slate, silestone, or black slag from electric arc furnaces.

2.3. Design of articulated structures

Another of the workshops carried out by the Department of Architectural Constructions and I. C. T. of the University is the design by the students of articulated structures in which each group was able to design an articulated

ISBN 978-84-8158-937-5

structure to be as high and resistant as possible, thus initiating them in the knowledge of the construction processes and the mathematical bases that apply in the technology of the structures. To do this, they formed several groups and made structures with spaghetti and gummy clouds as knots, trying to achieve the tallest and strongest structure possible.

Figure 6. School children making articulated structures

Figure 7. School children making higher articulated structures

In this way, creativity and ingenuity are encouraged, based on mathematical concepts, making it a very enriching activity for them.

3. Conclusions

The development of workshops by the University of Burgos, specifically by the Department of Architectural Constructions and I. C.T. with the aim of bringing science closer to the youngest is a totally gratifying task, since children become familiar with the environment of construction materials and construction procedures. To this purpose, the fact of participating in active workshops in the university laboratories makes it easier for them to understand the work carried out at the university, and makes science a game that they are part of. These workshops have great benefits, as they encourage children to understand the importance of reusing and recycling, as well as valuing the natural resources available to us. They themselves get to design sustainable construction materials, which are of great importance nowadays. They are also able to value the importance of mathematical knowledge to be able to build resistant articulated structures, as well as to encourage creativity for their development. In general, it is considered that the development of these activities is very beneficial for them, both in their current stage in preschool or primary school, as well as in their future.

4. Acknowledgements

Authors gratefully acknowledge the financial support of BU070P20 Project funded by the Fondo Europeo de Desarrollo Regional (FEDER) of the EU and the Junta de Castilla y León (Spain).

5. References

[1] Hofstein A. The Role of Laboratory in Science Teaching and Learning. In: Taber KS, Akpan B (Eds.) Science Education. New Directions in Mathematics and Science Education. SensePublishers, Rotterdam, 2017.

[2] Linn MC. The Role of the Laboratory in Science Learning. The Elementary School Journal, 97 (4), 401–417, 1997.

[3] https://projectchampionz.com.ng/2021/03/01/the-role-of-science-laboratory-in-the-teaching-and-learning-of-integrated-science-in-junior-secondary-school-in-plateau-state/

ISBN 978-84-8158-937-5

The Use of Computer Animation to Support Teaching of Science in Primary Education

EN Petraki
National and Kapodistria
University of Athens, Greece
evpetra@econ.uoa.gr

Abstract. Animation is an attractive and creative way of presenting educational concepts in primary education. Stop motion animation is frequently used in primary education: students create the physical objects with clay, plasticine, or other similar material (clay animation), paper (cut out animation) or they use objects (object animation) or they themselves animate the movements (pixelation), capture each frame with a camera and use a video editing software to play back the sequence of images rapidly and create the final animation.

The development of software environments like Java, Flash and other web-based applications enable teachers and students to create more complex animations that effectively present scientific concepts [1]. Researchers have carried out plenty surveys that prove the positive affect of animation in the student learning process [2-4].

The purpose of this paper is to present the research which was held for five years (2014-19) within the framework of the Animation Group of Creativity and Excellence in an Experimental Greek Primary School. During this period animation was used to familiarize primary school students (7-12 years old) with specific animation software, teach computer programming, represent algorithms, simulate physical phenomena, and present science concepts. Examples of using animation to support science teaching in primary education are presented in this paper. Through animation students acquired digital literacy and used their knowledge to build projects about science concepts. The results of the specific approach were totally positive for both teachers and students and helped students better understand science lessons. As a conclusion, animation is strongly recommended as a tool for teaching science in primary education.

Keywords. Animation, Primary Education, Science, Computer Programming, Digital Literacy.

1. Introduction

Children like to watch animated cartoons in their daily life as they consider them attractive and fun. The pedagogical use of animation in teaching school subjects has been studied by many researchers for many years. The integration of animated cartoons in different curricular subjects has had positive implications for teaching critical thinking skills in primary education [5]. The effects of using humor and concept cartoons in education are positive as they reduce anxiety level of the students, increase student achievements, improve their attitude toward the lesson and affect the retention of knowledge positively [6]. ICT plays a very important role as it provides software for creating animated stories in education. ICT also helps students' understanding of scientific concepts, hypothesis testing, developed problem solving skills in primary and secondary education [7].

2. The Animation Group of Creativity and Excellence

ICT is a separate school subject in Greek primary education that helps students acquire basic ICT skills, learn how to use specific software applications, learn computer programming and algorithms.

The current paper concerns the research implemented in an Experimental Greek Primary School for five years within the framework of the Animation Group of Creativity and Excellence. The Animation group first operated in the 2014-15 school year and its primary goal was to introduce students to the technique of animation with both traditional methods as well as modern techniques. In the years that followed, the students used programming environments such as Scratch, Alice, Web Cartoon Maker, etc. to create animations and despite the possible difficulties, the results were particularly encouraging and positive.

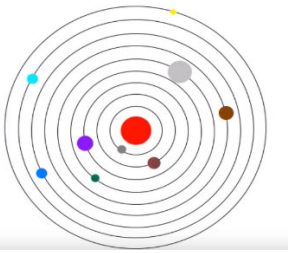
3. Animation science projects created by students

The students of the animation class individually or in groups, have chosen a science subject to study and created several

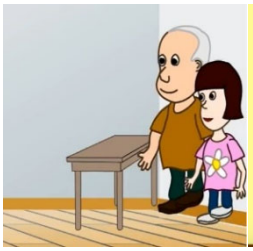
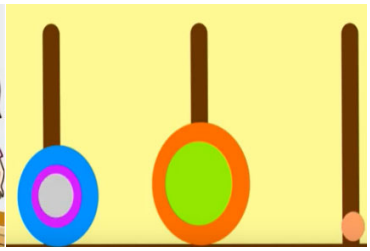
ISBN 978-84-8158-937-5

short animations about various scientific topics from mathematics, computer science, physics etc. Bellow, selected science animation projects created by primary school students are presented.

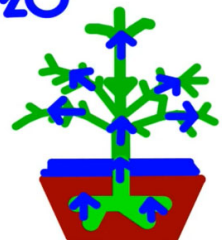
Planetary motions [8]: this animation project was created by a 9-years old student using Web Cartoon Maker programming environment and Stykz software. In the first few seconds of the animation two aliens are talking about the planets of our solar system. The second part of the animation represents the planery motions.

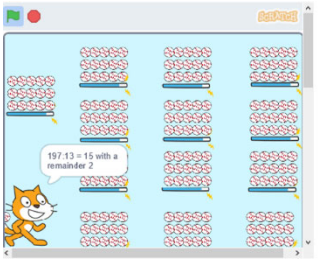
The towers of Hanoi [9]: it was created by an 11-years old student. In this animation a teacher explains to his student the definition of the algorithm and the second part of the animation simulates the Towers of Hanoi algorithm.

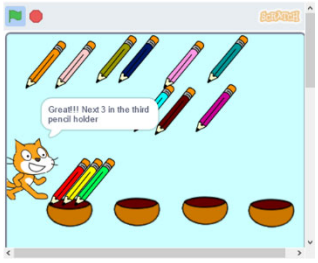



Photosynthesis [10]: This animation was created by two students and explains how plants use sunlight, water, and carbon dioxide to create oxygen and energy.



Animations for Math problems: Scratch projects created by group of students which use animation to present the solution of different math problems.





Rain and lightning [11]: Clay animation created by student that describes rain and lightning.


Cyberbullying [12], Copyrights [13], Lego WeDo 2.0 [14]: Students also created funny animations about cuberbulling preventions, copyright issues, their experience from using Lego WeDo 2.0 etc.

4. Conclusions

Current paper presents the approach of using computer animation to support science teaching in primary education. The experience of this approach had positive effects in two directions: it helped students acquire digital skills and in several cases computer programming knowledge and also helped them to better understand scientific concepts and physical phenomena. This kind of activities enforce student creativity, critical thinking, collaboration, motivation and personalization and are strongly recommended for supporting teaching of science to primary school students.

5. Acknowledgements

The author thanks all children for their active participation in this work and the National and Kapodistrian University of Athens for supporting the presentation of the specific research to the HSCI2022 International Conference.

6. References

[1] Barak M, Dori YJ. Science Education in Primary Schools: Is an Animation Worth a Thousand Pictures?. J Sci Educ Technol, 20, 608, 2011.

[2] Barak M, Ashkar T, Dori YJ, Learning science via animated movies: Its effect on students' thinking and motivation, Computers & Education, 56 (3) 839-846, 2011.

[3] Aksoy G. The Effects of Animation Technique on the 7th Grade Science and Technology Course. Creative Education, 3, 304-308, 2012.

[4] Aksoy G. Effect of Computer Animation Technique on Students' Comprehension of the "Solar System and Beyond" Unit in the Science and Technology Course. International Journal of Education, 3(1), 40-46, 2013.

[5] Attard R, Cremona G. The influence of animated cartoons on primary children's views of social reality: an ethnographic study in a Maltese primary school, International Journal of Primary, Elementary and Early Years Education, 50 (3), 329-347 2022.

[6] Berkay Ç, Gündoğdu K. The effect of using humor and concept cartoons in high school ICT lesson on students' achievement, retention, attitude and anxiety, Computers & Education, 103 (C), 144–157, 2016.

[7] Ranjusha A, Meera PK. Role of ICT in science education from primary to secondary school education in Kerala. EPRA International Journal of Multidisciplinary Research, 8 (1), 97–101, 2022.

[8] Animation created by students: Plenary motions https://youtu.be/ZRJdCthXI88

[9] Animation created by students: The Tower of Hanoi https://youtu.be/BPBspSoIVFU

[10] Animation created by students: Photosynthesis https://youtu.be/gosxekAmELE

[11] Animation created by students: Rain https://youtu.be/j3_2rDTF2II

[12] Animation created by students: Cuberbullying https://youtu.be/XZzIUcqJkms

[13] Animation created by students: Copyright https://youtu.be/lmloZXCKHPM

[14] Animation created by students: Lego WeDo 2.0 https://youtu.be/3suf2fCV8BA

ISBN 978-84-8158-937-5

Science Education for Wind Power Technique and Electricity Generator Driven by Ocean Waves

CH Chou
Vanung University, Taiwan, R.O.C.
chou0717@gmail.com

Abstract. The principle of a wind turbine is almost the same as that of a sailboat sailing in a direction perpendicular to the wind. Each section of the wind turbine is moving at a different speed. Similarly, each section of the wind turbine blade, rotating at a given rotational velocity, is moving at a different speed respectively.

A series of teaching aids were designed to illustrate the details about how the lifting force exerted on the wind turbine drives the blade to rotate. Therefore these teaching aids ensure the students and audiences realize the fact that indeed there are the lifting forces driving the blade in a bizarre manner.

A wind turbine is designed and established to harness wind energy to the greatest extent possible. Aiming at this goal, designers design the wind turbine through considering sequentially the following six aspects:

I. High AR turbine blades are optimal.
II. The best TSR and the number of blades are determined together..
III. Determining the install angle of the tip according to the best TSR
IV. The install angle of each section of the blade is determined according to the direction of the wind respective to each section.
V. The airfoil of each section can be optimized.
VI. The shape of the turbine blade can be refined to avoid losing energy.

The author is trying to invent a series of suitable teaching aids to help students understand these considerations. Some of the teaching aids are mature, some of them are not finished yet.

Furthermore, the author develops several feasible and workable methods for making a tiny professional wind turbine in order to offer the public an opportunity to enjoy making a miniature modern wind turbine. The interesting methods of making tiny professional wind turbines, which can drive a miniature electric generator, can be classified into two types.

The first type is directly shaping wood into a wind turbine. The second method is based on a composite material technique. In this second method, a suitable mold is made. A PVC wind turbine can be made in the mold. Because the PVC plate possesses the characteristics of a modern wind turbine, when we hold the tiny PVC wind turbine generation system walking gently in rest air, it is able to drive a tiny electric generator to produce electricity to light several LED.

Ocean wave driven generator, which is similar to wind turbine driven electricity generator is also a green energy technique. The author likes to share what have been finished in this field in Taiwan with science educators around the world. After surveying all electrical generators from ocean waves, the author have clearly discovered their deficiencies. By means of theoretical analysis, we find the fact that the energy transfer process shall be shortened and the mass and inertia of the so called working body which harnesses wave energy shall be as small as possible.

Author's discovery clarifies the direction of research on ocean waves driven electrical generator and how to design the details of the design of electricity generator driven by ocean waves.

Keywords. Teaching Aids, Wind Turbine, Electricity Generator, Ocean Waves.

1. Introduction

Wind power is the oldest green energy. It has been used by humans for thousands of years. Around the world, there are many highly unique wind mills made of materials easily obtained in local terrains that reveal the wisdom of each individual culture.

The modern wind turbine, designed much more sophisticatedly according to aviation science and techniques, transfers wind energy much more efficiently. The principle of a wind turbine blade is basically the same as that of the wing of an airplane. Both of them work by using lifting force. However, they use lift in different manners. It is worthwhile to emphasize

ISBN 978-84-8158-937-5

that the key technology of the wind turbine is essentially the aviation technology. A great deal of mature aviation knowledge, including data about airfoils, such as lift coefficient, critical angle and the characteristics of each airfoil, stall phenomena, not to mention composited materials technology, can be applied to the wind turbine.

Over the past several decades, wind power has become the most powerful and most mature green technology. Wind power industries grew significantly in many countries, including the United States and China. Many wind turbines appeared in various wind farms, offshore and inland, around the world providing growing electrical power for numerous families.

As a science educator, the author was the first to begin to teach numerous students how the modern wind turbine works and also the first to teach them to make an airborne wind turbine in Taiwan. This story was reported by the Discovery Channel and National Geographic Magazine.

In this speech, two main issues are carefully addressed, based on existing knowledge and the results of the author's own research in this field. One is how the wind turbine works by being exerted through lifting forces. The other is how to design a modern wind turbine in order that the wind turbine can harness wind energy as much as possible. Some innovative methods to make tiny professional wind turbines, which drive mini-generators to produce electric lighting of the LED, are discussed in the last pages.

2. How does a wind turbine work?

Actually, the lifting force can be used to drive various powerful machines, instruments and other necessities of modern life. The helicopter, wind turbine, turbine jet, turbo fan, turbo propeller, airplane, sail boat, steam turbine and even the compressor are all based on the principle of lifting force. Everybody knows that an airplane flies due to the lifting force exerted on the wing of the airplane. Although the lifting force can be utilized in various ways, we can understand how the wind turbine works by understanding how lifting force works.

Furthermore, the lifting force drives a sail of a sail boat sailing in the direction perpendicular to the wind direction in a counter-intuitive manner, just as the lifting force does on a wind turbine blade. A smaller component, which impacts the direction of the boat, involves the lifting force exerted on a sail and does the work of overcoming the drag of the boat. Similarly, a smaller component of the lifting force exerted on the blade of a wind turbine makes the blade move and rotates the whole wind turbine, which drives the generator to produce electricity. In this case, a small component of the lifting force is in-parallel with the direction of the blade moving.

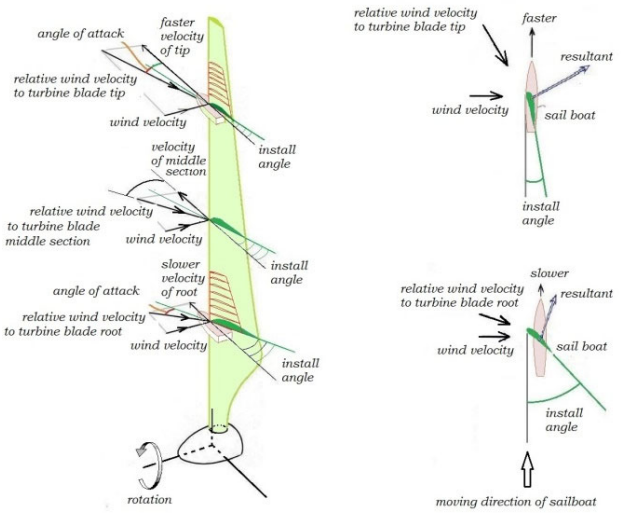


Figure 1. The sail boat and the wind turbine are driven by the lifting force in a similar manner. The component of the lift exerted on the sail overcomes the drag of the water. The component of the lift exerted on the turbine blade creates a torque driving the electricity generator

First, let's investigate some details of how a sail boat sails in a direction perpendicular to the direction of the wind, as shown in figure 1 (right). Assume the wind is blowing from the west and the boat intends to move toward the north. While the speed of the boat is slow, the relative direction of the wind to the sail boat is almost from the east. In order to use the lifting force normally, the orientation of the sail must be adjusted to make the angle of attack adequate. Therefore, the lifting force on the sail could be made bigger and the drag on the sail limited as the angle of attack remains adequate by adjusting the orientation of the sail. In this way, a bigger lift and smaller drag are exerted on the sail. The resultant of the drag and the lift

ISBN 978-84-8158-937-5

renders the component which is toward the direction of the traveling of the boat and drives the boat to move.

On the other hand, if the speed of the boat becomes greater and greater, the relative wind toward the sail becomes greater and most importantly the direction of the relative wind is also changed significantly, as shown in as the upper right picture in figure 1. The relative wind is blowing from the north-west. In order to create a lifting force, normally the orientation of the sail must be re-adjusted to make the angle of attack suitable at which the ratio of the lift and the drag are basically greatest. Again, the result of the lift and the drag also has the component which is in parallel with the direction of the sail boat and drives the boat to overcome the drag of water and to sail continuously.

Obviously, as the sail boat travels faster, the resultant of the lift and the drag has a profound component that forces the boat to move toward the east. Fortunately, the bottom of the sail-boat protrudes a so-called center board into water. The mainly west-directed lifting force exerted on the center board by the water is in the opposite direction of the east component of the lifting force exerted on the sail and cancels out the east component of the lift exerted on the sail.

In this situation, the east component of the lift exerted on the sail and the west component of the lift exerted on the center board form a huge torque relative to the center of mass of the entire boat. The huge torque, which would normally turn over the boat, must be cancelled out by using several intriguing and interesting methods.

The principle of a wind turbine is almost the same as that of a sailboat sailing in a direction perpendicular to the wind. As shown in figure 1 (left), each section of the wind turbine is moving at a different speed. The root section of the wind turbine is moving most slowly, just as the sail is moving slowly. The tip section of the wind turbine blade is moving much faster just as the sail moving faster. Similarly, each section of the wind turbine blade, rotating at a given rotational velocity, is moving at a different speed respectively while the sail is moving at a different speed.

Consequently, the install angle of each section of the wind turbine blade must be adjusted according to the direction of the relative wind to that section, just as the orientation of the sail must be adjusted according to the direction of the relative wind, which depends on the speed of the sail, to the sail. Therefore, the angle of attack of each section of the wind turbine blade would be suitable to guarantee that the lift exerted on each section is adequate and does positive work on each section. The wind energy is therefore transferred into the entire wind turbine to the greatest extent possible.

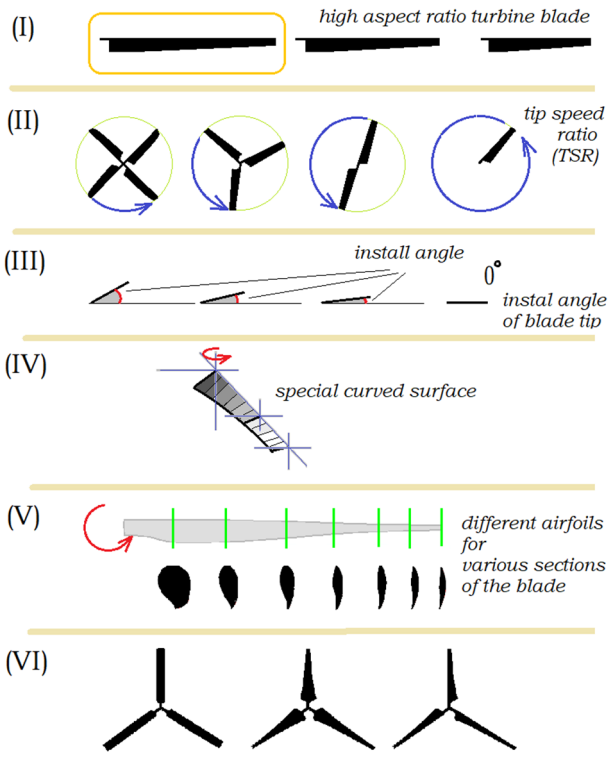


Figure 2. There are six sequential steps for designing an optimal wind turbine which can harness wind energy to the greatest extent possible

3. How to design an optimal wind turbine?

To rotate a wind turbine by the lifting force is not the only purpose of constructing a wind turbine. A wind turbine is designed and established to harness wind energy to the greatest extent possible, although the Bitz limit reveals that the maximum efficiency of energy transfer from the wind to the wind turbine is about 59.3%. Aiming at this goal, designers design the wind turbine according to the

ISBN 978-84-8158-937-5

following six main considerations. These six aspects for designing a wind turbine shall be considered sequentially, shown as figure 2.

(I). High AR turbine blades are optimal

Because the wind turbines basically are driven by the lifting forces and because the drags exerted on the turbines definitely cause the turbines to lose energy, high aspect ratio (AR) turbine blades, of which the lifting force is bigger and the drag is smaller, are always used for most modern wind turbines.

Although the wing of an airplane with high AR makes it more difficult to control the airplane, the high AR wing possesses the advantage that the ratio of the lift and the drag is much better, which benefits the performance of long distance flying. The high AR turbine blade possesses the same advantage and thus has a much better lift/drag ratio. Therefore, the wind does positive work on the turbine more efficiently and transfers more energy into the wind turbine.

Due to the same reason, certain birds, such as the albatross, frigate bird and arctic tern, flying for long distances without consuming much energy stored in their body, developed high aspect ratio wings through the evolutionary process. Moreover, several specially designed airplanes, including the Boeing 747, Tu 95, U2 and others, which are designed for long distance flying, have high aspect ratio wings.

This is the reason why the modern turbine blade looks long and narrow in general.

(II). The best TSR and the number of blades are determined together

Investigating the details about lifting force while the angle of attack (AOA) is in a reasonable range, we notice that while lifting force is exerted on the wing, a portion of the air flow, observed in the wing coordinate and originally flowing backward, is deviated slightly downward.

If we observe the same phenomenon in the ground coordinate, we find a layer of air above the wing and a layer of air under the wing, which are originally static, but are now guided downward by the wing passing through the air quickly. And the wing is thus subject to the lifting force.

In the case of the wind turbine, the same phenomenon occurs. In the ground coordinate, we found the speed of a layer of wind behind the turbine and that of a layer of wind in front of the turbine are both reduced simultaneously, marked by grey in figure 3.

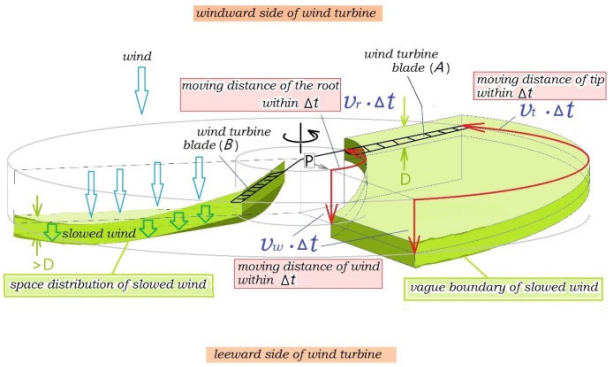


Figure 3. The tip speed ratio depends on the number of the turbine blades. The tip speed shall not be so fast that the following turbine blade denoted as B encounters lower energy wind caused by the leading turbine blade denoted as A

Obviously, the kinetic energy of the two layers of slower wind, is partially transferred into the kinetic energy of the wind turbine denoted as A, shown in figure 3. The thickness of these two layers together is about several times of the chord length of the turbine. The new oncoming wind with full energy continuously flows forward.

The following turbine, denoted as B in figure 3, is arriving at the same location, denoted as P, a time interval later. The turbine B can also partially harness the kinetic energy of layers of wind, of which the thickness is denoted as D in figure 3. If the following turbine blade rotates too fast and arrives at position P early, there is still a portion of low energy wind within the thickness D. In this case, the wind turbine does not be driven by the wind with full energy and in contrast loses energy to the mixed wind. If the following turbine rotates too slowly and arrives at position P too late, the amount of wind with full energy has already flowed far away from the thickness D and therefore the wind energy can no longer be harnessed by the wind turbine.

ISBN 978-84-8158-937-5

When the following turbine B, rotating at an optimal speed, arrives at position P just on time, it loses the kinetic energy of only a very limited amount of full energy wind, which has been out of the region denoted by D, and will not encounter the low energy wind thus to lose its own energy. Therefore, this is the best tip speed ratio (TSR) which is defined as the best ratio between the optimal tip speed and the wind speed. When the tip rotates at "the best TSR", the entire turbine blade can harness maximum percentage of the wind energy. Obviously, the number of turbine blades is larger and the best TSR is smaller. For the wind turbine, of which the number of blades is smaller, the best TSR shall be larger.

It is notable that while the wind turbine rotates at the best TSR, not only the tip of the turbine but also the whole turbine blade can harness the maximum portion of the kinetic energy of the wind. The best TSR and the number of high aspect ratio turbine blades are controlled and decided artificially and have nothing to do directly with the speed of wind.

For any given speed of wind, the best TSR, which is decided by the number of the blades, shall be reached by using suitable engineering methods. Rotating at the best TSR, each turbine blade is thus not influenced by adjacent blades and harnesses the wind energy efficiently. The remaining task is hence to optimize the performance of each turbine blade according to aviation science.

(III). Determining the install angle of the tip according to the best TSR

The best TSR depends on the number of the blades of a wind turbine and has nothing to do with the wind speed. The best TSR determines the direction of the relative wind respective to the tip section of turbine blade, as shown in figure 4. In order to make the angle of attack (AOA) of the tip section reasonable, the install angle of the tip section shall be coordinated with the direction of relative wind respective to the tip section.

The best TSR depends only on the number of the turbine blades, which relate to the so called solidity of the wind turbine, and vice versa. Figure 5 shows that for different wind speeds, the rotational speed of the wind turbine must be controlled artificially by using suitable engineering methods in order to make the TSR constantly remain the designed best value. If the wind speed is greater, the speed of the tip shall be adjusted to be larger simultaneously. Similarly, if the wind speed is smaller, the speed of the tip must be controlled at a lower speed.

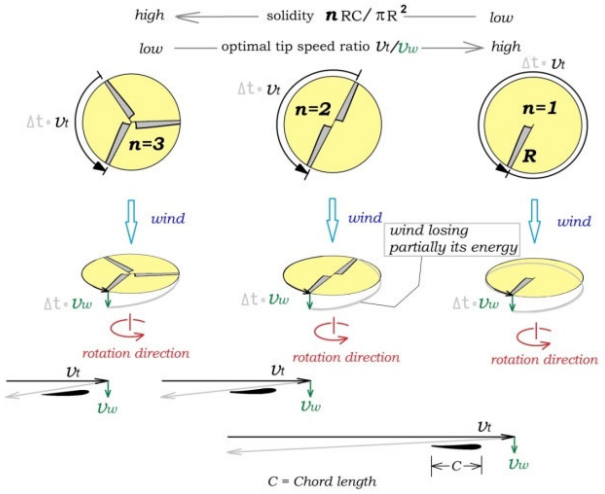


Figure 4. The number of the turbine blades, the optimal tip speed ratio (TSR) and the install angle of each section, including the tip section, are determined artificially and have nothing to do with the various speeds of wind in a natural environment

Therefore, the best TSR remains the designed value. It is clear that the direction of relative wind respective to the tip section depends on the TSR, shown as figure 5, and is decided by the number of the wind turbines.

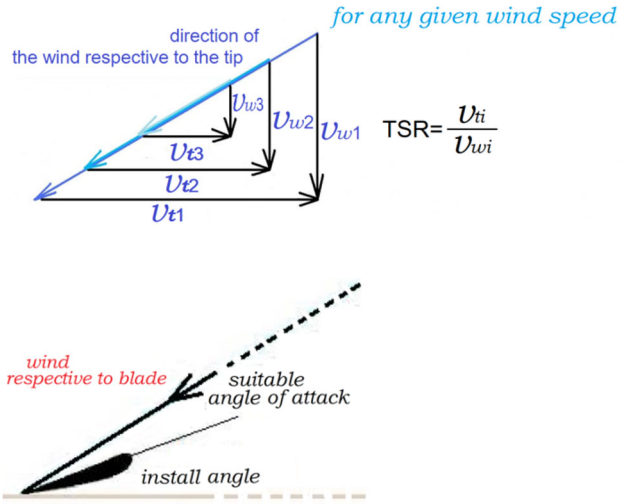


Figure 5. The best TSR determines the direction of the wind respective to the tip section (top). According to the relative wind direction, the install angle of the tip section is designed to ensure the angle of attack is optimized

ISBN 978-84-8158-937-5

According to the direction of the relative wind respective to the tip section, the install angle of the tip section is designed to ensure the angle of attack of the tip section is optimized (see figure 5). Therefore, because the angle of attack is optimized the tip section is subject to sufficient lifting force successfully.

(IV). The install angle of each section of the blade is determined according to the direction of the wind respective to each section

As we know, while the turbine rotates at optimal TSR, not only the tip section can harness the maximum portion of kinetic energy of the wind but also all the other sections, with different speeds, harness the maximum portion of kinetic energy of the wind.

However the speed of each section is different and the speed of the wind remains the same. Therefore, the optimal ratio between the speed of each section and the wind speed is different. Therefore the direction of the relative wind respective to the each section of the turbine blade is varied, shown as figure 6.

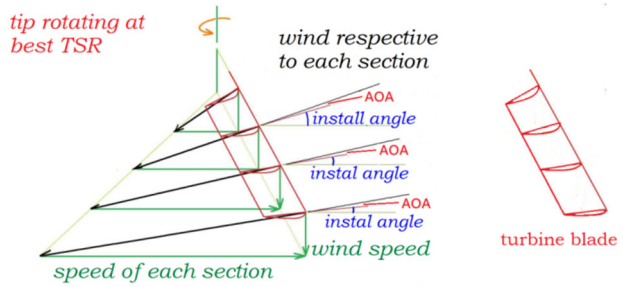


Figure 6. While the tip is rotating at the best TSR, every section of the blade works well, but the directions of the wind respective to various sections of the blade are different because the speeds of various sections are varied. Therefore, the install angle of each section shall be adjusted according to the relative wind direction. The turbine blade consequently is twisted intriguingly (right)

The install angle of each section of the turbine blade absolutely must be adjusted to ensure the angle of attack of each section in the optimized range to make the ratio between the lift and the drag as great as possible. Therefore, the wind does positive work on all sections of the turbine blade efficiently. This is the reason why the wind turbine looks like an intriguing twisted curved staff, shown in figure 6 (right).

(V). The airfoil of each section can be optimized

Because the speed of each section of the wind turbine blades is varied and the relative wind toward each section is also different, the airfoil of each section of the blade should be designed according to various considerations.

Of course, the most suitable airfoil of the tip section shall be selected in order that the noise of the tip section is depressed effectively and the ratio between lift and drag is reasonable.

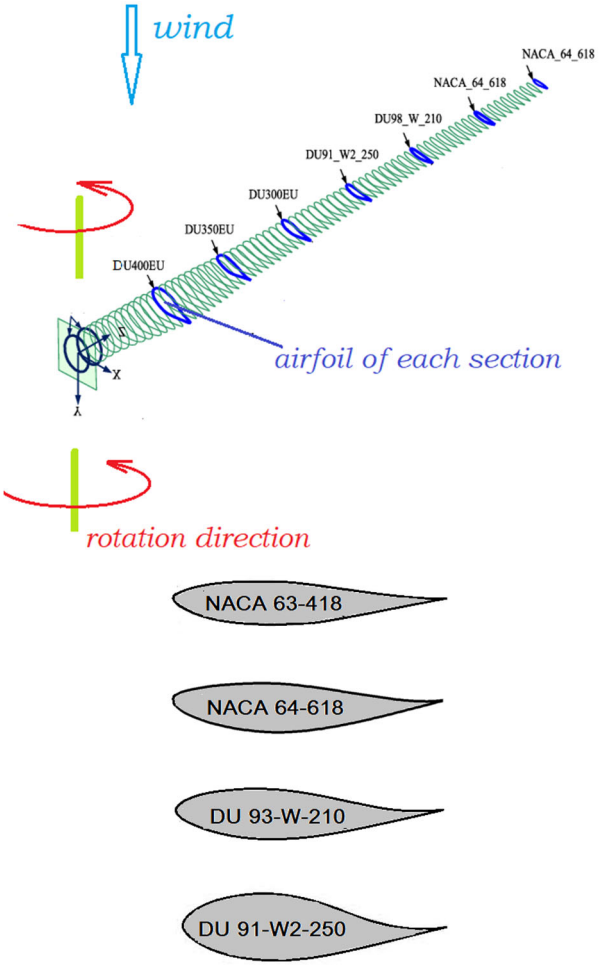


Figure 7. The airfoils of various sections are designed to optimize various performances of the entire turbine blade

For various sections of the blade nearer to the rotation axis, toward which the relative wind speed are slower, their airfoils are designed mainly considering the ratio between lift and

ISBN 978-84-8158-937-5

drag. Therefore the wind does work on the turbine blade more efficiently.

However, the airfoil of the root section of the blade is nearly a circle and the root section becomes a cylinder in order to make the whole blade sturdy enough to bear the wind force and also to make it easier to attach the wind turbine onto the main rotating axis.

Of course, designers must consider several significant factors, such as the principle of the wind turbine, the cost, the duration and sturdiness of the blade and more before making a final decision. Therefore, to design different airfoils for various sections is necessary and feasible, shown as in Figure 7.

(VI). The shape of the turbine blade can be refined to avoid losing energy

The last consideration is about the shape of the wind turbine which briefly influences the performance. The speeds of various sections obviously are different. In order to avoid unnecessary turbulences caused by the wind turbine, the faster sections of the blade are basically made narrower to decrease the Reynold number of the section. And the slower section of the blade could be made wider.

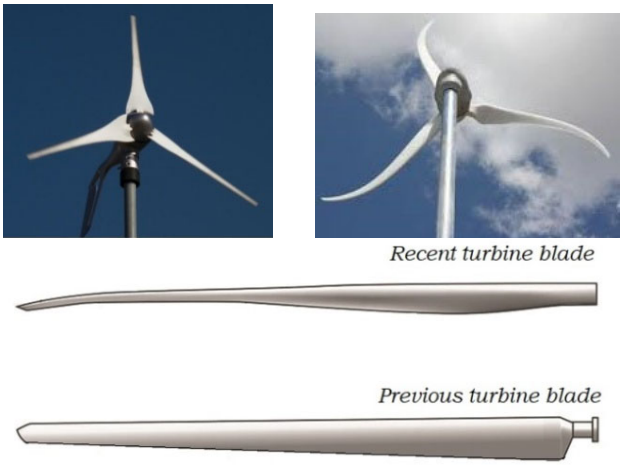


Figure 8. Carefully designing the shape of the turbine blade can suppress losing energy. The shapes of turbines (left) perform slightly better. The shape of recent turbine blades has been refined to optimize various performances of the wind turbine

Indeed further refining the shape of the wind turbine can enhance its performance, but the cost of making a better turbine is higher and the sturdiness of the turbine is decreased. Therefore, the shape of most modern wind turbine blades looks just like a strip with a narrow tip and a wider root, shown as figure 8.

Obviously it is necessary that we shall research further more details about every consideration mentioned here to be able to design and build an optimal turbine blade. However, this unique booklet has readily addressed the most significant factors that profoundly influence the performance of the wind turbine. This booklet can be treated as an indispensable reference for learners interested in wind power technology. The author strongly believes this pioneering book will inspire even more students to study wind power science and will provide them with the adequate knowledge to dig deeper in this field.

4. Interesting methods to make tiny professional wind turbine

Wind turbines rotating in the wind attract the attention of many children and adults. In fact, the wind turbine was one of the oldest toys for children. It is true and notable that many persons are interested in just making their own wind turbines and have no intention to study aerodynamics or aviation engineering further related to a wind turbine. To invent some feasible methods to build tiny wind turbines, which possess the characteristics of the modern wind turbine and can be used widely in science activities, is absolutely necessary and vital. To offer the public an opportunity to enjoy making a miniature modern wind turbine, the author develops several feasible and workable methods to fulfill this mission.

The interesting methods of making tiny professional wind turbines, which can drive a miniature electric generator, can be classified into two types.

The first type is directly shaping wood into a wind turbine. First, the wooden wind turbine is made with tools to remove unnecessary parts of a rectangular wood block. Second, the shape of the wind turbine can be refined and optimized with sandpaper. Making such a wind turbine unfortunately takes a longer time and produces much sawdust that pollutes the working site badly.

The wind turbine made in this way approaches the optimal professional wind

ISBN 978-84-8158-937-5

turbine, because several factors, such as installation angle, airfoil etc., can be adjusted carefully and sophistically to become qualified. This well accomplished wooden wind turbine is sturdy and durable. The performance of the wooden wind turbine for science education is obviously the best. Ironically, it is poorly feasible for science activities because the preparation is too cumbersome.

The other method is based on a composite material technique (see figure 9). In this second method, a suitable mold is made first. The author prefers making a wooden mold, because it is made easily with simple tools within a short period and it is sturdy enough to function as a mold. Several composite materials, such as paper and glue, balsa wood and glue, are used. The paper and balsa wood plate are cut into the shape of the wind turbine. After the wind-turbine-like paper is placed in the mold, glue is painted on this paper and then another similar paper is adhered to the top of the first one. Because the glue contains a portion of water, the papers are softened by the glue; two pieces of wind-turbine-like paper are forced to fit the shape of the mold with several strong clips. After the glue becomes dry and is solidified, a wind turbine made of paper, which possesses the characteristics of a modern wind turbine, is accomplished in the mold. This wind turbine is safe and durable enough for the purpose of science education, but it takes 24 hours to make one paper wind turbine. A balsa-wood plate is also used tentatively as the base material to make a wind turbine in a mold according to similar processes. The duration of the process remains an issue to prevent the wind turbine from being used widely in science activities.

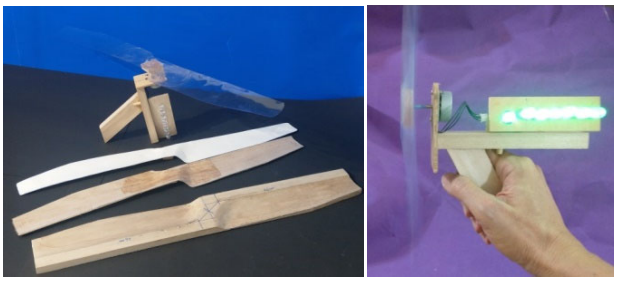


Figure 9. A finished wind turbine that can drive a tiny generator to light several LED (right). The mold used to form the shape of the wind turbine. The wind turbines made respectively of paper-based and balsa-wood-based composite materials, with a wind turbine made of PVC (left)

The author recently discovered that a PVC plate, of thickness about 0.6 mm, can be cut into a wind turbine with scissors. An expensive water jet is hence unnecessary to shape the PVC plate and the cost of making a PVC wind turbine is decreased significantly. The wind-turbine-like PVC plate is placed in the mold and is heated with hot air. After the temperature of the PVC plate is increased sufficiently, it becomes soft. The thus softened PVC plate is forced to fit the shape of the mold with hands wearing gloves. After waiting for a while, the PVC plate cools naturally and solidifies, completing a PVC wind turbine. Because the PVC plate possesses the characteristics of a modern wind turbine, when we hold the tiny PVC wind turbine generation system walking gently in rest air, it is able to drive a tiny electric generator to produce electricity to light several LED (see figure 9).

Its performance amazes people; the cost of the kit of the wind turbine generator becomes sufficiently cheap and reasonable. The newest PVC wind turbine definitely benefits related science activities in the near future.

5. Electricity generator driven by ocean waves

European Marine Energy Center classifies the existing ocean-wave converters into six types (see figure 10), apart from some special types that are not easily definable. The six types of electrical generators from ocean waves follow: 1 oscillating water column, 2 overtopping device, 3 attenuator, 4 point absorber, 5 oscillating wave-surge converter, 6 submerged pressure differential, with other special designs that cannot be classified precisely.

No such generator from ocean waves has been commercialized successfully so far. Scientists and engineers have no conclusive decision about the design of a useful generator of electricity from ocean waves.

We have investigated the nature of ocean waves. In most conditions, both the frequency and amplitude of ocean waves fluctuate appreciably. Moreover, the wave shape also varies. The coherence length of an ocean wave is small. In general, ocean waves are chaotic and random. These significant features of ocean waves must not be neglected.

ISBN 978-84-8158-937-5

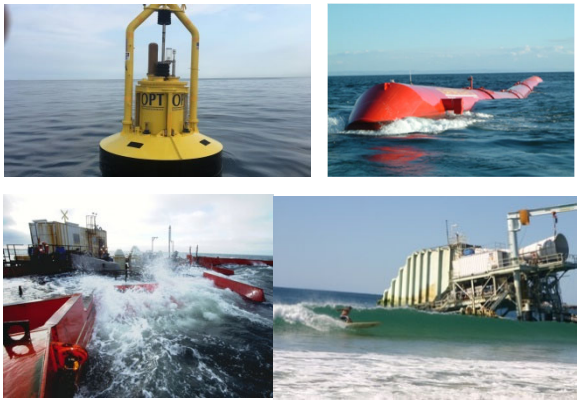


Figure 10. Various types of existing electrical generators from ocean waves. The point-absorber generator developed by OPT (bottom left) and the wave-powered generator (bottom right) refined previously in Taiwan but barely practical. Notably, the output of the early prototype is just 50 W

After surveying all electrical generators from ocean waves, we have clearly discovered their deficiencies. In most of such generators, the energy of an ocean wave, before conversion into electricity, is transferred into other forms of energy more than twice. During such a long energy transfer, much energy of an ocean wave becomes wasted.

By means of theoretical calculations, we find that the mass and the inertia of the working body, which is used to harness the energy of chaotic ocean waves, cannot be large; otherwise the efficiency of energy transfer is poor. In many designs, the mechanical parts of the working body are complicated, thereby increasing the mass and inertia of the working body; the efficiency of harnessing an ocean wave is consequently decreased severely. The technical feasibility of operating these complicated mechanical parts is also compromised.

From a survey of these existing electrical generators from ocean waves, we summarize an analysis of their energy transfer in figure 11.

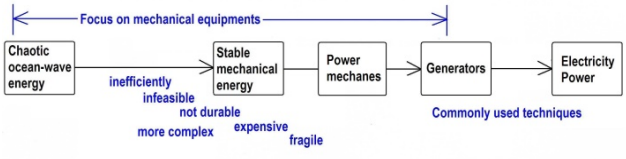


Figure 11. Overall strategy of designing other wave-powered generators

The failures of many ocean generators around the world highlight the fact that complicated mechanical equipment is impractical and that a lengthy energy transfer is counterproductive.

Our theoretical calculations yield another important discovery, namely that a smaller mass and inertia of the working body increases the efficiency of energy transfer. Complicated mechanical equipment or parts inevitably increase the mass or the inertia of the working body, so to decrease the efficiency.

The results of preceding tests of our early directly driven electric generators reconfirm the facts that the energy transfer must be simple and that the rotational inertia of the working body and related magnets inside the linear generator must be small.

To simplify the moving mechanical parts so as to decrease the rotational inertia of the working body and the joined magnets and to simplify the energy transfer are crucial, not only to increase the efficiency of energy transfer but also to ensure the technical feasibility. Harnessing wave energy is obviously a complicated problem, but a solution of the problem must be simple.

To avoid attaching the working body to a piston, chain etc. and to separate the working body from the main parts of the directly driven generator, we decrease the rotational inertia of the working body and simplify profoundly the energy transfer.

Figure 12 shows the transfer from ocean-wave energy to electrical energy. We use simple mechanical methods to transfer wave energy into electricity. As ocean waves are chaotic and random, the electricity stored in the so-called management circuit is also chaotic. Each capacitor in the management circuits is charged in variable conditions; as the mass and the rotational inertia of the working bodies are small, the energy transfer is straightforward, and its efficiency is large. The cost of the machine is modest; maintenance and operation of the system are cheap, increasing the reliability of the system.

Although in the management circuits the capacitors are charged in a variable manner, many mature or developing methods are available and reliable to produce stable

electrical output from the variously charged capacitors.

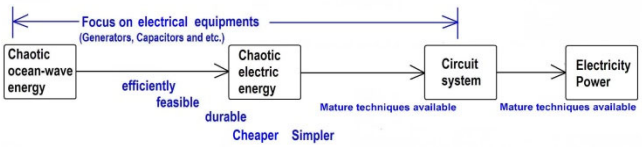


Figure 12. Transfer of ocean wave energy to electrical power in our directly driven generator

According to above analysis, we design and build several versions of a directly driven electrical generator by ocean waves. Related tests of the electrical generator directly driven by ocean waves reveals that the innovative design of the electrical generator driven by ocean waves is feasible and workable.

6. Acknowledgements

The author thanks t the Ministry of Science and Technology, R.O.C for the financial support.

7. References

[1] Chou CH. Avaiation engineering and the Wnd power technique, Taipei: Hai Shia Chin Fun, Inc., 2022.

[2] Chou CH. A Direcly Driven Generator of Electricity from Ocean Waves, Taipei: Hai Shia Chin Fun, Inc., 2018.

ISBN 978-84-8158-937-5

STEAM-Based Learning in Tesla Academy for Hands-On Science and Leaders Language School. The Edu Input and the Outcome!

E El-Shafey
Tesla Academy for Hands-On Science, Egypt
emad.writer2@gmail.com

Abstract. The aim of this contribution is to identify the Edu input and the outcome of using STEAM and PLB-based learning strategies in teaching science in both Tesla Hands-On Science Academy & Leaders Language school as well. I recorded students' knowledge improvement and the excitement in students" attitudes when teaching science using Hands-On activities via STEAM and PLB-based learning strategies. Consequently, some students involved in field projects, and some others were interested in national contests and international challenges. Such strategies inspired students to create new models, to be risk takers, persevere through failure to find innovative solutions to real environmental problems.

Keywords. STEAM / PBL Project-Based Learning, Hands-On Science, Student - Centered Approach, VSL Theory.

1. Introduction

As a physics teacher and founder of Tesla Academy for Hands-On Science, meanwhile a Science H.O.D at Leaders Language School, I attempted - with science staff - some strategies in teaching science in the last scholastic year.

I focused on STEAM & PBL (project-based learning) strategies, recording notes about the educational input and the outcome in both institutes as well. Also, as a science teacher I usually start science lessons with inquiry, to investigate some concepts, and to target the following objectives: acquiring knowledge, having positive attitudes and improving students" skills.

Exploring science with kids is considered to be one of the most significant methodologies of teaching and learning process, and the slogan "Here you you're an explorer!" acts as a magic key for student's curiosity. I noticed more improvement through teaching the curriculum and as a summer course "Science for Fun" too.

Actually, both project-based learning and STEAM (Science, Technology, Engineering, Art, and Math) education are growing well in both Leaders school and Tesla academy as well.

2. STEAM Education

STEAM Education means to educate and empower learners to imagine and create the future through play, ingenuity, and innovation using Science, Technology, Engineering, Art, and Math (STEAM) [1]

" Science & Technology, interpreted through Engineering & the Arts, all based in Mathematical elements". [2]

This is the definition by Georgette Yakman, CEO Founder of the STEAM Educational Movement 2006

And STEAM represents a paradigm shift from traditional education philosophy, based on standardized test scores, to a modern ideal which focuses on valuing the learning process as much as the results. "In essence, we dare our students to be wrong, to try multiple ideas, listen to alternate opinions and create a knowledge base that is applicable to real life as opposed to simply an exam".

Deron Cameron, Former UPES Principal – US's 1st STEAM Certified School, Current TCSS Curriculum Coordinator

2.1. STEAM-based Learning

As a science teacher, any good STEAM lesson is grounded in inquiry, problem-solving and process-based learning. In fact, this is one of the distinguishing characteristics between Arts Integration and STEAM. So, when viewing STEAM in the classroom, you want to pay close attention to the essential question and the process surrounding its exploration. So, whether you're using Arts Integration, STEAM, PBL and student-centered approach, these resources will make that process so much easier.

In the class or the science lab, you should discuss the following:

- What problems are being investigated and solved?
- How are both contents being used to explore the problems?
- Why is the process important to the question posed?

These are all important components to a STEAM classroom or lesson.

3. The Conversion Factor between STEM & STEAM!

Although similar STEAM and STEM education are not interchangeable terms. While STEAM uses the same concepts as STEM, STEAM also incorporates the arts and sometimes the humanities. However, educators say simply adding Arts to a STEM project or making the project “look pretty” doesn’t make it a STEAM lesson.

Instead, the Arts must be integrated into the lesson so students can see how each relevant discipline connects and works together. This allows students to develop and use skills naturally embedded in the arts and humanities, including empathy, creativity, and communication. [3]

Figure 1. The writer during an orientation to explain PBL-based learning to the parents

By using Arts Integration, STEAM, PBL and student-centered approach, these resources will make that process so much easier. Science teachers know that STEAM education isn't just the course content—it’s the process of being Scientists, Mathematicians, Engineers, Artists, and Technological Entrepreneurs.

Project-based learning can target one or more content areas. PBL and STEAM can complement each other in the classroom and school.

In fact, STEAM can be a great opportunity to create a lot of projects that hit Science, Math, Technology, and even Art content.

STEAM means is short inquiry, critical thinking, and process-based learning. That is extremely important. The entire idea surrounding STEAM lessons and the STEAM approach is that it’s based around questioning, really deep questioning by asking non-Googleable questions!

Inquiry, curiosity, being able to find solutions to a specific problem, and being creative in the finding of the solutions is at the heart of this approach. This means that the humanities are woven into STEAM just like everything else.

4. Success Skills

Skills like collaboration, creativity, critical thinking, and problem solving are part of any STEAM / PBL, and will be needed for students to be effective. Like the overall project, success skills are part of the glue of STEAM education.

In a STEAM / PBL project, science teachers teach and assess one or more of these skills. This might mean using an effective rubric for formative and summative assessment aligned to collaborating, collecting evidence, and facilitating reflection within the PBL project.

Figure 2. Jana Beshta, a student who participated in ISEF-Egypt 2022 contest with a project

ISBN 978-84-8158-937-5

For example, a teacher might choose to target technological literacy for a STEAM / PBL project, build a rubric in collaboration with students, and assess both formatively and summatively. When creating STEAM projects, we need also assessment of these skills to make sure that the project is successful. [4]

5. Planning Inquiries

When Science teachers design STEAM projects, they need to leverage a backward design framework and begin with the end in mind. Here are some questions to consider in planning:

- What two or more disciplines will be targeted and assessed? -
- How will students engage in real-world, authentic problem solving?
- What products will students create to demonstrate mastery of the content standards?

In Tesla Academy and Leaders School, students from Gr.1 to Gr.8 were interested in Hands-On Science activities, and enjoyed extra-curricular activities and field projects. Meanwhile the science staff enjoyed Hands-On science activities too.

In the last scholastic year, some of our students participated in National contests as ISEF- Egypt 2022 with projects, and another student has just participated in Khan Academy science contest: "Breakthrough Junior Challenge 2022" with a 90 sec. video titled: (The VSL Theory, Varying Speed of Light).[5]

Figure 3. Ahmed Ebrahem, who participated in Khan Academy Science Contest, "Breakthrough Junior Challenge 2022"

Figure 4. The writer with his student preparing for Khan Academy contest "Breakthrough Junior Challenge 2022"

It is an annual global competition for students to inspire creative thinking about Science and Math for ages 13-18 yrs. from countries across the globe to create and submit original video (90 seconds) that bring to life a concept or theory in Life Science, Physics or Mathematics.

High-quality STEAM education is high-quality project-based learning. While there will be attention to the disciplines embedded within STEAM, we must focus less on the content and more on the overall pedagogical implications for effective instruction, and use PBL to make learning happen.

6. Hands-On Science Activities

In the science booklets, we selected both core-curricular activities and the extra-curricular activities from the textbooks and some resources to cover the following science strands:

Life Science - Physical Science - Earth & Environmental Sciences - Energy & Mechanics - Space & Technology.

As the English edition of Janice Vaccinave"s series [6]:

- Chemistry for Every Kid
- Physics for Every Kid
- -Biology for Every Kid
- Engineering for Every Kid, and other resources. [7]

Then, STEAM Science booklets included a series of fun, interesting, creative and curriculum- linked introductions to Life on Earth including: the evolution and diversity of life; the structure of Bacterial, Animal and Plant Cells; Virus biology; Human Biology & the main body systems, the amazing science of DNA; the Big Bang, Evolution, Physics, Chemistry and more !

Figure 5. Hands-on science activities with lower grades

Figure 6. Science for fun! in the Summer Course

6.1 Science Project Topics

Here are suggested Science projects / activity topics to approach STEAM & PLB-based learning.

6.1.1. Life Science

Bacteria: Does reusing water bottles increase their bacterial content?

Bacteria: How clean are the tops of soda cans, and what is the most effective way to clean them?

Ionizing Radiation: How does ionizing radiation affect the germination and growth of plants?

Yeast: How does the amount of carbon dioxide generated by yeast depend on temperature?

6.1.2. Physical Science

Chemistry: Which plants and vegetables make the best dye?

Electrochemistry: How do the levels of salt and vinegar affect the amount of gas produced by electrolysis of water?

Magnetism: How does temperature affect a magnet?

Solar Cells: How does temperature affects solar cell energy production and storage?

6.1.3. Environmental Sciences

Acid Rain: How does acid rain affect algae and bacteria?

Air Pollution: What effect does sulfur dioxide have on lichens?

Lead: What is the lead content of drinking water at home and at school?

Water Pollution: Does pollution affect oxygen production in aquatic plants?

6.1.4. Earth and Space Science

Greenhouse Gases: How does the concentration of carbon dioxide affect plant growth?

Rocks: Does age affect the hardness of sedimentary rock?

Weather: Is there a relationship between the phases of the moon and the weather?

6.1.5. Mechanics & Energy

Solar Cells: How does temperature affect the efficiency of a solar cell?

Wind Energy: Can wind power be stored compressed air?

Wind Energy: What factors affect the generation of electricity by wind turbines?

ISBN 978-84-8158-937-5

Figure 7. "Here you are an Explorer! "

7. STEAM Education is the Future!

The world we live in will only continue to become more complex, and it's up to schools to ensure that students are equipped to adjust to its complexities. As the U.S. Department of Education states, it's more important than ever that our students and future leaders.

8. Conclusion

Why STEAM in Tesla Academy and Leaders school?

STEAM is not just about what, where or when – it's about why and how. STEAM is a process of application. It allows our students to create meaning for themselves and others.

Through STEAM, students are empowered to be curious learners and active explorers who seek creative solutions to questions that faced them in the real life. They can't just search for online, leading students to develop the soft and hard skills necessary to succeed.

The Edu outcome of science lessons eventually in both Tesla Academy and Leader School became so popular. STEAM-based learning encourages students to get curious about Science, Math, and Art activities.

9. Acknowledgement

I appreciate the creative Science staff: Ms. Radwa Janzori, Sara Sabry, Samah Qandel, Doaa Ahmed, and Hager Alsayed. I also appreciate Dr. Manuel Filipe, HSCI Network President [8] who succeeded in returning HSCI2022 conference to be in person after twice trails on line.

10. References

[1] https://www.steameducation.ca

[2] https://steamedu.com

[3] https://www.steam-ed.ie

[4] https://www.edutopia.org/blog/pbl-and-steam-natural-fit-andrew miller

[5] https://www.youtube.com/watch?v=9-XwOkWTjGE

[6] Vaccinave J, Chemistry for Every Kid, Chemistry for Every Kid: 101 Easy Experiments that Really Work. New York: Jossey-Bass, 2019.

[7] Glen Singleton. 365 Science Experiments, Heatherton- Australia: Hinkler Book, 2010.

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

Teacher Training on Virtual Labs and Low-Cost Science Experiments

FJ Redondas Maseda[1], *JB Vázquez Dorrío*[2], *B de Aymerich*[3], *MY Álvarez Granda*[4], *M García Calzada*[5]
[1]*IES de Candás, Spain*
[2]*Universidade de Vigo, Spain*
[3]*Universidad de Burgos, Spain*
[4]*CPR de Avilés-Occidente, Spain*
[5]*CPR de Gijón-Oriente, Spain*
javierredondas@yahoo.com

Abstract. The arrival of the pandemic situation forced science teachers to leave apart theirconsolidated experimental activities and look for alternatives to hands-on tasks, since they are crucial for science understanding. In this scenario, virtual labs and low-cost home experiments have emerged as a powerful option to be developed with students.

In this paper, we present a training online course based on virtual labs [1] and low-cost science experiments. This proposal was carried out in order to provide teachers with ideas, knowledge and appropriate skills to solve the lack of practices in laboratories and school workshops.

The contents and methodology of the training program were established by agreement between the responsibles of the teacher training centresand the speakers. Seven online synchronous sessions were carried out; where the hands-on tasks [2] were combined with guided activities in virtual labs [3-4]. Moreover, scientific apps [5] were introduced, showing the pedagogical value of smartphones as measuring intruments for science teaching. On the other hand, a complete set of resources and opportunities [6] have been provided to the attendees for their future professional development.

A collaboration platform, based on Microsoft Teams technology, was established for the course follow up and monitoring, including scheduling andimplementing online meetings, document sharing, persistent chats, and other useful pedagogical and organizational features, as well as assistance control and final evaluation. All sessions were recorded and these recordings have been kept available and ready to download for participating teachers.

Besides the synchronous gatherings, participant teachers were requested to reflect and create their own procedures and proposals in the form of a final activity. All final activities were collected in an online repository, which has also been made available in the platform for all participants.

After the course completion, participants were invited to evaluate the experience. A large percentage showed their strong agreement with the practical usefulness of the course contents; they revealed that the course contributed to broaden the range of activities to propose their students, in order to understand scientific evidences and to help to make science more attractive for them. A significant group of teachers claimed also for more specific activities for their own subject: biology, physics, technology, etc.

Keywords. Hands-on Science, Virtual Labs, Scientific Apps, Low-Cost Experiments, Teacher Training.

1. Introduction

The importance of teacher training is one of the most important key factors for improving the quality of education, it is one of the essential levers, if not the major lever, to make school more efficient and fairer. Although it is within the universities where initial training courses take place, the continuing and long-life education will have to develop and advance and progress the staff careers; in this framework, the role of teacher training centres is essential to promote the actualization of teachers in different pedagogical areas.

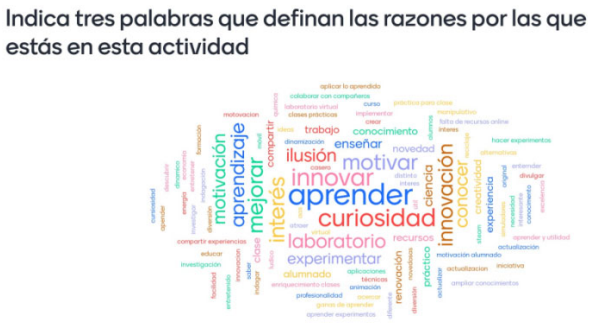


Figure 1.Results of the poll concerning the expectations of participants

ISBN 978-84-8158-937-5

The situation of the educational environment derived from health issues during the last two years has caused the need to think about new ways of adapting to blended learning and other circumstances. This adaptation is more difficult in scientific and technological subjects, since the impossibility of accessing the laboratories and workshops makes a hole in the knowledge of our students closely related with the key competences.

2. Motivation and goals

Scientific disciplines are intrinsically composed by theoretical and practical approaches and both of them are intimately intertwined in the construction of scientific knowledge. Hands-on activities are not an option to complement classroom tasks, but are essencial in science and technology education. Furthermore, hands-on experiences offer added value for the motivation of students towards their scientific training.

Figure 2. Compilation of resources provided to teachers during the course

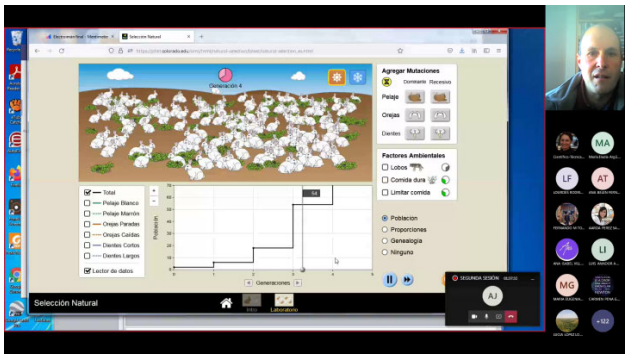


Figure 3. Online software (PhET) used to explore how organisms with different traits can survive in different environments

Traditional laboratories are usually a suitable workplace for these purposes. Nevertheless, the incorporation of other possibilities contributes to promote the need of experimentation for our students.

Taking this perspective into account, we have planned and developed a teacher training course based on hands-on low-cost activities, by using materials and tools easily obtainable (domestic materials in most of the cases), not dangerous (their handling can be done safely at home) and also easily affordable.

The main goals of this teacher training course are:

- Know the existence and explore the possibilities of alternative models to face-to-face laboratory practices.
- Get experience with the virtual laboratories and the GRAASP platform as an interactive tool for the creation of learning spaces at a global level.

Figure 4. Hands-on experiment with laser used to understand properties of light and geometrical optics

- Carry out different practical activities on virtual laboratory platforms.
- Provide teachers with confidence by carrying out different scientific experiments and technical developments with domestic utensils and materials, accessible in everyday situations and at low cost.
- Design a repository of laboratory manipulative activities, both virtual and domestic, for the scientific and technological subjects.

3. Development

Two editions of this course were launched during the school year 2021-22 with a high

demand from teachers from primary and secondary levels.

The development of the course was carried out using the Microsoft Teams online platform, which allows synchronous monitoring. Attendees can follow the video transmissions and ask questions in real time. Other features like asynchronous messaging and file sharing are also useful.

3.1. Course planification

The course contents were designed in order to give a general overview of a wide range of activities that teacher can carry out with their students, concerning the following topics:

- Introduction to virtual laboratories, Graasp platform and GO-LAB laboratories, JMOL, etc.
- Low cost experiments: materials and energy.
- Science in everything and for everyone

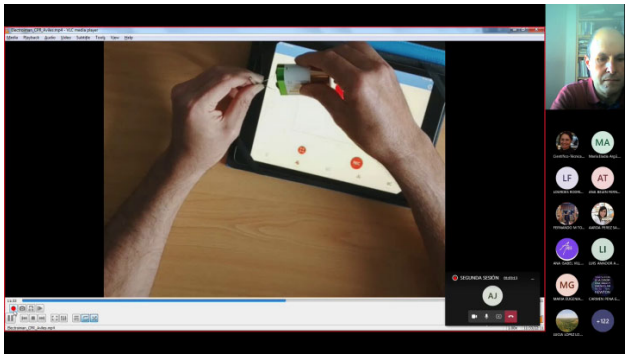


Figure 5. Using a scientific App to measure the magnetic field of a low cost and hand made electromagnet

- Low cost experiments: electricity and magnetism.
- Manipulative science.
- PhET Virtual Laboratory.
- Scientific Apps (Fizziq, Phyphox, etc.)
- Stellarium.
- Final activity: elaboration of a guide for the didactic application in the classroom of an activity related to the contents of the sessions.

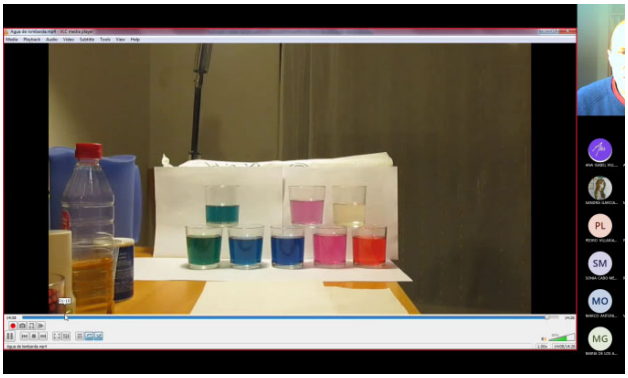


Figure 6. Experiment with red cabbage water as a method to measure the pH of different aqueous solutions

3.2. Course activities

The activities were carried out from October to December 2021 in the first edition of the course and from February to April 2022 in the second edition.

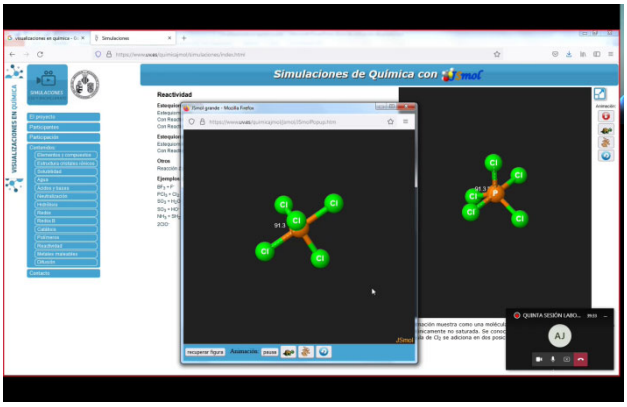


Figure 7. Using simulation of molecules structures for chemistry lessons

The structure was always the same: online synchronous talks from an expert showing the application of an online resource or a low-cost experiment.

During the sessions, teachers where motivated to interact through questions, interactive facilities (like menti.com), chat, following the experiment development at the same time than the expert.

In most of the cases, and according to the comments and opinions posted by the participants, the practical experiments could be done in real time, following the rhytm of the instructor. Nevertheless, some technical issues related with poor internet connections and unavailability of materials led participants to postpone the completion of some activities.

ISBN 978-84-8158-937-5

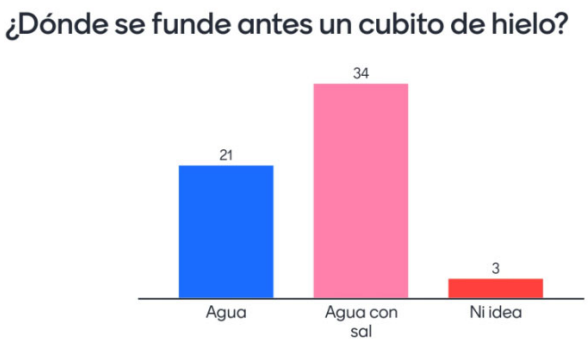


Figure 8. Results of a survey applied before carrying out a practical experiment

Figure 9. Results of a survey of participants preconceptions about the earth movements around the sun

Interactive polls were used as a tool to test regurarly the participants about some initial preconcepts, as well as for warm-up activities at the beginning of the different course contents. These pools also offered information about the success of the follow-up of the different hands-on experiments during the sesions. The information obtained from this survey has been very useful for the instructor to adapt his activities, as well as the timing of the different lessons.

To complete the training, teachers were asked to design a classroom activity, using the resources worked in the course or any other they knew, or they used. All these activities were compiled and made available to all of them through Teams.

This compilation of activies constitutes an important set of resources for all participants, ready to use in their classes or to propose to their students to develop as homework in blended learning situations.

Figure 10. Example of interactive poll used to get feedback from the attendees during the course sessions

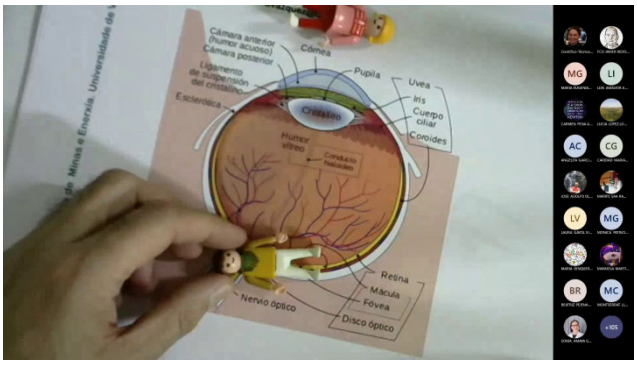


Figure 11. Experiment used to show how images are shaped inside the human eye

3.3. Assessment of participants

To get the certification, the participants had to assist to a minimum of six of the seven synchronous sessions and, in addition, they had to present an activity designed for their students.

After course completion, we got nearly 130 activities, mostly of them ready to apply to Secondary Science and Technology subjects (41 related to Biology and Geology, 66 to Physics and Chemistry, 3 to Maths and 10 to Technology) and the rest (17) have been proposed to apply to Kindergarden and Primary levels.

4. Evaluation

In one of the course editions, from the 148 teachers that followed the sessions, 117 completed the training, which means that they attended more than 85 % of the theoretical and practical lessons and send the final report in time. Keeping in mind that it was an online course, the number of teachers that ended training was significantly high, compared with

other similar training activities on other different topics. In the other second edition these numbers were quite similar.

In order to get feedback from the participants about their opinion about the suitability and pedagogical value of the experience, they were asked, through Forms application. The questions were designed to be rated from 1 to 5. We got 58 answers that showed the following results:

- Were the contents useful for your work? Rated with 3.52
- Was it what you expected? Rated with 3.19
- What do you think of the structure of the course? Rated with 3.76
- Were the methodology, strategies and materials suitable for the purpose? Rated with 3.55

In addition, they were asked about the suitability of the experts who led the course. They got a 4.0.

Finally, they were asked to make suggestions and the main idea we get from them is that they are interested in new training, separated for subjects and levels, with less applications but deeply reviewed.

5. Conclusions

This teacher training activity has been highly acknowledged in terms of practical usefulness and professional development, as can be deduced from the results of the evaluation questionnaires filled in anonymously by the course participants. Participant teachers showed their intention to continue with this kind of training. Nevertheless, some participants demand more specific courses for their own pedagogical field, since in this course they were trained in some aspects which are not relevant for their subjects. This fact is derived from the difficulty to offer appropriate contents for a wide range of sciences and educational levels: biology, physics and mathematics; kindergarten, primary and secondary levels.

6. Acknowledgements

The authors want to acknowledge the group of around 200 primary and secondary teachers who actively participate in the described activities, as well as their contribution to the repository of activities to be implemented by their colleagues in the classroom.

7. References

[1] https://www.golabz.eu/

[2] www.clickonphysics.es/

[3] https://phet.colorado.edu/

[4] https://chemcollective.org/

[5] https://www.fizziq.org/

[6] http://www.scientix.eu/

ISBN 978-84-8158-937-5

Creating of STEM – Equipment: Made a Galileo Refractor

K Minakova, M Kirichenko, R Zaitsev
National Technical University «Kharkiv Polytechnic Institute», Kharkiv, Ukraine
friday.marjory.johnes@gmail.com

Abstract. The simplest optical devices, lenses, have been used by humans since ancient Egypt, but for many centuries their use has been largely limited to creating a variety of optical effects for entertainment or religious purposes.

Only in the 17th century, with the invention of the Galileo Galileo telescope, optical instruments became firmly in the arsenal of scientific means of knowledge and significantly expanded the horizons of human knowledge. Principles laid down by scientists such as Galileo and Herschel and others have made it possible to create telescopes of truly gigantic proportions and launch them into space and make the greatest discoveries in astronomy - to discover exoplanets, to capture in lenses light comparable in age to our universe. But even the Galileo telescope, which looks like a small telescope against the backdrop of the Hubble Space Telescope, has already doubled the number of stars known since Ptolemy. Astronomer and theologian of the first half of the XVII century Anton-Maria Reita has found 2400 stars in the constellation Orion alone. The Huygens telescope magnified 100 times, while the Galilean instrument approached objects only 30 times. If Galileo saw something indistinct around Saturn, then Huygens was able to open and describe its rings.

And today, despite the growing role of radio astronomy, optical observations in recent years have identified the twins of our Earth, studied the structures of distant galaxies, and James Webb Telescope which now is ready to work will be the culmination of optical astronomy in outer space.

In this connection the question of introduce the schoolchildren into the basics of astronomy became very relevant. In this work a simple and budget solution was proposed for making a small lense based telescope which practically has design which very similar to the Galileo`s refractor. Especially interesting for schoolchildren is the practical study of basic principles of geometry optics and application of the simple telescope made by their hands for searching objects on the sky which are invisible for the human eye.

Several STEM workshops on the creation of the proposed simple telescope will allow the children to gain practical experience from creation optical devices and study the night sky.

Keywords. Optics, Lens, Refraction, STEM Equipment.

1. Introduction

There are many types of telescopes in the world today. Some of them are supermassive modern wonders, while others are just your usual daily telescope to which we are accustomed.

Nothing was an obstacle for researchers of the past, they were able to create their own rudimentary telescopes, having nothing but ingenuity and a desire to explore space, which they barely understood at the time. So let's explore how you can create your own, inspired by all these epic homemade telescope!!!

2. Galileo Telescope

Well, since we've been talking about a brief history of telescopes and showcasing some great homemade telescope designs, it seems appropriate that we start with a few Galileo's own telescopes, since it was homemade (and some of the first) centuries ago. They are still vivid examples of what someone can create!

Some interesting facts about the Galileo telescope:

- The original design, invented by Galileo Galilei in 1609, is commonly referred to as the Galileo Telescope.
- He used a convergent (flat-convex) lens and a divergent (flat-concave) eyepiece lens.
- The design did not have intermediate focus, resulting in an inverted and vertical image.
- Galileo's best telescope magnified objects about 30 times.

- The Galileo telescope could see the phases of Venus, as well as craters on the moon and four satellites orbiting Jupiter.

2. Equipment required

In essence, a telescope is a tool that allows you to look at distant objects. To do this, the telescope has a device that collects light from a distant object (lens or main mirror) and directs this light (image) into focus, where the second device (eyepiece lens) magnifies the image and brings it to your eye.

In a telescope, a lens that is close to your eye is called an eyepiece and is usually a short-focus lens or combination of lenses. The lens at the other end of the telescope is called the lens. The light from the distant subject is focused by the lens to form an image in front of the eyepiece. The eyepiece acts like a magnifying glass and magnifies this image like it`s shown on Fig.1. The magnification of the telescope can be found by dividing the focal length of the lens by the focal length of the eyepiece. The useful magnification of the telescope is limited by diffraction. This diffraction limit is approximately a 10-fold increase of three centimeters in lens diameter.

If the focal lengths of the lenses are known, it is possible to calculate their increase theoretically by the formula:

$$M = \frac{F_0}{F_e} \qquad (1)$$

where M- magnification of the telescope; F_0 - focal length of the lens; F_e - focal length of the eyepiece.

To make a simple telescope, you will need the following materials:

• two magnifying glasses - condenser lenses (convex lenses) - possibly with a diameter of 2.5-3 cm (preferably one larger than the other);

- a sheet of Whatman or thin cardboard;
- black paint;
- a piece of thick (1-1.5 cm) cardboard
- scotch tape;
- flashlight;
- scissors;
- ruler or roulette;
- glue;
- a white poster board or a sheet of thick white cardboard attached to the board;
- red and black insulating tape or red and black markers.

3. Creating a telescope

To create and assemble a telescope in the classroom, do the following. First of all, you need to determine the focal length of your lenses because it will depend on the length of the telescope.

a)

b)

Figure 1. Simple determining the focal length of the lens

If you do not know the focal lengths of the lenses and do not have enough time to determine them using a series of experiments with an optical bench. No need to worry. It is quite possible to determine the sum of the focal lengths of both lenses in a few minutes.

ISBN 978-84-8158-937-5

Figure 2. Lens preparation

Figure 3.Black painting of the tube walls

Place a tape measure or ruler on the floor near the wall perpendicular to it, and turn on the flashlight far enough away from the wall so that it shines on it and is almost a point source of light. Take the lens and place it in the light so that the image is projected on the wall. Move the lens along the ruler until the light from the flashlight collects at the point as shown in Fig. 1. Record the distance from the wall to the lens at this time. This will be the focal length of the lens.

The length of the assembled telescope will be slightly more than the sum of the focal lengths of the two lenses. Add the focal length values of the smaller and larger lenses together. Divide this length in two, then add another 2-3 inches. Using scissors, cut two rectangles from Whatman paper or thin cardboard, one side of which should correspond to half the length of the telescope, and the other calculate based on the diameter of the lens using the formula for the length of the circle so that folding formed a tube lenses. Cut a ring out of thick cardboard, the outer diameter of which corresponds to the lens, and the inner eyepiece (Fig. 2). This ring will secure the eyepiece and the lens and guide you in adjusting the telescope for sharpness.

The next step is to paint the inner surfaces of the cut out rectangles of Whatman black paint (Fig. 3). This is necessary to reduce the reflection of light from the walls of the tube and increase image quality.

Figure 4.Roll tubes

After the paint dries, roll the rectangles into tubes, making sure that the lenses fit snugly (Fig. 4). Insert the lens and centering ring into the opposite ends of the first tube (usually larger in diameter) and secure with glue. Similarly, fix the lens - eyepiece (Fig. 5). Connect the two cardboard tubes together - insert the eyepiece tube into the centering ring. You have now assembled a simple refractor telescope (Fig. 6).

ISBN 978-84-8158-937-5

Figure 5. Creating a lense and eyepiece tubes

Figure 6. Simple refractor telescope in assembly

Look through the telescope eyepiece and try to focus on a distant object or on a newspaper / magazine page. Move the two cardboard tubes in and out until you get a clear picture.

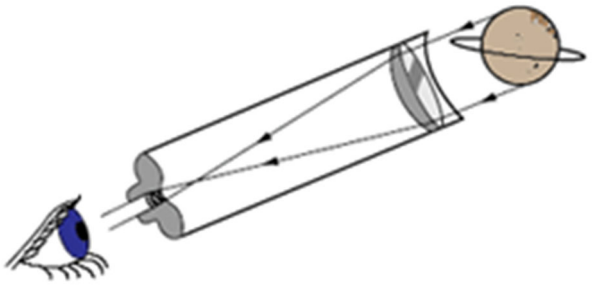


Figure 7. Illustration of a refractor telescope

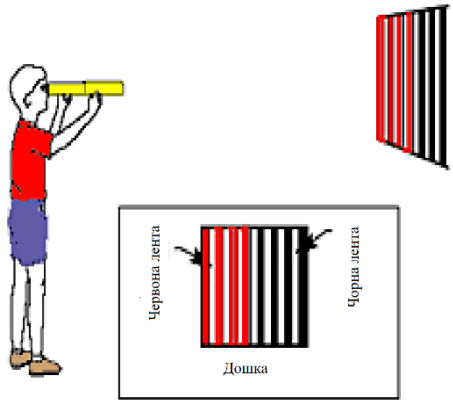


Figure 8. Calibration of a refractor telescope

Use red and black tape to make stripes on a white surface, to use them as a chart, to estimate the magnification of the telescope. Stand at one end of the room and look at the chart with red and white stripes and black and white stripes. Look directly at the chart with one eye and look at the telescope with the other eye. It may be a little difficult at first, but with practice you will realize that you can do it. How big is the image?

4. Conclusions

And now - wait for the night and try to look at the sky! You will discover the amazing world of stars!

Figure 9. Calibration of a refractor telescope

IMPORTANTLY!!! The main rule of observing the sky: never, under any circumstances, point the telescope at the Sun!

5. References

[1] https://www.youtube.com/watch?v=tnbSIbsF4t4

[2] https://www.youtube.com/watch?v=shPwW11MEHg

[3] https://www.youtube.com/watch?v=aICaAEXDJQQ

[4] https://www.youtube.com/watch?v=Ecdsqc

1wFoY

[5] https://www.youtube.com/watch?v=v6ihVeEoUdo

[6] Beiser A. Physics, Menlo Park, California: The Benjamin/Cummings Pub. Co., 1982.

[7] Hecht E, Zajac A. Optics, Reading, Massachusetts: Addison Wesley Publishing Company, 1987.

[8] Pedrotti F, Pedrotti L. Introduction to Optics, Englewood Cliffs, New Jersey: Prentice Hall, Inc., 1993.

[9] Pedrotti F, Pedrotti L. Optics and Vision. New Jersey: Prentice Hall, Inc., 1998.

[10] Serway RA. Principles of Physics. Orlando, Florida: Saunders College Publishing, 1992.

[11] Waldman G. Introduction to Light. Englewood Cliffs, New Jersey: Prentice Hall, Inc., 1983.

[12] Englert BG, Scully MO, Walthes H. The Duality in Matter and Light, Scientific American, 86 (Dec.), 1994.

[13] Weisskopf VF. How Light Interacts with Matter, Lasers and Light, Readings from Scientific American. W. H. Freeman and Company, 14-26, 1969.

[14] Optics and Optical Instruments Catalog. Edmund Scientific, Industrial Optics Division, Barrington, New Jersey.

[15] Melles-Griot Catalog. Melles-Griot Optical Systems, Rochester, New York, and Melles-Griot Photonics Components, Irvine, California

[16] Minakova K, Petrov S, Radoguz S, Tomashevskyi R. Inquiry Based Science Education in National Technical University "Kharkiv Polytechnic Institute" as a Way to Increase the Popularity of Natural and Technical Sciences. Hands-on Science. Advancing Science. Improving Education. Costa MF, Dorrío BV, Fernández-Novell JM (Eds.), 72-74, University of Barcelona, Barcelona, Spain, 2018.

[17] Minakova K, Petrov S, Radoguz S. How "Street Chemistry" and "Street Physics" settled at the National Technical University "Kharkiv Polytechnic Institute". Hands-on Science. Advancing Science. Improving Education. Costa MF, Dorrío BV, Fernández-Novell JM (Eds.), 354, University of Barcelona, Barcelona, Spain, 2018.

[18] Minakova K, Zaitsev R, Chiaverina C. Creating of STEM – Equipment: Transmission Information on Distance Using Laser Beam. Hands-on Science. Innovative Education in Science and Technology. Costa MF, Dorrío BV, Minakova K (Eds.), 84-89, National Technical University "Kharkiv Polytechnic Institute", Ukraine, 2019.

[19] Minakova K, Zaitsev R, Kirichenko M. Creating of STEM – Equipment: MagLev Train. Hands-on Science. Science Education. Discovering and understanding the wonders of Nature. Costa MF, Dorrío BV (Eds.), 104-111, Braga, Portugal, 2020.

[20] Minakova K, Kirichenko M, Zaitsev R, Danylchenko D, Fedorchuk S. Science Tech Weekend School “Welcome to photovoltaic universe!” Hands-on Science. Science Education. Challenges and Opportunities of Distant and Online Teaching and Learning. Costa MF, Dorrío BV (Eds.), 57-65, Braga, Portugal, 2021.

[21] Velyki naukovi ideyi, yaki zminyly Svit: textbook for the series of lessons of the interdisciplinary educational project "Great scientific ideas that changed the world" / Minakova K. O. [at all.] ; Nats. tekhn. un-t "Kharkiv. politekhn. in-t". – Kharkiv : NTU "KhPI", 2022. – 220 p. http://repository.kpi.kharkov.ua/handle/KhPI-Press/56285

Hands-on in the School Pond!

VM Martins[1], MFM Costa[2], MJ Araújo[3], ML Miranda[3]
[1]*AE André Soares in Braga, Portugal;*
[2]*Centro de Física das Universidades do Minho e do Porto, Portugal*
[3]*Casa da Ciência de Braga, Portugal*
chedas74@gmail.com

Abstract. The current sense of climate urgency poses significant challenges to the general population and, as a result, to schools. Environmental Education has a structuring importance in this context, taking into account its curricular transversality, focusing on the promotion of attitudes, values, and skills necessary to respond to the emergency situation revealed by several studies and international communications.

Natural Sciences curriculum guidelines emphasize the importance of science in everyday life, with applications in technology, society, and the environment. Problems/questions can emerge to guide learning when contextualized in real-life and current situations. They contribute significantly to the development of skills such as "reasoning and problem solving," "critical thinking and creative thinking," "scientific, technical, and technological knowledge and literacy" and "well-being, health, and environment" [1].

Active learning methodologies demand that students have direct contact with the phenomena that are to be investigated. Given that active engagement is required for understanding concepts and understanding the world, based on their experiences, it is important to note that verbal interactions alone are insufficient for developing metacognitive processes.

Students can interpret, substantiate, and build their own knowledge by encouraging investigative field/laboratory activities. With this in view, the Centro Ciência Viva de Braga (CCVB), Braga Ciência Viva Center's, developed activity "Pedagogical ponds" and "Creation and monitoring of pedagogical ponds" that has a significant impact on students who are involved and interact with this practical hands-on activity.

Keywords. Pedagogical Ponds, Environmental Education, Hands-on Activity, Natural Sciences.

1. Introduction

The concept of Environmental Education (EE) is relatively new, having been developed in response to a collective and increasingly global awareness of the need for a positive intervention for Nature and Sustainability as established at the UNESCO conferences in Belgrade back in 1975 and Tbilisi in 1977. At school, EE molds students into contributing members of society by instilling social values, attitudes, and knowledge centered on a single, but of utmost importance, concept: environmental conservation. The environment is regarded as a public good, essential to life and sustainability. Environmental education at school values not only environmental protection but also environmental recovery. Articulated actions for planning and promoting sustainable development should be promoted; it is within this framework that the school opens to EE. According to the Benchmark of Education for Sustainability [2], while the environment is a theme present in all curricular areas/disciplines of primary and secondary education programmes, namely Environmental Study, Personal and Social Education, Natural Sciences, Geography, History, Foreign Language, Philosophy, Chemistry, and Biology, its inclusion is not always defined explicitly and integratedly with the social/political and economic aspects involved. This referential emphasizes that in science-related programmes, an approach in which the established relationships between Science, Technology, Society, and Environment constitute the integrating matrix of the program's theme is favoured. This approach to integrated science education aims to leverage the development of essential skills that promote attitudes that recognise the significance of sustainable development.

The essential learning outcomes for the second and third cycles in Portugal are: students are able to characterize some of the existing biodiversity at the local, regional, and national levels, providing examples of relationships between flora and fauna in different habitats; identify invasive species of fauna and flora and their consequences for local biodiversity; and formulate critical opinions

ISBN 978-84-8158-937-5

about human actions that condition biodiversity and the importance of its preservation. Furthermore they should: value protected areas and their role in wildlife protection [3]; systematize trophic chains of aquatic and terrestrial environments prevalent in the school's surrounding region, indicating forms of energy transfer; interpret trophic chains, beginning with various examples of food webs; critically analyze examples of the impacts of human action that condition the food webs, discussing measures to minimize them in ecosystems; discuss causes and consequences of ecosystem change, justifying the importance of the dynamic balance of ecosystems and how their management can contribute to achieving the goals of sustainable development; as well as to discuss options for the conservation of ecosystems and their contribution to human needs [4].

It is also highlighted the articulation of knowledge between other disciplines, such as in Physics-Chemistry, to explain the main conditions on Earth that allowed the development and maintenance of life, or in Geography, to characterize an ecosystem in the area surrounding the school (levels of biological organization, biodiversity) from data collected in the field; relate abiotic factors - light, water, soil, temperature - with their influence. Another requirement is that students be able to interpret the impact of some abiotic factors on ecosystems in general and apply it to examples from the school's surrounding area. Students should also be able to explain different types of biotic relationships and distinguish between intraspecific and interspecific interactions, and interpret information about population dynamics derived from biotic relationships and assess its implications for ecosystems [5].

CCVB pedagogical offer "Biodiversity of the Pond" and the project "Creation and monitoring of educational ponds" have a significant impact on the school environment, providing integrated implementation of field and laboratory activities in the approach to Natural Sciences and Environmental Education. This experimental approach provides an opportunity to develop scientific processes and investigative skills that can be transferred to other areas of knowledge while learning science content.

2. Characterisation of the "Biodiversity of the pond" and the CCVB's "Creating and monitoring educational ponds" project

i. Educational ponds scientific characterisation

Ponds are fragile and unstable ecosystems with high ecological value. They are critical for the survival of endangered animal and plant species, as well as for providing essential ecosystem services to humans, and thus are of great conservation interest. Ponds are permanent or temporary bodies of standing water or water with very low flow that are defined by the Ramsar Convention as areas of marsh, fen, peat, and or water, natural or artificial, permanent or temporary, with standing or flowing water, fresh, brackish, or salt, including marine waters, that do not exceed six meters in depth [6].

Ponds are one of the least known ecosystems, but they are also one of the most interesting and important, given the biodiversity that exists in such a small area. Because these biomes are very sensitive and are seriously threatened worldwide, it is critical to preserve and regenerate them. As a result, the CCVB has developed this educational offer for schools with the goal of raising community awareness of the importance of these ecological sites.

ii. "Pedagogical ponds" pedagogical characterisation

The activity is designed to increase students' understanding and awareness of the importance of preserving wetlands through field activities utilizing active methodologies in the CCVB space. This pedagogical offer is intended for all schools of any educational level that plan to visit the CCVB after making a prior reservation. This activity is approached using an inquiry-based science teaching methodology, identifying problems that stimulate research, debate, exploration, experimentation, observation, conclusion, and communication, all supported by research from an Inquiry Based Science Education (IBSE) perspective. Curiosity is sparked by encouraging students to conduct research and carry out all scientific procedures in an hands-on way. An analysis of the students' preconceived notions about the pond is

performed, and a discussion of ideas is opened to verbalize them.

Figure 1. "Pedagogical pond" of Centro de Ciência Viva of Braga (CCVB)

iii. Creation and monitoring of educational ponds

The development and exploration of an educational pond as a teaching resource in a school setting aims to increase knowledge of biodiversity and the importance of these wetlands in the preservation and regeneration of local biodiversity. These habitats can support more biodiversity than rivers and lakes, as well as more rare and endangered species. It is also an important educational resource because it allows for the promotion of a variety of recreational and scientific activities that connect different disciplines and involve the school environment.

Some considerations must be made when building a pond, such as location, sun exposure, and orientation. The students are encouraged to handle and investigate all of the materials required for the construction of the pond, as well as to comprehend its physical characteristics. The screen used at the pond´s base must be flexible, able to accommodate any variation in the contours or movements of the soil, highly resistant to perforation, have a watertight membrane, and be resistant to ultraviolet rays. Following the screen, a net must be installed to allow the plants, as well as sand and stones, to be fixed. To protect biodiversity, the plants and animals used on the day of the pond's construction must be native species.

The Pedagogical Pond is created and monitored by CCVB biologists and ecologists, with financial support provided to the National Agency (Ciência Viva) at School Science Clubs (CCVnE) through the Human Capital Operational Program (POCH).

During the planning phase, the CCVB team of biologists visits the site to confirm the best conditions for the pond's implementation and to schedule the construction. This scheduling should ideally be coordinated with the Parish Council/Municipality for logistical support, equipment, and materials. Prior to beginning of excavation phase of the pond, all materials should be purchased. The dimensions of the canvas and netting are determined by the location of the pond. A pond should ideally have a surface area of $4m^2$ to $40m^2$, a maximum depth of 1m, and very gently sloping banks.

After digging the pond, a base must be laid to protect the screen, such as a geotextile blanket, cardboard, old blankets, or other material. The entire waterproofing structure (canvas) and the structure supporting the aquatic flora (shade netting) are installed in the next stage of pond construction. Once the entire structure has been stabilized, it is filled with running water, and water, plants, and animals are transported from an existing pond to the new ecosystem after a day. The CCVB biology team, as well as some students, employees, and teachers, are present during this phase to assist and monitor its execution.

Figure 2. Building a functional artificial pond

The pond ecosystem stabilizes after two months, and the phase of monitoring the physical and biological parameters of these spaces begin, as well as training students and teachers, particularly those involved with the CCVnE. Water samples are taken from the pond, and aquatic macroinvertebrates such as

ISBN 978-84-8158-937-5

the water scorpion, water beetles, dragonfly larvae, mosquito larvae, ephemeroptera, cyclops, oligochaetes, ostracoda, and freshwater snails can be observed using binocular loupes.

3. CCVB's network of educational ponds

The Educational Ponds Network was launched in 2018 as part of the CCVnE programme in School Groupings/Ungrouped Schools, Professional Schools, and Private and Cooperative Education Establishments, with financial support provided by the Ciência Viva National Agency through the Human Capital Operational Program (POCH) fund. The CCVnE works in schools to provide open spaces for students to interact with science and technology, as well as to educate and provide generalized access to scientific practises, promoting experimental teaching of sciences and techniques. The CCVnE fosters collaboration between formal and non-formal education systems by forming strong partnerships with scientific and higher education institutions, municipalities, Ciência Viva Centers, R&D (Research and Development) companies, museums, and other cultural institutions.

Ten educational ponds were built or recovered in several schools throughout the region, with the goal of supplementing the activities developed in the curricular context using active methodologies.

Figure 3. Pond of Agrupamento de Escolas de Briteiros

4. Activities at the educational Pond

The implementation of recreational and educational activities based on solid scientific knowledge, as well as the investigation of its biodiversity and ecological processes, are central to the approach of this Environmental Education action.

It is critical for participants to reflect on and raise awareness about the conservation of these habitats (Wetlands), as well as the protection and preservation of local biodiversity.

Figure 4. Brainstorm with students before collecting the water sample for observations

Following a brief brainstorm, students proceed to the CCVB pond in order to collect water samples, which they will later examine and sort in the experimental laboratory. They learn to identify the invertebrates present in the water sample collected using Petri dishes, Pasteur pipettes, and binocular loupes/digital microscope.

Figure 5. Observation and screening for observation with digital microscope

The level of pollution can be classified by identifying the invertebrates present in pond water samples. Some species, such as ephemerals, Daphnia Magna, and dragonflies, act as bioindicators, meaning they are sensitive to pollution in the water. During the practical

ISBN 978-84-8158-937-5

activities, students can take notes and identify the species in the pond by using identification guides or the internet. Water samples collected for laboratory analysis must always be handled with care and returned to the pond in the end.

Figure 6. Recognize the invertebrates with binocular magnifying lens (Ephemeroptera)

5. Conclusion

The activities developed within the "Learning Ponds" activities significantly improve theoretical content understanding and phenomenon explanation, as well as laboratory and field technique mastery. Learning becomes a metacognitive experience, according to Sá [7], when students are encouraged to develop a clear intentionality in their actions, becoming reflective in the planning, execution, and evaluation of activities. According to Piaget [8], children develop their way of thinking through interaction with the world around them. As a result, the use of active methodologies throughout the process adds meaning to the concepts addressed while also providing a clear representation of them. These processes are intended to improve learning quality and suggest a critical viewpoint by leveraging children's acquisition of certain scientific concepts.

According to Knoll [9], project involvement is a method for students to: i) develop independence and responsibility, and ii) practice social and democratic modes of behavior. The construction and monitoring of pedagogical ponds is based on active learning, in which students learn to connect theory to practice, and in which the student is the primary focus of the entire teaching-learning process. It achieves this by actively engaging students in the acquisition of knowledge, elevating the student to the role of protagonist in the learning process, and stimulating the search for knowledge through a hands-on approach.

The learning methodologies are strategically focused on engaging students in doing and thinking about activities, thereby involving them in their own learning. This type of project participation allows for the development of new skills such as teamwork, critical thinking, creativity, problem solving, communication, and project management [10].

Wetlands are disappearing dramatically. The loss or degradation of these ecosystems as a result of urbanisation, drainage, and intensive farming is linked to a significant decline in wildlife.

There is much we can do in our own schools, gardens, and communities to aid in the restoration and preservation of the ecosystem. Even a small pond can be an important ecological hotspot for biodiversity, attracting damselflies and dragonflies, as well as frogs and newts. It could also serve as a food source for birds, hedgehogs, and bats. One of the objectives of this lesson plan was to comprehend the significance of invertebrates such as water fleas, Daphnia magna, as bioindicators of invisible pollution and pond health. This crustacean is intolerant to pollution and toxicity and their presence means that the water pond is healthy and unpolluted. The students learned how to handle binocular magnifying glasses, and recognize some invertebrates such as Daphnia magna, dragonflies, aquatic beetles, aquatic snails, etc. It’s important to conclude that diversity is equal to healthy ponds and healthy aquatic systems.

A pond doesn't need to be big. Even a small pond can host more species than rivers and lakes. We can build a pond in home gardens and contribute to the increase of biodiversity and wetlands. It is also important to create pond networks between schools in the local area, between the community and to share their experiences using social media and digital tools. A pond is an excellent pedagogical resource to teach children and adults how a natural ecosystem works.

6. Acknowledgments

This work was supported by the Portuguese Foundation for Science and Technology (FCT)

in the framework of the Strategic Funding UIDB/04650/2020.

7. References

[1] Martins, O. *et Al*. Perfil dos Alunos à Saída da Escolaridade Obrigatória. Lisboa: Ministério da Educação. Direção-Geral da Educação, 2017.

[2] Câmara, A. *et A*l. Referencial de Educação Ambiental para a Sustentabilidade para a Educação Pré-Escolar, o Ensino Básico e o Ensino Secundário. Lisboa: Ministério da Educação, 2018.

[3] https://www.dge.mec.pt/sites/default/files/Curriculo/Aprendizagens_Essenciais/2_ciclo/5_ciencias_naturais.pdf

[4] https://www.dge.mec.pt/sites/default/files/Curriculo/Aprendizagens_Essenciais/3_ciclo/ciencias_naturais_3c_8a_ff.pdf

[5] https://www.dge.mec.pt/sites/default/files/Curriculo/Aprendizagens_Essenciais/3_ciclo/fisico-quimica_3c_8a_ff.pdf

[6] UN. Treaties and international agreements registered or filed and recorded with the Secretariat of the United Nations - Volume 996. New York: United Nations, 1983.

[7] Sá J, Varela P. Das Ciências Experimentais à Literacia. Uma Proposta Didáctica para o 1º Ciclo. Porto: Porto Editora, 2007.

[8] Piaget J. The Principles of Genetic Epistemology. New York: Basic Books, 1972.

[9] Knoll M. The project method: Its vocational education origin and international development. Journal of Industrial Teacher Education, 34. 59-80, 1997.

[10] Graaff, E, Kolmos, A. Management of Change: Implementation of Problem-Based and Project-Based Learning in Engineering. Roterdam: Sense Publishers, 2007.

ISBN 978-84-8158-937-5

De-Mystifying Science

D Balmer
SATRO and CASTME Education Adviser, UK
denise.balmer1@ntlworld.com

Abstract. Science is all too often seen as of little importance as it is the preserve of 'clever people'. Occasionally something like the recent Covid -19 pandemic raises awareness of the way scientists work and the necessity of us all to be involved. The author suggests that science needs to be 'demystified' and seen as something everyday, everywhere and vital to our existence as a species. The paper suggests how this can be done through extending ideas from childhood throughout education and awakening awareness of our surroundings for the benefit of all.

Keywords. Science, Relevant, Raising Awareness, Positive Image of Science, Informative.

1. Introduction

My lifelong mission has been to try to make 'science' acceptable to everyone – which I suppose is possibly the aim of most science teachers. There is currently a mystique about science amongst older children and adults which we need to dispense with so that we can look at science with open eyes or perhaps with the eyes of young children. To infants and toddlers everything is new and fascinating and perhaps we adults should look at things in this light. We should ask ourselves the same questions children ask, 'how' 'what' 'why'? Then perhaps we too can begin to understand our everyday environment, which is basic science.

2. Public attitudes to science

The public attitude to science is surveyed every few years in England and science was seen by the general public and 16-24 year old students in 2014 as being physics, chemistry and biology [1]. A later survey in 2016 [2] by the same association suggested adults recognised that understanding science was important and would 'provide jobs in the future'. However, most adults felt they gained their scientific knowledge through the media and suggested themes such as climate change and vaccinations as being topical. The latest survey in 2020 [3] showed a more positive attitude towards changes being made by science and technology but found that 16-24yr olds were somewhat negative about careers in science and engineering. This survey found that most scientific information was now gained online or through Facebook and Twitter….. possibly not the most reliable of sources.

When I asked primary science teachers were what they understood was science, 25% thought it to be solely physics, chemistry and biology [4] so it is hardly surprising that some children feel distanced from the subject at an early age. These teachers also had little recollection of learning science in primary school. Hopefully the benefit of different curricula now enables children to feel more favourable towards science. Secondary school science did not fare much better in these teachers' estimation, either, as it was generally deemed to be facts to be learnt for examinations then forgotten.

Joan Solomons survey in 2013 [5] about a town she called Market Place, identified the feelings of the general public living in a small town about science. She found that basically many people did not feel they understood what science was all about. An article [6] (as yet unpublished) in Spain suggests that most people gain their science information through the media – which is not always particularly accurate. The authors suggest that by writing a daily page linking current news with accurate science information, people are likely to absorb more science with understanding.

3. So what is science?

Initially it is probably necessary to define what we mean by 'science'. Dictionaries define science as 'knowledge ascertained by observation or experiment'. This seems a fairly straight forward definition – we all gain knowledge right from our earliest days through observation and experimentation. So why then does the word 'science' fill so may adults with dread: so much so that they instinctively shut out all thoughts? Science is everything and everywhere so everything is science, we can't get away from it! But there still persists this image of a scientist in a white laboratory coat, even today in primary school! Someone once quoted the whole of the periodic table to me –

ISBN 978-84-8158-937-5

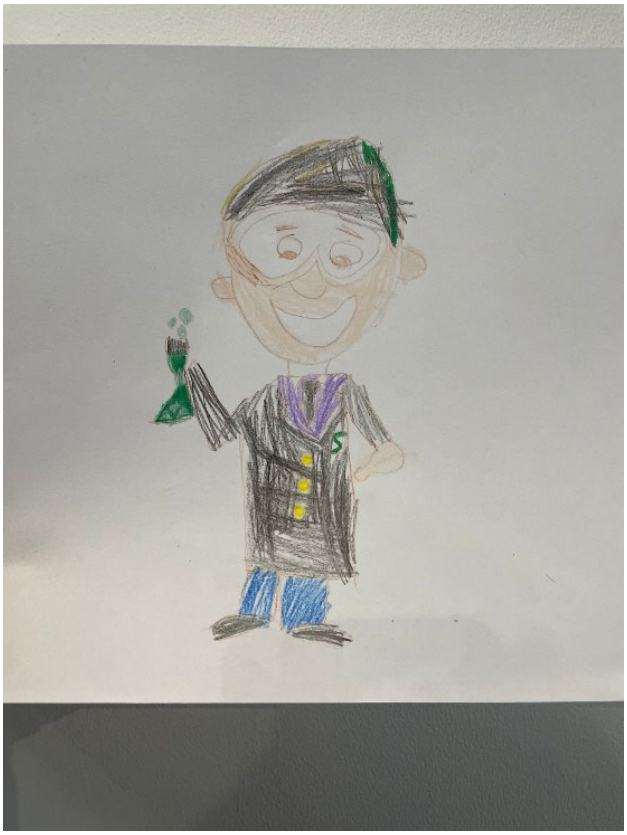
no problem, but when asked what it all meant, they had no idea, and went as far as to say that it never helped them except to pass the relevant examination. Surely this can't be acceptable? If we are going to teach a subject called science then it needs to be relevant, practical and useful, not facts which may never be recalled after an examination. We currently make this artificial division in science in our school programmes which is not helpful as all branches of science work together and are intrinsically linked.

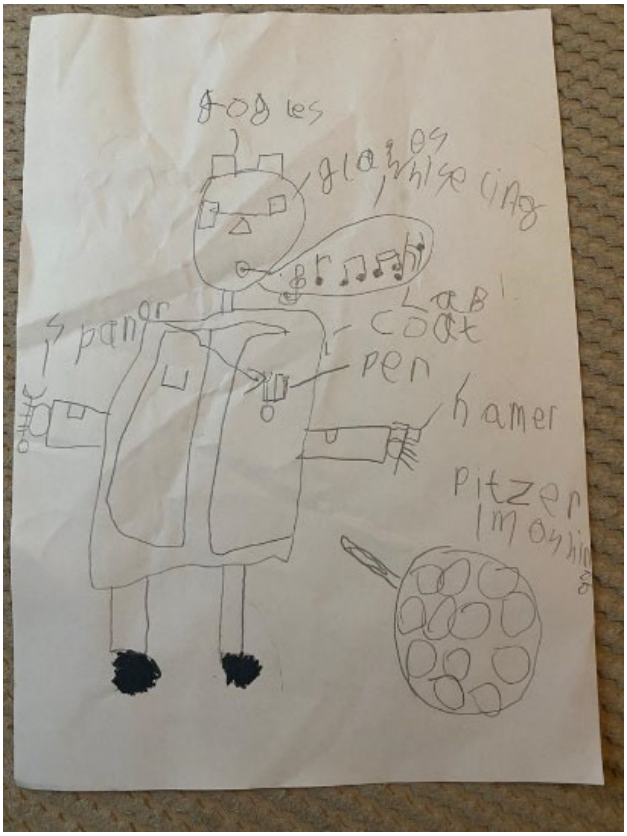
The world is full of natural scientists: farmers who know how and when to plant crops and how to look after animals; fisherman who know where to find fish and which days to go out in their boats because of the weather; sailors who could navigate without specialised equipment; people who understand how things work merely because they have used them and adapted them to suit their own use; Indigenous peoples who understand the use of plant and herb medicinal properties and know how to care for the soil; mathematicians who for centuries have calculated the movements of the planets and stars. These people have knowledge and experience handed down over generations which has been put to practical use. Surely this is what science should be for most people – understanding and putting to good use relevant practical applications of everyday science.

4. Recent children's ideas about scientists

Children have very specific views about scientists which stay with them all their lives. They must get their ideas from adults, teachers, or the media. In the past, when I asked children n primary school of almost any age to draw me a scientist, the picture would be a male in a white coat, usually with spectacles. I wondered how or if that perception had changed recently, so asked my great grandchildren and two other local children how they viewed scientists. Here are their responses

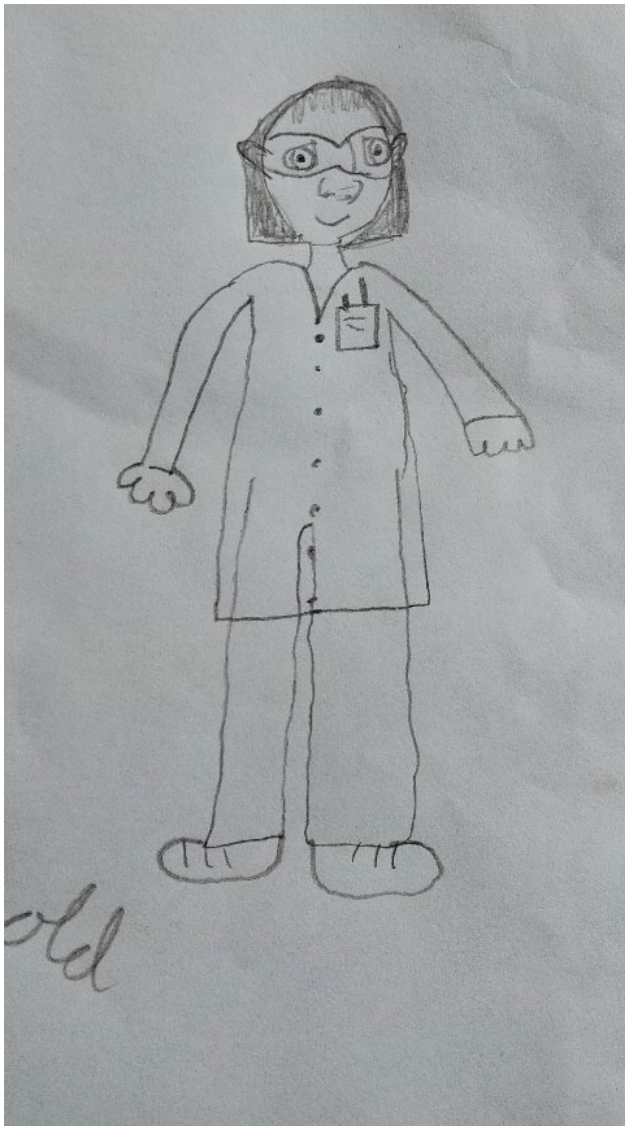
My great grandchildren had some interesting ideas about scientists. Pippa aged 5 says 'scientist are clever and make potions'. Her picture depicts a scientist in a black coat… Interestingly He is called Jessie… (we have no idea why! Albie aged 7 described his scientist: he wears goggles, holds a spanner, is whistling, wears a lab coat, he has a pen and a hammer and a pizza machine!! (most confusing to me, a cross between an engineer and a scientist perhaps?)





ISBN 978-84-8158-937-5

Albie said ‘a scientist invents things, they discover new things like rubber for a bouncy ball. They have experiments like two glasses, one is like a cave, upside down and one is a triangle with a line coming out of the top. They use pipettes to put small amounts of liquid from a beaker on a round disc and look at it under a microscope’.(his words).(I have given Albie various boxes of science experiments since Christmas, and more recently a book on kitchen science which he has been quite intrigued with and has done a lot of the experiments.)



The two other children who live nearby offered the following:

Jack aged 10 said that ‘they (scientists) wore a coat and glasses, and they are smart, They are helpful! (he declined to draw a picture for me although his crossed out picture shows a man with spectacles!)

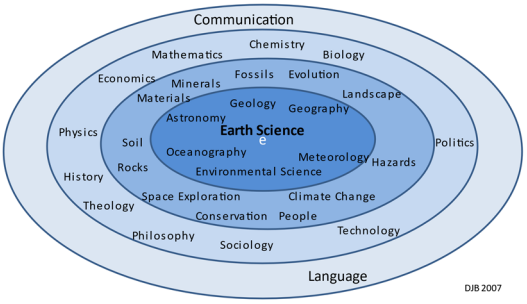
Yvie’s picture shows a lady scientist (hurrah!) once again she has spectacles and has a jacket and trousers! She rather looks like a doctor which is not surprising as Yvie has spent time in hospital. ‘Her coat is white with stain splotches on it‘ Yvie said.

It seems that the lab coat and spectacles are still part of the image these children have of scientists – and they all live in different areas, miles apart. Incidentally, I am not seen as a scientist by any of these children!! even though they know I work with rocks and fossils.

5. So why do people cringe at the word science?

I suggest that much adult apprehension towards the word is because of their connotations with the subject taught at school. We currently make this artificial division in science in our school programmes of physics, chemistry and biology which is not helpful as all branches of science work together and are intrinsically linked as Earth Science which I hardly ever mentioned.

The Importance of Earth Science



Even in primary school there is a subject called ‘science’, again subdivided. The frequent perception is that science is only what happens in that lesson and that science is a ‘difficult’ subject, only for ‘clever’ students. Indeed, in many schools, the three so called science subjects are off syllabus for children over the age of fourteen who are deemed ’not able to cope’, and a watered down ‘general science’ subject is taught. Even in Victorian times boys in England were taught engineering science whilst girls learnt domestic science!

In the past much English secondary school science seems to have been riddled with facts, with the exception of a few enlightened curricula - a major example being the SATIS

ISBN 978-84-8158-937-5

programme.[7]. This project, developed in the 1980s aimed to link science, society and technology. Ten books with 120 units were produced many focusing on everyday topics from vaccinations to electric cars. Looking at these now, the titles were very forward looking and it is sad that these units are not in use at present.

The latest science curriculum in the United States, although not used by all the States, is termed Next Generation Science and links Earth Science with engineering and human activity [8]. Students are expected to be able to analyse and interpret data on natural hazards for example, and be able to communicate their ideas with their peers. The curriculum is very practical and includes many problem solving exercises and opportunities for discussion of children's ideas. It was introduced after the USA Centre for Earth and Space Science education report suggested that the public were mostly unaware of the links between earth science and everyday happenings particularly hazards [9].

6. Science and society

Surely in this age of enlightenment we should all be able to see science for what it is – the knowledge of everything that is round about us, knowledge we gain through living. In the early 2000s some universities offered Science and Society courses and there was also a school programme called science and society. However, these seem to have disappeared and the only ones I could access were all from the United States. This curriculum offered everyday links for students to investigate about science and its effects in their communities but unfortunately has disappeared here without trace.

It seems to me that we are not currently making much progress in making science acceptable despite professing to teach science to all age groups in our schools. Perhaps this is where we are going wrong. Should we be *teaching* science? I am not sure that we need to *teach* science, we need to allow children to absorb what is going on round about them and encourage questioning at the earliest of ages. We should encourage play which most frequently is in the form of 'investigating 'and finding out. Young children love playing in puddles, splashing and getting water spread around. They will get wet and discover that water is wet. They will recognise rain as water and question its origins. They will want to know why puddles disappear and so on. Life is just full of questions at an early age, most of which are 'science'.

7. Why is science important to understand NOW?

Firstly the idea of the Nature of Science needs to be considered [10]. Whilst we can identify what we mean by the word science, we rarely think about understanding the nature, processes and methods used in science. The English primary science curriculum specifies that science be taught through the Nature of science, in other words observation, recording, testing, analysing, communicating with others and coming up with creative solutions to problems. This is what science *should* be but rarely is as time factors most often prohibit the practical aspects and the lesson becomes more factual.

Recently science topics have been in the news probably more than ever before. The COVID pandemic showed us the Nature of Science in an everyday world – how a problem is tackled on a universal scale by international scientists. Initially, scientists recorded data about the infection and how it spread. Teams of scientists then set about finding a vaccination which could contain some of the infection - by working together, communicating and sharing data and ideas and eventually coming up with a number of solutions. These solutions needed testing, results ratified and changes made to their solutions. This process was repeated over and over until an answer was found which seemed to work. Companies then worked together, ideas were shared, and several different approaches were used to come up with the radical vaccinations which are helping to control the infection.

Another major area where scientists are collaborating is in the production of energy in formats which are producing fewer greenhouse gas emissions. Examples are the production of so-called renewable energies using natural resources: wind and sun although currently tidal and wave power are not so highly valued or developed. Geothermal energy has long been utilised in areas with suitable volcanic heated water, but new ways of heating

buildings using heat pumps utilising ground heat energy from the sun are being developed. New kinds of batteries are being advanced using hydrogen and batteries that can store electricity for longer are being developed.

8. The current major science issue – climate change

Science observations covering the period since the Industrial Revolution shows that humans are increasingly adding carbon dioxide and other so called greenhouse gases into the atmosphere. Initially scares about the decreasing nature of our protective ozone layer sparked off many investigations into the use of aerosols and so-called CFCs. Our ozone layer protects the earth surface from the harmful sun's rays which cause cancers, and holes in this layer were initially detected over the Antarctic, then in other parts of the world. Fortunately it seems that we have been able to repair these so called 'holes' which are now decreasing in size by restricting the use of CFC chemicals.

Changes in our atmosphere with increasing amounts of greenhouse gases are not so easy to reverse however, and our behaviour seems to be increasing the planet's temperature. These issues surrounding climate change are another subject under great discussion by scientists – is this change anthropogenic? Are we really in another geological era [11] contrived by humans – the Anthropocene? What does Anthropocene really mean? The word refers to the time when human activities began to have a notable impact upon our planet in terms of its ecosystems and climate. Are we really abusing our planet by adding toxic gases to its atmosphere, destroying our forests and degrading our soils? We should all be aware of the real damage we are causing – and this, of course, is science.

9. How can we improve the image of science and appeal to the population at large?

Television documentaries are often scientifically biased these days. Many like the David Attenborough films are about our planet, its wildlife and their changing habitats. These are accessible for all ages and easily understood. Others are often more complex and rather more difficult to follow, like some of the Professor Brian Cox programmes about stars and galaxies and astrophysics. Programmes which capture current happenings in our environment like the British Winter, Spring or Autumn watch are extremely interactive and have a great following, though I am not sure that these are seen as being 'science'. Citizen science projects which involve anyone and everyone collecting data on a massive scale have proved very popular and rewarding. Our British garden bird watch survey also gains a great deal of support and provides valuable information about our garden birds.

10. Conclusion

Surely we are sophisticated enough as a population to realise that science is not just a word but a philosophy that embraces all of us. Science is for evervone and as such those of us who understand and teach it must ensure that it is acceptable to all whatever age. Teaching science is more complex than most other subjects because of its social, moral and ethical implications, its links to cultural and traditional beliefs and the inherent ideas brought to it by young children. We need to relate to their understanding before providing enabling experiences to help them make sense of our world. Perhaps we should all look at things and ask ourselves how this will affect that; what chain of events will occur if X happens; and why ? Then perhaps science concepts will begin to make sense. *Science should be fun, but also informative, and useful.* It is now more than ever really important that we understand the complex links between what we as humans do and how our actions affect our planet.

11. References and Notes

[1] Public Attitudes to Science Survey, British Association, 2014.

[2] Public Attitudes to Science Survey, British Association, 2016.

[3] 2020 Public attitudes to science British Association survey on line at https://assets.publishing.service.gov.uk › uploads › file

[4] Balmer D J. The potential of Earth Science for the development of primary school science. PhD Thesis 2019. UCL Library 2019.

[5] Solomons J. Science of the People. Routledge. London. 2013.

[6] Fonseca X et al .A physical concept in the press: the case of the Jet Stream (Research article in Press)

[7] https://www.stem.org.uk/resources/collection/2899/satis

[8] Next Generation Science Standards 2013. The NSTA quick reference guide to NGSS elementary school. Willard T(Ed.) NSTA Press. Arlington, 2013.

[9] Hoffman M, Barlow D. TERC report: Revolutionising Earth Science for the 21st century: Report and recommendations from a 50-state analysis of earth science education standards. Cambridge M.A. 2007

[10] https://www.nsta.org › nstas-official-positions › nature-s.

[11] The Anthropocene is a modern epoch. It refers to the period of time from which humans and our societies began to have notable impact on the Earth, in terms of its natural ecosystems and climate. The term was coined in the year 2000, by scientists E. Stormer and P. Crutzen.

ISBN 978-84-8158-937-5

Creating Blogs about Chemistry and Covid-19

C Sotério, SL Queiroz
University of São Paulo, São Carlos, Brazil
salete@iqsc.usp.br

Abstract. The Covid-19 pandemic highlighted the need to train scientists for the public communication of science and technology (PCST). Aiming at contributing to such practices, this work reports a didactic experience in which undergraduate chemistry students, in the role of science journalists, used the "Google Sites" platform to create science blogs for communicating the topic of sanitizers against Covid-19; and analyzes the content of these media from the perspective of an Analytical Framework. In total, 31 blogs were created, valorizing language features, visual, textual and digital resources.

Keywords. Blogs, Chemistry, Covid-19, Education, Google Sites.

1. Introduction

The Covid-19 pandemic has not only been a health crisis, but has also triggered several other problems, among which are an infodemic: a volume of information, not necessarily accurate, which is massively disseminated, mainly through social networks, during an epidemic event [1]. To combat the effects of this crisis, several scientists approached popular media in an unprecedented way to dialogue about science and technology. However, training these professionals for this purpose is still incipient.

Indeed, public communication of science and technology (PCST), when inserted in the context of higher education in natural sciences, has favored the development of communication, information literacy and mastery of media and technologies, as desirable for science education during the 21st century [2,3]. In Brazil, the curricular guidelines of undergraduate chemistry courses have valued generalist training, that is, one that promotes both technical and humanistic skills [4].

Given this context, science blogs have emerged as potential tools to fight the current infodemic and foster the aforementioned skills, as they promote the communication of scientific topics with non-specialist audiences in the digital environment [5]. Furthermore, these tools are part of a "media activist" phenomenon, in which a political exercise is endorsed through technological tools [6].

Therefore, this work aims to (i) report a didactic experience in which the students of a bachelor's degree in Chemistry at the University of São Paulo, in the role of science journalists, created science blogs on the topic of sanitizers against Covid-19; and to (ii) analyze the content of these websites from the perspective of an Analytical Framework already consolidated in the literature, described below.

1.1. Science Blogs Analytical Framework for PCST

Table 1 illustrates an adaptation of the Analytical Framework of Popular Science Texts (PST) [7] for the study of Science blogs.

Table 1. Science Blogs Analytical Framework

Science Blogs for PCST		
Content		
General Analysis		
Chemistry	Frontiers	Transversals
Specific Analysis		
Thematic	Characteristics of Scientific Activity	Approaches and Context
Format		
Language		
Verbal and Non-verbal		
Structure		
Layout and Tabs		
Visual, Textual and Digital Resources		
Hyperlink/ QR code	Multimediality	Multimodality

According to the Analytical Framework in Table 1, a Science blog for PCST can be analyzed according to its content and form. The general perspective of the content concerns the theme of the media, which can relate to the

ISBN 978-84-8158-937-5

topics covered throughout the formal teaching of Chemistry, such as kinetics; frontiers themes, that is, subjects that dialogue with Chemistry, such as Biology; and transversal, whose topics cross several subjects, as happens with nanotechnology.

Specifically, the content of a science blog can be analyzed from the perspective of its thematic, that is, its focus; the characteristics of scientific activity, such as raising hypotheses, data analysis, teamwork, etc; and approaches and context, which can cover social, political, environmental and other aspects.

Regarding the format of science blogs, the first subcategory, i.e., languages, allows the analysis of the use of language features when disseminating information. The structure and visual, textual and digital resources subcategories, in turn, are the ones that most differ from the original proposal in [7], regarding the study of PST, to allow the analysis of the particularities of a blog. The structure concerns the layout and navigation tabs of the website, which define the aesthetics and usability. On the other hand, visual, textual and digital resources promote interactivity, multimediality and multimodality by inserting hyperlinks, capital letters, images and integration with other media [9-10].

2. Research Context

This activity was developed in the context of the "Communication and Expression in Scientific Language I" course (2 credits/class), comprising the study of scientific documents and resources from the "Google for Education" platform, mandatory and offered remotely via Google Meet to freshmen of the bachelor's degree in Chemistry at the São Carlos Institute of Chemistry at the University of São Paulo. In all, 31 students (41.9% female and 58.1% male) created blogs on the topic of sanitizing products against Covid-19 which contained a main post on the topic (PST), which is the focus of this study analysis.

3. Activity Stages

Science blogs on sanitizing products and Covid-19 were created throughout the course in three stages (Figure 1).

Initially, the teacher explained the dynamics of the activity in class, which would be to create science blogs on the topic of Covid-19 and Chemistry for PCST using the "Google Sites" tool.

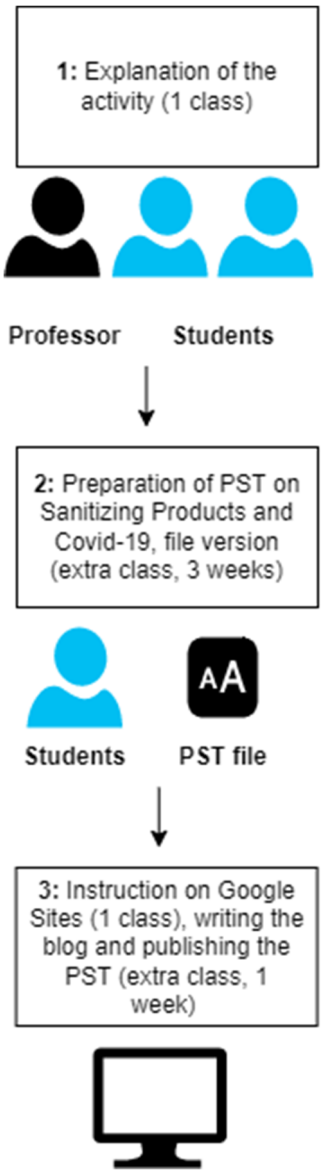


Figure 1. Preparation stages of science Blogs on sanitizing products and Covid-19. PST = Popular Science Texts

Afterwards, the students had a period of three weeks to prepare an extra-class PST as a word file, thus comprising the main post of the blog. 31 texts were prepared on the subject of sanitizing products.

In the final class of the activity, students received instruction on how to use the Google Sites platform in class. Finally, they created the blog outside school hours, in which the PST post would be made and should have the following elements: PST post on the blog online and as a pdf file for download, information

about the author, website scope and contact information; use of visual resources, and publication of the website on the Internet.

4. Methodology

The study methodology used in this work was Content Analysis [8], described in Table 2.

Table 2. Science Blogs Content Analysis Steps

Steps	Application
1. Preparing Information	Identification of blogs created by students on the topic of sanitizing products and Covid-19
2. Unitarization	Blogs as a context unit and its resources as an analysis unit
3. Categorization	Based on the PST Analytical Framework, adapted for the study of science blogs for PCST
4. Description	From the categories of the Analytical Framework
5. Interpretation	Comparison of the results found with the current literature

As exemplified in Table 2, the first step of the methodology, called preparing information, is related to the identification of the analysis material. In this study, this phase was based on the selection of blogs created by students through the Google Sites platform on the topic of sanitizing products and Covid-19.

The second one, related to unitarization, is based on defining context and analysis units, which are blogs and their resources, respectively.

The third one, which is the categorization of the analysis material, is based on developing categories, which can emerge from the analyzed material or considered in advance. In this study, the categorization emerged from the topics of the Analytical Framework (Figure 1), that is, from the literature.

The fourth one, concerning the description of the categories, referred to the synthesis and detailing of the analyzed content, explained in topic 1.1 “Science Blogs Analytical Framework for PCST” of this work.

Finally, the fifth and last step entails interpreting the categories, which, in this study, was done by comparing the results with the literature, as explained in the following topic.

5. Results and Discussion

Figure 2 illustrates one of the blogs produced by students.

Figure 2. Blog “Chemistry for Everyone”

As observed, the blogs had navigation tabs on the website, capable of directing the Internet user to different web pages. The content published in these tabs covered the PST as the main post, information about the student, blog scope and contact.

Regarding the General Analysis of the content, we identified 100% of Chemistry content in the blogs as they addressed the specific topic of sanitizing products; as well of transversal content, as they are compatible with the subject of the Covid-19 pandemic, which crosses different areas of knowledge. The presence of both contents is expected as PCST is often linked to the social aspects of science [11].

Specifically, the blogs focused on the topic of sanitizing products against Covid-19. The scientific character of the productions took place in different ways, both in the PST posts and in the information available on the website.

As an example, the blog in Figure 2 has the following words: “We are a group of scientists willing to work on the frontline, being responsible for public communication of science and technology, thus pacifying and bringing together the community and science, so that the two societies (civil and scientific) are always working together”. In fact, the students,

who are the content creators, created a specific tab of the blog to discuss their profiles inserting their curricula, in order to show Internet users that they had scientific training and that the PCST exercise, in this sense, was also part of one of their training assignments. The literature points out the need for more researchers to do activities of this nature as they are the main agents of knowledge production and can, thus, return the public funding granted to society [12, 13].

Regarding the blog publications, different resources were found that refer to scientific praxis: mention of scientific publications, research groups, data analysis, interpretation of results, description of methodologies, applications etc. - the latter in a prominent position as it served to correlate the chemical sciences with the production and study of sanitizing products.

Regarding the format, the language used in the media and its relationship with the scope of the respective blogs were analyzed. There was a great concern of students in contextualizing information using language features, such as comparisons and analogies. There was also a great effort to conceptualize scientific terms to soften more technical expressions, as occurred in "hydroxychloroquine is an immunomodulatory drug, that is, it promotes an increase in the immune system response". It is believed that this result was due to the students' familiarity with the sanitizing products, as they are present in everyday life, and this subject has been overexploited by the media during the Covid-19 pandemic. There were few posts that showed specific difficulties in the use of jargon, but it is a common challenge for people with science backgrounds [11].

Regarding the structure of the blogs, they all made use of navigation tabs and templates similar to the one illustrated in Figure 2, with the difference only in their vertical or horizontal arrangement. Moreover, cover images were used on the homepage of the sites, as well as image icons next to the respective titles. Regarding the arrangement of the texts, there was a variation of publication in one or more columns, with a division by topics, and adequate visualization of the blogs both via web and mobile. In fact, the layout has a great aesthetic appeal, corroborating the call to internet users' attention in PCST initiatives [7,14].

Visual, textual and digital resources were linked to interactivity, multimedia and multimodality favored by the web. Thus, blogs stood out as they mixing written language with visual resources (favored, for example, by the variety of fonts, colors and images), allowing Internet users to navigate through and beyond the content (by clicking on hyperlinks) and integrate with other platforms, such as google email and maps. Again, these resources indicate the potential of social media and web platforms to promote PCST to make the user an essential part of the experience [9,10].

6. Final Considerations

The didactic experience reported here allowed students of the bachelor's degree in Chemistry to practice the PCST, sometimes suppressed during the training in the natural sciences. The blogs, developed as products of this activity, illustrated the ability of the students in producing materials suitable for different niches of the non-specialist audience and with a great wealth of resources to capture the attention of the Internet user and promote an interactive experience. It is also believed that the familiarity of the students with the chosen subject, on sanitizers to fight the Covid-19 pandemic, has favored the achievement of the aforementioned results. We hope that this work can contribute to future initiatives of this nature.

7. Acknowledgements

We would like to thank the São Paulo Research Foundation (FAPESP), grant 2020/03233-0; and the National Council for Scientific and Technological Development (CNPq), grant 304974/2020-0.

8. References

[1] An ad hoc WHO technical consultation managing the COVID-19 infodemic: call for action. Geneva: World Health Organization, 2020.

[2] McMillan V, Huerta D. Eye on Audience: adaptive strategies for teaching writing. J. Coll. Sci. Teach., 32, 241-245, 2003.

[3] https://www.nsta.org/nstas-official-positions/quality-science-education-and-

21st-century-skills

[4] Zucco C, Pessine FBT, Andrade JB. Curricular directions for undergraduate Chemistry courses. Quim. Nova, 22, 454-461, 1999.

[5] Luzón MJ. Public Communication of Science in Blogs: Recontextualizing Scientific Discourse for a Diversified Audience. Written Communication, 30, 428-457, 2013.

[6] Câmara MT, Braighi AA. Midiativismo científico contra a Covid-19: Uma reflexão a partir da análise de blogs de ciência da Unicamp. Linguasagem, 146-175, 2021.

[7] Ferreira LNA, Queiroz SL. Ciência Hoje articles as a didactic tool in Chemistry teaching. Quim. Nova, 34, 354-360, 2011.

[8] Moraes R. Análise de Conteúdo. Revista Educação, 22, 1999.

[9] Deuze M. The Web and its Journalisms: Considering the Consequences of Different Types of Newsmedia Online. New Media & Society, 5, 203-230, 2003.

[10] Bardoel J, Deuze M. 'Network journalism': converging competences of old and new media professionals. Australian Journalism Review, 23, 91-103, 2001.

[11] Bueno WC. Comunicação científica e divulgação científica: aproximações e rupturas conceituais. Informação & Informação, 15, 1-12, 2010.

[12] Sagan C. Why we need to understand science. Skeptical Inquirer, 14, 263-269, 1990.

[13] Moreira IC. Como caminha o financiamento à ciência no Brasil: o que nos espera em 2018? Ciência e Cultura, 70, 4–5, 2018.

[14] Vieira CL. Pequeno manual de divulgação científica: um resumo. In: Dickson D, Keating B, Massarani L (Eds.). Guia de Divulgação Científica. Rio de Janeiro: SciDev.Net. Brasília, DF: Secretaria de Ciência e Tecnologia para a Inclusão Social, 2004.

ISBN 978-84-8158-937-5

Hands on Science Learning Starts in Play in the Earliest Years

SD Tunnicliffe
University College London, UK
s.tunnicliffe@@ucl.ac.uk

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 [1]. 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 chosen activity which is Hands-on, hence science, STEM, understanding begins from earliest days and is Minds- On. STEM experiences 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.. Apprenticeship, Early Years, Play, STEM, Progression, Tools.

1. Introduction

UNESCO [1] defines early childhood, years as those between birth to eight years of age. Medical experts researching early years and maternal- child bonding and subsequent development and hence benefit consider the first 10 or 1 days, which are of life, from conception to 2 years as the most critical time for the developing brain at this pivotal stage in a child's life they are shaped and influenced by the environment and people around them but most importantly their mother. The child is shaped and influenced by the environment and people around them but most importantly their mother [2]. These earliest years leading in many countries to pre-school are a distinct phase if a child's early learning, at home and in communities, which continues as 'informal' learning throughout their learning lives.

Early years Science learning is in reality STEM (Science, Technology, Engineering and Maths) in action in play. Learning does not occur in a linear manner but in a constructive developmental manner, sometimes referred to as the spiral curriculum and builds upon what came before, knowledge being developed increasingly in more depth The starting point for science and the other STEM subjects, creativity and critical thinking, is observation which recognised as the starting point of science [3] and also a basis of the beginning of mathematical understanding. Play begins from birth and is instinctive [4].

The umbrella use of 'science' in reality in early years refers to STEM. This acronym 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 [5]. Play in these early critical learning years, before formal school instruction begins, is a crucial stage in a child's learning journey. Play in children is not recreational as many adults regard such, because their recreational activities are a change from their everyday essential work. Play should not be ignored nor dismissed by STEM educators as trivial and as 'Just playing'. Early years Science is in reality STEM (Science, Technology, Engineering and Maths) in action in play.

2. What are The Early Years?

The early years, 0 to 8 years, has two distinct organisational stages, that of home and community and that of formal school. Early science embraces fundamental maths and engineering concepts, learners make sense of their environment. It is this sense which. unaware of the subject boundaries created by adults in academia., enables them to develop a holistic view of phenomena with which they interact Whilst adults are frequently bound in their thinking of Children's play by these very distinctions of discrete subjects. Such divisions well be met one in formal learning science education.

The first stage is that of pre-formal school. This stage is where children learn through play, observing, investigating and making sense for themselves of their surroundings in their communities. The culture in which the child lives is a contributor to the child's understanding and much play, especially games has its origin in particular legacy activities of the communities. These hands-on investigators develop their own theories explaining the phenomena from their understanding. Such are the 'voice' of the young learner. These personal constructs are

ISBN 978-84-8158-937-5

important for practitioners and school science teachers to recognise. However, such ideas do not match with the accepted theory taught in formal education and became known as alternate conceptions, first really discussed by Driver [6]. But such are not misunderstandings from the young child's view, they are 'my science', their interpretation of what they see and experience interpretated from their existing knowledge

The second stage of Early Years learning is delivered in formal school of formal school where teaching and hence the child's learning opportunities are guided by curricula mandated by governments in most cases. The distinct years inclusive of this stage vary from country to country, from birth to the statutory age. The second phase is that of formal school and formal pre-school areas embraced by the term "Early Years" but with very different emphasis and age range a and starting age of formal school. Where formal school begins at 7 years of age the preceding year is often designated kindergarten

3. The critical Importance of play

Humans are not the only species who play as they develop to adulthood. Play is observed in a few species and varies in form [7]. Smith [8] provides a comprehensive account of play in other animals and in humans. However, the youngest animals of species, including humans, have to learn to be one of their kind. How various animal species achieve this is a timely perspective before considering the role of human play in children [9-10] provide examples of societies providing children with miniature hunting weapons. In our Western societies, children play particularly in play groups with miniature replicas of everyday items in their lives and pretend through recreation for example making a meal using small plates, cups, imitation foods like pizza slices, miniatures of adult items used in meal preparation.

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 illustrating 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 [11].

The very youngest children are experiencing STEM in action, so we refer to STEM-E [12]. These individual free choice instinctive experiences are crucial as they begin to form their understanding through practical cause and effect of STEM actions.

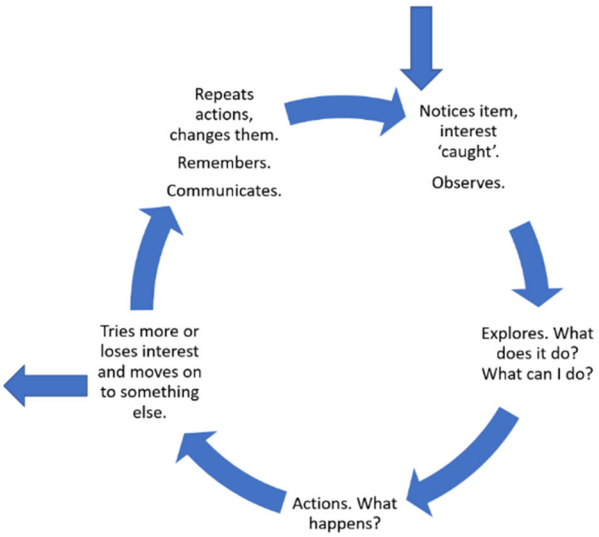


Figure 1. Tunnicliffe STEM Play cycle [12]

The cycle can be slightly changed to empathise a Technology play interaction Cycle [13]. In the interactions in most play, the player is also experiencing the handling objects, which are tools, hence, are a technology interaction.

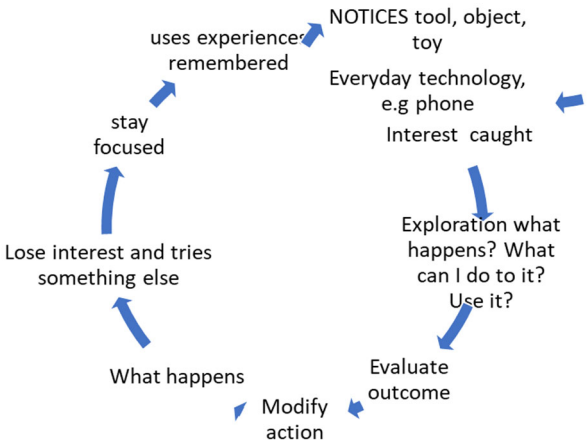


Figure 2. The Technology Tool Play Cycle [13]

Tools are items designed items designed for a purpose or used by the operator for a purpose for which they were not designed,

ISBN 978-84-8158-937-5

such as using a wooden stick form a tree to push another object. Toys, thus are tools, items designed for a purpose that is for children to use. However, usually designed by adults, not children who use the toy their way, not necessarily as the adult intended. A child develops basic skills of interaction such as picking up and item, pushing or pulling. These foundation experiences are also an interaction with technology. Interacting with an object to affect a result is a technology. Thus these early interactions can be referred to as STEM-E [12].

Humans are not the only organism to use tools. For example, the Baya weaver bird, (*Ploceus philippinus*) construct very elaborate nests and some primates use tools to obtain food. Toys and everyday objects with which children investigate act as tools as do the appliances of digital technology. So too does interactions with digital technology which Sakr [14] points out develop problem solving and creativity too. Interaction is similar to the process of language communication, the interaction by the child- the effect on the object-- the final outcome. Thus, play is an active dialogue.

4. Play is an apprenticeship for adult hood through categories of play

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. However, STEM, based play is of an entirely different category. It is identifiable in these various play genres as an inherent part. The science actions within play preschool, in play grounds have been observed. These types of play happen in parallel with STEM experiences. Children apply their knowledge skills and understanding to new situations based on their experiences.

Are some kinds of play a legacy from earlier less developed times? Rees-Edwards [15] suggests that the constructing shelters or dens, outside is an instinctive link with earlier humans way of life. Where there is no outside access, children construct such ‘dens’ under tables for example. Studies of play across cultures in the lives of children found that play is relevant amongst children and, often as a distinct apprenticeship for adulthood [16].As mentioned previously, it is important for those of us working in these early years of STEM awareness and development that play is children’s work as Roth et al, [5] and play is instinctive [4].

Re-enactment play activities of very young is one of the many genre of play identified by researchers. There is a distinct developmental sequence of activities. Athey [17] identified repeatable patterns of behaviour named as Schema. An example is how young children is what Athey [17] called Trajectory Schema with absorbing interest in movements up and down, forward and back. There is not one form of play, a number have been identified by various researchers. Rees- Edwards [15] for example lists 6 stages in play and 17 contemporary types of play. She points out (page 27) that initially the youngest of children observe their environment and make movements. It is not unusual to see a toddler under one just standing making movements practicing motor movements and watching at times other children playing. Fost [18] highlighted that children’s play has changed in the past half century to embrace digital technologies. He named this category cyber play.

5. Progressions of play through out early years

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 illustrating science, maths, engineering concepts in action, often employing a technology, or tool. Russell and McGuigan [19] discuss progression in Emergent science and cite areas of progressive development such as being able to plan stages of investigation, development areas such as developing an approach to listening, thinking showing curiosity about the environment describe a sequence of events in a logical way and such can be observed beginning in the earliest years of play.

There is distinct proregression both in socialisation with other children as well as the skills and understandings and the complexity of play episodes, building on what has gone

ISBN 978-84-8158-937-5

before. STEM play occurs in parallel with other genre of play whether it be re-enactment, narrative, imaginative or whatever and is frequently seen in object play which is also incorporated in other genre particularly can be regarded at Tool play, technology play. The interaction with the objects and observing an outcome. Interacting with an object to effect, a result is a technology. Rather as in leaning a language where the child starts with learning a name of object or action gradually building up the ability to put words together into phrases then sentences, so do does a child begin to learn science and the STEM subjects building up from small units of actions and outcomes?

The interaction with the objects and observing produces an outcome and this interacting with an object, a tool, to effect a result is a technology. It is a progressive. It starts from the basic actions and developing with manual dexterity, applying previous remembered experiences to a similar situation and trying out further sequential or unrelated actions. Observing children not yet at the verbal communication stage indicates that they are thinking and skiing themselves questions similar to those of the play cycle

One of the basic but popular activities with the youngest children, about 6 months old, who can sit up independently, from about 6 month of age, is interacting with blocks. Brightly coloured light plastic ones are the type I have observed more than others with the youngest.

Situation	Item	Stage	Child's action	Outcome
Baby sitting on floor aby a few brightly coloured plastic blocks	Bright plastic cube	First interaction. Notice and interest	Reaches out, touches, tries to grasp	After a few attempts if block small enough picks it up
As above	Bright plastic blocks	Reaches to the block	Grasps block using human power grip.	Picks it up and sets it down again
As above but can crawl	As above	Reaches to several blocks	Picks up one by one	and puts them in a line
Sitting, crawling			Collects serval blocks	Makes lines but carefully places block flush to neighbour
Standing by table or sitting on floor	As above	Picks blocks up one by one	Puts one block on another and another on single base block	A short tower but blocks not aligned so blocks on squarely on top of each other
As above	Repeats	Repeats	Repeats	Taller tower which falls over
As above		Recognising position of brick on each other makes more stable	Looking at carefully placing blocks on top of each other so balances	Tower which stands(to about 6 blockas0
As above		with larger base	Makes several towers side by side	
Standing by tables sitting on floor			Very high tower	Is stable some children delight in knocking over

Table 1. Progression in Block Play

Children interact with many everyday objects and materials as well as 'toys'. Observing the youngest children interacting with water out of home where they probably have already had some experience of water in bathrooms for washing purposes or in kitchens for cleaning utensils, as a drink or as rain. However, encountered in a different setting such as play group with different sources much as a stand alone washing up bowl or water dray but not associated with household tasks or a water tray in a play group, brings out different responses.

Water was the first material encountered by a new 11 month by, John, held over the water tray. He delighted, when his mother held him just above the surface of pacing his open palms onto the water and making splashes. The next time he met the water table he progressed to experimenting with putting things in the water and found some disappeared under the water but some, like the bath duck, floated. He pushed the floating duck back under the water, to remerged, when pushed it under again and so it went on until he lost interest.

This toddler to be was exploring the properties of the water and the effect through using forces, pushing. His mother linked the first experience to environments of water birds he had seen at the local pond when he pointed to a plastic toy duck in the water tray Children from walking toddlers upwards in age have an instinct to stamp in puddles splashing as much as they can. Using this force action on the surface of the water and they stamp and splash readily.

A group of an almost 2 years old boy and a girl, who was celebrating her second birthday that day, in her party dress, interacted with water, not by floating and sinking items but by using small foil dishes to scoop up water and then tip up the dish emptying the water back into the bowl. Time and time another adult. After some time they progressed to scooping and filling a tube open at one end with water and emptied that out. Small flat sponges had been provided on the side m we thought they would wet them and squeeze out the water. No. They kept them at the side and used them to mop up and water that was splashed onto the table. Possibly modelling home activities of mopping up. A modelling of behaviour observed or taught at home. However, most

ISBN 978-84-8158-937-5

play actions are related to physics, maths and engineering by observing adults. What about life sciences and earth science?

The early understanding of the biological domain is less evident than is the interaction with objects in typical play with toys and everyday items. Although child from its earliest consciousness is experiencing the being alive, life processes such aa hunger, feeling, and excretion The biological phenomena of the world outside themselves gradually comes to their attention through observations, particularly sight and sound but also temperature and touch. They gradually recognise that plants, are green and are faced in the ground and that objects that move acne be animals, An basic early years activity is asking teaching the youngest child the names of the main parts of the human body which can be enlarged into game with an adult, most often their mother of touching either the child's external part, for example, nose, ear, hand, or that of their mother. Some youngsters at about 1 to 18 months delight in putting a note (like a post it notes) on the named part of their mother. They progress to being able to stick the post its or a card with a part of an external feature, such as an ear, onto the relevant part of an outline of a child's body shape. Awareness of light and dark, the outside weather are beginnings of earth science as between awareness.

Earth sciences may be met through soils in house plants inside or when outside on for example, pavements and parks. Toddlers are frequently observed dropping to the ground and sifting sand or silty soil though their hands. Handling mud and soft clay found outside attracts them. They experience the climate for themselves and begin to associate clothes and behaviours to differing weather phenomena. They start to notice day and night, shadows, stars, the sun, clouds and the changing shape of the moon. Outside they experiences different coverings of the earth, shapes of the land as well as interruptions to the surface of rocks, plants, ponds and other water bodies as well as human constructed surfaces. Much of these interactions are solely observational or experiential as part of other activities unlike the focused interaction with toys and other object in active play.

6. Conclusion

The starting point of STEM learning is for the children to experience involvement with items or 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 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 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 apply the skills and understanding acquired through earlier play and interacting with objects or observing natural phenomena, are developed and honed in play. Such skills are the soft skills needed for 21st century development where no longer can people be reliant on just facts but on applying knowledge and understanding. Teachers and parents ought to be aware of this vital stage in a child's learning journey, especially in this 21st Century where skills of problem solving, critical thinking and applying knowledge, not just learning facts, are a necessity in a rapidly changing, challenged world. Not facts.

7. References

[1] UNESCO. (2019). Early childhood care and education [Web page]. United Nations Educational, Scientific and Cultural Organization. https://en.unesco.org/themes/early-childhood-care-and-education

[2] Lakenpaul M, Smith T. The role of nutrition in pregnancy and infancy in children's cognitive development, 2019. https://www.zero2expo.com/artists/monica-lakhanpaul/

[3] Wilson R. Promoting the Development of Scientific Thinking. Excelligence Learning Corporation, 2007. http://www.earlychildhoodnews.com/earlychildhood/article_print.aspx?ArticleId=409

[4] Roth WM, Goulart MIG, Plakitsi K. Science education during early childhood. A cultural historical perspective. Dordrecht: Springer, 2013.

[5] Gopnik A. The philosophical baby: What children's minds tell us about truth, live and the meaning of life. New York: Random House, 2011.

[6] Driver R. The pupils as scientist. Milton Keynes: Oxford University Press, 1983.

[7] Fagen IR. Animal Play, games of Angels, Biology, and Brain. In Pellegrini AD (Ed.), The Future of Play Theory, 23- 44. New York: Sate University of New York Press, 1995.

[8] Smith P. Play in Animals and Humans. Abingdon: Basil Blackwell, 1986.

[9] Safina C. Becoming Wild: How Animals learn to be Animals. London: OneWorld.

[10] Reide F, Johannsen N, Hogberg A, Nowell A, Lombard M et al. The role of play objects and object play in human cognitive evolution and innovation. Evolutionary Anthropology, 27, 46–59, 2018.

[11] Tunnicliffe SD. Talk and Do Science at Home. Talk given at Professional Development Institute, Jamaica. Early Childhood Directorate, Ministry of Education, Government of Jamaica Online, May 17th 2021, 2021.

[12] Tunnicliffe SD. STEM in Early Years Play. Poster and talk given at National Assoctaions for Research in Science Teaching, Vancouver Canada, March 2022.

[13] Tunnicliffe SD. (2022) Engaging children in Technology. Talk given at Professional Development Institute, Jamaica. Early Childhood Directorate, Ministry of Education, Government of Jamaica Online, May 19th 2022

[14] Sakr M. Digital Play in Early Childhood. London: Sage Publications, 2020.

[15] Rees-Edwards, A. Types of Play in Ed J. Waters-Davies in Introduction to Play London: Sage, 26 – 39, 2022.

[16] Callaghan T, Moll H, Warnecken F, Liskowiski U, Behene T, Tomasello M. Early Social cognitions in three cultural contexts. Monograph of the Society for research in Child Development, 76 (2), 1-142, 2011.

[17] Athey C. Extending Thought in Young Children. London: Paul Chapman, 1990.

[18] Fost JL. The changing culture of play. Journal of Play, 1-2, 117–130, 2012.

[19] Russell T, McGuigan L.An updated perspective on emergent science, Early Child Development and Care, 187(2), 284-297, 2017.

ISBN 978-84-8158-937-5

The Attitude of Visual Impaired Students towards STEM: A Pilot Study

A Baptista[1], *A Chrysargyri*[2], *R Costa*[3], *P Serra*[4], *S Franco*[1], *MFM Costa*[1]
[1]*Centro de Física das Universidades do Minho e do Porto, Portugal*
[2]*Protoporia in Athens, Greece*
[3]*Agrupamento de Escolas Henriques Nogueira in Torres Vedras, Portugal*
[4]*Instituto Superior de Educação e Ciências in Lisboa, Portugal*
abaptista@fisica.uminho.pt

Abstract. Understanding and gathering information about the attitudes of visual impaired students concerning sciences, technology, engineering and mathematics (S-STEM) is an important issue for the school and for the teachers when planning inclusive classrooms in STEM context.

With the purpose of accessing the way visual impaired students relate to S-STEM, a questionnaire was applied in two samples of students from Portugal and Greece. The influence of sex, academic level, country and type of vision impairment was evaluated as main factors using a factorial ANOVA.

The analysis of the questionnaires showed that the academic level was the single factor with statistically significant effect on S-STEM. This drives to the conclusion that visual impaired students generally have a similar attitude towards S-STEM when comparing with other students.

Keywords. Blind, Inclusive Classrooms, Low Vision, STEM, Visual Impairment.

1. Introduction

The current labour market demands workers with good background in sciences, technology, engineering and mathematics (STEM) [1]. Responding to these demands raises two main challenges to the education systems related to STEM: attracting students and promoting efficient teaching methodologies.

In the case of inclusive classrooms with visual impaired students (VI), i.e., low vision and blind, extra efforts are necessary to adapt these methodologies to the students' visual condition. Thus, understanding the students' attitude toward STEM is a starting point to construct these inclusive processes. Therefore, this pilot study aims to assess the attitude of visual impaired students from lower and upper secondary education towards STEM in two European Countries.

Table 1. Information on students from different vision conditions

Country	Normal sight	Low vision	Blind
	n; mean age (years); SD	n; mean age (years); SD	n; mean age (years); SD
Portugal	25; 16.2; 1.2	7; 17.4; 2.2	4; 18.3; 1.5
Greece	26; 15.8; 1.5	13; 15.7; 2.8	8; 16.1; 2.4

n= number of students; SD=standard deviation

2. Methods

Thirty-six students, including normal sight, low vision and blind (8 males, 24 females; and 4 that preferred not to answer about their sex) from Portugal and forty-seven (24 males, 21 females and 2 that preferred not to answer about their sex) from Greece were enrolled in this study (Table 1). The Portuguese students' group, with an age (mean ± standard deviation) of 16.7±1.6 years old ranging from 14 to 19 years old and the Greek students' group, with an age of 15.8±2.1 years old ranging from 11 to 19 years old, answered a questionnaire about Student Attitudes toward STEM (S-STEM) [2] from November 2021 to March 2022. The questionnaire, as shown in Table 2, intended to assess five types of attitudes: Science, Technology & Engineering, Mathematics and 21st Century Skills. The response used a Likert scale: 'Strongly disagree', 'Disagree', 'Neither agree or disagree', 'Agree', and 'Strongly agree'. To these claims were attributed scores from 5 ('Strongly agree') to 1 ('Strongly disagree').

A mean score resulting from all four attitudes assessed was obtained for each subject and considered to represent the subject's S-STEM score, where higher numbers represent better attitude.

Table 2. Questionnaire to measure Student Attitudes toward STEM (S-STEM) [2]

Skill	Item
Math	1. Math has been my worst subject. 2. I would consider choosing a career that uses math. 3. Math is hard for me. 4. I am the type of student to do well in math. 5. I can handle most subjects well, but I cannot do a good job with math. 6. I am sure I could do advanced work in math. 7. I can get good grades in math. 8. I am good at math.
Science	9. I am sure of myself when I do science. 10. I would consider a career in science. 11. I expect to use science when I get out of school. 12. Knowing science will help me earn a living. 13. I will need science for my future work. 14. I know I can do well in science. 15. Science will be important to me in my life's work. 16. I can handle most subjects well, but I cannot do a good job with science. 17. I am sure I could do advanced work in science.
Engineering and Technology	18. I like to imagine creating new products. 19. If I learn engineering, then I can improve things that people use every day. 20. I am good at building and fixing things. 21. I am interested in what makes machines work. 22. Designing products or structures will be important for my future work. 23. I am curious about how electronics work. 24. I would like to use creativity and innovation in my future work. 25. Knowing how to use math and science together will allow me to invent useful things. 26. I believe I can be successful in a career in engineering.
21st Century Skills	27. I am confident I can lead others to accomplish a goal. 28. I am confident I can encourage others to do their best. 29. I am confident I can produce high quality work. 30. I am confident I can respect the differences of my peers. 31. I am confident I can help my peers. 32. I am confident I can include others' perspectives when making decisions. 33. I am confident I can make changes when things do not go as planned. 34. I am confident I can set my own learning goals. 35. I am confident I can manage my time wisely when working on my own. 36. When I have many assignments, I can choose which ones need to be done first. 37. I am confident I can work well with students from different backgrounds.

To study whether vision affected S-STEM we applied the factorial ANOVA, where in addition to vision, sex, school level (lower secondary or upper secondary) and country were also used as main factors.

3. Results

The results presented in Table 3, Table 4 and Figure 1 show that vision does not affect S-STEM-score.

Of the other main factors, only the school level had a statistically significant effect, with lower secondary students having a better S-STEM.

Also, none of the interactions between main factors were statistically significant (Table 4). However, the interaction School-level*Vision was on the borderline of statistically significance (p=0.051). Therefore, School-level*Vision was reorganized into six groups, as depicted in Table 3 and Figure 1.

Table 3. Descriptive statistics per group

Group of students	Number of subjects	Mean (SD)
Lower secondary AND Normal sight	8	3.95 (0.44)
Lower secondary AND Low vision	9	3.52 (0.57)
Lower secondary AND Blind	4	2.84 (0.59)
Upper secondary AND Normal sight	43	2.96 (0.74)
Upper secondary AND Low vision	11	3.48 (0.54)
Upper secondary AND Blind	8	3.19 (0.43)

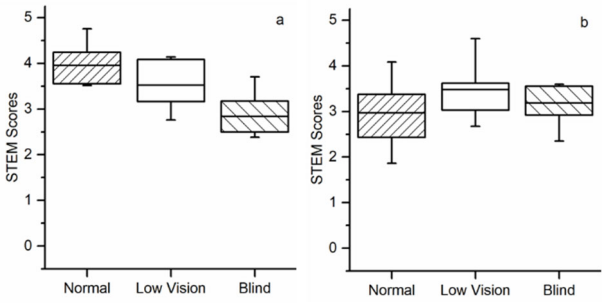


Figure 1. STEM Scores for students with normal vision, low vision and blind; considering two school levels: a) lower secondary and b) upper secondary. The box is determined by the 25th and 75th percentiles. The whiskers are determined by the 5th and 95th percentiles. The horizontal line represents the mean values

A one-way ANOVA followed by a post-hoc tests (Tukey) was used to explore differences between these six groups related to S-STEM.

Table 4. Parameters (main factor and interactions) of factorial ANOVA

Factors	F	p-value
Country	1.7	0.19
School-level	7.5	<0.01
Sex	0.7	0.50
Vision	1.6	0.21
Country * School-level	0.7	0.40
Country * Sex	1.8	0.18
Country * Vision	0.5	0.64
School-level * Sex	0.5	0.58
School-level * Vision	3.2	0.05
Sex * Vision	0.6	0.64
Country * School-level * Sex	1.7	0.19
Country * School-level * Vision	1.3	0.28
Country * Sex * Vision	0.2	0.82
School-level * Sex * Vision	0.7	0.51
Country * School-level * Sex * Vision	-	.

The results showed statistically significant difference only between the lower-secondary-education-AND-normal-sight and upper-secondary-education-AND-normal-sight (one-way ANOVA: $F=4.36$, $p<0.01$; Tukey: $p<0.01$), which confirms that school level has a relevant effect on STEM score.

4. Discussion/Conclusion

In conclusion, VI students generally have a similar S-STEM to their counterparts with normal vision, indicating that the educational system/society does not demotivate these students for STEM. This can be a facilitator when planning inclusive STEM classes.

5. Acknowledgements

This work was partially funded and supported by ERASMUS+ Programme; School Education Strategic Partnership – KA201 Agreement Number: 2020-1-PT01-KA201-078451.

This work was partially funded and supported by the Portuguese Foundation for Science and Technology (FCT) in the framework of the Strategic Funding UIDB/04650/2020.

The assistance of the INSIDE team, namely Teresa Neto, Athanasios Mitzifiris, George Antonakos, Giorgos Giorgakis, Marianna Araouzou and Klaire Leigri is gratefully acknowledged.

6. References

[1] Rocard M. Science Education NOW: A renewed Pedagogy for the Future of Europe, Brussels: European Commission, 2007. http://ec.europa.eu/research/science-society/ document_library/pdf_06/report-rocard-onscience- education_en.pdf

[2] Unfried A, Faber M, Stanhope DS, Wiebe E. The Development and Validation of a Measure of Student Attitudes Toward Science, Technology, Engineering, and Math (S-STEM), Journal of Psycho-educational Assessment, 33, 622-639, 2015.

ISBN 978-84-8158-937-5

PET-A – Polyethylene Terephthalate Algae

J Sá, M Costa, P Pereira, N Francisco
Colégio Cedros in Vila Nova de Gaia, Portugal
nunofrancisco@colegiocedros.pt

Abstract. Nowadays it's common knowledge that the use of all types of plastics should be avoided due to their very high environmental impact. Our investigation's goal is the recycling of used PET (polyethylene terephthalate) bottles, some of them collected on the Portuguese shore, and the mixing of algae, collected in the same place, with this recycled PET in order to produce a more sustainable 3D printing filament. This allows the reduction of the plastic/volume ratio in the finished product, making it possible to produce the same parts with less plastic material and potentially increasing the biodegradability of the finished product.

Keywords. 3DPrinting, Algae, Sustainability, PET, Recycling.

1. Introduction

Because of the enormous quantity of plastic disposal by several industries, the interest in biodegradable composites is growing and, consequently, the production and advancement of these materials is getting more attention. The plastic recycling rate is relatively low compared to the amount of plastic produced, most of which are disposed of in landfills. However, their decomposition is quite slow, being able to stay in nature for centuries before decomposing [4], so it is necessary to recycle plastics so there is less accumulation in nature. Conventional plastics are causing a lot of environment damage and are affecting various organisms on both land and water [7]. As we are trying to reduce our dependence on crude oil for fuels, we also need to reduce the use of petroleum for producing plastics. The demand for plastic-based materials continues to grow, adding environmental stress [1]. In recent technological advancement, plastics have also gained interest and attention specifically in 3D printing applications. 3D printing is a form of additive manufacturing, the parts are made by the addition of material instead of its removal. This technology enables everyone to turn a 3D computer-aided design (CAD) file into a real physical object. Material extrusion in fdm 3D printing is achieved through fused-deposition modelling wherein a material, usually in the form of plastic filament, is fed by being forced out of the 3D printer's nozzle, printing and forming the model layer-by-layer. There are instances of 3D printing in which metallic filaments are being used but the majority of 3D printer filaments are made up of plastics. The inherent material property of a 3D printer filament will affect the print quality of a 3D object. The commonly used thermoplastic resins include PLA (polylactic acid), polypropylene (PP), low-density polyethylene (LDPE), high-density polyethylene (HDPE) and polyethylene terephthalate glycol (PETG). The fabrication of polymeric 3D printer filaments is usually done through the process of extrusion. The starting material may be a powdered or granulated thermoplastic resin or recycled post-consumer product that is fed into the extruder through the feed hopper and is converted into a continuous uniform molten material. The molten plastic is shaped through a die and is finally extruded to its final shape through standardized diameters that are compatible with the 3D printer's intake. As the thermoplastic filament resins may be commercially available, several innovations employ recycling of plastics which involves recovery of scraps and waste and reprocessing into a 3D printer filament [5]. Natural fibres are an inexhaustible source of biobased materials and are used in the production of some plastics. As a filler in the polymeric material, cellulosic fibres such as flax, ramie, jute, sisal, and hemp have been used for reinforcing the polymeric substance for many years. Algae are a vast and cheap source of natural fibres which can be used as filler in polymer-matrix composites. However, the knowledge on the properties of algae-filled composites is very scarce and traditional biodegradable polymers have poor mechanical, thermal, and electrical properties with processing difficulties. Many countries around the world have encountered problems with algae proliferation on the coast and this very useful resource is usually wasted because it's not being used properly. That's why the properties of the bio-composites should be improved, because this "waste" has serious potential to be used in a good sustainable way [3, 6]. The impact of plastic in nature can be reduced by recycling the waste material and

ISBN 978-84-8158-937-5

avoiding the production of more plastic, while ensuring our needs are met. Our project's main aim is the recycling of PET plastic from disposed bottles and turning this waste into 3D printing-compatible filament. The addition of algae biomass as a filler not only reduces the amount of plastic per volume of printed parts, but also increases the biodegradability potential of this materials.

2. Methodology and materials

2.1. Materials

Sample of brown, green and red algae; 100 kW thermistor; PET bottle samples; 50 W heater cartridge; Convection oven; Custom made PET bottle cutter; Mortar; Vulcano style hotend; Pestle; Vulcano style nozzles; Geeetech A10M 3D printer; 0,4 mm filter; Ironing equipment; Crème Brûlèe burning tool.

2.2. Material Preparation

We used samples of brown, green, and red algae collected in Portugal's northern shore, in Valadares Beach (41°05'32.7"N 8°39'29.6"W) at 5 p.m. (Image 1). The algae were dried in the sun and washed of any debris with running water and brushes. The algae were then dried again in a conventional oven at 55 ºC. for 24 hours. We then shredded the samples into fine powder using a mortar and a pestle and passed them through a 0.4 mm civ so that it doesn't clog the nozzle when we later use the compound for 3D printing (Image 2 and 3). Samples of PET were also needed, these were gathered through used bottles from our school's community and from pollution in the beach. In this study we didn't do a previous selection of the materials, however, there are selection methods such as ELECTRE [5]. We removed any kind of labels and glue residue from the bottles and cleaned them off any impurities.



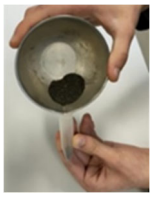


Image 1, 2, 3. Gathering algae and PET samples, Shredding the algae samples into powder, Transferring the shredded algae into a filtering container

2.2.1. Production of PET strips

The bottles were turned into long strips using a custom cutter (Images 4, 5, 6 and 7). We determined the necessary strip width by calculating the cross-sectional area of regular filament and then dividing it by the thickness of the bottle. There were two types of bottles, the thickest type had 0,4 mm ± 0,02 mm walls and the thinnest 0,22 mm ± 0,02 mm. The calculation results can be seen in the following table.

Table 1. Required strip's width based on desired filament diameter

Filament's diameter (mm)	Thin strip's width (mm)	Thick strip's width (mm)
1,5	8,04	4,42
1,6	9,14	5,02
1,75	10,93	6,01

Image 4. Custom cutter

Producing 1,5 mm or 1,6 mm diameter filament would be sub-optimal since most consumer 3D printers are designed to print with 1,75 mm filament, but this is the closest we can get to the correct size due to our methods of production. Our extrusion nozzle was custom-made by enlarging a 0,8 mm volcano-style nozzle with a drill. Having that in mind, we had to find a drill-bit with the correct diameter, the closest we were able to find was 1,5 mm. This wasn't close enough for it to be a usable filament, so we simply tried to loosen the perforation by moving the drill around in its hole, in an attempt to loosen it. In this way we

ISBN 978-84-8158-937-5

were able to have an approximately 1,6 mm nozzle hole, which was already good enough.

Image 5. PET strips made from the bottle

Images 6 and 7. Cutting the bottles into strips

2.2.2. Joining the PET strips with the algae powder

The first method used to mix the algae dust with PET was to lay the PET strips flat and put them in the oven covered with algae dust, changing the temperature in 25 ºC increments until we reached 200 ºC. We expected to partially fuse the strips and coat them with algae, unfortunately this was unsuccessful. In our second attempt we laid the PET strips flat, covered with algae dust, like in the first method (image 8), and then ironed them, with parchment paper separating the iron and the strips, once again, this failed, as the algae remained at the surface of our strip (image 9). The third method consisted of the same initial process of laying the strips flat, covered with algae power, but this time using a kitchen appliance that serves for making Crème Brûlèe to partially fuse the PET. This appliance reaches a higher temperature than the iron (we measured 200 ºC on the iron and over 300 ºC on the kitchen appliance), which was promising, but once again, we weren't able to reach the desired results, the algae didn't incorporate in the PET.

Image 8. Setup of the PET and the algae for the ironing

Image 9. Resulting product after the ironing, as we can see, the algae clearly didn't incorporate properly in the strip

We also tried to stick the algae powder to the plastic strips temporarily with a thin layer of glue just before inserting this product into a hotend, hoping these two materials would join with the heat and the glue would be dissolved and disappear, this hasn't led to good results since the algae and glue clogged the system. In the first three methods described we applied pressure and tension to the strips to prevent them from curling on themselves. As we couldn't reach the desired results with any of these possible procedures, we came up with

ISBN 978-84-8158-937-5

other ways to mix the algae and plastic, explained in the next paragraph.

2.2.3. Making the filament

Before making PET-A we produced some filament just from the PET strips, without the algae, as a proof of concept. We pulled the strips through our custom 3 mm to 1,6 mm nozzle, inside the heater block. The plastic melts and its shape adapt into a round profile, turning it into 1,6 mm PET filament (image 10) [2]. This was very successful, and we were even able to print a part with this material. To produce PET-A filament we considered a series of different possible methods listed in the paragraph above, but in our final attempt to produce this composite we decided to add the algae, not to the strips but further down the line, to the PET filament itself.

In this procedure, PET filament is used to print an object with a filament-compatible shape. In each printing layer, the print is paused, and algae powder is sprinkled on top of the shape. Effectively trapping algae in between the layers, incorporating it in the object, making our PET-A filament. Due to time constraints this is yet to be properly tested.

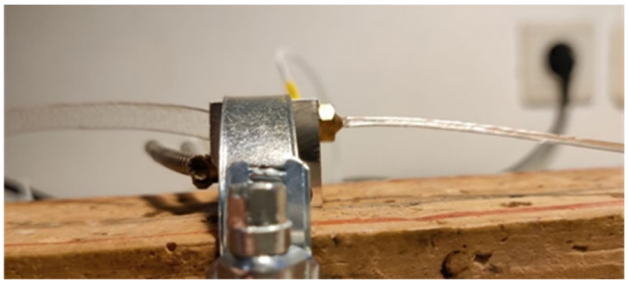


Image 10. Converting the PET strips into filament

We have also developed a contraption that automatically pulls the filament through the hotend and winds it up automatically (image 11). In this way we can have a more consistent diameter in the filament, as it is affected by changes in the pulling speed. This also enables us to produce more filament, faster.

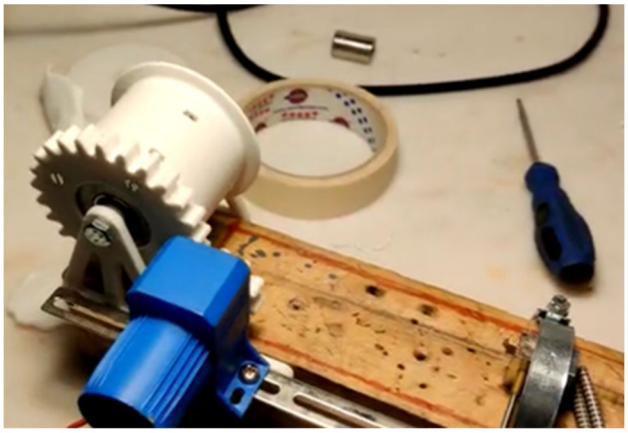


Image 11. Automatic filament pulling mechanism

2.3. Printing the produced filament

With the previously made PET-only filament we were able to print a small keychain (images 12 and 14), this print had good results. This polymer will also be tested the same way as the PET-A filament and compared to the most used 3D printing filament (PLA).

After producing the PET-A filament, several samples will be printed to study the best conditions and print settings for this filament. We will also observe this polymer's behavior while printing, checking parameters such as bed adhesion, stringing and emission of VOCs.

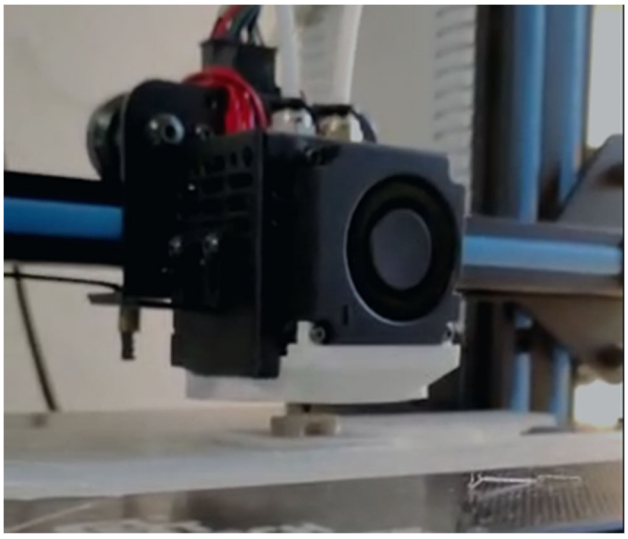


Image 12. Printing with the PET filament

2.4. Testing PET-A composite's properties

We will test aesthetic print quality, layer adhesion, stiffness, and thermal resistance. We will also make a test in more real-world load

ISBN 978-84-8158-937-5

conditions with a hook and a progressively increasing weight until the parts fail. For the temperature testing we will print long rectangle specimens and progressively heat them in the oven until they start to deform under a small load. The test objects will be set up in a custom-made wooden support and will be loaded with a heavy nut in the center. We tested the material stiffness by applying a varying weight in the center of a long rectangle with known dimensions, we then measured the deformation using calipers and calculated young's module. The layer adhesion will be tested with some hooks (image 13), we printed several samples, some of them lying down and some standing in the printer's build-plate, so that we can compare the material's normal strength and the layer adhesion. We then loaded them with a progressive weight until they broke. All these tests' results will be performed with PET, PET-A and PLA and the results will then be compared.

Image 13. PLA test hooks

3. Results and Analysis

Before producing our PET-A filament we made a sample of PET-only filament from a Schweppes bottle, without algae. This filament was printed successfully. The printed object had all the characteristics of a successful 3D print (image 14), it was solid, its contours were well defined and sharp and there weren't any obvious issues with the printing capabilities of the polymer like stringing or low bed adhesion. The only downside was that there wasn't enough filament to finish the part, leaving us with an incomplete keychain. It is also important to refer that the strip that was obtained by cutting the bottle had a constant thickness and there were no problems related to the cutting process. There were no huge differences between the object that was printed by PET filament and the same model printed with the most commonly used filament, PLA (polylactic acid) (images 14 and 15). However, there was a slight difference in the surface finish. We can see it comparing the pet-made object to the PLA-made one. The model was sliced using Ultimaker Cura 5.0.0 Beta and the print settings can be found in the table below.

Table 3. Our print settings for PET plastic

Layer height	0.3 mm
Initial layer height	0.3 mm
Extrusion width	0.4 mm
Wall thickness	1.2 mm
Wall line count	3
Top/bottom thickness	0.9 mm
Top layers	3
Bottom layers	3
Infill Density	20%
Infill Pattern	Cubic
Printing temperature	250 °C
Build Plate temperature	80 °C
Scaling Factor Shrinkage Compensation	100%
Flow	100%
Speed	40 mm/s
Retractions	Enabled
Retraction Distance	5 mm
Retraction Speed	45 mm
Fan speed (2ndlayer and above)	100%
Initial layer fan speed	0%
Minimum layer time	10 s
Minimum Speed	10 mm/s
Supports	Disabled
Build Plate Adhesion	Raft
Raft Extra Margin	15 mm
Raft Air Gap	0.2 mm

Trying to mix the algae with the pet strips, our first procedure was to lay the PET strips flat and put them in the oven covered with algae dust. We expected the high temperatures to soften the PET and, consequently, coat the

ISBN 978-84-8158-937-5

strips with algae (image 16). However, the results weren't what we expected. Despite this, the result was quite interesting, once the strip got an interesting shape, rolling over itself and, most importantly, the algae were trapped inside the resulting curled strip (image 17 and 18).

Image 14 and 15. PET keychain and PLA keychain, respectively

Image 16. Preparation of PET strip + algae to go into the oven

Image 17. PET strip and algae in the oven

Image 18. Resulting product of PET in the oven

4. Discussion

Unfortunately, we didn't obtain all the desired results yet. However, we still managed to produce PET-only filament and print with it, having very satisfactory results. In addition to printing with it, a curled strip of PET with algae inside, resembling PET-A filament, was also made. Having that into account, we conclude this project is still in its beginning, and there is definitely room for improvement. Firstly, we expect to be able to continue with the production of PET-A as described in the last, untested, procedure in 2.2.3 (making the filament), as well as printing with it. It's also important to note that the tests listed in 2.4 (Testing PET-A composite's properties) will also be performed in the near future, as the evaluation of this polymer is an important part of this study. Comparing the results obtained in our tests by different types of filament we will be able to access how our compound stacks up against other less environmentally friendly alternatives and how viable it is as a more sustainable substitute. Although we weren't successful in our attempts to mix algae and PET, we have learned about this material's behavior when subjected to different levels of heat and these findings will prove themselves of great use when developing other compound mixing techniques. We also think it's possible to further improve our research by experimenting with the addition of other powders like ground, used, coffee grains, to several different types of thermoplastics like PLA and ABS.

5. Acknowledgements

The authors would like to acknowledge the help provided by Henrique Miguel Pereira, 9th grade student at Colégio Cedros, in the formatting and ensuring the guideline compliance of the paper.

6. References and Notes

[1] Rahman A, Miller CD. Microalgae as a Source of Bioplastics. In Rastogi RP,

Madamwar D, Pandey A (Eds.), Algal Green Chemistry, Elsevier, 121-138, 2017.

[2] Awaja F, Pavel D. Recycling of PET. European Polymer Journal, 41(7), 1453-1477, 2005.

[3] Ahmed B, Sultana S. A Critical Review on PLA-Algae Composite: Chemistry, Mechanical, and Thermal Properties. Textile Science & Engineering, 10-7, 2020.

[4] Chen X, Yan N. A brief overview of renewable plastics, Materials Today Sustainability, 7–8, 2020.

[5] Exconde MKJE, Co JAA, Manapat JZ, Magdaluyo ER. Materials Selection of 3D Printing Filament and Utilization of Recycled Polyethylene Terephthalate (PET) in a Redesigned Breadboard, Procedia CIRP, 28-29, 2019.

[6] Bulota M, Budtova T. PLA/algae composites: Morphology and mechanical properties. Composites: Part A, 73, 109-115, 2015.

[7] Kumar Kalita N, Anil Damare N, Hazarika D, Bhagabati P, Kalamdhad A, Katiyar V. Biodegradation and characterization study of compostable PLA bioplastic containing algae biomass as potential degradation accelerator, Environmental Challenges, 3, 2021.

[8] J Sá, M Costa, P Pereira are 12th grade students; N Francisco is the supervising teacher.

ISBN 978-84-8158-937-5

Media and Digital Skills of Visual Impaired Students

A Baptista[1], *A Chrysargyri*[2], *R Costa*[3], *P Serra*[4], *S Franco*[1], *MFM Costa*[1]
[1]*Centro de Física das Universidades do Minho e do Porto, Portugal*
[2]*Protoporia, Athens, Greece*
[3]*Agrupamento de Escolas Henriques Nogueira in Torres Vedras, Portugal*
[4]*Instituto Superior de Educação e Ciências, Portugal*
abaptista@fisica.uminho.pt

Abstract. The developed world is being proactive in transitioning to a digital society. Thus, understanding and gathering information about the Media and Digital Skills (MDS) of visual impaired (VI) students is an important issue for evaluating this group's present and future integration into society.

With the purpose of accessing VI students' MDS, a questionnaire was administered to two samples of students, one from Portugal and the other from Greece. A multiple linear regression model was used to modulate the effect on MDS of age, sex, country, and type of vision impairment.

The model justifies a considerable amount of MDS variance, with age and vision being statistically significant factors. In the model, MDS improves with age increment, and blinds have lower MDS scores than their normal sight counterparts.

Considering that blindness impairs the MDS of this subject group, particular efforts should be made by schools and society to potentiate the improvement of MDS in this specific group.

Keywords. Blind, Digital, Inclusive Classrooms, Low Vision, Media and Digital Skills, Media, STEM, Visual Impairment.

1. Introduction

In the way toward the digital society, Media and Digital Skills (MDS) are critical for contemporary life, including daily routines, school and work [1]. In order to fully integrate into society, low vision and blind people (Visual Impaired, VI) must acquire proficiency in MDS. Therefore, this study aimed to assess the MDS of VI students from lower and upper secondary education in two European Countries.

Table 1. Information on students from different vision conditions

Country	Normal sight	Low vision	Blind
	n; mean age (years); SD	n; mean age (years); SD	n; mean age (years); SD
Portugal	25; 16.2; 1.2	7; 17.4; 2.2	4; 18.3; 1.5
Greece	26; 15.8; 1.5	13; 15.7; 2.8	8; 16.1; 2.4

n= number of students; SD=standard deviation

2. Methods

Thirty-six students, including normal sight, low vision and blind (8 males, 24 females; and 4 that preferred not to answer about their sex) from Portugal and forty-seven (24 males, 21 females and 2 that preferred not to answer about their sex) from Greece were enrolled in this study (Table 1). The Portuguese students' group, with an age (mean ± standard deviation) of 16.7±1.6 years old ranging from 14 to 19 years old and the Greek students' group, with an age of 15.8±2.1 years old ranging from 11 to 19 years old, answered a questionnaire about MDS [2] from November 2021 to March 2022. The questionnaire, as shown in Table 2, intended to assess five types of skills: Operational, Navigation, Social, Creative and Mobile. The response used truth claims ('Not at all true of me', 'Not very true of me', 'Neither true nor untrue of me', 'Mostly true of me', and 'Very true of me'), and a 'don't know' option. To these claims were attributed scores from 5 ('Very true of me') to 1 ('Not at all true of me') and 0 to 'don't know'. A mean score resulting from all five skills assessed was obtained for each subject and considered to represent the MDS of the subject, where higher numbers represent better skills.

A model to predict the MDS scores using the multilinear regression analysis was developed considering the variable age and the categorical variables sex, type of vision impairment and country.

Table 2. Questionnaire to measure Student Media and Digital Skills [2]

Skill	Item
Operational	I know how to open downloaded files I know how to download/save a photo I found online I know how to use shortcut keys (e.g. CTRL-C for copy, CTRL-S for save) I know how to open a new tab in my browser I know how to bookmark a website I know where to click to go to a different webpage I know how to complete online forms I know how to upload files I know how to adjust privacy settings I know how to connect to a WIFI network
Information Navigation	I find it hard to decide what the best keywords are to use for online searches I find it hard to find a website I visited before I get tired when looking for information online Sometimes I end up on websites without knowing how I got there I find the way in which many websites are designed confusing All the different website layouts make working with the internet difficult for me I should take a course on finding information online Sometimes I find it hard to verify information I have retrieved
Social	I know which information I should and shouldn't share online I know when I should and shouldn't share information online I am careful to make my comments and behaviours appropriate to the situation I find myself in online I know how to change who I share content with (e.g. friends, friends of friends or public) I know how to remove friends from my contact lists I feel comfortable deciding who to follow online (e.g. on services like Twitter or Tumblr)
Creative	I know how to create something new from existing online images, music or video I know how to make basic changes to the content that others have produced I know how to design a website I know which different types of licences apply to online content I would feel confident putting video content I have created online I know which apps/software are safe to download I am confident about writing a comment on a blog, website or forum I would feel confident writing and commenting online
Mobile	I know how to install apps on a mobile device I know how to download apps to my mobile device I know how to keep track of the costs of mobile app use

Table 3. multiple linear regression model parameters

Independent variables	Best model (R^2=0.26; p-value <0.0001)	
	Coefficient (95% CI)	p-value
Constant	1.08 (-0.38 to 2.54)	0.15
Age (years)	0.18 (0.09 to 0.27)	<0.001
Sex (reference: male)	Not a predictor	
Female		
Unknown		
Vision (reference: normal)		
Low Vision	-0.34 (-0.75 to 0.07)	0.10
Blind	-1.01 (-1.51 to -0.51)	<0.001
Country (ref.:Portugal)	Not a predictor	
Greece		

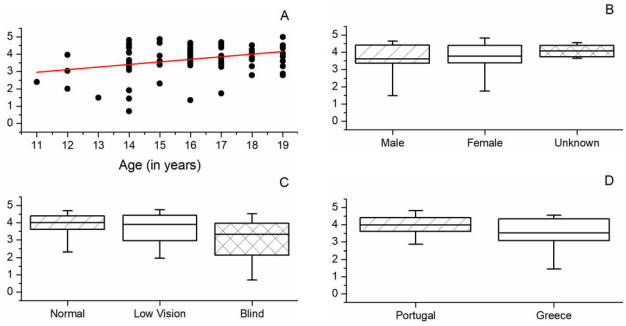


Figure 1. Media and digital skills scores for students considering: A) age; B) sex; C) vison; D) Country. The box is determined by the 25th and 75th percentiles. The whiskers are determined by the 5th and 95th percentiles. The horizontal line represents the mean values

3. Results

We found that age (P <0.001) and blindness (P <0.001) are associated, respectively, with a higher score and lower score after adjusting for sex and country. Together, these two measures explain 26% of the variance in scores performance (Table 3). Surprisingly, low vision students were not statistically significant different (p>0.05) from normal sight students.

4. Discussion/Conclusion

Considering that blindness impairs the MDS, particular efforts should be directed to these students by schools and society to mitigate this situation and capacitate them to the challenge of digital society, which is critical for their effective inclusion in the present and future.

5. Acknowledgements

This work was partially funded and supported by ERASMUS+ Programme; School Education Strategic Partnership – KA201 Agreement Number: 2020-1-PT01-KA201-078451.

This work was partially funded and supported by the Portuguese Foundation for Science and Technology (FCT) in the framework of the Strategic Funding UIDB/04650/2020.

The assistance of the INSIDE team, namely Teresa Neto, Athanasios Mitzifiris, George Antonakos, Giorgos Giorgakis, Marianna Araouzou and Klaire Leigri is gratefully acknowledged.

6. References

[1] Zhao Y, Llorente AMP, Gomez MCS. Digital competence in higher education research: A systematic literature review, Computers & Education, 168, 2021.

[2] van Deursen A, Helsper EJ, Eynon R, Development and validation of the Internet Skills Scale (ISS), Information Communication & Society, 19, 804-823, 2016.

ISBN 978-84-8158-937-5

Ready to Innovate – Maths&Sports4all (RIMAS)

V Baños-Martínez[1], *AA López Gallego*[2], *A González Santa Olalla*[2]
[1]*University of Burgos, Spain*
[2]*Colegio Virgen de la Rosa in Burgos, Spain*
vbanos@ubu.es

Abstract. The project Ready to innovate: Maths&Sports4all (RIMAS) aims to promote maths learning through Physical Education, from a gender perspective. We want students to improve results, change their perception towards maths and increase their performance and level of satisfaction. Also, we intend to promote the scientific vocation especially among the girls, always keeping co-education in mind. The objective is to develop a toolkit for students between 6 and 11 years old to learn, expand and reinforce mathematics content through physical education by training teachers in this new approach. This project is being developed within the framework of the European Erasmus+ programme.

Keywords. Maths, Physical Education, STEM, Didactic Unit, Gender Equality, Erasmus+.

1. Introduction

The Erasmus programme, which has benefited millions of young Europeans, began in 1987 as a mobility grant for university students, with the aim of enabling them to spend a year of their studies in another country. This commitment to promoting exchange and improving students' skills and qualifications began with 11 countries and involved 3,244 students, of whom 250 were Spanish. The programme received the Prince of Asturias Award for International Cooperation in 2004.

The Erasmus+ scheme was launched in 2014, and a new one in 2021, with extended lines and innovations.

Through the various programmes, teaching and non-teaching staff have access to Learning Mobility opportunities to extend and enhance their professional development, as well as to come into contact with teachers from other European countries with whom they can engage in collaborative activities or create strategic partnerships. These actions encourage the exchange of good practice and the sharing of innovative approaches to tackle common problems such as early school leaving and low levels of basic skills.

According to the European Commission Annual Report, in 2020 more than 2,400,000 students and teachers participated in the programme, 933,172 [1] of which in KA2 projects, like Ready to Innovate: Maths&Sport4all.

Several research assure that education in Europe is equal in terms of gender perspective. However, we know that, due to cultural tradition, certain countries still make distinctions between boys and girls and give more value to the male figure. On the other hand, Physical Education is a subject positively valued by most students and despite its benefits to improve physical condition and health, many teenagers decrease physical activity or certain sports because they consider that they masculinize them. Likewise, the percentage of girls enrolled in STEM (31 %) and Physical Education (20 %) careers or degrees is low. In addition, it is quite common that a high number of students feel rejection towards mathematics, which makes them more unwilling towards learning this subject and others highly linked to it.

For this project, the partnership is made up of seven partners, including a university, a mathematicians' group of researchers, four schools and a technical partner and it should be carried out transnationally because today there are many methodologies in Maths and Physical Education, possibly some more useful than others. An international team of professionals in mathematics, education and physical education along with the tests conducted in different countries give this new way of understanding teaching a special nuance that makes it unique and that will keep it in time. Finally, an online teacher training course for the implementation of didactic units linking Maths and Physical Education, will be developed. The expected results are, for example, an increase in motivation and interest towards mathematics, which will lead students to obtain better results, in Mathematics, Science and other subjects; provide teachers with manipulative tools with the presence of ICT to increase students' level of knowledge;

ISBN 978-84-8158-937-5

develop critical thinking and gender equality in students; or improvement of linguistic, social and civic competence. This RIMAS idea gives students an opportunity to learn mathematics in an interactive manner and making the classroom an inspiring place to work. Students will have access to ICT, free software and open educational resources, which will facilitate the learning process.

RIMAS is a KA201 type project, Strategic Partnership for Information Development, coordinated by the Colegio Virgen de la Rosa de Burgos, with the participation of the following partners: Sojuz na istrazhuvachi na Makedonija - SIM Skopje, and OOU "Naum Naumovski Borche" from Skopje, from North Macedonia, Osnovna skola "Branko Radicevic" from Novi Sad, Serbia, Gulbenes novada viusskola, from Gulbenes, Latvia and the University of Burgos and Centro Regional de Servicios Avanzados S.A., from Burgos, Spain.

2. Didactic Unit

The main objective of this Didactic Unit is the teaching of Mathematics through Physical Education in the last stage of Primary Education, which is from 10 to 12 years old. At the same time, the aim is to provide the teaching with a gender perspective, in order to guarantee equality between male and female students.

The questions that arise when approaching this Didactic Unit are, on the one hand, if it is true that our students lose interest in mathematics during their school years and, on the other hand, if the transversal teachings can help to recover their interest in this subject.

Studies related to this problem confirm how students lose interest in mathematics as they move up in their education, mainly because they do not find its usefulness in everyday life [2]. For his part, Huertas [3] assures that, when mathematical activities are carried out starting from real environments, and working with tools within their reach, learning of conceptual, analytical and social processes is achieved.

In relation to Physical Education, Serrano, Azofeifa and Araya [4] state that all mathematical knowledge acquired at an early age is acquired through movement and play. Studies conducted by Prieto and Martínez [5] confirm this idea, concluding that as students increase the practice of physical activity, their performance in Mathematics increases.

In conclusion, it seems advisable to apply Physical Education methodologies in the teaching of Mathematics, in order to recover the interest of students, especially those who are acquiring higher levels of education and whose chances of dropping out of school - according to PISA results- are higher [6].

2.1. Didactic objectives and content

The didactic objectives (DO) of the didactic unit are the following ones:

A. Develop individual and teamwork habits, effort and responsibility in studying, as well as attitudes of self-confidence, critical sense, personal initiative, curiosity, interest and creativity in learning.
B. Acquire in at least one foreign language the basic communicative competence that allows students to express and understand simple messages in everyday situations.
C. Develop basic mathematical skills and start problem solving:
    1) Perform elementary calculation operations applied to real situations using estimates in those situations that require it.
    2) Identify geometric figures and measure their perimeter and area.
    3) Statistically analyze the results obtained in real life situations.
D. Develop their affective abilities in all areas of personality and in their relationships with others, as well as an attitude against violence, prejudice of any kind and sexist stereotypes.
E. Know their own body and its possibilities and develop basic motor skills in practice contexts, using the game as an essential learning resource, in accordance with educational intentions, and as a didactic tool due to its motivating nature.

On the other hand, contents for Maths are divided into four blocks: numbers, measurement, geometry and statistics and probability and probability. In the same way, Physical Education contents are presented in

four blocks: body knowledge, motor skills, games and sports and, finally, physical activity and health.

According to the characteristics of our students and to the context of this didactic unit, the transversal elements that will be present throughout its development will be: reading comprehension, oral and written expression, Information and Communication Technology, entrepreneurship and civic education.

2.2. Methodology and organization

In this Didactic Unit the methodology seeks to connect the subject of Mathematics and Physical Education from a dynamic perspective, which is achieved through the planning of justified activities based on the stated objectives and available resources.

Despite the fact that mathematics throughout history has played a role of great relevance, being present in most of the sectors that make up knowledge [7], nowadays its teaching is characterized by being dehumanized [8], giving rise to a subject that has no relationship with other areas. For this reason, it is essential to guarantee meaningful learning, relating the subject with previous knowledge and with aspects of daily life [9], as well as a cross-cutting education that links the different subjects and challenges all the actors that are part of school culture. Students become the protagonists of their learning autonomously because they listen, ask questions, have doubts and suggest solutions [9].

In this context, the use of gamification is proposed as an innovative alternative that aims to motivate students and promote a greater interest in mathematics through the spontaneous pleasure generated by game mechanics. In addition, it allows the use of other methodologies and tools such as cooperative learning and the use of Information and Communication Technology. Gamification is a concept capable of involving and increasing the student's taste for learning, but it should not be seen as an isolated aspect of other tools and methodologies [10]. In order to make a game, it is necessary to determine how does it work and what role the player plays within it. Other components of great importance in the games are the rules, the objectives and the results [11]. Within the classroom, the role of the teacher is decisive when it comes to achieving an educational goal, then the teacher has to establish the objectives to be achieved with the activity clearly and precisely [12], so that the students perceive that learning is rewarded and they come to consider that success is closely related to effort [13].

The 21st century is presented as a time of transcendental changes, making it necessary for the citizen to adapt correctly to the new society [14]. In this knowledge society, the teacher must lead the change in the conception of teaching, adapting it to the new times and the current characteristics of their students [15]. Information and Communication Technology, responsible of this rapid social transformation, is established as an essential tool today introducing a wide range of applications in teaching [16]. Consequently, including this new dimension within the teaching-learning process is crucial for students to become capable citizens, included within society and the world around them [14].

On the other hand, and in relation to cooperative learning, Chamoso and Rawson [17] established that one of the most relevant factors in teaching is cooperation between students. However, it should not be confused with simple group work, because the main factors in cooperative learning are: positive interdependence between the students that make up the group; feeling responsible for their work and that of their classmates; positive interaction between members, collaborating reciprocally to achieve common goals; the learning of social competences thanks to interaction; and the follow-up, feedback and individual and group evaluation of the students [18].

Collaborative learning uses diversity as a mean to achieve learning, because each student contributes their own knowledge and talents in a different way, and this promotes mutual support and creates scaffolding situations [19]. In this way we increase the performance of our students, since we are creating a positive relationship between them through socialization.

The creation of a favorable and motivating context is essential in the correct development of the educational process. Appropriate

ISBN 978-84-8158-937-5

motivation and a favorable emotional state are necessary for learning, as well as a set of values that foment a particular type of learning and a supportive cultural context.

In the evaluation we take into account that the ideal student is no longer the student who has learned the lesson by heart, but the one who has learned the necessary knowledge through autonomous and cooperative learning [20]. For this reason, during the evaluation we have several options at our disposal. Through self-assessment, the student is aware of everything he has learned and the process he has carried out autonomously. Furthermore, using peer assessment, students work cooperatively and they can assess their classmates. For the students, it is interesting knowing the opinion of their classmates regarding aspects such as their attitude, the division of tasks or the fulfillment of expectations.

Formative Assessment is a type of assessment whose purpose is not only to evaluate but is integrated into the teaching-learning process itself, to identify difficulties and student progress. In this way, changes adjustments can be introduced to achieve the proposed objectives [21]. Formative Assessment puts the evaluation before the qualification. The role of feedback is fundamental, which improves student learning, as well as teaching practice [22]. This active methodology makes students more aware of what they learn, encourages the development of the ability to self-regulate learning, identifies skills and transforms them into competencies, and creates various feedback channels.

This type of evaluation has other advantages, and one of them is that students are allowed to participate in the process of developing the evaluation criteria. Self-regulation or, in other words, "the student's ability to control and decide on their performance and work times" [22], also plays a fundamental role within of this evaluation method. In addition, intra or intergroup co-assessments are frequently used. These techniques will make students more aware of their level of success, according to the observation of the results of the rest of their classmates and how they could use this knowledge outside of the classroom. On the other hand, formative evaluation enables each one of the members of the classroom to give their contribution using different feedback mechanisms, or channels. Whether in writing, orally, video, individually or in groups, these types of activities are highly motivating for students [22].

Table 1. Lesson 2. Memory & Petanque

Memory
Students will be placed in a row. At a certain distance (it could be modified) there will be several cards face down, with different mathematical elements. The first in line will have to reach the cards and will pick up two of them. If there is a couple of cards, the student will be able to take them back to the team. If not, the cards will have to be face down and the student will have to come back to the row, so that the next partner can leave. The cards will be matched up following this: • Roman numerals – natural numbers. • Rounding natural numbers to ten and hundred. • Rounding natural numbers to the tenth or hundredth. • Proper and improper fractions. • Equivalent and irreducible fractions. • Fractions – percentages. • The Metric System and converting units (litres-mass, lengths, volumes...) • Equivalent triangles according to their angles. • Classification of quadrilaterals. Results must be collected on the Didactic Unit notebook.
Petanque
We will weigh the different game balls: • Use of instruments for weighing: scales, weighing scales… • Through the game, units of measurement will be worked between players' balls and the boule (small ball), as well as the distance of throws made: • Use of conventional instruments (ruler, meter), expressing the result using the International System of Units: millimetres, centimetres, decimetres, and meters. • Use of non-conventional instruments (feet, spans, palms, different objects...) Data will be collected.

With this set of techniques, we try to get students to interact directly with the contents and knowledge, reaching real learning, as real as the environment that surrounds them. They become protagonists in a familiar and friendly environment, assuming responsibility for the learning process and reaching the objectives set in the activities [23].

Each session will last 50 minutes, structured as follows:

- 5 minutes: material preparation.
- 5 minutes: review of the lesson dynamic.

- 30 minutes: activities development.
- 5 minutes: discussion of the data collected.
- 5 minutes: co-evaluation.

A total of 11 sessions will be held, some in the classroom and some in the gym or the playground. Lesson 2 is shown as an example in Table 1.

2.3. Evaluation

This gamification consists of 9 Physical Education challenges in which they have to apply the mathematics knowledge acquired in the classroom.

By having to apply the knowledge they have learnt in math class in a relaxed and motivating environment such as the PE classroom, we will promote the study of math among our pupils. The arrangement of the teams in the game promotes the female role as an important cog in the resolution of the challenges. This is one of the ways of promoting these two subjects among this population group, achieving, without a doubt, an increase in the interest of women in Mathematics and, of course, in Physical Education. In these units, the classic stereotypes in Mathematics and PE are set aside.

The assessment of the gamification-integrated DU will be developed taking into account different methodologies, we analyze from the particular to the more global.

On the one hand, students can obtain points and stars for overcoming the different challenges, and on the other hand, they can earn keys if they show that they are developing the competences established in the evaluation of the unit.

2.3.1. Assesment tools in each challenge

Summative and qualitative evaluation will be used. While summative assessment is concerned with studying how effective the educational process has been, qualitative assessment evaluates what the students have learned, how they have learned and what they have learned for. Therefore, at the same time, we measure the competences acquired by our students in a real environment. As the students are the evaluators themselves, we generate an evaluation system in which the student receives feedback on each of the challenges and will be able to understand what he/she has done right or wrong, thus fostering a group self-correction system that generates learning.

In this didactic unit, all groups start with three stars, which are the jokers that they can use to look up clues for the completion of the challenges and move on to the next one. Not all the challenges are worth the same, as there will be three challenges in which they will be able to get a star - a challenge star - whose value will be 2 times the initial star. Each successful challenge is worth 10 points, each failure to complete the challenge will be penalized with 2 points. Each group can only be penalized twice per challenge. All challenges have two parts in which Mathematics and Physical Education are combined, with five points per part. The winning group will be the one with the highest number of points and the highest number of stars, so that, with equal points, it will be the badges that establish the tie-breaker.

2.3.2. Co-assessment and self-assessment

At the end of the gamification, the groups will carry out a co-evaluation in which each student will have to make an evaluation of each component of the group to which he/she belongs and at the same time his/her self-evaluation.

They will have to assess the ability to work in a group, the equal distribution of tasks, the involvement, as well as the interpersonal skills. Thanks to this activity, everyone will get to know themselves better and will be able to improve if necessary, as well as feeling an integral part of the assessment process.

By making use of the formative assessment guidelines and involving our students in the process, we will achieve a higher level of motivation [24].

2.3.3. Assesment of competences

The evaluation of the competences developed will be carried out using the competences evaluation rubric included in the field notebook, assessing each item between 1 and 0 in correspondence with each skill that we evaluate throughout the activity. Each skill has a different weight and the evaluation of the group's skills is translated into a mark between zero and ten.

Thanks to this activity, everyone will get to know themselves better and will be able to improve if necessary, as well as feeling an integral part of the evaluation process.

3. Conclusion

Thanks to the project design it will have a very positive impact on the local communities of the four countries. Seminars and exchanging experiences about good practices and methodologies in teaching math and sports will be developed. We believe that “by doing” is the best method to learn a practical matter as it is maths. Teachers will get ideas on how to improve that process in order to make students more motivated about studying maths. Implementation of RIMAS tools to math education is expected to rise-up the conscience about the importance of acquiring math matter. Regional networks of people from partner institutions involved in the project will be established and will be enabled to hear and see experiences, practices and methodologies from different countries and all those people will be directly involved in making changes in the current practices. This will ensure the application of new developed tools at regional and national level, giving full access to the students, teachers and others involved in education. The new and innovative developed approach will be in line with individuals’ needs. New practices including sports will be implemented in order to help those groups of students that have difficulties in acquiring math matter. This should also result with increased quality of education and better achievements in mathematics in all participating countries and in Europe, too. The structure and the activities of the project are such that the project outputs can be applied in all partner countries and having in mind the essence of the problem and its presence in other Europe countries too, the application of all project outputs can easily be transferred abroad, giving the project one wider European context.

4. Acknowledgements

This project has been co-funded by the Erasmus+ Programme of the European Union.

5. References

[1] European Commission, Directorate-General for Education, Youth, Sport and Culture, *Erasmus+ annual report 2020 : statistical annex*, Publications Office of the European Union, 2021. https://data.europa.eu/doi/10.2766/038079

[2] González RM. Un modelo explicativo del interés hacia las matemáticas de las y los estudiantes de secundaria. Educación matemática, 17(1), 107-128, 2005.

[3] Cruz Huertas J. Estrategia para ampliar la visión de las matemáticas y suscitar el interés por la investigación. UNIÓN, Revista Iberoamericana de Educación Matemática, 45, 44-60, 2016.

[4] Serrano Madrigal A, Azofeifa Lizano A, Araya Vargas GA. Aprendizaje de las matemáticas por medio del movimiento: una alternativa más de la Educación Física. MHSalud: Movimiento Humano y Salud, 5(2), 1-20, 2008.

[5] Prieto Andreu J, Martínez Aparicio C. La Práctica de Actividad Física y su Relación con el Rendimiento Académico. Revista de Educación Física, 4(34), 3-12, 2016.

[6] Amores Fernández FJ. Fracaso y abandono escolar en España. Profesorado, Revista de Currículum y Formación del Profesorado, 14(3), 319-321, 2010.

[7] Peralta Coronado J. La matemática en el arte, la música y la literatura. Tendencias Pedagógicas, 2, 235-244, 1998.

[8] Servais W. Humanizar la enseñanza de la matemática. Revista de bachillerato, 13, 3-22, 1980.

[9] Bermejo Fernández V. ¿Por qué fracasan nuestros alumnos en matemáticas? Programa de Intervención para la Mejora del Rendimiento Matemático (PEIM). En Secretaría General Técnica (Ed.). La orientación escolar en centros educativos, 359-378, Madrid, España: MEC, 2005.

[10] Glover I. Play as you learn: gamification as a technique for motivating learners. In Herrington J, Couros A, Irvine V (Eds.), 1999-2008, World Conference on Educational Multimedia, Hypermedia and Telecommunications, Chesapeake, Virginia, EEUU: AACE, 2013.

[11] Contreras Espinosa R. Gamificación en Escenarios Educativos. Revisando literatura para aclarar conceptos. In Contreras Espinosa R, Erguia J (eds.), 11-17, Experiencias de Gamificación en las Aulas, Barcelona: Institut de la Comunicació (InCom-UAB), 2013.

[12] Sánchez-Aparicio J. Videojuegos y gamificación para motivar en educación. Andalucíaeduca, 120, 6-8, 2014.

[13] Pérez-Pueyo Á. El estilo actitudinal en educación física: evolución en los últimos 20 años. Retos. Nuevas tendencias en Educación Física, Deporte y Recreación, 29, 207-215, 2016.

[14] Barrio de la Puente ML, Quintanilla Rojo M, Barrio de la Puente JL. Tecnología y educación de adultos. Cambio metodológico en las matemáticas. Revista Complutense de Educación, 18(1), 113-132, 2007.

[15] Fernández Solo de Zaldívar I. Juego serio: gamificación y aprendizaje. Comunicación y pedagogía: Nuevas tecnologías y recursos didácticos, 281-282, 43-48, 2015.

[16] González Santa Olalla A, Celada Perandones P, López Gallego A. Construyendo e innovando aprendizajes en Geometría para fomentar la creatividad del estudiante y la educación patrimonial. In de la Fuente Ballesteros R, Munilla Santiago C (Eds.), 183-192. Visiones transdisciplinares en torno a patrimonio, creatividad y poesía, Valladolid, España: Verdelis, 2019.

[17] Chamoso Sánchez JM, Rawson WB. En la búsqueda de lo importante en el aula de Matemáticas. Suma, 36, 33-41, 2001.

[18] Lobato Fraile C. Hacia una comprensión del aprendizaje cooperativo. Revista de Psicodidáctica, 4, 59-76, 1997.

[19] Zariquiey F. Guía para diseñar y poner en marcha una red de aprendizaje cooperativo. Colecctiivo Cinética, 2015.

[20] Puga Peña LA, Jaramillo Naranjo LM. Metodología activa en la construcción del conocimiento matemático. Sophia: colección de Filosofía de la Educación, 19(2), 291-314, 2015.

[21] Melmer R, Burmaster E, James TK. Attributes of effective formative assessment, 2015, Washington, DC: Council of Chief State School Officers, 2008.

[22] Hortigüela Alcalá D, Pérez Pueyo A, González Calvo G. Pero… ¿A qué nos referimos realmente con la Evaluación Formativa y Compartida?: Confusiones Habituales y Reflexiones Prácticas. Revista Iberoamericana de Evaluación Educativa, 12(1), 13-27, 2019.

[23] Pérez-Pueyo Á, Hortigüela Alcalá D, Fernández-Río J. Evaluación formativa y modelos pedagógicos: Estilo actitudinal, aprendizaje cooperativo, modelo comprensivo y educación deportiva. Revista Española de Educación Física y Deportes, 428, 47-66, 2020.

[24] Pérez-Pueyo A, Hortigüela Alcalá D, Gutiérrez-García C, Fernández-Río J. Rúbrica para Actividades Cooperativas, 2020.

ISBN 978-84-8158-937-5

Attitudes of Young People to Safe Listening to Reduce Risks of Hearing Loss

I Berezovska[1]*, M Holovchak*[2]
[1]*University of Informatics and Management in Rzeszow, Poland*
[2]*Vocational Nursing School in Sambor, Ukraine*
iberezovska@wsiz.edu.pl

Abstract. The aim of this study was to gain a better understanding of how well adults and children are aware of the possible causes of hearing loss. Students and teachers (324) were asked about their willingness to follow simple rules to avoid hearing loss. 91,7% respondents know that some causes of hearing loss are avoidable. Exposure to loud sound is not treated as a risk factor by each third. However 88,6% respondents recognize the need for sound volume control. Survey findings provide useful insight for educators and public health administrators planning prevention of hearing loss.

Keywords. Hearing loss, risk factor, prevention, listening behaviour, safe listening, avoidable cause, loud noise, sound control.

1. Introduction

The World Health Organization (WHO) declared the alarming data on hearing loss due to unsafe recreational listening practices. More than 1 billion young people (12-35 years old) are at risk for hearing damage due to recreational exposure to loud sound [1]. To battle with these risks WHO launched the Make Listening Safe initiative in 2015. WHO aims to change listening practices and behaviours through “raised awareness about the need for and means of safe listening, and implementation of evidence-based standards that can facilitate behaviour change in target population groups” [1].

The Make Listening Safe initiative is implemented in three main ways identified in collaboration with all stakeholders in the field:

1. Creation of evidence-based standards including (a) the WHO-ITU Global standard for Safe listening devices and systems. and (b) the Global standard for safe listening venues and events;
2. Increasing awareness through developing and disseminating evidence-based materials for safe listening including (a) a handbook titled Be healthy, be mobile, (b) Media brief on safe listening, and (c) Communication materials such as flyers, posters, brochures, infographic;
3. Investing in research into safe listening in collaboration with global partners to better understand the current state of affairs, to ensure WHO leverages current best practices around the globe, and to uncover future need of safe listening interventions.

Many causes may lead to hearing loss. However some of them are avoidable that gives more flexibility in prevention of hearing loss. Limited research is available to date documenting the attitude of young people to recreational exposure to loud sound which is definitely one of the most common avoidable causes of hearing loss.

To address this lack of data, the main objective of this study was to gain a better understanding of how well adults and children are aware of the possible causes of hearing loss, primarily avoidable ones. The study examined the following research questions:

1. How much do young people know about the causes of hearing loss?
2. Do young people know that some causes of hearing loss are avoidable and how common are they?
3. Do young people consider exposure to loud sound at entertainment venues as a risk factor of hearing loss?
4. Do young people recognize the need for control of exposure to sound in entertainment venues?
5. Would young people follow safe listening practices and promote safe listening to avoid recreational noise-induced hearing loss?

2. Study participants and instrument

The particular interest to the study was the impact of young people’s knowledge of avoidable hearing loss risks on their attitude to implementation of safe listening strategies. Therefore, the study population was high school and university students and young teachers in Ukraine and some HSCI member

ISBN 978-84-8158-937-5

countries.

For the survey, a questionnaire was designed by the authors and developed using Google Forms. The online survey instrument was reviewed and pretested by colleagues knowledgeable about teaching students with hearing impairment [2[to help ensure content validity before widely distributing the survey. Survey questions asked respondents about their knowledge regarding risk factors of hearing loss, attitudes to exposure to loud noise and willingness to follow simple rules of safe listening at entertainment / recreational venues to avoid hearing loss.

In January 2022, students and teachers of the target audience were invited to participate in an anonymous online survey. Data collection concluded after two months at the end of March 2022.

3. Results

A total of 324 students and teachers completed the on;line survey in Ukraine and some HSCI member countries. None of the responses were incomplete; therefore, all responses were included in the analysis. The majority of respondents were high school or college students (258 or 79.6%). The remaining respondents (66 or 20.4%) worked as teachers or administrators at different educational institutions.

As seen in Table 1, young people have a good understanding about what factors may damage their hearing. However not many of them realize that some medications and environmental noises are also risk factors - only 41,1% and 25% correspondingly.

Table 2 illustrates that the majority of respondents (91,7%) are aware of the possibility to avoid hearing loss.

Respondents were asked to estimate how common hearing loss due to avoidable causes that can be prevented through implementation of public health measures are in children and young adults. According to respondents, only half of them (55,6%) realistically estimate a portion of hearing loss in children and young adults due to avoidable causes.

Survey participants were asked to answer if they believe entertainment noises are a risk factor (Table 4). The term "risk factor" indicates something that increases the likelihood of a specific outcome in the future in the absence of a direct real cause. Thus, risk factors are statistical. They exist in the present or in the future, not in the past. If they become actual, they have become causes, not risk factors. Causes are real. They exist in the past and in the present. In the future, causes have the potential to cause diseases. So, future causes are essentially statistical, and they become risk factors.

Table 1. Awareness of hearing loss causes

Complications of some diseases	277	85,5
Ageing	257	79,3
Recreational noises (e.g. motorcycling, listening to loud music etc.)	218	67,3
Occupational noises	210	64,8
Heredity	197	60,8
Some medications	133	41,1
Environmental noises	81	25

Table 2. Awareness of avoidable hearing loss causes

Those who aware	297	91.7
Those who are not aware	27	8.3

Table 3. Estimates of hearing loss in children and young adults due to avoidable causes

Those who believe it less than 50%	180	55.6
Those who believe it more than 50%	144	44.4

Comparable numbers of respondents consider exposure to loud sound/noises at recreational/entertainment venues to be both a cause (67,3% in Table 1) and a risk factor (69,1% in Table 4) of hearing loss.

Table 4. Exposure to loud noise at entertainment venues as a risk factor of hearing loss

Yes	224	69,1
No	100	30,9

Respondents were then briefed that, according to WHO, unsafe listening practices put over 1 billion young adults at risk of

ISBN 978-84-8158-937-5

permanent hearing loss which could be avoided. Additionally, nearly 60% of hearing loss in children is also due to avoidable causes.

After that survey participants were asked if they recognize, being aware of this information, the need for control of exposure to loud sound in entertainment venues. Table 5 shows that a strong majority (88,6%) believe sound volume control should be ensured at recreational/ entertainment venues.

Table 5. The need for control of exposure to loud sound in entertainment venues

Yes	287	88,6
No	37	11,4

Table 6 shows that nearly the same portion of survey participants (87%) is ready to follow safe listening practices and promote safe listening. They believe that recreational noise-induced hearing loss can be avoided through implementation of safe listening strategies and reduction of exposure to loud sounds in recreational/entertainment settings.

Table 6. Willingness to follow safe listening rules to avoid hearing loss

Yes	282	87
No	42	13

4. Conclusion

This study resulted in several key findings important to assessing the challenge of making listening safe. Despite the documented negative effects of recreational noise-induced hearing loss, it remains challenging to make people engaged in safe listening habits. These habits seem quite obvious - “(1) lowering the intensity of loud music, and (2) shortening the listening duration of loud music” [3].

While the study was limited to the academic community of students and teachers, it illuminates the role of knowledge. Even a brief numerical data regarding the scale of avoidable hearing loss in young adults provided to participants in the course of the survey influenced a good deal their attitudes towards exposure to loud sound in entertainment venues and the need to control the intensity of loud music. Individuals who lack knowledge, tend not to feel particularly at risk, and do not see the benefits of prevention. Knowledge is one of factors identified as those which “can be influenced by a health communication intervention” [4].

Currently no recommendations or standards for recreational noise exposure are obligatory, and young people may expose themselves frequently to unsafe listening levels. This is evidence of a critical need for educating and motivating the general public to stop risky behaviour and for promoting healthy listening habits in young adults. Educators and public health administrators engaged in planning the prevention of hearing loss can use the survey results to address factors which may persuade young people to adopt safe listening behaviours.

5. References

[1] https://www.who.int/activities/making-listening-safe

[2] Berezovska I, Minakova K. Best World Practices for Hearing Impaired Learners: the Project Overview. Hands-on Science. Science Education. Challenges and Opportunities of Distant and Online Teaching and Learning. Costa MF, Dorrío BV (Eds.), 135-140, Braga, Portugal, 2021.

[3] Gopal KV, Champlin S, Phillips B. Assessment of Safe Listening Intentional Behaviour Toward Personal Listening Devices in Young Adults. Int. J. Environ. Res. Public Health, 16(17), 3180, 2019.

[4] Diviani N, Zanini C, Amann J, Chadha S, Cieza A, Rubinelli S. Awareness, attitudes, and beliefs about music-induced hearing loss: Towards the development of a health communication strategy to promote safe listening. Patient Educ. Couns., 102(8), 1506-1512, 2019.

Hands-on Virtual Experiments. Workshop on Virtual Laboratories: How to work with Inquiry Learning Spaces and GoLab Environment

S Zurita i Món[1], *C Díez*[2]
[1]*Departament d'Ensenyament de la Generalitat de Catalunya, Spain*
[2]*Scientix Ambassador*
INTEF Trainer, Spain
szurita@xtec.cat

Abstract. Online laboratories, remote or virtual, are one of the many tools digital technologies have introduced in our classrooms and has opened possibilities that were not present before. They facilitate learning about concepts as well as experimentation and scientific method in STEM subjects.

But teachers need to know this labs and how to use them in classroom. This paper describes the workshop to tackle those issues: How can teachers use online labs as effective scaffolding tools to explain abstract concepts and to provide an environment for discussion, exchange and construction of knowledge?

Keywords. Community for Science, IBSE, Online Laboratories, Scientific Method, STEM Curriculum.

1. Introduction

There are many collections of open digital educational resources to design innovative educational scenarios. The use of online laboratories, remote or virtual, and the access to real scientific databases allow learning about concepts, models and experimentation and scientific method in STEM subjects in flexible environments.

How can teachers use online labs as effective scaffolding tools that explain abstract concepts and provide an environment for discussion, exchange and construction of knowledge?.

Online laboratories can be used in teachers instruction lessons to simulate on screen experiments that are traditionally performed in school laboratories Online laboratories provide opportunities to use materials, virtual equipment and tools designed to replicate a real laboratory that can't be used or afforded in common school equipments.

On the other hand, the use of an inquiry learning (IBSE or Inquiry-Based Science Education) [1,2], is much closer to the method of real scientific work, and it also allows students to work on a series of basic thinking skills that we want to develop in all students.

Which are the STEM competences that can be addressed by online laboratories?. Where could we search Labs online and pedagogical material associated to them?

How can we use virtual labs to develop basic investigative skills and allow to learn efficiently about scientific method [3]?

This are the questions that the proposed wokshop pretends to discuss and adress.

2. Objectives

The goals of the workshop are:

1. Know what online labs are, which types exist and where teachers can find them
2. Reflect about the advantages, limitations and ways to use them in secondary education science and technology classrooms.
3. Practice the search for online labs on a specific subject and discuss their availability.
4. Discuss the way we can use online labs in our classrooms and explain some notions about inquiry practices.
5. Look for didactic material associated to labs in Golab project and understand the philosophy and possibilities of sharing materials in the graasp [4] platform of the project.

3. Structure of the workshop

The workshop is divided in four parts

1. Basic knowledges

   Where we will talk about the precious experience of participants with labs (hands-on or online) and explain the main concepts related to them, covering objectives 1 and 2.

2. Looking for online labs

ISBN 978-84-8158-937-5

We will see the difficulties of looking for labs in an open search, as compared to the possibility of using collections of labs like the one curated by Golab project. This part deals with objective 3

3. Using online labs in classroom

   We will discuss the ways to use online labs with a group of students to learn concepts or science abilities, and introduce inquiry learning, covering objective 4

4. Looking for and evaluating activities that use online labs in Golab project repository

   We will share some quality inquiry learning spaces included in Golab platform graasp and evaluate their main features. This part deals with objective 5.

5. Teachers proposals and closure

   Finally, we will discuss the possibility of creating our own activities and evaluate the workshop

3.1. Basic knowledge

This part of the workshop begins with an introductory activity aimed at knowing the pre-concepts and previous experience with hand-on labs and online labs of the assistants.

After that, we will define the three basic types of online labs (remote labs, virtual labs and database collections) and see some of the examples in Golab and Phet collections.

To close this first part, we will discuss with participants which are the reasons to use this kind of tools in classroom and the difficulties we can meet.

3.2. Looking for online labs

Looking for online labs with a specific problem of theme in mind is not as easy as one might think when using general searching tools.

First, and this is one problem shared by repositories and by general searchers, the recovering of the curricular subjects and themes is far from perfect. There are fields, specially in physics, with a long habit of using simulations, while in other subjects like geology, engineering or maths scholar online labs are much less common.

On the other hand, resources found in on opened searches are not always easy to use. Sometimes they have no proper manual and it's not simple to deduce the way to deal with them. And is really time-consuming to discover the usability and availability conditions: are they free? Can they be used by 30 students at the same time? Do we have access as school? Do they collect data from our students…?

In this second part of the workshop participants will look for labs in two of the more important open collections for secondary education: Golab [5] and Phet [6]

3.3. Using online labs in classroom

In third part of the workshop we will discuss how can we, as teacher, use the labs in our classrooms, with a quite numerous group of students, in order to achieve significant learning goals.

Online labs can be used in teachers explanations as a way to visualize ideas and models and boost student comprehension of phenomena.

Students can be allowed to play and interact by their own with the simulations. Even if some authors [7] have defended the potential of this approach, our experience is that is not very useful in formal education, because learning is slow and superficial, complicated to direct, and students tend to stay really short times involved in the lab if not directions are given to them, unless a specific objective is given to them.

On the other hand, labs are poweful tools when combined with inquiry learning proposals. In the workshop we will discuss the different levels of inquiry [8] and how important the presentation on the questions presented to the students is to improve their learning.

We will work on the structure of learning spaces and inquiry cycles proposed by Golab project.

3.4. Looking for and evaluating activities that use online labs in Golab project repository

This part of the workshop is aimed at addressing the last objective.

We will explain how to look for materials in Golab site, will analyse some quality learning spaces proposed and discuss possibilities, advantages and disadvantages of the proposed digital environment and format.

3.5. Teachers proposals and closure

After that, participants will have time to look for other didactic activities proposed, evaluate them and, if they desire, imagine propositions or ways to present and use a specific online lab to maximize students learning.

The last activity will be a short reflection about what we have learned and how useful that would be in our professional realities.

4. Conclusions

This paper describes and propose the structure for a workshop where participants will learn about online labs and their didactic use in primary or secondary education.

We will focus on Golab environment, that is a repository of online labs with an inquiry pedagogical proposal associated and an online space where teachers can create, share and modify classroom activities with this methodological orientation.

5. Acknowledgements

To European Schoolnet, international network to mobilizes the integration of STEM knowledge and technologies as an engine for improvement, to respond to the need for professionals in 21st century Europe [4]. To GoLab NextLab a European collaborative project [5]. To Scientix the Community for Science Education in Europe [6].

6. References

[1] Rocard M. Science Education NOW: A renewed Pedagogy for the Future of Europe, Brussels: European Commission, 2007. http://ec.europa.eu/research/science-society/ document_library/pdf_06/report-rocard-onscience- education_en.pdf

[2] Minstrel J, van Zee EH. Inquiring into Inquiry Learning and Teaching in Science. Washington: American Association for the Advancement of Science, 2000.

[3] Brinson JR. Learning outcome achievement in non-traditional (virtual and remote) versus traditional (hands-on) laboratories: a review of the empirical research. Computers & Education, 87, 218-237, 2015.

[4] https://graasp.org/

[5] https://www.golabz.eu/labs

[6] https://phet.colorado.edu/en/

[7] Mitra S. The Hole in the Wall: Self-organising Systems in Education. New York NY, 2006.

[8] Buck LB, Bretz SL, Towns MH. Characterizing the Level of Inquiry in the Undergraduate Laboratory. Journal of College Science Teaching, *38*, 52-58, 2008.

ISBN 978-84-8158-937-5

Valentina Tereshkova and Hedy Lamarr through Scientific Experimentation. A Science Show about Their Role throughout History

I Estévez Juncal, A Novas Arribas,
A Porto Rodal, M Quiroga Bóveda
IES Johan Carballeira in Bueu, Spain
wscientifics@gmail.com

Abstract. It is well known that women's role in science has always been left to a second screen, dominated by masculine presence. Even though the difference between the number of men and women centuries ago is comprehensible due to historical context, it cannot be justified nowadays. At the same time, the fact that women have a lower presence in science is just the result of a masculinised and patriarchal society. The lack of feminine references in the media and textbooks is, not only unfair for those people, but also a scourge that according to multiple studies is the main reason for the absence of women in STEM degrees and the key for their visibilization to promote the STEM vocation among women.

With this approach it is intended to visibilize the role of two scientific references, Hedy Lamarr and Valentina Tereshkova, through a science show that links their lives and their major contributions to scientific experiments that walk with the narrative and provide support to make them known.

Keywords. Hands-on, science demonstration, stemnisim, women in science.

1. Introduction

Historically, it was believed that women and young girls didn't have the capacities required to develop science [1]. This fact, always subordinated to the masculine monopoly established in this area, incited the femenine population's exclusion from scientific spheres, with few exceptions.

Even though this situation is comprehensible based on the historical context, currently the paradigm is different. It continues to exist a discrimination against women in science, despite it has been demonstrated over and over that they do have the necessary competences to participate in it. Nonetheless, it is still found a noteworthy difference between the number of men and women that ingress annually in the different STEM degrees [1,2] and even there is still an impressive percentage of people that assure that women aren't valid for scientific work [3].

The source of this conflict can be found not only in the legacy of masculinized and patriarchal society, but also in the lack of feminine references in the media [4-6], textbooks [7,8] and inherently daily in communities. Such absence, based on several studies, affects remarkably the number of women that decide to pursue STEM vocations and visibilization in the media [9,10].

This project puts the spotlight on the necessity of changing this situation and provides feminine scientific referents that stir up the vocation of women in science and support their decision of studying STEM degrees. For this, two women are taken, Hedy Lamarr and Valentina Tereshkova, as a starting point to develop a narrative discourse through their lives, achievements and contributions to science. Everything is integrated into a science show, which presents these two women in an entertaining and engaging way to the public, for a better and improved learning, using scientific experiments.

The show composes an example of comprehensive learning, for its didactic nature, as well as light, that pursues teaching the public essential science and equality issues while getting in touch with feminine referents [11]. Hence, it spreads the interest in knowing more scientists and increases the inclination of the assistants towards the scientific area. Thereupon, the show aims to serve as a bridge between basic science and the big public, essentially through communication and emotions, so that it emphasises the need of upgrading and implementing these qualities in the scientific spheres. It should be noted the lack of performances of the same kind, so it is believed that this approach is of particular interest.

It is well known that we live in a society that seeks to hide and remove women and girls from the scientific world, thus creating a great barrier that does not reveal the number of

ISBN 978-84-8158-937-5

female references.

To explain this phenomenon and link them with the show, metaphorically related experiments will be used, revealing two great scientists.

Therefore, in order to break down these barriers and find these hidden references, in the first experiment, a non-Newtonian fluid will be created, using corn flour and water, which will be linked through a poetic form with the quicksand that they intend to hide from the women scientists of the world. This way, it is intended to demonstrate that under that oppression great treasures can be found, such as Valentina Tereshkova or Hedy Lamarr, who despite their contributions, few people know about them.

Therefore, experiments related to their achievements will be treated individually. In the case of Valentina, two types of rockets will be created, using air pressure and alcohol as propellant. For Hedy Lamarr three experiments will be carried out, two related to acid-base balances, by extracting a natural indicator from red cabbage and commercial indicators, and the third consisting of creating an air cannon.

To finish with the experimental part of the show, two demonstrations will be held. In them, special emphasis will be placed on fire, since it will be used as a metaphor in reference to the discrimination against women that has been discussed throughout this article. The first consists of the creation of flames of different colors, while the second will consist of planting fire in your hands. The latter will be the great closing, referring to the Phoenix. The fire will represent the rebirth of the figures of women scientists and the struggle to preserve their role and contributions without falling into oblivion.

Finally, a conclusion to this entire show will be made, with great emphasis on the work of Valentina Tereshkova and Hedy Lamarr and on the necessary visibility to have female references.

2. Show description

The show will be carried out by 4 people and will last 45 min. During this, a series of scientific demonstrations will be carried out as a master session interspersed with manipulative activities for small groups. All this serves as a common thread to publicize the role of two scientific women, Hedy Lamarr and Valentina Tereshkova, as well as to provide female references in science and raise awareness of the historical importance of women in science and society.

3. Experiments

3.1. Unearthing the woman scientist. Preparation of a non-Newtonian fluid with corn flour

3.1.1. Introduction

It is intended to show in a metaphorical way the concealment of female figures in science. For this, reference is made to the quicksand created with corn flour.

3.1.2. Objectives

- Making visible the female figure in science.
- Present a manipulative activity based on a non-Newtonian fluid.

3.1.3. Materials

- Cornmeal.
- Water.
- Container to introduce the mixture.

3.1.4. Process

First, a small amount of cornmeal is added. Water is then added until a dense liquid with the desired texture is achieved by kneading the mixture.

Figure 1. Playing with the non-Newtonian fluid

ISBN 978-84-8158-937-5

Once obtained, the purpose of this experiment is to visualize that to the touch it behaves like a liquid substance but, by exerting pressure, the substance increases its hardness. However, when the pressure decreases it returns to its initial shape. This experiment allows the public to be able to play with it, since its hardness can be modified by hitting or throwing it as it can be seen in figure 1.

3.1.5. Justification

A non-Newtonian fluid is one in which the shear stress is proportional to the strain rate.

An example of a low-cost non-Newtonian fluid with household materials is obtained by mixing cornstarch and water [12].

3.2. Remembering Valentina Teresh-kova. Building an air rocket

3.2.1. Introduction

The first protagonist is the woman who started a new normality in the field of cosmology, introducing a large succession of female astronauts.

For this reason, this experiment allows the figure of Valentina Tereshkova to be brought closer to the public by creating rockets that will be propelled by an instrument created in the session itself, with this type of rocket, all participants can carry out a small-scale launch.

3.2.1. Objectives

- Show a rocket propelled by air pressure.
- Relate the role of Valentina Tereskova with an experimental demonstration.
- Encourage the public to make a rocket that can be propelled by themselves.

3.2.2. Materials

- For each launcher
    - 2 PVC tubes of 35 mm diameter.
    - 1 straight elbow for 35 mm PVC union.
    - 1 bottle with a stopper of 1 L.
    - 2 metal brackets.
    - Scotch tape.
    - Contact glue.
- PVC glue.
- 1 paper roll tube
- 1 cardboard cone.
- Cutter.

3.2.3. Process

First, the participants will be divided into small groups.

Next, the rocket is made by taping the cone with the kitchen paper tube.

Later, the launcher is assembled, joining the brackets to the PVC tube. Next, a hole will be made in the bottle cap and it will be attached to the bottom of the tube with contact glue. An example of this launcher could be seen in Fig. 2.

Figure 2. Example of the launcher

The rocket is placed on top. In order for the rocket to be propelled, the bottle must be stepped on. For this, the groups will be placed in respective rows for the launch of the rocket.

3.2.4. Justification

When stepping on the bottle, the air is compressed in it and is expelled towards the area of the rocket, thus causing it to fly away [13].

3.2.5. Security

It is necessary to leave a clear area for the rocket to fall.

3.3. A small step for the human being, a big step for equality. Ethanol-powered rocket launch

3.3.1. Introduction

Valentina Tereskova has gone down in history as the first woman to travel to space, becoming a benchmark all over the years.

This activity is intended to relate their history and achievements with an experimental demonstration. This consists of creating, again, a rocket propelled on this occasion by a combustion produced with ethanol.

3.3.2. Objectives

- Show a rocket powered by a gaseous fuel.
- Carry out a controlled explosion.
- Significantly link the role of Valentina Tereskova with an experimental demonstration.

3.3.3. Materials

- Long cane lighter.
- Drilled cap.
- 100 mL plastic bottle.
- 96º alcohol.

3.3.4. Process

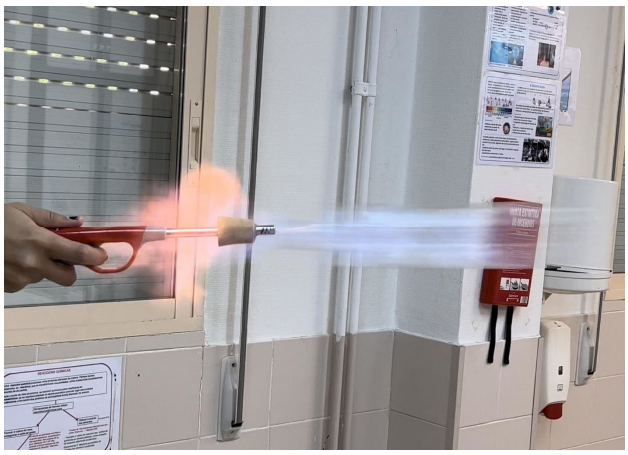


Figure 3. Demonstration of the alcohol rocket

First, the bottle is filled with a small amount of ethanol. Subsequently, it is covered and shaken to evaporate the fuel. Possible droplets are then removed without evaporating, as they can cause burns. Finally, the pressurized lighter is inserted, checking that there are no drops of ethanol left, and the flame is lit, causing the bottle to shoot forward (Fig. 3).

3.3.4. Justification

The combustion of ethanol in the presence of oxygen generates CO_2 in a gaseous state and water (eq.1) [14]. This CO_2 causes an increase in the internal pressure in the bottle, which causes it to shoot forward.

$$C_2H_5OH_{(g)} + 3\,O_{2\,(g)} \rightarrow 3\,H_2O_{(g)} + 2\,CO_{2(g)} \qquad \Delta H^0 = -890\,KJ \quad (1)$$

3.3.5. Security

A long-stemmed lighter should always be used since in the first instant of combustion a flame will be propelled backwards, which may cause minor burns.

3.4. All groups matter. Obtaining the LGTBIQ+ flag from commercial acid-base indicators

3.4.1. Introduction

According to the latest research by COGAM, the Collective of Lesbians, Gays, Transsexuals and Bisexuals of Madrid, carried out in 2019, 17% of Secondary students did not consider themselves heterosexual and almost 10% of them preferred to maintain their sexual orientation in secret [15]. In addition, this same study concludes that almost 40% of the students surveyed present some type of slight prejudice towards LGTBI people, and that 10% have somewhat more intense prejudices.

That is why affective-sexual education and sexual diversity are basic pillars to be treated in order to achieve a climate of respect and tolerance against LGTBIQ+phobias.

This experiment aims to teach new ways of creating hidden messages, taking Hedy Lamarr and her "Secret Communication System" project as a reference, to bring the little ones closer to their figure in an attractive way. In addition, this occasion is used to show more inclusive values with the LGTBIQ+ flag.

The role of Hedy Lamarr was of vital importance for the development of the Second World War, since the projectile guidance system had serious deficiencies, since it was easily discovered by the enemy. For this reason, together with George Antheil, he

ISBN 978-84-8158-937-5

developed an encryption system by changing the transmission frequency based on the design of the rolls of a player piano. This system is the basis of Wi-Fi and modern wireless communications [16].

3.4.2. Objectives

- Make the LGTBIQ+ flag appear with acid-base reactions.
- Make citizens aware of the importance of affective-sexual diversity.
- Show the figure of Hedy Lamarr in an attractive way, relating it to encrypted messages.

3.4.3. Materials

- 6 test tubes.
- 1 rack.
- 5 Pasteur pipettes.
- 1 washing bottle

3.4.4. Reactives

- 0.5M NaOH.
- 0.1M HCl.
- Phenolphthalein solution.
- Thymolphthalein solution.
- p-nitrophenol solution.

3.4.5. Process

First, the indicator solutions are prepared as follows: For the phenolphthalein solution, 1 g of it is dissolved in 60 mL of 96º alcohol and 40 mL of distilled water are added.

For the dissolution of thymolphthalein, 0.1 g of it is dissolved in 60 mL of 96º alcohol and 40 mL of distilled water are added.

For the dissolution of p-nitrophenol, 2 g are dissolved in 60 mL of 96º alcohol and 40 mL of distilled water are added [17].

Second, the 6 test tubes are filled as follows, to thereby obtain the LGTBIQ+ flag.

- Tube 1 (Red):
  - 5 drops Phenolphthalein.
  - 2 drops p-nitrofenol.
  - 1 drop HCl 0,1 M.
- Tube 2 (Orange):
  - 1 drop Phenolphthalein.
  - 5 drops p-nitrophenol.
  - 1 drop 0.1M HCl.
- Tube 3 (Yellow):
  - 1 drop p-nitrophenol.
  - 1 drop 0.1M HCl.
- Tube 4 (Green):
  - 2 drops Thymolphthalein.
  - 3 drops p-nitrophenol.
  - 1 drop 0.1M HCl.
- Tube 5 (Blue):
  - 1 drop Thymolphthalein.
- Tube 6 (Violet):
  - 1 drop Phenolphthalein.

With the help of a washing bottle in which the 0.1 M NaOH solution was introduced, the test tubes were filled, thus obtaining the LGTBIQ+ flag, as can be seen in Fig. 4.

Figure 4. LGTBIQ+ flag with tubes

3.4.6. Justification

Table 1. Colors of the different acid-base indicators and shift ranges

Indicator	Phenolphthalein	Thymolphthalein	p-nitrophenol
Color acid form	Colorless	Colorless	Colorless
Turn range	8.2-10	9.3-10.5	2.7-3.9
Color basic form	**Fuchsia**	**Blue**	**Yellow**

All the indicators used here do not present color in their acid form [18,19], as reflected in Table 1. With the appropriate combination of these, a wide spectrum of colors will be

obtained with which the LGTBIQ+ pride flag will be obtained.

3.4.7. Security

Although hydrochloric acid and sodium hydroxide are used in low concentration, the use of laboratory gloves and glasses is recommended. The indicators phenolphthalein and thymolphthalein are not classified as dangerous according to Directive 67/548/CEE. p-nitrophenol is toxic by inhalation and ingestion.

3.5. Revealing secret messages with Hedy Lamarr. Use of red cabbage to obtain a natural pH indicator.

3.5.1. Introduction

The second scientist treated here, Hedy Lamarr, is known worldwide for her contribution in the field of war to fight against the Nazis, as mentioned above.

This time she will show a way to make color changes by taking cryptographic messages as a reference.

3.5.2. Objectives

- Change the color of various substances using manipulative materials without danger.
- Make the figure of Hedy Lamarr visible.

3.5.3. Materials

- For each group:
  - 1 Erlenmeyer flask.
  - 1 Rack.
  - 5 test tubes.
- Reagents:
  - Red cabbage.
  - 96º alcohol.
  - Sodium bicarbonate.
  - Lemon juice.
  - Vinegar.
  - Ammonia.
  - Soda.

3.5.4. Process

First, the participants are separated into groups of approximately 5 people. Each receives an Erlenmeyer flask along with a rack and 5 test tubes.

Secondly, to obtain the extract from the red cabbage, several leaves are cut from it and placed in the flask. They are covered with alcohol and left to stand until the solution turns purple, which indicates that the extraction of anthocyanins has been successful.

A small aliquot of the red cabbage extract is added to each test tube and diluted in water to the volume of the tube. Finally, the substance to be analyzed is added and the color change is observed.

3.5.5. Justification

Red cabbage has pigments known as anthocyanins, which change color depending on the pH, making it an excellent natural pH indicator [20].

3.6. Making the invisible visible. Visualization of longitudinal waves by air cannon.

3.6.1. Introduction

Hedy Lamarr's main contribution is based on something a priori invisible, radio waves. To bring wave movements closer to the general public, a longitudinal wave is created with an air cannon into which smoke has been previously introduced.

3.6.2. Objectives

- Show a longitudinal wave.
- Visualize the scientific contributions made by Hedy Lamarr.

3.6.3. Materials

- Commercial air cannon: Airzooka. [21]
- Smoke machine.

3.6.4. Process

A small amount of smoke from the fog machine is drawn into the air cannon. The

ISBN 978-84-8158-937-5

cannon is then started up and the longitudinal waves are emitted.

3.6.5. Justification

A mechanical wave is a disturbance travelling through a material or substance that is the medium of the wave. As the wave travels through the medium, the particles that constitute the medium experience displacements of various types, depending on the nature of the wave. A longitudinal wave is one in which the motions of the particles in the medium are back and forth in the same direction as the wave travels. A longitudinal wave can be created by the stretching of an elastic membrane confined in an open tube. If smoke is introduced into it, so the front of the wave can be visualized [22].

3.7. Eliminating prejudices. Obtaining colored fire by combustion of metallic salts

3.7.1. Introduction

With this demonstration it is intended to show in a metaphorical way the consequence of misogynistic thinking throughout history, that is, flames of different colors are lit, referring to how female figures have been hidden in science.

3.7.2. Objectives

- Make visible the importance of female role models in science.
- Light fires of different colors.

3.7.3. Materials

- 3 lighters
- 3 atomizers

3.7.4. Reactives

- NaCl dissolution
- KBr dissolution
- H_3BO_3 dissolution

3.7.5. Process

Solutions are prepared in a 50% hydroalcoholic solution by adding a small amount of solute. Each solution is transferred to their respective atomizers. These solutions are vaporised over a flame to obtain the desired colours.

3.7.6. Justification

Under normal conditions, atoms are in their state of minimum energy, by providing energy to these atoms through combustion, the electrons pass to an excited electronic state, absorbing part of said energy. When the electrons return to their fundamental electronic state, they emit radiation in the form of light, which gives the flame a characteristic colour [23] according to table 2 [24]:.

Table 2. Colors of the different metals in the flame

Cation	Colour
Na^+	**Yellow**
Li^+	**Red**
B^{3+}	**Green**

When projecting solutions of salts of different metals onto a flame, different colours are obtained in the flame as can be seen in the Fig. 5.

Figure 5. Example of the different flame colors.

3.7.7. Security

When working with fire it is necessary to establish a security perimeter. The use of an insulating blanket is recommended.

3.8. The rise of the phoenix. Combustion of hydrocarbons on the palm of the hand.

3.8.1. Introduction

This experiment is intended to metaphorically symbolize the elimination of misogynistic thoughts through the appearance and disappearance of fire.

3.8.2. Objectives

- Create a controlled flame.
- Symbolically refers to the concealment of female figures in science.
- Create a show with fire.

3.8.3. Materials

- Butane.
- Crystalizer.
- Water.
- Lighter.
- Liquid detergent.

3.8.4. Process

To carry out this experiment, first the container will be filled with water and a small amount of soap will be added. The butane canister is then submerged upside down and the valve is pressed, thus generating bubbles containing butane.

Secondly, the hand is soaked in plenty of water. Small bubbles are caught in the hand and set on fire (Fig. 6).

3.8.5. Security

When working with fire it is necessary to establish a security perimeter. The use of an insulating blanket is recommended. A protective barrier should be created on the arms with the water.

Figure 6. Example of the flame in hand

4. Acknowledgements

To the IES Johan Carballeira for the space, material and support received and to all the people who have given us an opportunity.

5. References

[1] https://elpais.com/elpais/2018/06/10/planeta_futuro/1528661907_969674.html

[2] Ramos Rodríguez A. Análisis de la presencia de las mujeres científicas en los libros de texto de educación secundaria y su repercusión en las carreras STEM. TFM, Universidad de Cadiz, 2021.

[3] Villar C. ¿Mujer y ciencia? Aún hay escépticas. Faro de Vigo.

https://www.farodevigo.es/galicia/2022/06/12/mujer-ciencia-hay-escepticas-67176034.html

[4] García Nieto MT. ¿Son invisibles las mujeres científicas? Estudios sobre el Mensaje Periodístico, 19, 783-792, 2013.

[5] https://mujeresconciencia.com/2018/02/14/la-prensa-las-cientificas/

[6] https://mujeresconciencia.com/2017/10/18/marti-dominguez-las-mujeres-ciencia-estan-infrarrepresentadas-la-fotografia-prensa-espana/

[7] https://elpais.com/politica/2018/07/07/actualidad/1530952055_654127.html

[8] https://www.educacionyfp.gob.es/dctm/revista-de-educacion/articulos363/re36312.pdf?docu

mentId=0901e72b817fcfba

[9] https://www.educaweb.com/noticia/2021/02/10/visibilizar-cientificas-mas-chicas-estudien-carreras-stem-19450/

[10] https://www.educaweb.com/noticia/2017/11/29/eleccion-carrera-enfoque-genero-factores-clave-implicaciones-socioeducativas-16203/

[11] Romero-Ariza M. El aprendizaje por indagación, ¿existen suficientes evidencias sobre sus beneficios en la enseñanza de las ciencias?. Revista Eureka sobre enseñanza y divulgación de las ciencias, 14(2), 286-299, 2017.

[12] https://www.ucm.es/data/cont/docs/76-2015-03-19-Fluido%20no%20newtoniano.pdf

[13] Tomás Serrano A, Hurtado-Pérez J. Cohetes de aire: Construcción, fundamentos y aplicaciones didácticas para el estudio de la Física en bachillerato y secundaria. Revista Eureka Sobre Enseñanza y Divulgación de Las Ciencias, 16(3), 1–10, 2019.

[14] de Prada Pérez de Azpeitia FI. La asombrosa química de las deflagraciones controladas. Revista Eureka Sobre Enseñanza y Divulgación de Las Ciencias, 17(2), 1-10, 2020.

[15] https://cogam.es/wp-content/uploads/2020/04/LGBTfobia-en-las-aulas-2019.pdf

[16] https://espacio.fundaciontelefonica.com/evento/hedy-lamarr-y-el-sistema-secreto-de-comunicaciones/

[17] Durán Torres C, Aguilar Muñoz ML. Reacciones encadenadas: del reloj de yodo al arco iris químico. Revista Eureka sobre enseñanza y divulgación de las ciencias, 8(1), 105-110, 2011.

[18] Petrucci RH. Química General. Pearson Educación, 2011.

[19] https://www.merckmillipore.com/ES/es/product/4-Nitrophenol,MDA_CHEM-106798?

[20] Chang R, Goldsby KA. Química. McGrawHill Educación, 2013.

[21] https://www.amazon.com/-/es/Imagine-Airzooka-Juguete-verde-Plateado/dp/B00C2S97HA/ref=pd_lpo_2?pd_rd_i=B00C2S97HA&psc=1

[22] Sears FW. Fisica Universitaria. Pearson Educación, 2011.

[23] Chang R, Goldsby KA. Química. McGrawHill Educación, 2013.

[24] Sanger MJ. Flame tests: Which ion causes the color? Journal of Chemical Education, 81(12), 1776A, 2004.

ISBN 978-84-8158-937-5

PBL at School: A Case Study ALGAE - Analysis of Global Warming in Algae Efficiency

I Sárria, J Reis, R Rocha
Colégio Luso-Francês in Porto, Portugal
rita.rocha@lusofrances.com.pt

Abstract. Two 12th grade students from Colégio Luso-Francês wanted to develop a project related with the impact of climate change on biodiversity. The research was conducted in MIP [Research Project Methodologies], an extra-curricular discipline, which applies a Project-Based Learning [PBL] methodology to the formal curricula. In HSCI 2022 the authors will present ALGAE.

Keywords. Project-based learning, climate change, biodiversity, algae, ecosystem services, beta-diversity.

1. Introduction

1.1. Background information

Global climate change is among the main drivers of the overall decline in biodiversity [5]. Canopy-forming algae are considered to be ecosystem-engineers, sustain critical ecosystem services in coastal habitats, such as food, protection and breeding grounds for other organisms, CO_2 sequestration, nutrient cycling, and shoreline protection [6][8]. Many algae species are suffering declines [14]. If climate change affects marine biodiversity, the opposite is also true.

The loss of marine biodiversity is weakening the ocean ability to play its role as a global ecological and climate regulator [7]. The Atlantic coast of Europe is a hotspot of warming, being the Iberian Peninsula one of the most affected areas by climate change [3]. For most temperate brown algae, the Iberian Peninsula is the southernmost distributional limit, serving as refuge in the last glacial period [2].

Rising temperatures lead to one of three behavior patterns: adaptation, migration or extinction. Research indicates that the key for the species adaptation capacity may reside in beta-diversity as a means to provide insights into local and regional biodiversity patterns [13].

1.2. Objectives of the research

ALGAE research aimed at study the impact of thermal stress in *Fucus guiryi* algae performance, using productivity as an indicator. To achieve this objective, two populations from North [Viana do Castelo] and South [Algarve] of the Portuguese coastline were compared regarding induced temperature gradual increases, as a mean to predict the most adapted under global warming scenarios.

2. Materials and Methods

2.1. Sampling area characterization

ALGAE research was conducted in two sampling areas: Praia Norte, Viana do Castelo, Portugal [41.69776, -8.85097] and Praia da Amoreira, Algarve [37.35043, -8.84523] (Fig. 1).

Figure 1. Sampling area; Praia Norte, Viana do Castelo [41.69776, -8.85097]; Praia da Amoreira, Algarve [37.35043, -8.84523]

Amoreira is an embayed beach located at the Southwest Portuguese Atlantic Coast, backed by a dune field and bounded in the south by the Aljezur rivulet mouth. Amoreira is characterized by semi-diurnal ocean tides with winds and waves along the seasons predominantly coming from Northwest, [4], with an average sea surface temperature [SST] peak in the range 20 to 23°C during summer and 15 to 16°C during winter. Praia Norte is a rocky shore, with abundant low tide channels and rock pools, with a typical pattern of a beach sheltered with brown algae [*Fucus spp*.,

ISBN 978-84-8158-937-5

Pelvetia canaliculata and *Ascophyllum nodosum.* The North Winds at Praia Norte, named “nortadas”, generate in this area a phenomenon of upwelling during the period between June and October, favouring an increase in biological productivity. The average SST in Praia Norte peak in the range 18 to 21°C on around during summer and 13 to 14°C during winter. This difference may be the driver to morphological between populations.

2.2. Biomodel characterization

Fucus guiryi had been just recently described as an own species [15], being previously classified as *Fucus spiralis*. This genus is still in an early stage of speciation [11] and still able to hybridize [10]. Its Atlantic distribution consists mainly of edge populations, often located in the most southern ranges. At these locations, they present higher genetic diversity because of long-term persistence, leading to the accumulation of mutations [11]. By contrary, newly colonized populations at northern locations, occupying the available habitats after the last glacial maximum, tend to have lower genetic diversity [11]. *Fucus guiryi* southern distribution extends from the South Portugal, Macaronesia, and the Moroccan and West-Saharan coast. At southern limits, the algae seems to have a potentially greater thermal tolerance, in comparison to northern ones [9].

In our research, we noticed morphological difference among northern and southern populations. Viana’s algae grew in larger, more developed clusters with smaller stipes, protruding midrib, smaller air bladders and larger fronds. Meanwhile, the Algarve individuals had longer stipes, discreet midrib, fuller air bladders and shorter fronds. The samples differed also in general length, those from Viana being around 10cm and the ones from Amoreira around 6,5cm. These contrasting morphologies of the populations were a possible indicator of a different response towards temperature variations. The brown algae grows in communities with other species from the same genus, mainly *Fucus vesiculosus* and *Fucus spiralis*, which makes the process of sample identification and collection difficult (Fig. 2).

Figure 2. Morphological diferences between *Fucus guiryi* (top) *Fucus vesiculosus* (middle) and *Fucus spiralis* (down)

2.3. Sampling and sample treatment

Fifteen specimen were collected from Praia Norte, Viana do Castelo, and Praia da Amoreira, Algarve, during February ’22 and March’22, with low tide.

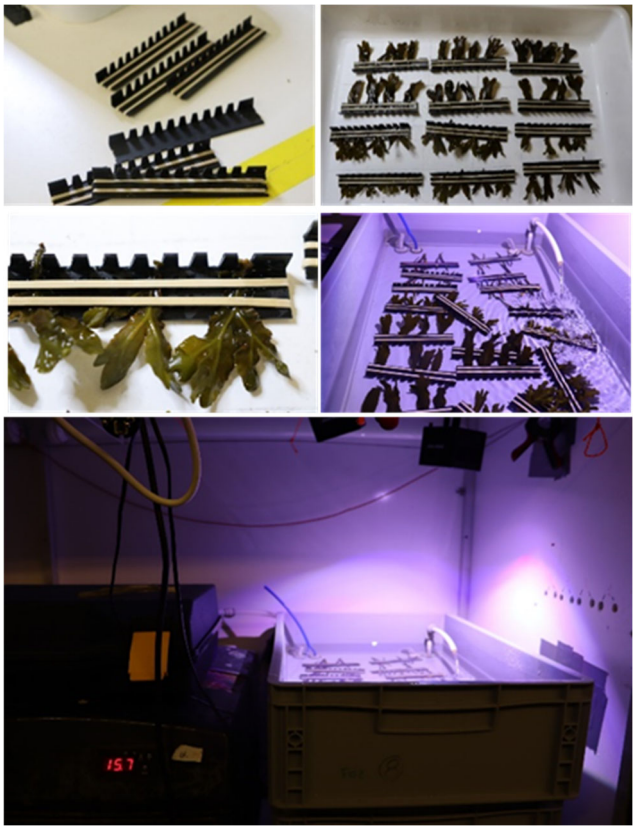
The organisms distribute themselves in the intertidal according to their capacity of adaptation to periodical change of rising and falling tide, undulation; temperature, salinity, dissolved oxygen and pH variations, which function as limiting factors. *Fucus guiryi* colonizes the upper intertidal, being exposed in low tide. Three homogeneous peopling were identified and five specimen were collected from each peopling, guaranteeing a size homogeneity. The algae were transported to the laboratory in an icebox, and put in seawater tanks at 15ºC, for acclimatization during fifteen days.

2.3.1. Algae Incubation Chamber

The incubation chamber contains four 10cl Plexiglass tanks in a bath with continuous water circulation, maintained at the desired temperature with the use of a cooler and a warm water bath. Water inside the incubation chambers was mechanically filtered and UV

filtered through an ozone treatment. Each tank has an electromagnetic spinner in the bottom, which settles in a heating base, and is closed airtight with sensors [OXYPro®, PreSens] attached to the lid, that measure the water's oxygen concentration [ppm] and temperature in successive 20s intervals. The tanks are connected to an external computer, which plots the data collected in graphs of O_2 concentration as a function of time, one for each tank. The box's interior is lined with six LED strips, which simulate the sun's light intensity during the day in the two sampling locations: Viana - 25, 85, 140, 390, 690 µmol.m^{-2}.s^{-1}; Amoreira - 20, 85, 160, 415, 770 µmol.$^{m-2}$.$^{s-1}$) and are activated by an external switch.

2.3.2. Experimental set up



Figures 3a-e. *F. guiryi* – specimen mounted on a grid before incubation

The experiment was conducted at Aquatic Organisms Bioterium (BOGA) indoor facilities of CIIMAR - Interdisciplinary Centre of Marine and Environmental Research. To test the effect of increasing temperature on algae performance, the specimen were exposed to four different temperatures [T15°C, T18ºC, T21ºC and T24ºC], being 15°C established as the lower limit, corresponding to the annual average temperature in the NW Iberia upwelling system. The following temperatures correspond to different hypothetic warming scenarios.

Forty-eight algae were selected for the experiment. After being washed with distilled water, they were weighed and their initial mass was recorded. The specimen were then mounted in a plastic grid using cable ties (Fig. 3a-d). For each temperature range, six specimen were transferred to incubation chambers (Fig. 4) each with 4 tanks of 0,098 L capacity.

Two equal incubation chambers were used, one for each population. In each incubation chamber, three tanks contained the algae and one was left as control.

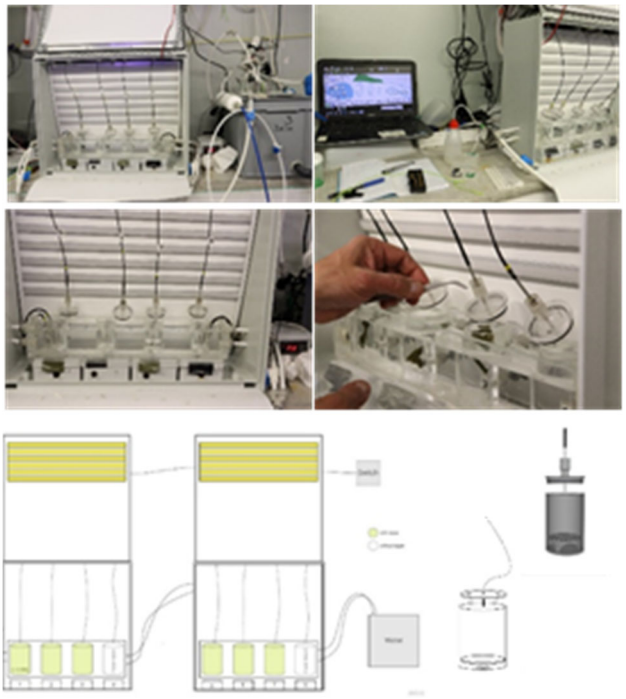


Figure 4. Experimental set up – Incubation chambers with 4 tanks of 0,098 L capacity

Each tank was completely filled with seawater and sealed airtight, in order to prevent any air bubbles affecting the sensors. A total of eight procedures were executed for the four experimental temperatures [T15ºC, T18ºC, T21ºC and T24ºC], two procedures for each temperature which ensured result accuracy. The control contained no algae with the goal of measuring the respiration rate from the microorganisms in the seawater used in the incubation, which was minimal due to the

ISBN 978-84-8158-937-5

mechanical filtering, UV filtering and ozone treatment employed that eliminated the majority of undesired microorganisms. The incubation chambers were closed and the sensors activated, as well as the heating bases and spinner so as to maintain an homogeneous temperature in all the chambers and along the whole procedure. The procedures were conducted in cycles of 30min of darkness, followed by five 20min cycles with light intensity increment, measuring the oxygen concentration throughout all the cycles.

2.4. Data analysis

O_2 concentration was plotted as a function of time for each cycle, being the graph line slope from the darkness and light cycles, the Respiration rate and Gross Primary Product [GPP], respectively. The Net Primary Product [NPP] was calculated using equation 1:

$$NPP = (V \times GPP)/ m \quad (1)$$

where:

V - tank volume

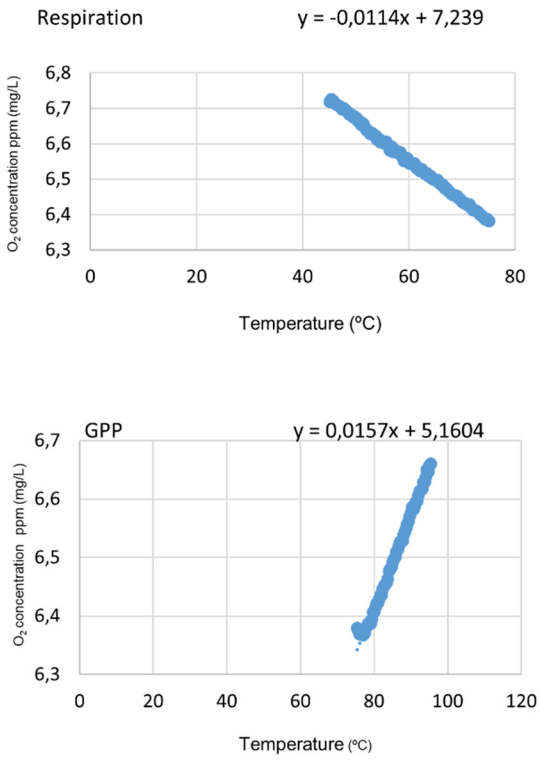
m - algae weight

For each temperature, an average of the highest NPP value was made and plotted as a function of temperature with two series, comparing the two populations.

3. Results

3.1. Respiration/GPP rates

For each temperature, two series of incubations were conducted, one for the Amoreira population and one for Praia Norte population. 6 graphs were made for each specimen at each temperature, corresponding to the 6 cycles of increasing luminosity intensity. Respiration and GPP rates were plotted through O_2 concentration as a function of time. Fig. 5a-b show the respiration rate at 18ºC at the first experimental cycle [0-30min], with a decrease in O_2 concentration [consumption] due to the darkness, and the GPP rate at the same temperature at the second experimental cycle [30-50min], with an increasing O_2 concentration due to a luminosity condition shift. The graph line slope gives the Respiration rate and GPP values for each experiment.



Figures 5a-b. Respiration rate at 18º C in darkness and GPP rate with light

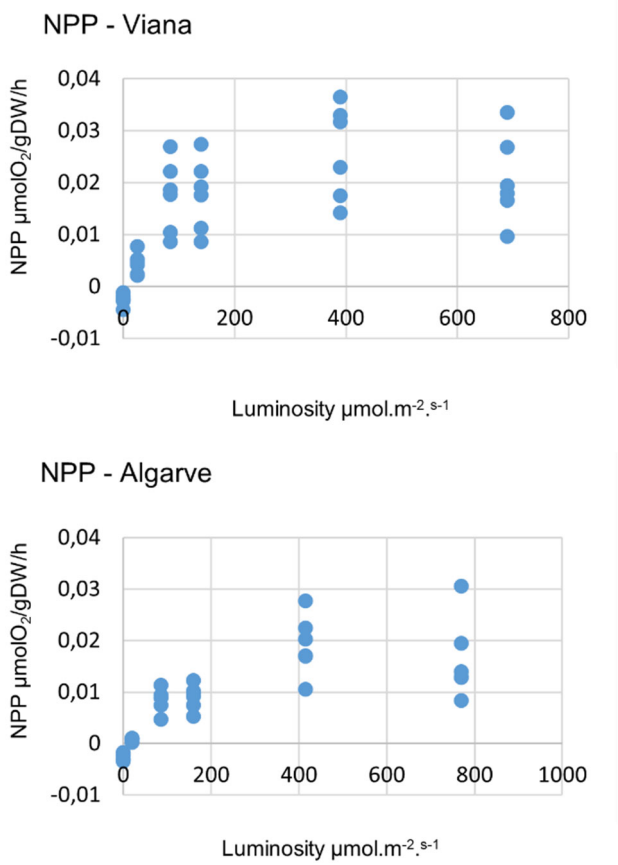
3.2. Productivity rates [NPP]

The Net Primary Product [NPP] for each specimen was calculated at each cycle, for each temperature range, for each population. Each NPP was then plotted as a function of luminosity intensity. Figs. 6a-b show NPP at 15ºC for Amoreira populations and for Praia Norte. At the same luminosity, there is an intraspecific variability regarding productivity rates in both populations.

When we compare both populations, Viana presents a higher productivity at all luminosities for the same temperature.

Fig.7 shows productivity as a function of temperature. In the case of Viana's population, the respiration had a rapid increase, with a mean respiration rate of 2,175 µmolO2/gDW/h when exposed to 15ºC and 2,884 µmolO2/gDW/h at 18ºC, which was followed by a rapid decrease from the 2,884 µmolO2/gDW/h at 18ºC to 1,651µmolO2/gDW/h at 21ºC. As for Algarve's population, the respiration rate was slowly decreasing with the most significant leap from 1,658 µmolO2/gDW/h at 18ºC to 1,248 µmolO2/gDW/h at 21ºC.

ISBN 978-84-8158-937-5



Figures 6a-b. NPP at 15º C for Viana do Castelo and Algarve populations

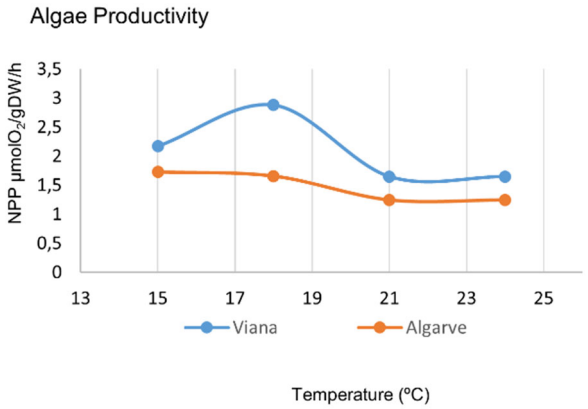


Figure 7. Productivity at different temperatures for Viana do Castelo and and Algarve populations

4. Discussion and conclusion

Results put in evidence a clear difference in the population's behaviour towards a temperature increase. Viana's population, being used to a cooler environment, has an almost instant reaction, exhibited in the first temperature increment, followed by a drop with the second increment, creating a graphic line similar to a parabola. In contrast, the population from Algarve, used to a warmer environment, had no outstanding reaction towards the temperature increase, creating a more linear graphic line.

We can also observe that, even though the northern population shows a higher reactivity, it had a higher photosynthetic efficiency overhaul compared to the southern population.

Nevertheless, the impacts of our experimental driver seemed to be dependent on species intraspecific morphological variation, confirming previous research [1]. Algarve's population seem to present a greater thermal tolerance, maybe due to its higher genetic diversity as a result of long-term persistence, leading to the accumulation of mutations. By contrary, Vianas's population presented a lower thermal tolerance, maybe as a result of lower allelic richness, as a result of a spread of few alleles at the front when expansion of the species from south occurred. As a consequence, while the southern population presented higher thermal tolerance and lower productivity, northern population, by contrary, has a higher production and a lower resistance to thermal stress. In our research the highest thermal limit induced in the experiment was 24ºC. As southern populations already face this range of mean SST during summer peak, we could think that a highest thermal limit had to be tested in order to induce stress in algae southern population. However, historic data evidence that Fucus guiryi populations are already been declining during the past decades [12], which lead us to conclude that at this temperature, southern populations are already facing thermal stress.. This can be seen by the decrease in productivity as temperature increased. Fucoid species tend to have a relatively low dispersal potential and therefore tend to retain genetic signatures of past range shifts [11]. This can be used as a model in climate change shift scenarios. In a predictable ocean warming, the Portuguese coast can face a migration of southern population towards north and, in an extreme scenario, populations can become extinct. Being key species in intertidal ecosystems, the consequences in coastal communities are as unpredictable as harmful.

5. Acknowledgements

F Arenas & A Chambrerie - Laboratory of Coastal Biodiversity, CIIMAR – Interdisciplinary Centre of Marine and Environmental Research, University of Porto, Portugal.

6. References

[1] Anderson C, Scott G. The Occurrence of Distinct Morphotypes within a Population of Fucus Spiralis Journal of the Marine Biological Association of the United Kingdom, 78(3), 1003–1006, 1998.

[2] Assis J, Berecibar E, Claro B, Alberto F, Reed D, Raimondi P, Serrão EA. Major shifts at the range edge of marine forests: the combined efects of climate changes and limited dispersal. Sci Rep, 7 44348, 2017.

[3] Belkin I. Rapid warming of large marine ecosystems. Prog Oceanogr, 81, 207–213, 2009.

[4] Capitão R, Fortes C, Bertin X, Guerreiro M, Simões A. The use of numerical models as complement of wave measurements in Amoreira Beach, Aljezur. ICCCM, 2010 . http://repositorio.lnec.pt:8080/jspui/bitstream/123456789/1002213/1/ICCCM2010_Capit%c3%a3o_et_al.pdf

[5] Casado-Amezúa P, Araújo R, Bárbara I, Bermejo R, Borja Á, Díez I, Fernández C, Gorostiaga JM, Guinda, X, Hernández I, Juanes, JA, Peña V, Peteiro C, Puente A, Quintana I, Tuya F, Viejo RM, Altamirano M, Gallardo T, Martínez, B. Distributional shifts of canopy-forming algae from the Atlantic coast of Southern Europe. Biodiversity and Conservation, 28, 1151–1172, 2019.

[6] Duarte C. Reviews and syntheses: hidden forests, the role of vegetated coastal habitats on the ocean carbon budget. Biogeosci Discuss,1–17, 2016.

[7] Gomes-Vale C, Arenas F, Barreiro, R, Piñeiro-Corbeira C. Understanding the local drivers of beta-diversity patterns under climate change: The case of algae communities in Galicia, North West of the Iberian Peninsula. Diversity and Distributions, 27, 1696–1705, 2021.

[8] Krause-Jensen D, Duarte CM. Substantial role of macroalgae in marine carbon sequestration. NatGeosci, 9, 737–742, 2016.

[9] Lourenço C, Zardi G, McQuaid C, Serrão E, Pearson G, Jacinto R, & Nicastro K.. Upwelling areas as climate change refugia for the distribution and genetic diversity of a marine macroalga. Journal of Biogeography, 43(8), 1595–1607, 2016.

[10] Neiva J, Pearson G, Valero M, Serrão E. Drifting fronds and drifting alleles: Range dynamics, local dispersal and habitat isolation shape the population structure of the estuarine algae Fucus ceranoides. Journal of Biogeography, 39(6), 1167–1178, 2012.

[11] Prinz A. Evolutionary History of the Fucus spiralis / Fucus guiryi Complex Large-scale Analysis of the Distribution Range and Genetic Structure across the Northern Hemisphere, 2020. https://sapientia.ualg.pt/bitstream/10400.1/15512/1/Thesis_Amelie.pdf

[12] Riera R, Sangil C, Sansón M. Long-term herbarium data reveal the decline of a temperate-water algae at its southern range. Estuarine, Coastal and Shelf Science, 165, 159–165, 2015.

[13] Tingley M, Beissinger S. Cryptic loss of montane avian richness and high community turnover over 100 years. Ecology, 94, 598– 609, 2013.

[14] Wernberg T, Bennett S, Babcock RC, de Bettignies T, Cure K, Depczynski M, …, Wilson S. Climate-driven regime shift of a temperate marine ecosystem. Science, 353, 169–172, 2016.

[15] Zardi G, Nicastro K, Canovas F, Costa, JF, Serrão E, Pearson G. Adaptive Traits are maintained on Steep Selective Gradients despite Gene Flow and Hybridization in the Intertidal Zone. PLoS ONE, 6(6), 2011.

Virtual Learning Environments – Issues of Design and Inclusion

F Sousa
Interdisciplinary Centre of Social Sciences, Campus of the University of the Azores – CICS.NOVA.UAc, Portugal
francisco.jr.sousa@uac.pt

Abstract. This paper is based on two research projects related to Virtual Learning Environments (VLE) – MAPE and IGEAD –, with special emphasis on issues of inclusion and design. Inclusion will be considered from different perspectives: student inclusion, geographical inclusion, faculty inclusion, and institutional inclusion. Design will be considered at the crossroads of instructional design with other kinds of design (e.g. web design and graphic design). Findings from MAPE and IGEaD projects will support claims on the importance of low-cost yet scientifically valid VLE in institutions that lack resources, for the sake of inclusion, notwithstanding the importance of highly sophisticated VLE.

Keywords. Inclusion, Instructional Design, e-Learning, Virtual Learning Environments.

1. Introduction

Educational Technology has enormous potential for social inclusion in various contexts. For example, it contributes to the qualification of senior citizens and residents of rural areas [1]. In insular territories – such as the Azores archipelago – it is particularly important to take advantage of such potential. In fact, the limitations of islands in terms of access to quality education can be attenuated by Educational Technology, especially by e-learning in the context of Distance Education. Virtual Learning Environments (VLE) can be considered the basic enablers of e-learning, and can be understood as electronic information systems for the full administrative and didactical support of learning processes [2]. A VLE is also a social space that can be co-constructed by students [3]. Designing a quality VLE requires attention to the students' characteristics and needs, in order to ensure meaningful learning [4].

This paper presents some findings from two research projects related to VLE and inclusion that have been developed in the Azores Islands, Portugal.

One of them is MAPE, meaning modular, asynchronous, participative and emergent. Its implementation began at the University of the Azores, Portugal, in 2011. It studies the development of a model for VLE specifically designed for some courses provided by a Higher Education Institution that has *campi* in three of the nine islands of the archipelago, which raises issues of inclusion. The main technological resource that sustains VLE based on MAPE is the *Moodle* platform, a well-known open source Learning Management System.

The other project is IGEaD, meaning "the potential of Distance Education in the promotion of geographical inclusion in the Azores". Its implementation began in 2020 in the Azores. Compared to MAPE, IGEaD has a wider scope, for it deals with more research questions than MAPE. It also involves more participants and uses a wider variety of research methods and techniques. In both projects, inclusion is considered from different perspectives. One of them is student inclusion. Distance Education can be especially inclusive for students who are also workers, and for students who live far away from the campus, which connects to geographical inclusion, that is, issues of territorial (in)equality.

Attention to faculty inclusion is also needed, inasmuch as instructors' digital competences are variable, which implies that frequently the implementation of Distance Education programs depends on the immediate availability of digitally competent instructors and/or on the provision of professional development programs for some faculty members.

It is also important to consider institutional inclusion, because some Higher Education Institutions can hardly afford the maintenance of quality hardware and software, let alone staff qualification and the expertise that is needed for the development of Distance Education projects.

Issues of instructional design are considered in both projects, but they are more central in MAPE, because designing VLE is at its core. Design principles that have guided successive prototypes of the model are based on the assumption that the development of a VLE can

ISBN 978-84-8158-937-5

benefit from a wide range of contributions, beyond instructional design and Educational Technology. Accordingly, insights from web design, from graphic design, and from other kinds of design, as well as knowledge of universal principles of design [5], might be useful [6].

2. MAPE project – objectives and methodology

MAPE project is aimed at studying the development of a model for VLE that might fulfil the needs of a Higher Education Institution that faces the challenges of serving an archipelago of nine islands with scarce resources. Its general objectives are to evaluate students' satisfaction with MAPE and to improve it.

A course based on MAPE model is organized in modules – usually 6 per semester, which implies that each module lasts for 2 or 3 weeks. Each module has an entry panel with the structure shown in Figure 1. The first line shows the number of the module. It also shows when it begins and when it ends. The second line summarizes the content of the module. The third line provides a link to a page that informs the students about the tasks that they are expected to perform during the module. Guidelines for those tasks can be provided by text, video or podcasts. The fourth line leads the student to a page with information about the expected learning outcomes for the module. It also provides rubrics that indicate achievement criteria. The fifth line provides a link to a forum. Forums ensure ongoing dialogue between the participants – instructor and students. In some modules students' participation is assessed and graded. The last line leads the student to a page with information about his performance in the module. Such information is provided by the end of the module and includes recommendations for improvement.

The methodology followed by MAPE project is based on Educational Design Research [7-8], which is focused on the evaluation of prototypes of an educational intervention being developed. Such evaluation addresses issues of validity, usability and effectiveness. Prototypes can be evaluated through a wide range of methods, including screening, expert appraisal, walkthrough, micro-evaluation, and try-out [9].

Figure 1. Entry panel for a module

Expert appraisal, micro-evaluation and try-out have been the methods more frequently used for evaluating the validity, usability and effectiveness of MAPE. Most of the data has been collected through student questionnaires.

3. IGEaD project – objectives and methodology

IGEaD project studies the potential of Distance Education for the promotion of geographical inclusion in an insular context, and it includes three more specific objectives: to understand Azorean students' experiences of Distance Education, to understand how interested residents in peripheral parts of the Azores are in online programs that can be provided by the University of the Azores, and to evaluate the receptiveness of prospective students to models of Distance Education developed at the University of the Azores.

Data have been collected through questionnaires and interviews with students and prospective students, professors, and school leaders.

Considering that one of the approaches to Distance Education developed at the University of the Azores is MAPE model, there has been some integration between MAPE and IGEaD.

4. Results

Data collection and analysis in the context of IGEaD is not finished yet. Therefore, the results presented in this paper are partial and preliminary. However, they are focused on central issues. In order words, their contribution to the achievement of research objectives is very important.

ISBN 978-84-8158-937-5

Firstly, results from a student questionnaire related to MAPE will be presented. Secondly, results from a questionnaire applied to Professors of the University of the Azores will also be presented. In both cases, issues of inclusion and design will be emphasized.

4.1. Some results from MAPE

Results from a questionnaire applied to first-year students of a bachelor program were selected. The questions addressed a wide range of issues related to the students' satisfaction with regard to the VLE of a course that followed MAPE model. The course was attended by 25 students, 22 of which responded to the questionnaire.

One of the questions was especially focused on issues of design. Students expressed their opinion about the overall organization of the VLE with regard to its adequacy to their needs. As Figure 2 shows, most students considered that the organization of the VLE was sufficiently adequade, but even more students considered that it was more than sufficiently adequate.

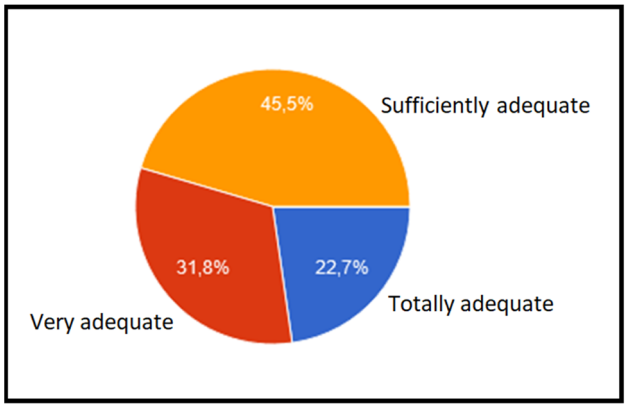


Figure 2. Overall organization of the VLE

More specifically, students rated the clarity of the guidelines included in the VLE. Approximately 60% of them considered them very clear and approximately 40% considered them sufficiently clear (Figure 3).

The question that was more directly focused on issues of inclusion was: Do you think that more students would attend Higher Education if more academic programs were provided online? 60% of the students answered yes and 40% answered no (Figure 4).

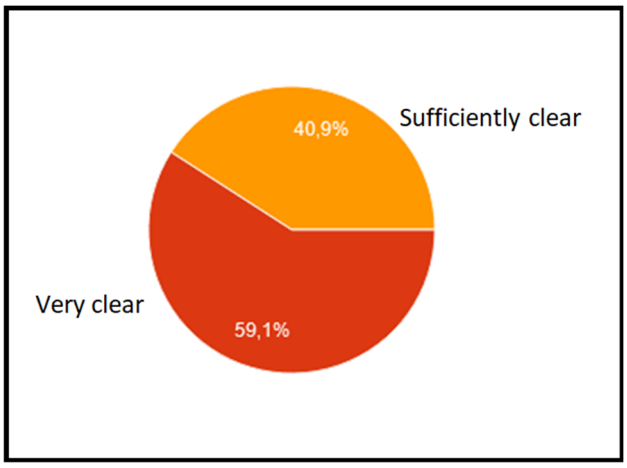


Figure 3. Clarity of the guidelines

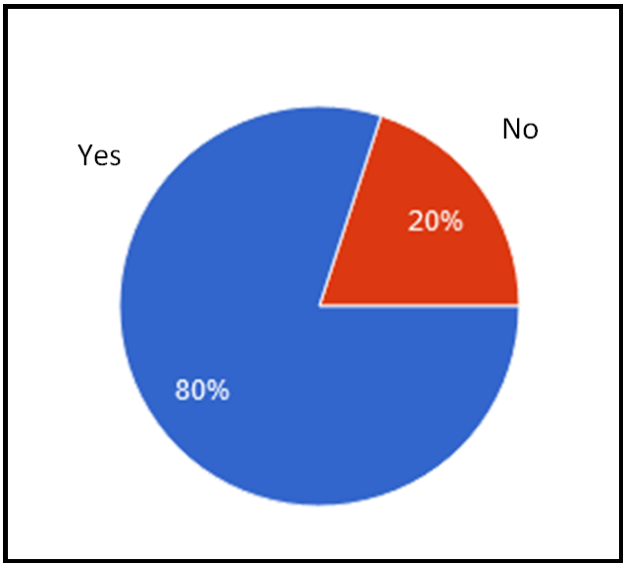


Figure 4. Importance of Distance Education for the inclusion of more students

4.2. Some results from IGEaD

60 professors of the University of the Azores answered to a questionnaire focused both on their own experience of Distance Education from the instructor's perspective and on their perspectives about Distance Education. 58,5% of the respondents already had some experience of teaching online before the Covid 19 pandemic.

As Figure 5 shows, most of the respondents tend to teach online by engaging in synchronous rather than asynchronous activities. Only 3 professors (5%) stated that they worked in a predominantly asynchronous mode.

ISBN 978-84-8158-937-5

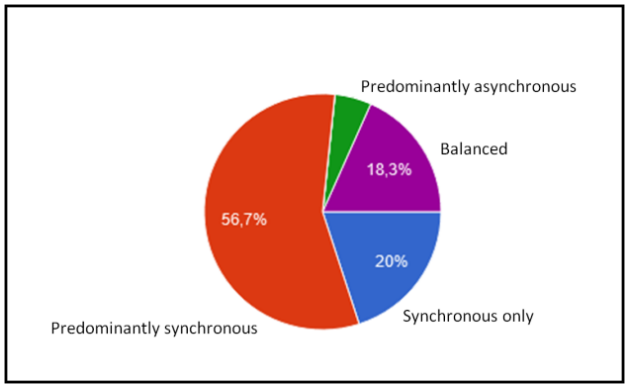


Figure 5. Prefered type of instructional design

93,5% of the respondents consider that Distance Education can facilitate access of all the population of the Azores to Higher Education (Figure 6). Some arguments expressed by a minority of respondents who consider the opposite include, for example, the statement that "social inclusion entails personal, face-to-face contact".

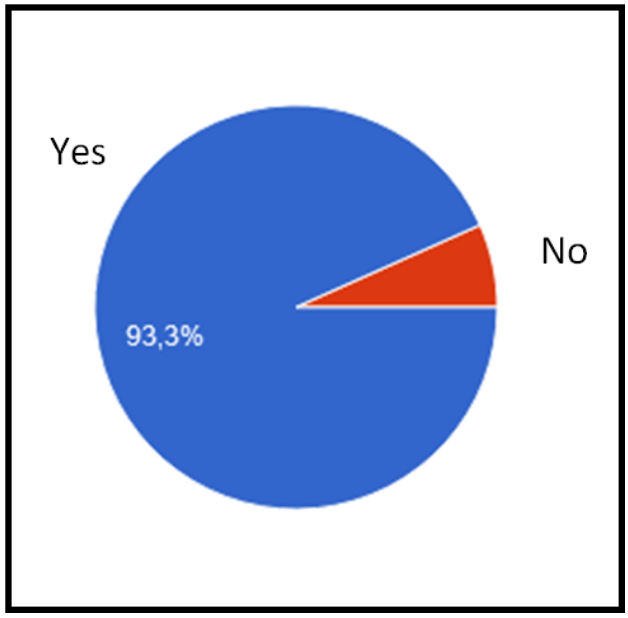


Figure 6. Importance of Distance Education for social and geographical inclusion

5. Conclusions

The results provide evidence of student satisfaction with regard to the design of MAPE model.

Analysis of data collected from professors by questionnaire did not disclose any other model for the design of VLE that might have been developed at the University of the Azores. Considering that synchronous online instruction can be accomplished by simply connecting to a standard webconferencing tool, it is not dependent on the design of VLE. Therefore, the respondents' preference for synchronous work and the fact that only 3 of the professors stated that their approach to Distance Education is predominantly asynchronous further support the conclusion that designing VLE is not a priority in that Higher Education Institution.

MAPE is a low-cost solution, based on a user-friendly platform – *Moodle* –, which might facilitate faculty inclusion and institutional inclusion, considering that the University of the Azores is peripheral in the national context.

The results also show that the majority of the respondents – students and professors alike – acknowledge the importance of Distance Education for the promotion of social, academic, and geographic inclusion.

6. Acknowledgements

IGEaD project is funded by the Regional Board of Science and Technology (Azores) – Reference M1.1.C/C. S./014/2019/01.

Este trabalho é financiado por fundos nacionais através da FCT – Fundação para a Ciência e a Tecnologia, I.P., no âmbito do projeto «UIDB/04647/2020» do CICS.NOVA – Centro Interdisciplinar de Ciências Sociais da Universidade Nova de Lisboa.

This work is financed by national funds through FCT - Foundation for Science and Technology, I.P., within the scope of the project «UIDB/04647/2020» of CICS.NOVA – Interdisciplinary Centre of Social Sciences of Universidade Nova de Lisboa.

7. References

[1] Ramón C, Peniche R, Cisneros-Cohernour E. Challengers of teachers in an effective rural secondary school in Mexico. Journal of Education and Learning, 8 (1), 143-149, 2019.

[2] Mueller D, Strohmeier S. Design characteristics of virtual learning environments: state of research. Computers & Education, 57 (4), 2505-2516, 2011.

[3] Dillenbourg P, Schneider D, Synteta P. Virtual Learning Environments.

Proceedings of the 3rd Hellenic Conference "Information & Communication Technologies in Education". Dimitracopoulou A (Ed.), 3-18, Kastaniotis Editions, Greece, 2002.

[4] Lencastre J. Metodologia para o desenvolvimento de ambientes virtuais de aprendizagem: development research. Educação online – pedagogia e aprendizagem em plataformas digitais. Monteiro A, Moreira JA, Almeida AC (Eds.), 45-54, De Facto Editores, Santo Tirso, Portugal, 2012.

[5] Lidwell W, Holden K, Butler J. Universal principles of design, Beverly: Rockport, 2003.

[6] Sousa F. A importância do design no desenvolvimento de ambientes virtuais de aprendizagem. Revista internacional de formação de professores, 3 (1), 227-244, 2018.

[7] Van den Akker J, Gravejeijer K, McKenney S, Nieveen N. (Eds.). Educational design research. London and New York: Routledge, 2006.

[8] McKenney S, Reeves T. Conducting Educational Design Research, London and New York: Routledge, 2012.

[9] Nieveen N. Formative evaluation in Educational Design Research. An introduction to Educational Design Research. Plomp T, Nieveen N (Eds.), 89-101, SLO, The Netherlands, 2010.

ISBN 978-84-8158-937-5

Plants, My Dear Friends

A Trompeta Carpintero
University of Alicante, Spain
antonia.trompeta@ua.es

Abstract. This proposal intends to enhance the importance of plants in our life. Addressed to small children, it consists of fifth IBSE workshops, from the knowledge of their familiar environment and deep knowledge of a friendly tree to the understanding of plant's nutrition process and the growth of a seed; finishing with the looking for an engineering solution for the lack of water or for the cultivation of vegetables in flood conditions. It is presented as a Moodle Course for infant teachers that can be followed from the Scientix web.

The proposal is dedicated to understanding and estimating plants for their key role in our life, as well as compromising us for the looking for a solution to a real problem "the lack of food" in many countries.

It tries to offer a way of teaching and learning Natural Science in conditions of uncertainty, so it is presented as a Moodle course that can be followed by in-service or pre-service Infant Teachers from home (Scientix Moodle). For this purpose, the course includes presentations, photos, and videos of applications in schools.

Addressed to pre-school, primary students, and to Special Needs Education students. It has been applied largely by pre-service teachers from UA in their Practicum phases.

It includes different STEAM subjects, such as Natural Science, Geography, Maths, Ethics, and Engineering; since its lessons engage literacy (readings about water in the world, scientific language) and numeracy (studying the quantity of water in countries), physical health (vegetables for food) and emotional foundations (happiness to help people)

In the same way, it implies some STEAM careers, from Urban growers, Botanic and ecological specialists to Greeners and Civil Engineers. It enhances the 1st century skills, critical thinking, collaboration, communication, and creativity, especially about our responsibility in the preservation of our environment and the looking for solutions to food problems and migration to better places to live. It involves, as key aims, the understanding of the way plants obtain their food following an inquirí-based process as well as promoting an appreciation of plants. Students will be engaged in hands-on steps and activities in their familiar natural environment.

To this end, four topics are proposed: My natural environment, Plants' nutrition, Seed growing, and the problem of water.

Those topics include workshops dedicated to knowing their familiar environment and deep knowledge of a friendly tree; the understanding of plant's nutrition processes of creating their food and obtaining energy; the tracking of the growth of a plant from seed; finishing with the looking of engineering solutions for the lack of water and/or for the growing plants in flood conditions.

In deep, the activities of the workshops could be summarised as follows:

- First workshop: "Trees around me" - A visit to their familiar environment is the first activity. Students use their mobiles to take photos of the trees around them (leaves, trunks, flowers, and seeds, to create an inquiry notebook of their familiar trees. (Fig.1 and Fig. 2)

Figure 1. Studying the trees around me

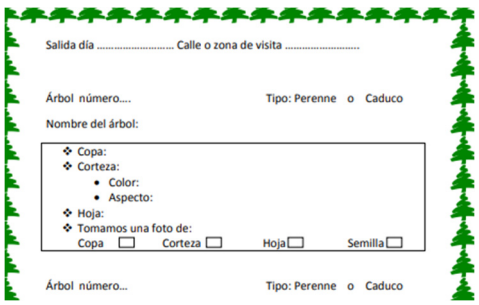


Figure 2. Part of the tree notebook

ISBN 978-84-8158-937-5

- Second workshop: “My friend tree” - A long-term activity, taking notes of their friend tree tracking from Autumn to next Summer – Fig. 3. Students are bound to estimate this friend tree.

Figure 3. Studying my friend tree

- Third workshop: “What does a plant need to live?” – Workshop dedicated to the processes of photosynthesis and breathing. The workshop engages children in the research of their need for water, air, and light to make their own food - glucose (Fig. 4, Fig. 5, Fig. 6) - and the way of obtaining energy with the inclusión of oxygen. The workshop (Fig. 7) finishes with the need for a model of nutrition. The nutrition process is simplified to be understood by small children

Figure 4. Plants with water, light, and air

Figure 5. Plants no light

Figure 6. Plants no air

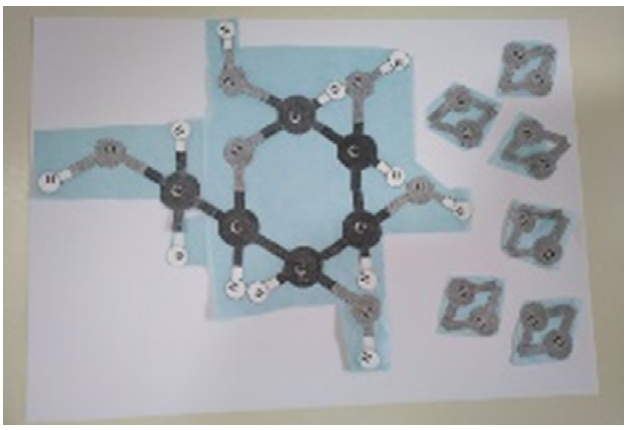


Figure 7. Model of nutrition. Creating Glucose

ISBN 978-84-8158-937-5

This inquiry process should lead to the following conclusions: Plants create glucose with water and CO_2, in the presence of light. Plants obtain their Energy burning glucose with the help of O_2. Nutrients are needed to create proteins and to start the second reaction (Fig. 8 and 9).

Figure 8. Small children studying plants need

Figure 9. Taking care of plants. Water, light, air

- Fourth workshop: “How can I get a plant” – Workshop dedicated to exploring the growth of plants from seeds. (Fig. 10, 11, 12)

Figure 10. Plants growing from seeds – The potato hair

Figure 11. Measuring the growth of plants from seeds

Figure 12. The tulip growth. Dramatization

- Fifth workshop: How can we help people to grow their own vegetables in places without water or in flood conditions? How can we

get water from underground? Could we grow plants out of the soil?

Showing them the real problem of lack of food in different countries due to the lack of water or floods. Children must look for real places in the world with those real problems (Sudan, Bangladesh). Then they can write to schools in those places to get in touch and offer their help, maybe with donations. And to finish with they could put in their place creating an engineering device to get up underground water, and/or to grow vegetables without soil.

Keywords. Infants, Inquiry-Based Science Teaching, Natural Based Solutions, Plants Nutrition, Water Problems.

Acknowledgments

To Professor J. Martínez Torregrosa, UA, with gratitude.

References

[1] Codrington S. Science in Urban Public Gardens, Nuffield foundation, 2006.

[2] Harlen W. Principios y Grandes Ideas para la Educación en Ciencias. Popular Ed., 2012.

[3] Foresman S. Science Lab Manual. USA: Addison-Wesley, 2000.

[4] Stringer J. Science and Technology ideas for the under 8s. ASE, Hatfield, 2018.

[5] Sunley C, Bourne J, Norman A. Science directions. Early years. London: Collins, 2000.

[6] Trompeta A. Enseñar Ciencias por indagación. https://ocw.ua.es/es/ciencias-sociales-y-juridicas/ensenar-ciencias-por-indagacion-desde-las-primeras-etapas-de-la-educacion.html

[7] Trompeta A. Unidad didáctica Los Seres Vivos. UA, 2014. https://rua.ua.es/dspace/bitstream/10045/35556/2/SERES_VIVOS_HABITATS_cast_2014.pdf

[8] Trompeta A. Unidad didáctica: La naturaleza. ¿Pueden los niños investigar su entorno natural? Rua, UA, http://hdl.handle.net/10045/83732

[9] Trompeta A. Mi árbol amigo Moodle course Scientix EU, 2022.

[10] Trompeta A, Plants, my Dear Friends, Moodle Course, Scientix. EU http://moodle.scientix.eu/course/view.php?id=919

[11] http://www.fibonacci-project.eu/

[12] https://explorify.uk

ISBN 978-84-8158-937-5

"Blind Test" Are the Waters All the Same? The Chemical Magic of Water!

C Almeida-Rocha[1]*, C Alvarenga*[2]*,*
J Gomes[2]*, J Nunes Santos* [3]
[1]*University of Lisbon, Portugal*
[2]*Colégio Valsassina in Lisbon, Portugal*
[3]*University of Coimbra, Portugal*
joaogomes@cvalsassina.pt

Abstract. The United Nations General Assembly elected the year 2022, dedicated to "Groundwater".

There is an urgent need for efficiency in education, literature and awareness of the wealth of mineral water in our Portuguese and Iberian territory, on a global scale that reaches all of us. Portugal is the country in the Iberian Peninsula with the greatest richness and diversity in the occurrence of natural mineral waters. [6] Due to the rocks through which the water circulates, and the very rich geological heterogeneity characteristic of our country. Portugal comprises the greatest chemical diversity of the natural mineral waters of the Iberian Peninsula. [3] Our ecological footprint must be attentive to this wealth, which must be known and protected by all. If the present is now in our hands and is the guarantee of the future of the little ones, these will be the new messengers and guardians of this treasure and we must be the adults and educators who must share the knowledge of good practices, of acting and teaching to preserve. [4] Understanding the interaction of water with the environment that surrounds it (nature, soil, rock, aquifer, air, plants, microbiology, human activity and health), knowing the Water Cycle, awakening to the five senses (sight, hearing, taste, smell and touch) of water, the discovery of the importance of plants in the analytical methods of the 19th century. XVII - XIX of water, all these questions can be clarified through History (Greek, Roman, Arab, Jewish and contemporary cultures and societies). [1] These ways of transmitting the testimony of knowledge provide the stimulus for critical thinking and reflection. The integration of the youngest and the community, in the different educational and informational dissemination activities (workshops, lectures, conversations, exhibitions, living science initiatives in situ visits, live science, planting and cultivating water) are ways to captivate and encourage the achievement of this mission successfully, in which adults are cultivated by the youngest and the youngest the messengers of respect and knowledge that guarantee humanity, potability and future with water. The Activity developed by the students of Colégio Valsassina 4C class, offers the opportunity to present and make known the Portuguese Hydrological Heritage; raise awareness of the ecological footprint in water; raise awareness of the consumption we make of water in our daily lives without realizing it; understand the meaning of the acidity of water, what is acidic and alkaline; water hardness, soft water and hard water; understand that the waters we drink have different characteristics from each other, taste, smell and color reactions. [2] This activity carried out at Valsassina College by the 4ºC class also allows us to refer back to the time of our grandparents and great-grandparents, at that time, when there was still no water on the tap and the clothes were washed in the tank, and the pitcher went to the fountain. In this surroundings of a sea of waters we sail to the reflection of our ecological footprint with questions very pertinent that got us all thinking. [5] Questions like: Did you know that we consume 2400 liters of water in a hamburger? How many liters do we spend on a cotton sweater? And in tennis? And in 2 grams of microchip from cell phones, computers and televisions? Did you know we spent 32 liters of water, just to have 2 g of microchip that do we use in technology? And that Portugal is part of the group of countries that consume the most Water? And that Portugal is the country of the Iberian Peninsula richer and more diversified in natural mineral water and thermal? And that water heals and gives health? And that Portugal, more specifically Cabeço de Vide, has a water very different from all the others that are we used to drinking it and that it even mixes with olive oil? And that is a unique water in our country and very rare in the world? and that the scientists national, international and NASA studies it to compare with the environments of the planet Mars and of other bodies in our Solar system? It is necessary and important to care for and preserve the our Hydrological Heritage, because, after all, the waters are not all the same.

Keywords. Analitical History of Water**,** Hidrogeological Heritage, Mineral Natural

Waters, Iberian Peninsula.

References

[1] https://www.youtube.com/watch?v=4CVrL36OFfI

[2] https://www.youtube.com/watch?v=B4HcohazAFU

[3] https://www.rtp.pt/play/p5280/e409894/linha-da-frente?fbclid=IwAR2vQHhMAzCk7e-VBe4RWR_85lov7Mgj4cRJp9bo2IGhd_oeH0vH315qmJI

[4] https://www.youtube.com/watch?v=jmGSqD59-sw

[5] https://www.epal.pt

[6] Brochure of the European Bottled Water Federation, 2008.

ISBN 978-84-8158-937-5

Analyzing Visual Representation in Brazilian Chemistry Textbooks

MS Lima, C Sotério, HM Larine, SL Queiroz
University of São Paulo, Brazil
salete@iqsc.usp.br

Abstract. Despite the significance and widespread use of visual representations in Science Education, it is common to find students who experience difficulties in reading graphs, charts, maps, tables, equations, etc., mainly due to the way they are presented in textbooks [1]. Different types of visual representations can be found on a continuum, depending on the amount of contextual detail that they have [1]. Research on how non-textual representations are conveyed in Chemistry textbooks shows the close relationship between them regarding scientific knowledge development [2,3]. This study investigates the characteristics of visual representations of two textbooks (TB1 [4] and TB2 [5]) used for higher education in Chemistry in Brazil. Considering this, the semantic and functional study of the visual representations was carried out, considering their external elements, especially the text, the caption, and indexing [6,7]. The context provided by these elements helps us to interpret the visual representations. Nine chapters from TB1 were selected, with a total sum of 393 pages. Regarding LD2, thirteen chapters were selected with a total of 392 pages. As a first step of the analysis, the visual representations on each textbook were identified and quantified, as follows: photographs, iconic drawings, schematic figures, chemical structures, maps, diagrams, graphs, tables, and equations. Next, the visual representations were categorized based on their contiguity [6], captions [6], indexical references, and function [7]. As results, the textbooks have, on average, approximately two visual representations per page, most of them having little resemblance to the phenomena and objects they seek to represent and a high level of abstraction, namely: chemical structures, graphs, tables, and equations. Considering the abstract nature of the chemistry language, targeted at a scientific audience, these are the types of visual representations that students will have most contact with in their academic and professional careers, which puts into perspective the need for special attention to how they are included and conveyed, not only in scientific texts, but also in the classroom. Its worth noting that photographs and schematic figures stand out in the textbooks, and considering this, the diversity of types of visual representations corroborates the multi-representational nature of Chemistry. Regarding the contiguity of visual representations, most of them have direct or proximal contiguities, that is, the visual representations are immediately available to the reader after being cited in the text. The prominent use of referential indexes is also notable. These characteristics decrease the cognitive efforts needed to establish a link between the visual representations and the content discussed in the textbook. There is an abundant use of captions, not only to name the visual representations, but also to instruct readers (students) on how to visualize what is being depicted. Regarding their functions, illustrative visual representations predominate, constituting an important visual resource for the exemplification and concretization of the studied concepts. However, an imbalance between the frequency of illustrative and explanatory visual representations can be observed, which suggests that their true pedagogical potential is not fully achieved. The explanatory function not only plays an important role in the representation of the chemical knowledge, but also in improving the understanding of this knowledge, complementing, and supporting the text, and presenting the reader with its importance for science [7]. In fact, scenarios could be found that represent deficiencies and obstacles, specifically, uncontinuous, uncaptioned, unindexed, and decorative visual representations, which shows evidence of a deficient instructional content. Regarding this, textbook authors need to be aware of the way in which the visual representations will be published, so that it is comfortable for the reader and enhances their understanding. Teachers and educators also need to pay attention to such aspects, identifying the strengths and weaknesses of the visual representations found in textbooks and used in the classroom, to suppress deficiencies and foster their pedagocial potential.

Keywords. Visual Representations, Text-books, Chemistry.

Acknowledgements

São Paulo Research Foundation (Grants 2018/23809-3; 2020/14789-9; 2020/03233-0) and the Brazilian National Council for Scientific and Technological Development (Grant 304974/2020-0).

References

[1] Roth WM, Pozzer-Ardenghi L, Han JY. Critical graphicacy: Understanding visual representation practices in school science, Dordrecht: Springer Science & Business Media, 2005.

[2] Han JY, Roth WM. Chemical inscriptions in Korean textbooks: semiotics of macro- and microworld. Sci. Educ., 90, 173-201, 2006.

[3] Goes LF, Chen X, Nogueira KSC, Fernandez C, Eilks I. An analysis of the visual representation of redox reactions and related content in Brazilian secondary school chemistry textbooks. Science Education International, 31, 313-324, 2020.

[4] Atkins P, Jones L. Chemical Principles. Porto Alegre: Bookman Editora, 2012.

[5] Brown TL, Lemay Jr HE, Bursten BE, Burdge JR. Chemistry: The Central Science. Campinas: Pearson Education, 2005.

[6] Slough SW, Mctigue EM, Kim S, Jennings SK. Science textbooks' use of graphical representation: a descriptive analysis of four sixth grade science texts. Reading Psychology, 31, 301-325, 2010.

[7] Pozzer LL, Roth WM. Prevalence, function, and structure of photographs in high school biology textbooks. J. Res. Sci. Teach., 40, 1089-1114, 2003.

ISBN 978-84-8158-937-5

AquaCoLab: Collaborative Laboratories and Citizen Science for Monitoring the Quality of Freshwater Systems

P de La Fuente, A Canepa, B de Aymerich, M Diez, MA Queiruga-Dios
University of Burgos, Spain
pdelafuente@ubu.es

Abstract. Freshwater ecosystems are fundamental for biodiversity and for human beings, they provide important ecosystem services and help in the balance of the earth system in general [1]. However, freshwater systems are among the ecosystems most threatened by human activity, with more than 80% of these ecosystems containing biological, physical-chemical and socio-economic signs that human beings leave with their activity [1]. Among the threats faced by these ecosystems is the discharge of chemical products, nitrification, salinization, channeling, loss of cross-sectional and longitudinal connectivity, loss of biodiversity and lack of effective management measures for total conservation [1,2]. Currently, the approach to the study of aquatic systems is changing from a "Top-down" approach, in which the competent authorities monitor the ecological state, to a "Bottom-up" approach, where local communities actively participate in monitoring and development. of conservation strategies for these ecosystems [3]. It is in this collaborative scenario of the management of natural ecosystems that Citizen Science (CC) plays a very important role.

Citizen Science (CC) defined as the process in which members of civil society contribute effort and dedication in some of the stages of scientific knowledge [4, 5] allows generating such valuable information as traditional science [6]. In addition, CC allows for a space-time scope that traditional science rarely reaches, with a very important role in bringing citizens closer to STEM areas (science, technology and mathematics), conservation and increasing the general perception of ecosystem services [7]. The general lack of interest, especially among students, in STEM areas has been incorporated into political agendas to achieve an increase in the degree of citizen involvement [8]. It is for this reason that CC activities not only serve to generate valuable information due to the amount of information generated, but also because they encourage the participation of civil society in scientific activities.

The general objective of the project is to implement a citizen participation methodology for monitoring the quality of freshwater systems through collaborative laboratories (CoLabs) made up of people from society in general and civil groups, educational centres, etc. using different citizen science platforms, which allow:

1. Characterize the environmental quality of freshwater systems.
2. Increase scientific culture by helping to improve knowledge, environmental assessment and responsible innovation of freshwater systems.
3. Promote and improve the active participation of society in the study and care of these ecosystems.
4. Promote STEM vocations in the educational context.

The AquaCoLab workflow encompasses: I) the creation of “CoLabs” and definition of sampling areas, ii) characterising the participant’s perception and knowledge of freshwater systems at the beginning and the end of the project, iii) impart the training workshops for the representatives of each “CoLab” regarding the theory and practice of citizen science and its different platforms for gathering scientific data, iv) collection of environmental/ecological data by the "CoLabs", v) impart the data analysis workshops to validate observations and general results of the project and vi) development of a scientific dissemination campaign throughout the project.

The hydrological, hydro-morphological and biological states of the river, are obtained following the indicators of The European Water Framework Directive (WFD), using the methodology of the RiuNet citizen science project [9]. These results reresents an orietative assessment of the ecological status of the river. Both aquatic and riparian biodiversity are characterized using the Observation.org citizen science platform [10] to determine: i) the taxonomic composition of species associated with the river ecosystem, ii) the presence of invasive alien species, iii) the presence of non-native and planted species and iv) the presence of species typical of the river ecosystem, as indicators of good conservation

status. The physical-chemical state of the river section is evaluated using the colourimetry technique. To characterize the impact of litter and river fragmentation on these ecosystems, we used the eLitter [11] and AMBER (Adaptive Management of Barriers in European Rivers) [12] citizen science platforms, respectively. To foster the implementation and development of new citizen science tools for the monitoring, study and conservation of aquatic ecosystems, we work together with: i) the Polymer Laboratory of the University of Burgos (POLYMER) [13] in the determination of contamination by phenols in water (nonylphenols and octylphenols), through the use of polymeric biosensors and ii) with the company Hacking Ecology S.L. [14] in the testing of the Nayad multiparametric probe built following the "maker" philosophy based on an Arduino platform with free and open source code.

The AquaCoLab project is developed in the province of Burgos since 2020 until now. From the beginning, more than 900 people have participated in 21 CoLabs: 11 educational centers (primary and secondary school), seven non-profit organizations, two communal associations and one ecotourism enterprise. These CoLabs have monitored 27 transects of 14 rivers through the Burgos Province.

The results showed that the majority of the studied rivers had a moderate ecological quality and they would not comply with the EU directive framework (mainly due to the low punctuation in hydrological and hydromorphological quality, because in general, the biological quality determined with the aquatic macroinvertebrate evaluation were good). The identification of the macroinvertebrate community of the rivers as a bioindicator of the quality of water is one of the activities that the participants, of all ages, liked the most.

CoLabs have registered a total of 2400 observations of flora and fauna of the river ecosystems studied. Data are available in the AquaCoLab web portal on the Observation.org platform [15]. The taxonomic groups with more observations are plants (54.6%) and birds (23.1%). Such difference is probably due to the facility to take an observation and the most knowledge by the participants of these groups of species.

The most abundant residues found are plastic (mainly candy wrappers and bags), the filter of cigarettes, and hygienic wipes. This activity caused a special surprise to the younger participants. The common feeling is that “it is totally unexpected to find so many residues and garbage because at the first sight it is normally not appreciated at all” and they usually get more and more involved in the activity.

Keywords. Citizen Science, Freshwater ecosystem, River Monitoring, STEM vocations, Students Engagement.

Acknowledgements

AquaCoLab project is supported by the Spanish Foundation for Science and Technology - Ministry of Science and Innovation.

References

[1] Elosegi A, Sabater S. Conceptos y técnicas en ecología fluvial, España: Fundación BBVA, 2009.

[2] Zufiaurre R, Martín-Ramos P, Cuchí JA. Nitrates in Groundwater of Small Shallow Aquifers in the Western Side of Hoya de Huesca (NE Spain). Agronomy, 10, 22, 2020.

[3] Rolston A, Jennings E, Linnane S. Water matters: An assessment of opinion on water management and community engagement in the Republic of Ireland and the United Kingdom. PloS one, 12, 4, e0174957, 2017.

[4] European Commission and Socientize consortium (Eds.). Green paper on Citizen Science for Europe: Towards a society of empowered citizens and enhanced research, 2013.

[5] Serrano Sanz F, Holocher-Ertl T, Kieslinger B, Sanz García F, Silva CG. White Paper on Citizen Science in Europe, Socientize Consortium, 2014.

[6] Kosmala M, Wiggins A, Swanson A, Simmons B. Assessing data quality in citizen science. Frontiers in Ecology and the Environment, 14(10), 551–560, 2016.

[7] Kobori H, Dickinson JL, Washitani I, Sakurai R, Amano T, Komatsu N, Miller-

Rushing AJ. Citizen science: a new approach to advance ecology, education, and conservation. Ecological Research, 31, 1–19, 2016.

[8] La Caixa, Obra social, FECYT y Everis (Eds.). ¿Cómo podemos estimular una mente científica? Estudio sobre vocaciones científicas, 2015.

[9] https://eu-citizen.science/project/227

[10] https://eu-citizen.science/project/68

[11] https://elitter.org/

[12] https://amber.international/

[13] https://www.ubu.es/polymers-polymers

[14] https://hackingecology.com/es/

[15] https://aquacolab.observation.org/map_lastobs_v2.php

Educational Robotic Platform for Teaching in Different Education Levels

D García-Costa[1]*, E Lopéz-Iñesta*[1]*,*
A Suarez[1]*, P Amador Martínez*[1]*,*
R Fayos-Jordan[1]*, MA Queiruga-Dios*[2]*,*
F Grimaldo[1]
[1]*University of Valencia, Spain*
[2]*University of Burgos, Spain*
daniel.garcia@uv.es

Abstract. This contribution presents an ongoing project based on an educational robotic platform intended for teaching robotics in different education levels. Educational Robotics is not understood as a single subject but considered as a didactic strategy in which the robot is used as a tool to solve a specific problem. The use of robots makes it possible to carry out dynamics based on creativity and innovation so that students are challenged and they must solve it by programming the robot with the proper behaviour. Educational Robotics has other advantages when used as a teaching tool because it facilitates the acquisition of knowledge playfully, it can improve the motivation of students and it is based on collaborative work. Therefore, a new prototype of a transversal educational robot that can be used in all educational levels because of its structure and implementation is described. Even though mechanics and electronics are two of the main fundamentals of robotics, we consider that they can result in an obstacle when a professor or student tries to use a robot. Consequently, the proposed platform includes the main sensors and actuators connected to the control unit via standard connectors. This kind of connectors eases the introduction of new elements to the robot with the aim of avoiding problems related to the hardware part. Concerning the mechanics, it is provided with a robust 3D printed structure that integrates the electronics at the same time that protects it against collisions. With this approach, we consider that the student can be totally focused on the programming part instead of having to take into account the problems that a wrong connection could generate in the functioning of the robot. In addition, to provide different levels of abstraction while programming the robot and thus facilitate its application at different educational levels a virtual remote laboratory has been developed where the robot can be programmed and the result of the execution sent by the students can be seen.

The remote lab has 3 different levels of abstraction. A level of programming by graphic blocks (scratch style blocks), a level of programming by code and a more advanced level in which it is necessary to upload a project in zip format. As a web application it is accessible throw the internet and can be used on different devices, such as computers or tablets.

Keywords. Learning-by-Doing, Remote Laboratory, Robotic Platform, STEM Education.

References

[1] Lepuschitz W, Koppensteiner G, Merdan M. Offering Multiple Entry-Points into STEM for Young People. In Merdan M, Lepuschitz W, Koppensteiner G, Balogh R (Eds.), Robotics in Education. Advances in Intelligent Systems and Computing, 41-52, Cham: Springer, 2017.

[2] Atmatzidou S, Demetriadis S. Advancing students computational thinking skills through educational robotics: A study on age and gender relevant differences, Robotics and Autonomous Systems, 75 661-670, 2016.

[3] Zaldivar-Colado X, Zaldivar-Colado U, Niebla-Zatarain J, Del-Valle Z, Marmolejo-Rivas C, Magana-Solano C. Educational potential of robotics in higher education: A papertian approach. IATED Digital Library, ICERI2018 Proceedings, 1039-1043, 2018.

[4] Afari E, Khine MS. Robotics as an Educational Tool: Impact of Lego Mindstorms, International Journal of Information and Education Technology, 7 (6), 437-442, 2017.

[5] Castro E, Cecchi F, Valente M, Buselli M, Salvini P, Dario P. Can educational robotics introduce young children to robotics and how can we measure it?, Journal of Computer Assisted Learning, 34, 970-977, 2008.

[6] Suarez-Zapata A, García-Costa D,

Martínez-Delgado PA, Martos-Torres J. Contribución de la robótica educativa en la adquisición de conocimientos de matemáticas en la Educación Primaria, Magister: Revista miscelánea de investigación, 30 (1), 43-54, 2018.

[7] Lombardi MM, Authentic learning for the 21st century: An overview. Educause learning initiative, 1, 1-12, 2012.

[8] Johnson L, Adams Becker S, Estrada V, Freeman A, Kampylis P, Vuorikar R, Punie Y. Horizon Report Europe: Schools Edition. Luxembourg: Publications Office of the European Union. Texas: The New Media Consortium, 2014.

[9] Adams Becker S, Cummins M, Davis A, Freeman A, Hall Giesinger C, Ananthanarayanan V, NMC Horizon Report: 2017 Higher Education Edition. Texas: The New Media Consortium, 2017.

[10] Vázquez–Alonso A, Manassero–Mas MA, Taberner-Ferrer J. Factores que influyen sobre la elección de estudios superiores deficiencias y tecnología, Enseñanza de las ciencias: revista de investigación y experiencias didácticas, Número Extra, 3642-3648, 2013.

[11] Sanders ME. STEM, STEM education, STEMmania, The Technology Teacher, 68(4), 20-26, 2009.

ISBN 978-84-8158-937-5

MEDNIGHT: Activities, Resources, Events and More about the Mediterranean Science

C Perea[1,2], T Anagnostopoulos[3], R Dominguez[4], M Martínez[5], M Saenz[6], J Fuster[7], M Pieri[8], T Arsan[9], G Saglamer[10], M Trimarchi[11]
[1]*MUDIC in Orihuela, Spain*
[2]*Miguel Hernández University, Spain*
[3]*SCICO, Chalandri Creece*
[4]*El Caleidoscopio Proyectos de Ciencia y Cultura in Alicante, Spain*
[5]*FISABIO in Valencia, Spain*
[6]*INCLIVA in Valencia, Spain*
[7]*Agencia Estatal Consejo Superior de Investigaciones Científicas in Valencia, Spain*
[8]*SCICO CYPRUS LTD, Cyprus*
[9]*Kadir Has Universitesi, Turkey*
[10]*European Women Association, Belgium*
[11]*Universita Degli Studi Di Messina, Italy*
perea@umh.es

Abstract. More than 500 million people on three continents are united by the world's largest sea, the Mediterranean. Our strategic geographic location and the shared history gives us a common character and common challenges. Mediterranean Researchers' Night – MEDNIGHT is a European grant of the Marie Skłodowska-Curie Actions under Horizon Europe call [1]. The objective is to generate a Mediterranean unity, providing awareness about common problems, fostering scientific careers, reinforcing researchers' commitment and progress, and putting science and scientists at the cornerstone of our future and a relevant matter. MEDNIGHT shows the attractiveness and importance of the researchers' work and professions to the general public, and specially for girls and boys, carrying out a series of activities framed under the common umbrella of what we have come to call "Mediterranean Science" placing particular emphasis on youngsters and female researchers and showing the potential of R&D as a source of progress and well-being. Mediterranean Science relates to research developed in the our territories but also the countless collaborations with other EU researchers. Mediterranean Science is focused on Mediterranean relevant topics according to our culture, way of life or current challenges: Sea and pollution, Climate and clean energies, Diet and nutrition, life and Health. Many online and face-to-face diverse activities are organised by MEDNIGHT consortium in Valencia, San Juan, Orihuela, Torrevieja, Messina, Lesvos, Nicosia, Istanbul (Main cities), and also Lliria, Santa Pola, Limnos, Rhodes, Syros Eyupsultan, Kadikov, or El Cairo, among others (Satellite cities).
MEDNIGHT's objective builds on this momentum and aims to generate a strengthened Mediterranean unity, acknowledging our common issues and highlighting the value and support of science, research and technology towards our major concerns: Science is the future and is a matter for men, women, children and youngsters.
The European Union designs and promotes various global actions to make scientific and technical careers attractive to young people. The European Science Week in the past or the European Researchers' Night and the Open Schooling programs promoted by SWAFS today are some of the strategic lines developed to try to promote young people towards scientific professions of the future. MEDNIGHT will contribute towards these EU strategic goals to promote scientific vocations among the young and highlight their value to the general population. We aim to show the attractiveness and importance of the researchers' work and professions to the general public, carrying out a series of activities framed under the common umbrella of what we have come to call "Mediterranean Science".
This is about making visible the set of scientific activities as well as researchers themselves from our close environment and we will therefore concentrate our efforts on highlighting Mediterranean science as part of our historical and cultural heritage, as well as the importance and benefits that it can bring to us all as a society and to the environment, to be part of the research world.
We will place special emphasis on female researchers in the Mediterranean. Historically, science achievements have been coupled with men and women often remain in the background. carried out by men has been shown, which makes it difficult for a large part of the population, women, to identify themselves with the achievements. Our ultimate goal is that young people and society in general feel attracted to research careers

ISBN 978-84-8158-937-5

and to science and for this we will generate a strategic framework that allows us to focus the efforts of the participating entities under the same vision.
Project Partners: The current proposal for 2022 and 2023 has evolved over the past 3 years in order to include more institutions from countries around the Mediterranean, however, builds on the successful implementation of the previous two Researcher's Nights (2020, 2021). More specifically, MEDNIGHT was initiated in 2020 and involved twelve institutions from the Valencian Community and the Region of Murcia, in the southeast of Spain. In 2021 the consortium was expanded to include partners from Greece and Cyprus. This year, the consortium is further enriched with new partners from more Mediterranean countries (Turkey and Italy). The project coordinator (SciCo Greece) is neutral in order to guide and coordinate all partners, whereas all project partners are submitting a common proposal to ensure equal and active involvement from everyone, an approach already validated and supported by the success of previous events. The current consortium is a continuation of the previous project, having replaced a number of Spanish universities with universities from other Mediterranean countries to ensure further diversity, a broader Mediterranean concept and a wider collaboration arch.

Keywords. Mediterranean Science, Scientific Vocations, Engagement, Gender Gap, Scientific Communication.

References

[1] https://marie-sklodowska-curie-actions.ec.europa.eu/calls/msca-and-citizens-2022
[2] https://mednight.eu/

Museums and STEAM Education: Teach, Train and Connect

C Perea[1], *J Roldán*[1,2], *R Martínez*[2], *J Parres*[2]
[1]*Miguel Hernández University, Spain*
[2]*MUDIC in Orihuela, Spain*
perea@umh.es

Abstract. From the appearance of the first science and technology centers, such as the San Francisco Exploratorium in the 1960s, and up to the present day, we can find numerous studies and research on science museums.

This work aims to explore the role of science museums in STEAM education. For this we have carried out a bibliographic review of works, studies and research related to science museums and STEAM. Among the revised bibliography we highlight [1-37] . We have also reviewed the offer of activities that the museums that belong to the Association of Museums and Centers of Science and Technology of Spain [38] and a selection of 15 museums of the Ecsite network [39].

Once the collected data has been analyzed and, based on our experience as the management team of the Science Didactic and Interactive Museum of the Vega Baja del Segura of the Valencian Community (MUDIC-VBS-CV), we observe that there are three fundamental aspects in which science museums contribute to the field of STEAM education: teacher training, learning science and technology, as well as connecting the different actors involved in STEAM education such as police makers, scientists, educational system and companies.

All this reverts to the stimulation of scientific-technological vocations, which is one of the objectives in the origin of STEM education, as well as, in the increase of the scientific capital of society in general and of young people in particular.

Keywords. Education, learning, Science Museum, STEAM, Teaching, Training,

References

[1] Allen S. Designs for Learning: Studying Science Museum Exhibits that do More Than Entertain. Science Education, 88(1), 17-33, 2004.

[2] Falk J.H. Testing a museum exhibition design assumption: Effect of explicit labelling of exhibit cluster on visitor concept development. Science Education. 81, 679-687, 1997.

[3] Falk JH, Dierking LD. The Museum. Experience Revisited. Walnut. Creek, CA: Left Coast Press. 2013.

[4] Brajčić M, Kovačević S, Kuščević D. Learning at the Museum, Croatian Journal of Education, 15; 159-178, 2013.

[5] Rennie LJ, Johmston DJ. The nature of learning and its implications for research on learning from museums. Science Education, 88(S1), 4-16, 2004.

[6] Faria C, Guilherme E, Gaspar R, Boaventura D. History of science and Science Museums: an enriching partnership for elementary school science. Science and Education, 24, 983-1000, 2015.

[7] Okvuran A, Karadeniz C. Teacher's impact on museum education and design of new-generation school and museum collaboration in Turkey. Museum Management and Curatorship, 37(1), 17-43, 2022.

[8] Hein GE. Learning in the Museum, London: Routledge. 1998.

[9] Griffin J. Learning to learn in informal science settings. Research in Science Education 24, 121–128, 1994.

[10] MacManus PM. Topics museums and science education. Studies in Science Education. 20, 157-182, 1992.

[11] Guisasola J, Morentín M. ¿Qué papel tienen las visitas escolares a los museos de ciencias en el aprendizaje de las ciencias? Una revisión de las investigaciones. Revista Enseñanza de las Ciencias, 25(3), 401–414, 2007.

[12] Anderson D, Lucas KB, Ginns IS, Dierking LD. Development of knowledge about electricity and magnetism during a visit to a science museum and related post-visit activities. Science Education, 88(1), 17-

33, 2000.

[13] Cooper S. An Exploration of the Potential for Mathematical Experiences in Informal Learning Environments. Visitor Studies, 14(1), 48-65, 2011.

[14] Gyllenhaal ED. Memory of Math: Visitors' Experiences in an Exhibition about Calculus. Curator: The Museum Journal, 49(3), 345-364, 2006.

[15] Kelton M. Math on the Move: A Video-Based Study of School Field Trips to a Mathematics Exhibition. A dissertation for the degree of Doctor of Philosophy in Mathematics and Science Education. University of California. San Diego State, 2015.

[16] Pattison S, Rubin A, Wright T. Mathematics in Informal Learning Environments: A Summary of the Literature. Project Maths in the Making. https://www.informalscience.org/stes/default/files/InformalMathLitSummary_Updated_MinM_03-06-17.pdf.

[17] Chin CC. Museum Experience a Resource for Science Teacher Education. International Journal of Science and Mathematics Education, 2, 63–90, 2004.

[18] Guisasola J, Morentin M. Primary and Secondary Teachers' Ideas on School Visits to Science Centres in the Basque Country. International Journal of Science and Mathematics Education, 13(S1), 191-214, 2015.

[19] Guisasola J, Morentin M. The role of science museum field trips in the primary teacher preparation. International Journal of Science and Mathematics Education, 13, 965–990, . 2015.

[20] Choi KH, Chan HS, Lee HJ. Elementary school teachers´ perceptions on the use of educational programs in science museums. Journal of Korean Elementary Science Education, 25(3), 331-337, 2006.

[21] Kartini D, Widodo A. Exploring Elementary Teachers', Students' Beliefs and Readiness toward STEAM Education. Mimbar Sekolah Dasar, 7(1), 58-69, 2020.

[22] Romero-Ariza M, Quesada A, Abril AM, Cobo C. Changing teachers' self-efficacy, beliefs and practices through STEAM teacher professional development. Journal for the Study of Education and Development, 44:4, 942-969, 2021.

[23] Aglamdi A. Exploring Early Childhood Teachers' Beliefs About STEAM Education in Saudi Arabia. Early Childhood Education Journal, 2022.

[24] Villa M. Learning at the Science Museum. A study on the public's experiences with different types of visit at the Museo Nazionale de la Scienza e de la Tecnologia "Leonardo de Vinci" in Milan, Italy. Journal of Science Communication, 15(4), 2016.

[25] Andre L, Durksen T, Volman ML. Museums as avenues of learning for children: a decade of research. Learning Environ. Res., 20, 47–76, 2017.

[26] Oficina Internacional de Educación de la UNESCO. A Resource pack for gender-responsive STEM education, IBE/2017/OP/CD/01, 2017.

[27] Routledge Handbook of Public Communication of Science and Technology. Edited By Massimiano Bucchi, Brian Trench. 2021.

[28] Koster EH. In search of relevance: Science centers as innovators in the evolution of museums. Daedalus, 28(3), 225-234, 1999.

[29] Whitmerimer M. Museum 4.0 as the Future of STEAM in Museums. STEAM Journal, 2(2), 14, 2016.

[30] Chávez Charro JM, Neira L, Lacalle-Calderon M. Scientific Competence in Developing Countries: Determinants and Relationship to the Environment. Sustainability, 13, 12439, 2021.

[31] Carvalho DF. Contributions of Science Museums for Teacher Education in Brazil. Creative Education, 12, 1079-1089, 2021.

[32] Dawson E. Equity in informal science education: Developing an access and equity framework for science museums

and science centres, Studies in Science Education, 50(2), 209–247, 2014.

[33] Dawson E. Not designed for us. How science museums and science centers socially exclude low-income, minority ethnic groups. Science Education, 98 (6), 981–1008, 2014.

[34] Nelson DL, Cox MM. Lehninger Principles of biochemistry, London: Macmillan Education, 2017.

[35] Serret N, Earle S (Eds.). ASE Guide to primary science education. Hatfield: The Association for Science Education, 2018.

[36] Renn O, Webler T, Rakel H, Dienel P, Johnson B. Public participation in decision making. A three-step procedure. Policy Sci., 26, 189-214, 1993.

[37] Mandíková D, Drozd Z. Physics Education from the Cradle to the Grave. Hands-on Science. Growing with Science. Costa MF, Dorrío BV (Eds.), 79-83, Agrupamento de Escolas André Soares, Braga, Portugal, 2017.

[38] https://museosdeciencia.es/

[39] https://www.ecsite.eu/

ISBN 978-84-8158-937-5

Practical Workshop in the AquaCoLab Project. Technological Tools and Citizen Science for the Knowledge and Care of Biodiversity

A Canepa, P de La Fuente
University of Burgos, Spain
pdelafuente@ubu.es

Abstract. Freshwater ecosystems are fundamental for biodiversity and for human beings [1]. However, these ecosystems are one of the most threatened by human activity in the world [1]. Among the most important threats faced by these ecosystems (and by the global ecosystem) is the loss of biodiversity [1,2]. Because the pace at wich species are lost and the rapid increase in human pressure, citizen science acivities rised as a convenient way to characterize biodiversity [3]. Citizen Science (CC) activities, where members of civil society contribute effort and dedication in some of the stages of scientific knowledge [4, 5] allows generating such valuable information as traditional science [6]. In addition, CC allows for a space-time scope that traditional science rarely reaches, with a very important role in bringing citizens closer to STEM areas (science, technology and mathematics), conservation and increasing the general perception of ecosystem services [7, 8]. It is for this reason that CC activities not only serve to generate valuable information due to the amount of information generated, but also because they encourage the participation of civil society in scientific activities.

The AquaCoLab project aims to implement a citizen participation methodology for monitoring the quality of freshwater systems through collaborative laboratories (CoLabs) made up of people from society in general and civil groups, educational centres, etc. using different citizen science platforms, which allow:

1. Characterize the environmental quality of freshwater systems.
2. Increase scientific culture by helping to improve knowledge, environmental assessment and responsible innovation of freshwater systems.
3. Promote and improve the active participation of society in the study and care of these ecosystems.
4. Promote STEM vocations in the educational context.

The AquaCoLab workflow encompasses: I) the creation of “CoLabs” and definition of sampling areas, ii) characterising the participant’s perception and knowledge of freshwater systems at the beginning and the end of the project, iii) impart the training workshops for the representatives of each “CoLab” regarding the theory and practice of citizen science and its different platforms for gathering scientific data, iv) collection of environmental/ecological data by the "CoLabs", v) impart the data analysis workshops to validate observations and general results of the project and vi) development of a scientific dissemination campaign throughout the project.

To evaluate both aquatic and riparian biodiversity the Observation.org citizen science platform [9] is used. Observations from this citizen science platform are shared on the Global Biodiversity Information Facility (GBIF) and with more than 58 million records, Observation.org is the platform that contributes the most global biodiversity records to the GBIF [10], including information for all kinds of living things and also information about perturbations for biodiversity (i.e. human impact on nature).

By using this platform unther the AquaCoLab project, we can determine: i) the taxonomic composition of species associated with the river ecosystem, ii) the presence of invasive alien species, iii) the presence of non-native and planted species and iv) the presence of species typical of the river ecosystem, as indicators of good conservation status.

Along this practical workshop, we will be able to: i) review the platform and observations submitted by citizens, ii) explore observations recorded under the AquaCoLab portal in observation.org [11], iii) creates our own profile and download the Obsidentify app to record biodiversity data [12] and iii) develop an in situ biodiversity assessment (bioblitz), thus becoming citizen scientists for biodiversity.

Keywords. Citizen Science, Freshwater Ecosystem, STEM Vocations, Biodiversity.

Acknowledgements

AquaCoLab project is supported by the Spanish Foundation for Science and Technology, Ministry of Science and Innovation.

References

[1] Elosegi A, Sabater S. Conceptos y técnicas en ecología fluvial, España: Fundación BBVA, 2009.

[2] Zufiaurre R, Martín-Ramos P, Cuchí JA. Nitrates in Groundwater of Small Shallow Aquifers in the Western Side of Hoya de Huesca (NE Spain). Agronomy, 10, 22, 2020.

[3] Rolston A, Jennings E, Linnane S. Water matters: An assessment of opinion on water management and community engagement in the Republic of Ireland and the United Kingdom. PloS one, 12, 4, e0174957, 2017.

[4] European Commission and Socientize consortium (Eds.). Green paper on Citizen Science for Europe: Towards a society of empowered citizens and enhanced research, 2013.

[5] Serrano Sanz F, Holocher-Ertl T, Kieslinger B, Sanz García F, Silva CG. White Paper on Citizen Science in Europe, Socientize Consortium, 2014.

[6] Kosmala M, Wiggins A, Swanson A, Simmons B. Assessing data quality in citizen science. Frontiers in Ecology and the Environment, 14(10), 551–560, 2016.

[7] Kobori H, Dickinson JL, Washitani I, Sakurai R, Amano T, Komatsu N, Miller-Rushing AJ. Citizen science: a new approach to advance ecology, education, and conservation. Ecological Research, 31, 1–19, 2016.

[8] La Caixa, Obra social, FECYT y Everis (Eds.). ¿Cómo podemos estimular una mente científica? Estudio sobre vocaciones científicas, 2015.

[9] https://observation.org/

[10] https://www.gbif.org/dataset/search?type=OCCURRENCE

[11] https://aquacolab.observation.org/map_lastobs_v2.php

[12] https://observation.org/apps/obsidentify/

ISBN 978-84-8158-937-5

Real Science at Secondary School: From Antarctic Samples to a Scientific Poster

O Segundo-Mendoza[1,2]*, SE Jorge-Villar*[1]
[1]*Universidad de Burgos, Spain*
[2] *C.C. Sta. Mª la Nueva y S. José Artesano in Burgos, Spain*
osegundo@ubu.es

Abstract In this work, we present real scientific research carried out with secondary school students. The students were able to analyse by themselves samples from Antarctica, in the facilities of a Spanish national research centre (CENIEH). The experience was developed in face-to-face and online mode and finished with a virtual conference, in which the students exposed their scientific posters.

When teaching science at schools, there is almost always methodological adaptations of the experimental activities to the student level. Students know that what they are doing is an approximation of what scientists do, therefore laboratory tasks become another educational activity. There are many works demonstrating that bringing our pupils to the real world increases their interest for the subject and improves their learning [1,2]. Although real science is not always accessible to all education centres, the online teaching can become a very useful instrument to provide a true approaching of research institutions, scientists, real scientific instrumentation and authentic samples to students all around the world to develop proper scientific research.

In this work, we present our experience with 56 students, 38 of these were online and 18 were at the laboratory. The experience was carried out in the CENIEH (Centro Nacional de Investigación en Evolución Humana, Burgos, Spain), which belongs to the Unique Scientific and Technical Infrastructures (ICTS) national network. It is a high-level research centre in Spain with different laboratories from which we used the Microscopy and the Archaeometry laboratories.

The research topic was *"Is there extraplanetary life? Looking for extremophilic life signals in the rocks*". We worked with the students following the steps that this scientific field has developed over the last years. For that purpose, leaded by a scientist that is working in the field, we stablished our proposal around four workshops: I Workshop) How to address the problem of looking for life outside the Earth; II Workshop) Life on Earth: where, when and how; III Workshop) Looking for life on Mars: why, where and how; IV Workshop) Learning how to find bio and geo-markers of life on Mars: studying extremophile organisms on Earth. And, finally, we organised a virtual conference entitled "Looking for life on Mars: Study of extremophile in rocks", where our students showed the scientific posters they designed with the data collected using real scientific instrumentation from real samples.

For this work, we had three samples from Antarctica, one endolith and two liquens, which were analysed by scanning electron microscopy (SEM-EDS); Raman spectroscopy and X-ray diffraction (XRD). The students that were in the laboratory were able, apart from touching the real samples, to use the instrumentation and carry out their own analyses. The online students were able to see how their equals had the ability to utilize different analytical techniques and knew that they could have accomplished their own experiments too.

The research was distributed in three sessions of around four hours each. During the first session, we implemented the workshops; in the second meeting, we distributed our students in two groups for accomplishing the analyses and, in the final session, we analysed the results and guide the students to design a scientific poster.

With this proposal, science loses his halo of being an activity for a few and very clever scientists and becomes something affordable for ordinary people. Our students realize they can implement real science, achieve analyses, obtain conclusions and present their results as real scientists do in real conferences.

Keywords. Real Science, Secondary School, Virtual and Face-to-Face Teaching.

Acknowledgements

These analyses/experiments were performed in the Archaeometry laboratory at CENIEH facilities with the collaboration of CENIEH Staff: Chitina Moreno Torres, Mª Isabel Sarro

Moreno; David Larreina García; Belén Notado Collado and Ana Álvaro Gallo."

References

[1] Lupión-Cobos T, Franco-Mariscal AJ, Gambero JRG. Predictores de vocación en Ciencia y Tecnología en jóvenes: Estudio de casos sobre percepciones de alumnado de secundaria y la influencia de participar en experiencias educativas innovadoras. Revista Eureka sobre Enseñanza y Divulgación de las Ciencias, 16(3), 310201-310221, 2019.

[2] Osborne J, Simon S, Collins S. Attitudes towards science: A review of the literature and its implications. International Journal of Science Education, 25(9), 1049-1079, 2003.

ISBN 978-84-8158-937-5

The Mobile Phone: A Powerful Lab in Your Pocket

LC Pardo, A Paz
Universitat Politècnica de Catalunya, Spain
luis.carlos.pardo@upc.edu

Abstract. We all have mobile phones (almost). And we use them nowadays for everything: from making photos to perform the surveillance of our sleep. What these two examples have in common is that they use the sensors and camera that is in our phone. We can, in fact, also use these sensors to perform experiments and to explore the world around us in a scientific way.

We have started using the mobile phone to perform experiments at Tibidabo amusement park four years ago within the Fisidabo project [1] using the mobile phone as a tool to investigate the physics behind the rides. However, two years ago the pandemic stopped all our ongoing projects [1,2]. We used this unusual situation to start the developement of simple scientific experiments that could easily be done with the materials that can be found at home, or that could easily be buyed in a supermarket. Up to this point nothing new. But we used the capabilities of our mobile phone to perform *quantitative* experiments, substituting the "look what happens when…" for a better scientifically suited "measure what happens when…".

We designed the experiments so that the same activity could be used to perform a first easy analysis (with not much maths) that could be done by almost anyone. We proposed then questions of increasing complexity in which more sophisticated analysis was necessary to get an answer. All the experiments were (and are) open to anybody in the "Steam a classe" web [3]. An example will be self explanatory: Let's investigate the physics of a punch.

We ask students to give a punch in the air and measure the acceleration by holding tight the mobile phone in the hand [4]. The first thing we propose is to measure how "hard" was the punch by measuring the maximum acceleration. We gathered the measurements from all students to give an average of the maximum fist acceleration. Also, if this was explained, this bunch of data could be used to introduce/calculate uncertainty in measurements. We also asked the students to correlate with age and arm length, by putting together all their results. We did that using a web-based form, but can also be done collecting the data of a classroom.

We can go a little but further and perform an analysis of the time-dependent acceleration recorded by the mobile phone. We proposed to measure how many seconds long was the punch in the air. We can go deeper in the analysis taking the average acceleration and the duration of the punch to calculate, using kinematics, the final velocity of the fist. Finally, for the bravest, we proposed to integrate the acceleration in order to obtain the velocity profile of the fist [5].

We proposed in the "steam a classe" web experiments ranging from chemistry (measuring a bubbling chemical reaction velocity using the sound it makes), to optics (obtaining the famous $1/r^2$ distance law of light intensity) going through mechanics (calculating the friction coefficient using a phone movie).

Teachers used our web to keep students doing experiments during the pandemics, and asked them to write reports on the obtained results. After the pandemics the teachers are still using the experiments, and therefore we have kept our web open. Indeed, we will be having a teacher training on the use of the mobile phone to perform "*quantitative* kitchen experiments". We keep developing new activities to be used at the school with low cost materials using the sensors of the mobile phone.

Keywords. Mobile Phone, Quantitative Experiments, Kitchen Experiments, Low Cost Experiments, Physics, Chemistry, Dynamics, Amusement Park.

Acknowledgements

We would acknowledge the amusement park Tibidabo and the Barcelona Town Hall (BSM) to support us in the development of our science activities in Barcelona city.

References and Notes

[1] https://fisidabo.upc.edu/ca

[2] https://visions.upc.edu/ca

[3] https://visions.upc.edu/ca/steam-a-classe

[4] The measurements where performed using the app “arduino science journal”, https://www.arduino.cc/education/science-journal

[5] A second integration would lead to the position as a function of time. But already the first integration is noisy due to measurement errors, that means that a second integration would be even less accurate than that yielding to the velocity profile.

ISBN 978-84-8158-937-5

How to Learn, Make and Admire Science: Hands-on Activities for Environmental Caring

S Curiel-Alegre, B Velasco-Arroyo, JJ González-Plaza, C Rumbo, N Fernández-Pampín, JA Tamayo-Ramos, S Martel, R Barros
University of Burgos, Spain
scuriel@ubu.es

Abstract. In recent years, the role of researchers has become increasingly recognized by the general public. Biotechnological-based projects of diverse disciplines have been paid increased attention. The International Centre of Critical Raw Materials (ICCRAM), belonging to the University of Burgos (UBU) has, among its main objectives, to expand dissemination and communication actions towards younger audiences, with the aim of achieving greater visibility of the scientific projects developed at our facilities, through specialized workshops and trainings. Apart from disseminating the projects themselves, the main goal of these activities should be always the promotion of the scientific thinking. For this to happen, the individuals who are part of society must be attracted by Science from some point of view. But not only does “learning about Science” or “learning Science” itself must be enjoyable: it is essential that there is a significant bulk of the population that knows “how to do Science” (Manzanal and Hueto, 2011, cited in [1]). Providing the basic tools for scientific literacy from an early age, always from an attractive and motivating perspective, could be a key for the change in the current paradigm [1] and [2].

In order to promote Science, “you must first get to know the scientists”, especially recognizing and admiring the role of renowned scientists from history. From the research group on “Sustainability, Environment and Toxicology” of ICCRAM, we believe it is important to present our own researchers and their work, so young people can learn and appreciate ongoing scientific research in our city and, in this way, to awake scientific interest on them.

At ICCRAM, we have been engaged in numerous hands-on science activities, being very active and taking advantage of events such as the "Castilla y León Science Week", the "European Researchers' Night", the "11th February 2020/21/22" initiative, International Day of Women and Girls in Science”. Likewise, we have been actively participating at different workshops in "La Estación", as well as during warm welcomes from Burgos schools and collegues, carrying out different activities in their centres.

The common thread of all the activities were biotec projects developed at ICCRAM, e. g., " GREENER" or “SURFBIO”, among others. With the support of the Scientific Culture and Innovation Unit from UBU (UCC+i), the researchers involved in the projects have taught and guided the young people on how to carry out experiments on plant physiology, soil science, microscopy, microbiology and electrochemistry. The students could get to know some of the techniques developed in the daily job, in a very simple and funny way. In these workshops, they were introduced to special branches of Engineering and Biology, i.e., “Bioremediation” and “Phytoremediation”, which are the use of living organisms and plants to help cleaning-up contaminated soil and water sites, leading to the protection of the environment in a sustainable manner. With basic, but very interactive and didactic experiments, the young people who participated in the workshops were able to learn different mechanisms of bioremediation. But they became conscious of something more important: the need to increase and disseminate the awareness on the relevance of caring for the environment, for human health and the planet, and the urgency to be surrounded by clean soils and water, making them concerned on the difficulty and scarcity for resources to carry out these strategies of decontamination. “*Showing how soil is important in everyday life can create connections to soil, because people care about things they see as impacting their quality of life. Education can demonstrate these connections and may take place in either formal or informal settings and over a wide range of age groups”* [3].

All the activities were designed for different educational levels, ranging from 5 years-old to 16 years-old. At the onset of the activities, there was always a brief space of time dedicated to presenting the projects to the students, and to make them aware of the importance of caring for the environment.

This way of divulgating and bringing students closer to Science makes it more attractive, provoking on them the awakening of a scientific vocation that may not have existed before, with the exciting experience of getting to know first-hand the researchers in their city. The workshops organized by ICCRAM researchers have made emphasis to highlight to young women scientists, all achievements made so far by women in STEM (Science, Technology, Engineering and Mathematics) subjects. At this regard, at ICCRAM we have been very active participating during the 11th February initiative, used as a response to the urgent need to "*Make the work of women visible and try to persuade female students to opt for scientific and technological careers*". This "International Day of Women and Girls in Science" aims to facilitate access to science for girls and women and seeks equality and parity for those women who are already part of the scientific community.

In conclusion, with simple, funny, and real experiments presented by real scientists, ICCRAM fulfils, among its main objectives, not only the achievement of the scientific goals but the contribution to pave the way towards: (i) support on making more frequent meeting scientists with young audiences to disseminate their work in an attractive atmosphere; (ii) to popularise Science and specific projects and the intrinsic methods, and to teach how to make Science thus future young researchers can be engaged; and (iii), last but not least, to strengthen the role of women in Science.

Finally, we should remark that, at ICCRAM, we are very conscious and strongly support the current EU roadmaps aligned with environmental protection, specially related with decontamination of water and soil. Accordingly, we work to be in line with the objectives marked in the MISSIONS launched to face the main challenges. For instance, we are completely aligned with the targets proposed in HORIZON-MISS-2022-SOIL-01-07: “Foster soil education across society” [4].

Keywords. Science, Bioremediation, Environment, Awareness, Research, Divulgation, Women, Workshop.

Acknowledgements

We sincerely acknowdledge the financial support from the GREENER and SURFBIO projects of the European Union's Horizon 2020 research and innovation program (Grant Agreement No. 826312 and 952379, respectively). S. Curiel is granted by a pre-doctoral contract by Junta Castilla y León (ORDEN EDU/1508/2020, de 15 de diciembre). We really appreciate the support and facilities from the UCC+i from UBU.

References

[1] Viveros S. El método por investigación en el desarrollo de competencias científicas en situaciones de biología molecular y biotecnología, en la educación media. 2011. (Doctoral thesis). Available in (CB-0450254.pdf).

[2] France B. Location, Location, Location: Positioning Biotechnology Education for the 21st Century. Studies in Science Education, 43, 88-122, 2007.

[3] Brevik EC, Hannam J, Krzic M, Muggler C, Uchida Y. The importance of soil education to connectivity as a dimension of soil security. Soil Security, 7 100066, 2022.

[4] European Commission Decision C(2022)2975 of 10 May 2022. Horizon Europe. Work Programme 2021-2022. 12. Missions.

Integrating English, Literature and Science through Project-Based Learning: A Proposal in Higher Education

D Ruiz Hidalgo
University of Burgos, Spain
drhidalgo@ubu.es

Abstract. New methodologies, understood as potentially motivating resources, allow both teachers and students to create new teaching contexts in which not only the acquisition of theoretical contents, but also the learning processes themselves take precedence. These active methodologies, such as Project Based Learning (PBL), which are already present in other educational stages, tend to get a very theoretical nuance when it comes to University classrooms. It is essential to start transforming this educational reality towards more practical approaches for the benefit of future teachers.

Such methodologies aim at giving a response to a new role of students in the classroom, for the so-called “digital natives” who need to know technologies’ potential in the implementation of new projects, for the benefit of their own learning.

PBL requires active and responsible students working in teams, concluding with a final product, developing deeper levels of understanding and new skills that will help them in their future professional work. Projects must go through a careful and rigorous planning, management and evaluation process that helps students learn fundamental academic content, skills and competencies.

This study analyses the learning context of students in the second year of the Bachelor’s degree in Early Childhood Education in terms of motivation, interest and learning in the subject "Early Learning of the Foreign Language: English", applying Project Based Learning (PBL) to the university classroom, integrating Science and Literature. The PBL methodology culminates in the public presentation of a product of student learning. Groups present the results of their final project to their peers, fostering a culture of continuous review and feedback. The final project is based on a story from English literature, integrating subject content areas, such as Science, through activities, games, music and ICT. The language is adapted to preschool, as well as vocabulary and Science content.

This research is based on a qualitative questionnaire and was completed with focus groups of undergraduate students in the last two academic years. The results reflect excellent levels of motivation and learning, as well as the acquisition of strategies and teaching skills for teaching foreign languages and Science through experiments in Early Childhood Education. According to the results obtained, there is evidence that Project Based Learning implemented with ICT facilitates active participation, competences´ development, social skills and improvement in the acquisition of subject content by student teachers. Therefore, PBL and CLIL methodology (Content and Language Integrated Learning) are closely linked in the improvement of language learning in Early Childhood Education.

Keywords. Active Methodologies, English, Literature, Science.

References

[1] Atienza J. Aprendizaje Basado en Problemas. In Labrador M, Andreau, M.(Ed.) Metodologías activas, 11-2. Ediciones Universidad Politécnica de Valencia, 2008.

[2] Bradley-Levine J, Mosier G. Literature Review on Project-Based Learning. University of Indianapolis Center of Excellence in Leadership of Learning, 2014.

[3] Cálciz AB. Metodologías activas y aprendizaje por descubrimiento. Revista digital innovación y experiencias educativas, 7(40), 1-11, 2011.

[4] Coll C, Mauri T, Onrubia J. Análisis y resolución de casos-problema mediante el aprendizaje colaborativo. Revista de Universidad y Sociedad del Conocimiento, 3(2), 29-36, 2006.

[5] Lobato C. Hacia una comprensión del aprendizaje cooperativo. Revista de Psicodidáctica, 4, 56-76, 1997.

[6] Johnson DW, Johnson RT, Holubec E. El

aprendizaje cooperativo en el aula. Barcelona: Paidós, 1999.

[7] Prensky M. Digital natives, digital immigrants, in On the Horizon, MCB University Press, 9(5), 2001.

[8] Salinas J. Innovación docente y uso de las TIC en la enseñanza universitaria. Revista de Universidad y Sociedad del Conocimiento, 1(1), 1-16, 2004.

[9] Silva J, Maturana D. Una propuesta de modelo para introducir metodologías activas en educación superior. Innovación educativa, 17(73),117-131, 2017.

[10] Thomas JW, Mergendoller JR, Michaelson A. Project-based learning: A handbook for middle and high school teachers. The Buck Institute for Education, 1999.

[11] Toledo Morales P, Sánchez García JM. Aprendizaje basado en proyectos: una experiencia universitaria. Profesorado: Revista de curriculum y formación del profesorado, 22 (2), 429-449, 2018.

ISBN 978-84-8158-937-5

Challenges of the 21st Century in Education: Emerging Technologies

EM Gomis, C Perea
Miguel Hernández University, Spain
eva.gomis01@goumh.umh.es

Abstract. Technology is advancing rapidly and nowadays, the knowledge of the emerging technologies such as Artificial Intelligence and Science of Data has become essential to properly prepare citizens in an increasingly interconnected globalized future.

Artificial intelligence is present in our lives when example, we do an internet search, we use GPS to arrive at a site, we ask "Siri" about the weather, we unlock our mobile phone with fingerprint recognition, face or voice. But sometimes, due to ignorance, it goes unnoticed. for most of us. AI will change working models current, and for this self-taught, creative citizens will be needed, capable of solving problems and with soft skills

Today we have a large amount of source data enormously varied: from log files, email, social networks, sales data, patient information files, sports performance data, sensor data, cameras security and many more. But, while there is more data available than ever, we have the computing power necessary to perform useful analysis and reveal new insights.

Data science is the study of large amounts of data, that can reveal insights that can help make decisions strategic. And for this, curious people are needed, with critical thinking and decision-making ability.

The educational situation for our digital society requires constant updates, but above all, it demands innovation in teaching-learning practices [1]. For this reason, the educational system has the challenge of training students to develop skills and competencies that allow them to be able to insert themselves in the jobs of the future and to achieve this, it must begin to develop them from the first educational levels.

To this end, the course "Application of technologies Emerging in Education: Artificial Intelligence and Data Science" with the following objectives:

1. Understand the role of technology and its advances in the society
2. Know emerging technologies (AI, Data Science, robotics,…) its risks and benefits.
3. Promote digital transformation and innovation in the system educational.
4. Promote scientific-technological vocations in careers STEM.
5. Promote respect and gender equality.

This course is part of an investigation into the need impending literacy and training in emerging technologies, as part of the professional development of Education teachers Primary and Secondary in the classrooms of the 21st century, to achieve the students and their connection with the main challenges and global challenges of the 21st century that they will have to face.

Keywords. Mediterranean Science, Scientific Vocations, Engagement, Gender Gap, Scientific Communication.

References

[1] https://ec.europa.eu/info/funding-tenders/find-funding/eu-]funding-programmes/digital-europe-programme_en

Community Service to Share Learning and Science

M Queiruga-Dios[1]*, MJ Santos Sánchez*[2]*,*
MA Queiruga-Dios[3]*, A Queiruga-Dios*[4]
[1]*Universidad Francisco de Vitoria, Spain*
[2]*Universidad de Salamanca, Spain*
[3]*Universidad de Burgos, Spain*
[4]*Universidad de Salamanca, Spain*
queirugadios@usal.es

Abstract. Service-learning (SL) is considered as a learning experience where knowledge and skills interact, it is an activity in which students develop community service. SL promotes students and faculty engagement while doing cooperative education that benefits students, faculty, and community members, i.e., communities and universities. This cooperation can be developed with several distinct projects such as online or on-campus projects, neighborhood community services, or projects in a different country [1, 2].

The central element of SL is who receives the service: the wider community [3]. This active learning approach promotes students' creativity and lead them to think outside classroom [4].

In recent years authors proposed their students the participation in SL projects. Depending on the degree and the university, SL is integrated into credit-bearing courses, or it is included in curricular or extracurricular activities [5].

The espacific proposal was related to scientific dissemination activities aimed at stimulating and sharing science with children from families in need. These families used to receive food from the food bank and are regular users of the canteen for poor people in Salamanca (Spain).

Students from the master in training teachers prepared and implemented a one-day activity with those children. Master's degree students conducted some experiments in chemistry and physics to play and learn with children. This out-of-class experience was benific for all people involved on it. First, children were really happy, and they interacted with young scientists providing ideas and quick responses to questions about the expriments. On the other hand, the feedback from master's degree students participated in these activities showed that it was an enriching experience very different from the rest of activities from their studies. Finally, people responsible from the canteen for poor people were very grateful because with such activities children learn and play at the same time, and they change for some hours their lives.

Keywords. Service-Learning, Community Service, Active Learning.

References

[1] Felten P, Clayton PH. Service-learning. New directions for teaching and learning, 128, 75-84, 2011.

[2] Queiruga-Dios, M, Santos Sánchez, MJ, Queiruga-Dios, MÁ, Acosta Castellanos, PM, Queiruga-Dios, A. Assessment methods for service-learning projects in engineering in higher education: A systematic review. Front Psychol., 12, 629231, 2021.

[3] Derreth RT, Wear MP. Critical online service-learning pedagogy: justice in science education. J. Microbiol. Biol. Educ., 22, 1–7, 2021.

[4] Bielefeldt A, Paterson K, Swan, C. Measuring the impacts of project-based service learning, ASEE Annual Conference, Austin, TX, 2009.

[5] Oakes W. Service-learning in engineering: a resource guidebook. High. Educ, 165, . 2004. http://digitalcommons.unomaha.edu/slcehighered/165

ISBN 978-84-8158-937-5

How to Learn Calculus in an Easier and More Efficient Way

CH Chou
Vanung University, Taiwan, R.O.C.
chou0717@gmail.com

Abstract. Most of Calculus textbooks are extremely tedious. However, many students who have to learn Calculus are afraid of learning Calculus. Moreover, now of days students seldom focus their attention on studying any topic for a long time because they get used to get the knowledge from websites, which is fast way..

Although Calculus is extremely important for learning college or university courses, Calculus is not so complex and difficult as most textbooks describe. It is possible to teach students Calculus in an easier and more efficient way. Obviously the students still have to spend more time to study the details of Calculus. However, if the students have already known the whole complete picture of Calculus, which is very simple, to study the details of Calculus becomes more enjoyable. The situation is quite similar to the fact that after knowing how the main buildings and roads of a city are designed, the tourists can enjoy the sightseeing around the city much more efficiently.

The author tries to illustrate the whole picture of Calculus concisely by showing them the following several key points. (1) The Calculus is just about the addition and subtraction of any function. (2) In the college or university courses there are a lot of issues that relate to functions. And we can us a diagram to describe vividly a function and related calculation of the function. (3) There are two kinds of calculations about a function which are frequently conducted and extremely useful. But even high school students can understand these two calculations without any difficulty. (4) Assuming dx is infinitely approaches to zero, we can make a very useful and convenient approximation. The approximation helps us to solve many science and engineering problems efficiently. (5) In Calculus, there are many differentiation algorithm and inverse differentiation algorithm, which are pretty technical and shall be memorized. By using these algorithm people can retrieve the original exact f(x) from approximated df(x). (6) Finally the author solves several real science problems by using Calculus in order that students can understand the whole story about the principles of Calculus and applications of Calculus.

The author uses very few definitions and principles to explain the whole story of Calculus from the first key point to the last one, and neglects strict mathematics proofs of certain issues, such as limitations. Too many mathematics proofs prevent students from understanding the whole pictures of Calculus in a reasonable short period of time.

The author connects function and Calculus in the unique manner and describes the related calculations of Calculus by a diagram of the function involved in the calculation. The author avoids misleading students. For example, in most textbooks there are too many home works which are about how to compute an area between tow curves. These home works make students believe the integral is just about computing the area inside a closed curve or the volume of object with special shape.

In the short presentation, how to apply Calculus to a real engineering and science problem is emphasized.

A miniature Calculus course, that offers students a guide of learning Calculus, is absolutely necessary. Any comments on the short presentation are very welcomed. Let's work together to improve the course. The author believe we shall find an easier but efficient way to allow even high school students understanding Calculus, which was invented about 400 years ago and shall not bother our students anymore.

Keywords. Calculus, Derivatives, Integrals.

Acknowledgments

The author thanks t the Ministry of Science and Technology, R.O.C for the financial support.

References

[1] https://www.mathsisfun.com/calculus/

ISBN 978-84-8158-937-5

Informal Learning Programs and Environment as a Way to Enhance STEM Education Process. Examples from Tunisian Experience

S Sedrette
Monastir Science Palace, Tunisia
ssedrette@gmail.com

Abstract. Interactive science centers are significant informal learning sources for Science and Technology where exhibits and hands-on activities are employed as learning tools. In this immersive environment, the student interacts directly with scientific information and experience, and can apply his skills.

The outdoor science program, which reaches the poor and needy regions, contributes to the spread of scientific culture and gives a chance to the remote schools and associations to be familiar with STEM education.

These science centers contribute also to improve science teaching by offering their facilities to learn about STEM education and to acquire additional competencies and skills in their area of competence in order to develop their performance on the one hand, and to create an environment for interactive learning in their own schools, on the other.

Science Festival and competitions provide an opportunity for those interested in scientific activities and those working to spread the culture of learning and research to show their innovations and creations, in order to achieve the desired communication between the various scientific structures and different segments of society. Therefore, each year, high school seniors from across Tunisian regions face judges and share their scientific projects, and test their problem-solving abilities.

Due to the special circumstances brought on by the COVID-19 pandemic An online platform has been developed for this purpose and an early announcement of competitions has been well studied so that the entire target audience is kept informed of all the news of the challenge.

The existence today of a great number of scientific associations and the increasing number of science clubs in the educational institutions (primary, secondary and university) in Tunisia is the output of science centers programs operating in the field for almost 30 years.

Keywords. Education Process Enhancement, Science Centers, Science Learning, STEM, Tunisia.

ISBN 978-84-8158-937-5

Investigation of Science and Art Center Teachers' Opinions on STEM Education Approach

E Sahin, Ö Celebi
Yasemin Karakaya Science and Art Center, Turkey
erhansahin38@gmail.com

Abstract. The purpose of this study is to determine the views of Science and Art Center (SAC) teachers about STEM education approach. The phenomenology design, one of the qualitative research method designs, was used in the study. The research was carried out with 25 SAC teachers (11 women, 14 men) who work in different science and art centers with 25 different course areas of the 2020_2021 academic year in Turkey. A semistructured interview form prepared by the researcher was used to collect the data. The data were evaluated by using the content analysis method. The interview form is composed of questions about STEM applications and STEM competencies in general. It is understood from the data that the teachers who use the STEM education approach in their activities are mostly science and mathematics branches. The participants stated that providing teacher training, a learning environment, technical infrastructure, and sufficient budget which are provided in science and art centers are the main conditions necessary for STEM Education [4]. Among the results of the study is that in training provided in the field of STEM education is very important for teaching service, but is not sufficient in number, quality, duration, planning, and academically. More than half of respondents stated that present educational content and practice examples related to STEM education for gifted students are not sufficient [3]. However, it was stated that a STEM education environment and content design should be created for gifted students. SAC teachers gave positive feedback about the applicability of STEM Education in science and art center. This process will ensure interdisciplinary cooperation, communication and learning, provide students with practical training in the STEM process, enable them to learn by experiencing, improve students' high-level thinking skills, increase interest and motivation by making lessons fun; provide talent development, develop students' 21st century skills, provide permanent learning, contribute to the training of qualified manpower and awareness of new professions. It can be said that these findings are in harmony with the literature [1-2, 5].

Keywords. STEM, Science, Art Center, Gifted Student, Teacher.

References

[1] Kim DH, Go DG, Han MJ, ve Hong SH. The effects of science lessons applying STEAM education program on the creativity and interest levels of elementary students. Journal of the Korean Association for Research in Science Education, 34(1), 43-54, 2014.

[2] Kang NA. Review of the effect of integrated STEM or STEAM (science, technology, engineering, arts and mathematics) education in South Korea. Asia Pac. Sci. Educ., 5, 6, 2019.

[3] Sternberg RJ. Teaching and assessing gifted students in STEM disciplines through the augmented theory of successful intelligence. High Ability Studies, 30(1-2), 103 -126, 2019.

[4] Şahin E. ve Yıldırım B. Determination of theeffects of STEM education approach on career choices of gifted and talented students. MOJES: Malaysian Online Journal of Educational Sciences, 8(3), 1-13, 2020.

[5] Herro D, ve Quigley C. Exploring teachers' perceptions of STEAM teaching through professional development: implications for teacher educators. Professional Development in Education, 43, 416–438, 2017.

ISBN 978-84-8158-937-5

Melanogaster: Catch the Fly. First European Network of Citizen Science in Adaptation Genomics

O Segundo-Mendoza[1,2]*,*
M Aldea-Segura[1,3]
[1]*Universidad de Burgos, Spain*
[2] *C.C. Sta. Mª la Nueva y S. José Artesano in Burgos, Spain*
[3] *Colegio Niño Jesús School -Fundación Edúcere in Burgos, Spain*
osegundo@ubu.es

Abstract. In this workshop, we present a Citizen Science Project [1] on adapatation genomics in which pupils from different schools in Spain (and other countries in Europe) are catching and classifing hundreds of fruit flies (*Melanogaster*). These living flies are sent to the Laboratory of Evolutionary and Functional Genomics (González Lab) of the Institute of Evolutionary Biology (CSIC-UPF) in Barcelona.

"***Melanogaster: Catch the Fly!***" is the first citizen science project on genomics of adaptation led by Dr. Josefa González, principal investigator at the Laboratory of Evolutionary and Functional Genomics of the Institute of Evolutionary Biology at Barcelona, and co-founder of the European Consortium for Genomics of Drosophila Populations. The project is co-led by Roberto Torres, director of the science dissemination association La Ciència Al Teu Món, in collaboration with and the European Consortium for Genomics of Drosophila Populations. The project also involves the participation of the Genomics, Bioinformatics and Evolution group of the Dept. of Genetics and Microbiology at the UAB.

Students can collaborate in the project at different levels. The first of them consists of collecting fruit flies from orchards near their location, in which they must previously have collected the climatic variables (temperature, wind, sunshine...) and writing down all these elements, as well as incidents that might have occurred. During the collection and classification of the flies. These flies are classified into species (*Drosophila melanogaster, D. Suzukii, D. simulans*,…) and are separated into males and females.

All this prepares students to a very important part of scientific research: the systematic collection of samples, the development of a capacity for observation and scrupulous laboratory work, logging all the variables and incidents. The responsibility of collaborating with an international genomics laboratory and the feedback received with the results of the collection, notes,.. makes students take responsibility for the process while at the same time feeling proud to be part of the research.

The samples collected, classified and separated are sent to GonzalezLab (the females must be sent alive) where they are genetically sequenced, in order to analyze the genomic elements involved in the adaptation of these organisms to environmental factors. The aim is to understand which genes and phenotypes are involved in adaptation and which mechanisms are involved. Fly populations from Burgos are particularly relevant in the study of how thermal oscillations affect the genome of these individuals.

Keywords. Citizen Science, Secondary School, Genomics, Evolution, Melanogaster.

Acknowledgments

The citizen science project #MelanogasterCTF is organized by Laboratorio de Genómica Evolutiva y Funcional del CSIC, and the scientific dissemination platform La Ciència Al Teu Món (LCATM).

With the collaboration of the European Drosophila Population Genomics Consortium (DrosEU), and with the collaboration of the Spanish Foundation for Science and Technology – Ministry of Science and Innovation. (FECYT) and the European Research Council (ERC).

Thanks to the whole staff in GonzalezLab: Dr. Josefa González, Dr. Miriam Merenciano, Roberto Torres, Anna Vila,… and the every partner schools collaborating in this project that are always ready to help.

References

[1] Melanogaster: Catch the Fly! – Teacher guidelines, 2021 https://melanogaster.eu/home/?lang=en

ISBN 978-84-8158-937-5

Monastir Science Palace: Towards a National Leader in STEM Learning

S Nasr
Monastir Science Palace, Tunisia
salah1nasr1@gmail.com

Abstract. Monastir Science Palace (MSP) is a public non-administrative establishment placed under the Ministry of Higher Education and Scientific Research. It was created according to 36-2007 of June 4, 2007 law. Its objective is to create a scientific, cultural and intellectual dynamics among the different categories of citizens. It is notably charged of:

- contributing to the promotion, popularization and dissemination of scientific culture in society. This vocation is closely related to the objectives of the 2030 Agenda of Sustainable Development, as adopted by the United Nations at the summit of 25 September 2015.
- early coaching young people and encouraging them to create and innovate.

In fact, nowadays, teaching science is no longer the exclusive task of academic institutions but also those of scientific centers, which are likely to increase the interest of young people in the sciences, develop their curiosity, their motivation, their understanding and learning. In addition, it is of paramount importance to familiarize the society with the scientific culture so that it understands its positive outcomes in the daily life. Thereby, the MSP needs to position its education programs at the center of its activities.

To do this, the establishment has developed a range of programs and activities addressed to a wide and varied public. We particularly cite:

- Organization of guided tours for the benefit of students: the objective is to familiarize students to handle, play and experiment for increasing their admiration to sciences.
- Mobile Sciences' Program: each school year, the MSP organizes a series of visits to schools across the country, in coordination with the regional education offices. Through various workshops and interactive exhibits, our mediators aim to simplify a number of scientific concepts to students in a fun way and to arouse their interest, as well as that of teachers, in scientific and technical progress.

The mobile science' program has allowed us to visit schools in all governorates of the country and continues to spread more and more. We attach great importance to this program which we try to develop further by integrating new concepts of teaching science, technology, engineering and mathematics. As mentioned above, current science education in most national institutions has shown its limits. Often unidirectional, limited to the module taught and based on memorization, such teaching rarely arouses the curiosity of young people and does not encourage them to criticize, innovate or solve real-world problems. The objective of the PSM is then to introduce, consolidate and establish in the national education system the concepts of the 21st for science education and particularly STEM education. Training, provided by an international expert, on the STEM approach is scheduled at the PSM from June 15 to 26, 2022. This training is not only dedicated to the establishment's facilitators, but also for the benefit of a hundred researchers, secondary and higher education's teachers and leaders of scientific clubs and associations. A testimony on this experience will also be presented in this paper.

Keywords. Creative Learning, Critical Thinking, Scientific Culture, STEM Education.

ISBN 978-84-8158-937-5

Capturing and Viewing Stereoscopic Images

S Riba, J Escofet
Universitat Politècnica de Catalunya, Spain
jaume.escofet@upc.edu

Abstract. This work shows an experience based on obtaining stereoscopic or 3D photographs in the classroom. First, we compare stereoscopic vision and the images captured with two cameras. After this, different rules that allow obtaining good stereoscopic images are presented. Three types of cameras have been used: a smartphone camera, a photographic camera (both digital), and an analog camera specifically designed to obtain 3D images. Analog images have been converted to digital and all digital images have been processed with an image editing tool. Finally, images are presented in stereoscopic pair format to be seen by a 3D viewer as well as in anaglyph format to be seen with colored glasses.

Keywords. Photography, Image 3D, Stereograms, Stereoscopic Images.

1. Introduction

Stereoscopic vision is a process of visual perception in which an in-depth sense of sight creates different perspectives of received information by the horizontal separation of two eyes.

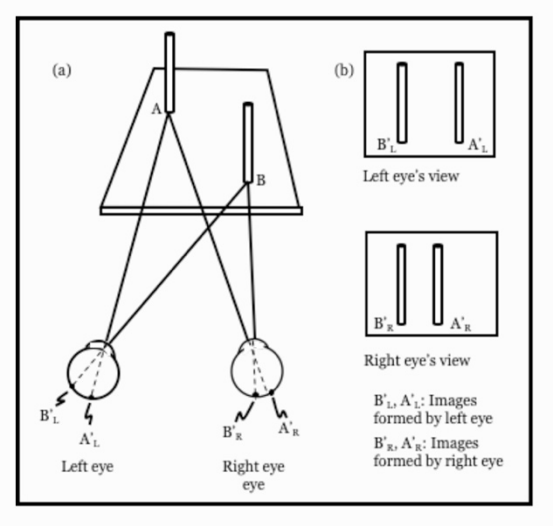


Figure 1. Stereoscopic vision. b) Mechanism of image formation in each eye. b) Image formed by each eye

2. Capturing stereoscopic images

Just as in stereoscopic vision stereoscopic images need two cameras, separated by the intraocular distance (IOD), to be obtained [1].

Two images are captured, one for the right eye and the other for the left eye. This is achieved with a single camera shooting two photographs from different positions (Figure 2(a)). It is clear that the subject, in this case, must not move during the entire procedure, otherwise, the two images would be too different. Another way is to mount the two objectives (L and R) in a common chassis as shown in figure 2(b), this is the real stereo camera, which can also be considered as the union of two simple cameras. It is also possible to make stereo images with two cameras assembled as shown in figure 2(c). In all cases inter lens separation or shift is the same as IOD and it has been taken IOD = 65 mm.

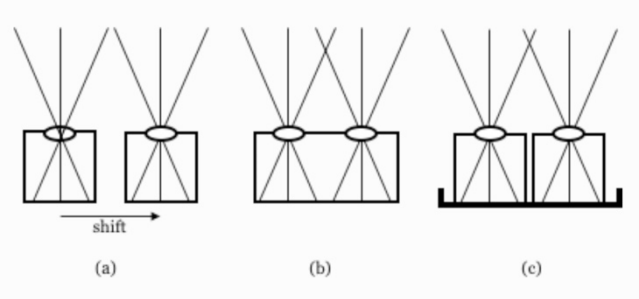


Figure 2. Diferent image capture systems. a) Shifting a single camera. b) Camera with two lens. c) Two cameras assembled

In order to obtain correct stereoscopic images several rules may be considered. The most importants are:

1. Every picture must be sharp from near to far distances.
2. In the finished framed pictures there is to be no vertical parallax. Identical points in both single views must always lie on the same horizontal.
3. With one mono-camera, only stereo exposures of non-moving objects may be made.
4. The camera should not be tilted (rolled).
5. Both single-views may not be transposed.

ISBN 978-84-8158-937-5

In this work three kind of cameras has been used: A smartphone camera, a consumer digital camera and an analogic stereoscopic camera.

3. Viewing stereoscopic images

Images captured as specified in the previous section must be suitably prepared to be correctly observed.

In this work, two different methods of viewing stereoscopic images have been used: The anaglyph and the stereoscope viewer. Both methods consist in presenting two different images to each eye.

Anaglyph method consists in coloring the left eye image in red and the right eye image in cyan and overlying both images. Looking at the resulting image with colored glasses of the same color for the same eyes, two different images are formed for each eye, and thus stereoscopic vision is obtained.

To view the image through a stereoscope [2], it is necessary to present both images (left and right) with their homologous points separated by the distance IOL. So that both eyes also see different images.

4. Results

Figure 3 displays an anaglyph and figure 4 shows a stereoscopic pair. Both have been captured by a simple consumer camera shifting the lens the distance IOD.

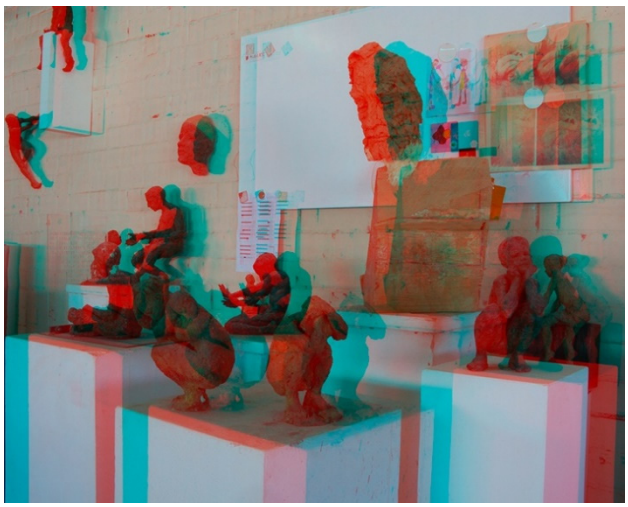


Figure 3. Anaglyph image

Figure 4. Stereoscopic pair prepared to be viewed by a stereoscope

5. Conclusions

Through the practice of stereoscopic photography, students are introduced to the topic of stereoscopic vision. Just as stereoscopic photography does not exist without two eyes, stereoscopic photography does not exist without two lenses.

Photography topics such as the knowledge of the different features of the camera and specifically lens focusing and depth of field need to be assimilated by the students for a correct realization of the stereoscopic images.

Image processing issues such as coloring channels and superimposing them in the case of anaglyphs as well as scaling the images and composing them, separated IOD distance, as a pair of images for their correct viewing with the stereoscopic viewer are necessary for the correct viewing of the images.

Obtaining and viewing stereoscopic images is an activity that captivates students who feel satisfied when they get good results. This goal is not difficult to achieve.

6. References

[1] Greenslade TB, Merrit WG. Experiments with stereoscopic images. The Physics Teacher 11, 215-221, 1973.

[2] Crane HR. How things work - Uncommon Uses of the Stereoscope. The Physics Teacher 25, 588, 1987.

Rocket Development – Tafra Aerospace

TAFR Alves
Personal Development in Viana do Castelo, Portugal
tiago.alves@g9telecom.pt

Abstract. The project herein presented intends to design, build, and test very small-scale solid propellant rocket engines that will later equip rockets developed by us.

High, consistent and predictable performance is our goal. Therefore, we aim to have a good quality manufacture and design of the engines. To evaluate the performance of the rocket engines, we built a test stand, with wifi connectivity, that communicates with a central server. There is also a web interface that provides control and data visualization of the burn process. The same test stand will be used as a base station for future launches. We deal with miscellaneous knowledge areas like chemistry, physics, mechanics, electronics and software programming. All hardware and software was developed specifficaly for this project.

We also aim to show that aerospace engineering is not a *monster* of a subject. This project demonstrates that with few resources it is possible to develop very small-scale engines that resemble the real big ones.

Keywords. Rockets, Tafra Aerospace, Aerospace engineering, DIY.

Acknowledgments

We would to thank the Colégio do Minho, in particular, to Sofia Pires; and to the companies: Ingrenor for providing sorbitol for the production of propellant; JGomes for welding works; G9Telecom, for providing telecommunications and software resources; and, Web community for practical and theoretical knowledge.

References

[1] https://www.tafra.pt/

[2] https://www.nakka-rocketry.net/

[3] Sutton GP, Biblarz O. Rocket Propulsion Elements. New York: John Wiley & Sons, 2001.

ISBN 978-84-8158-937-5

Ukrainian Education in Times of Uncertainty

I Berezovska, M Rataj
University of Informatics and Management in Rzeszow, Poland
iberezovska@wsiz.edu.pl

Abstract. The war brought about a devastating impact on education in Ukraine. The uncertainity of war scenarios is the worst of all. There is no clear and specific date when peace would return to the country. Under stressful circumstances, when people don't even know what will happen tomorrow the feeling that life lacks meaning may occur. By Frankl [1], there is always a meaning, and every person has a purpose and responsibility - they just need to be found to understand. If people can do it all, it will become clear what life expects of us and it will once again have meaning, even under uncertainty of the war. The purpose of all who work in education is to identify issues, help to overcome them, to maintain educational system and ensure further education in this time of uncertainty. International education community has demonstrated solidarity with Ukrainian teachers, researchers and students who had to flee ruined universities and research centers. There are several models and practices of integrating migrants in new environments [2]. The following challenges may be considered as primary with integrating faculty and student from Ukraine in Poland: language barrier; background of education and qualifications; social habits, behavior and qttitudes; employment. The University of Informatics and Management in Rzeszow (Poland) has developed successful intergration patterns based on comprehensive and competent support that ensure positive results in adapting Ukrainian colleagues and their families.

Keywords. Uncertainty, Ukraine, Education, Sustainable Adaptation, Poland, Intercultural Difference.

References

[1] Frankl VE. Man's search for meaning. Boston: Beacon Press, 2006.

[2] Passiatore Y, Pirchio S, Carrus G, Maricchiolo F, Fiorilli C, Arcidiacono F. Intercultural practices and inclusive education in Europe: can migration be a resource for individual and societal development? Eur. J. Psychol. Educ., 34, 209–224, 2019.

ISBN 978-84-8158-937-5

Writing Popular Science Texts on Treatments to Fight Covid-19

C Sotério, SL Queiroz
University of São Paulo, São Carlos, Brazil
salete@iqsc.usp.br

Abstract. The race to develop new drugs and studies of those already known made headlines in popular media throughout the Covid-19 pandemic, especially when mass vaccination had not yet been made available. At the same time, the population closely followed the provisional nature of science, as new studies were published to corroborate or refute previous ideas, leaving room for misunderstandings and the dissemination of fake news. Thus, drugs against the disease have become a matter of important clarification, leading to the potential to foster communicative skills of those who are pursuing careers in chemical sciences.

Therefore, this work aims to (i) report a didactic experience in which freshman students of the Bachelor's degree in Chemistry at the São Carlos Institute of Chemistry at the University of São Paulo wrote popular science texts (PST) on the subject; and (ii) analyze the textual content of these productions based on a PST Analytical Framework.

As a result, the content of the PST was categorized as part of the chemistry sphere as it addresses technical issues related to the formal teaching of this science, and transversal as it dialogues with areas that permeate different disciplines.

Specifically, the approaches were varied: 25.0% focused on reporting recent research on potential new drugs, treatments or process improvements; 25.0% sought to demystify important aspects of existing medicines to fight the pandemic, such as dexamethasone and remdesivir; 16.7% warned about the risks of self-medication; 8.3% focused on phytotherapy; and 25.0% used mixed strategies. At the same time, the texts mentioned research, interpretation of results, and applications, highlighting aspects of scientific praxis.

Regarding the structure, as well as the textual and visual resources, the students endeavored to develop layouts that addressed professional productions of scientific journalism, including creating covers, eye-catching titles, fragmented texts, and illustrations, showing mastery of digital resources.

However, the students´ greatest difficulty was related to the linguistic aspect. Despite the use of language features to contextualize the information, their PST often addressed very technical issues and brought chemical formulas and mechanisms that are not recommended in this type of production. This attitude can also be interpreted as both a lack of familiarity with PST writing and academic preciosity.

In general, public communication of science and technology facilitates the development of both technical and humanistic skills. Indeed, the activity reported here contributed to the development of critical thinking, information literacy, and communication, proving to be an efficient strategy to prepare future scientists to dialogue with non-specialist audiences.

Keywords. Chemistry, Covid-19, Education, Medicines, Popular Science Texts.

Acknowledgements

We would like to thank the São Paulo Research Foundation (FAPESP), grant 2020/03233-0; and the National Council for Scientific and Technological Development (CNPq), grant 304974/2020-0.

References

[1] Sotério C. The provisional nature of science evidenced in times of pandemic. Alternautas, 2021, 8, 82-99.

[2] https://www.nsta.org/nstas-official-positions/quality-science-education-and-21st-century-skills

[3] Ferreira LNA, Queiroz SL. Ciência Hoje articles as a didactic tool in Chemistry teaching. Quim. Nova, 2011, 34, 354-360.

[4] Vieira CL. Pequeno manual de divulgação científica: um resumo. In: Dickson D, Keating B, Massarani L. (Eds.). Guia de Divulgação Científica. Rio de Janeiro: SciDev.Net. Brasília, DF: Secretaria de Ciência e Tecnologia para a Inclusão Social, 2004.

ISBN 978-84-8158-937-5

Come on a Geological Safari!

D Balmer
SATRO and CASTME Education Adviser, UK
denise.balmer1@ntlworld.com

Abstract. Safaris are an excellent way of getting children interested in almost anything. They are an exciting way of introducing topics to any age group though of course they mostly appeal to younger children. The objective behind any safari type expedition is to introduce the scientific skills in an enjoyable way. That is to look around and observe, take notes (record) what you see, then analyse the data. This may tke the form of plotting graphs or thinking about where materials came from and how, or the links between the recordings – if this is an ecology safari. It is always important to allow enough time for discussion at what has been observed before the session finishes.

I have led a range of 'safaris' which include hunting for wild (mini)beasts, fossil hunting in gravel paths, and a 'who lives on my wall' investigation. Come and join a geological safari – it sounds grand but really we are looking for geology either out of doors or indoors on a very simple scale! We will look for all the geological materials either within a room or outside.

You can add and adapt the idea to suit your particular children and their needs. Please bring some paper and writing pencil/pen. Recording sheets will be shown which you can adapt or you might prefer to prepare your own. Science is fun!

Keywords. Observation, Recoding Information, Having Fun.

ISBN 978-84-8158-937-5

Testing Eyes Protection against UV

L Afonso[1,2]*, L Peralta*[1,3]
[1]*Laboratório de Instrumentação e Física Experimental de Partículas in Lisboa, Portugal*
[2]*Agrupamento de Escolas de Benfica, Portugal*
[3]*Universidade de Lisboa, Portugal*
lafonso@lip.pt

Abstract. Sunglasses protect eyes from visible and UV radiation. UV radiation can damage retina. Eyes have protective mechanisms, such as closing eyelids or decreasing pupil diameter. These mechanisms are activated in the presence of intense visible light, so filtering only this component can leave eyes unprotected from UV radiation. We reconstructed and improved a device that allows access to reduction in visible and near UV light intensity introduced by coloured lenses. The system is based on colour LEDs and a photosensor with integrated amplification. Experimental activity was applied to high school students in physics class in 12th grade.

Keywords. LED, Photosensor, Sunglasses.

References

[1] Peralta L. Proteção contra a radiação ultravioleta fornecida por óculos de sol. Revista Brasileira de Ensino, 42, 0144, 2020.

ISBN 978-84-8158-937-5

Science and Technology for a Sustainable Future

A Rey, D Rojo
University of Burgos, Spain
alejandrorl@ubu.es

Abstract. La Estación de la Ciencia y la Tecnología (The Science and Technology Station) of the city of Burgos is a centre managed by the Scientific Sulture Unit (UCC+i -UBU) of the University of Burgos, whose aim is, among others, to encourage STEAM vocations among young people. Throughout the year, La Estación carries out numerous activities: specific workshops, scientific events, talks with researchers and annual courses, among others. One of these annual courses is UBUProyecta, which secondary school students attend every week for an hour and a half and in which they carry out activities related to science and technology. However, the course is not just about carrying out one-off workshops each week, but throughout the year, a thematic story is created that unites all these small activities. This year, 2021/2022, the theme is "Science and technology for a sustainable future".

What problems does our planet have right now, can we do something to help it, what role do we have, is there a solution to the problems we are seeing? These are, among others, some of the questions they have had to try to answer over the course of the UBUProyecta course. Group activities, dynamics and project-based learning have been some of the resources they have had to use to see if they were able to understand what is really happening.

The type of activities carried out, the formation of groups among young people, the assignment of roles, collaborative work or project-based learning, have allowed us to have a global vision of how teenagers react to this type of learning. In addition, it has allowed us to obtain results and reflect on the autonomy of adolescents, work on environmental topics or their ability to express their opinions.

Keywords. Project-Based learning, STEAM, Sustainability.

ISBN 978-84-8158-937-5

Citizen Science and Youth Clubs: The Domus Experience

P Barciela
Museo Domus, Spain
patricia@casaciencias.org

Abstract. The Domus of Science Museums has launched, in collaboration with the California Academy of Sciences, a programme dedicated to citizen science and youth. Science Action Club (SAC) works with museums, libraries, schools and other entities, and has managed, since 2011, to involve more than 18,000 young people every year to learn about their environment. As young people make authentic discoveries in their community and contribute to large-scale research projects, they develop an intrinsic motivation to value and protect natural spaces.

The programme uses citizen science as an education and engagement strategy: a way to address science, technology, engineering and mathematics (STEM) learning objectives, to teach STEM skills and to create STEM identities in young people so that they become a generation of critical thinkers capable of caring for their natural environment. SAC aims to get young people excited about science and nature by enabling them to actively contribute to authentic research, connect with the global scientific community and reflect on their progress over time.

High-quality training and professional development of educators is a cornerstone of the programme. Blended learning consists of an online course for and a face-to-face day. With this blended learning format, the online training is completed prior to the face-to-face workshop, with the goal of getting a clear overview of the full programme experience and available resources. The transition to a blended learning format has been key to addressing the question of how the programme can be scaled without losing high quality programme delivery.

The face-to-face workshop creates an environment where new and repeat participants can share knowledge, ask questions and practice with SAC programme activities in a supportive, learning environment. Educators learn which STEM concepts to emphasise with young people, which science practices to highlight and how to address challenges that activity leaders will face, such as lack of safety in science topics or the insecurity of being in nature. In the training, examples of successes and lessons learned are exchanged, constructive feedback is given, and common situations from the perspective of young people and activity leaders are dramatised. In addition, facilitation and implementation of citizen science activities and experiences are practiced.

Keywords. Citizen Science, Youth Clubs, Science Museum.

ISBN 978-84-8158-937-5

Networking and Creativity

J Díaz Marcos[1,2]*, E Conches*[2]
[1]*University of Barcelona (CCiTUB/IN2UB), Spain*
[2]*El NanoEscopista. Spain*
jordinano@gmail.com

Abstract. Adaptable activity based on how creativity tools can be applied in the classroom, in scientific communication or can be used to generate synergies in networking sessions.

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.

Keywords. Creativity, Education, Networking.

ISBN 978-84-8158-937-5

STEM from Robotics: How to Improve the Attitude towards Mathematics in 5th and 6th Grade Students in Spain

CA Ferrada Ferrada
University of Los Lagos, Castro Chile
cristian.ferrada@ulagos.cl

Abstract.

La investigación está relacionada con la implementación de un proyecto interdisciplinar con un enfoque de trabajo en las áreas STEM (Science, Technology, Engineering y Mathematics) aplicados en centros educativos de Educación Primaria de 3º ciclo, insertos en contextos vulnerables de la ciudad de Granada. El trabajo con los estudiantes se realiza según la metodología IBSE (Inquiry-Based Science Education), la cual se sustenta como una forma de enseñanza de la ciencia basada en la indagación y la resolución de problemas, en consonancia con la adquisición de prácticas científicas. La metodología evaluativa trabajada en el proyecto es cuantitativa; la actitud hacia las matemáticas y ciencias se evalúa mediante instrumentos diseñados ad hoc por medio un pre-test y pos-test.

Keywords. STEM Education, Attitude, Mathematics, Robotics, Robotics.

1. Introduction

As a way of responding to the diverse needs of the globalized world and promoting the development of scientific competencies, the STEM movement (Science, Technology, Engineering and Math) arises. The dizzying changes in the world in which we live do not cease in their technological advances, and current students must be prepared for the continuous transformations in the development of technology. Given this scenario, it is important to strengthen skills in STEM areas and promote the participation of students seeking to encourage the incorporation of students in the disciplines mentioned, for [1] the learning developed based on a STEM education, is generated as the result of the integration of various contents, being indispensable to promote in societies in the process of technification [2]. A STEM approach is seen as an integrative model of technoscientific disciplines, because of the flexibility of its areas [3]. Therefore, we believe that the development of a teaching and learning approach in STEM competencies privileges the work of interdisciplinary didactic activities, with a flexible conception of the areas of knowledge, being an approach to the scientific world and concepts [4].

The design of this research is framed under quantitative research, since the use of attitude measurement scales, through the administration of Pre and Post tests, following a quasi-experimental design [5]. As a result of the non-randomness of the students with whom the experimental group will work, they are formed prior to the experiment, and do not include a control or comparison group. A comparative Pre-test and Post-test analysis will be applied to the experimental group.

As for the instrument administered pre and post intervention, they consisted of the questionnaire applied in the area of mathematics the Attitudes towards Mathematics Scale (EAM) of 32 items, grouped into 4 dimensions [6]. The analyzed questionnaire, correspond to a sample of 88 pretest and 89 posttest students, being the experimental group N=15. The curricular contents worked on correspond to the curricular areas of Mathematics: "Mathematical processes, methods and attitudes", "Measurements", "Statistics and Probability".

For the comparative analysis of their results, the use of a methodological strategy of Matching is considered, which through the selection of selected sub-samples, seeks to minimize the initial imbalances through student pairings [7]. for subsequent comparison of results. The objective is to create a balanced sample to reduce differences between participants and non-participants according to factors of age, sex, course.

The distribution of the experimental and control groups, matched by means of the matching strategy, is presented below; in Table 1, the matching is made on the basis of mathematics grades.

ISBN 978-84-8158-937-5

Table 1: Constitution of the control group (grades in Natural Sciences and Mathematics subjects)

Cod.	Curso	Sexo	Calificaciones Matemáticas	
			Exp.	Control
E1 – C1	5º B – 5º B	F – F	5	5
E2 – C2	5º A – 5º A	M – M	7	7
E3 – C3	5º A – 5º A	M – M	7	7
E4 – C4	5º A – 5º A	M – M	5	5
E5 – C4*	5º A – 5º A	M – M	5	5
E6 – C5	5ºA – 5º A	F – F	5	6
E7 – C1*	5º A – 5º A	F – F	6	5
E8 – C6	5º A – 5º A	M – M	9	9
E9 – C3*	5º A – 5º A	M – M	7	7
E10 – C7*	5º A – 5º A	M – M	5	4
E11 – C7*	5º A – 5º A	M – M	5	4
E12 – C8	6º B – 6º B	F – F	8	7
E13 – C9	6º B – 6º B	F – F	6	6
E14 – C10	6º A – 6º A	F – F	9	9
E15 – C11	6º A – 6º A	M – M	8	8
Media			6,467	6,267
Des. Estándar			1,506	1,624
Z (Mann-Whitney)			-,363	
Sig.			,717	

*Se utiliza el mismo control para distintos experimentales.

Table 2. Constitution of the control group (attitudes toward mathematics)

Cod.	Curso	Sexo	Dimensión 1		Dimensión 2		Dimensión 3		Dimensión 4		Total	
			Exp.	Ctrl.	Exp.	Ctrl.	Exp.	Ctrl.	Exp.	Ctrl.	Exp.	Ctrl.
E1 – C1	5º B – 5º B	F – F	40	34	29	30	10	12	7	14	86	90
E2 – C2	5º A – 5º A	M – M	31	41	35	41	18	14	12	14	96	110
E3 – C3	5º A – 5º A	M – M	36	26	37	38	13	18	13	14	99	96
E4 – C4	5º A – 5º A	M – M	34	31	36	34	10	16	10	13	90	94
E5 – C4*	5º A – 5º A	M – M	36	31	32	34	11	16	11	13	90	94
E6 – C5	5ºA – 5º A	F – F	48	27	34	37	10	17	11	13	103	94
E7 – C1*	5º A – 5º A	F – F	38	32	38	30	20	12	12	12	108	86
E8 – C6	5º A – 5º A	M – M	29	25	35	39	13	12	14	16	91	92
E9 – C3*	5º A – 5º A	M – M	30	26	40	38	20	18	14	14	104	96
E10 – C7*	5º A – 5º A	M – M	27	35	38	31	12	12	14	14	91	92
E11 – C7*	5º A – 5º A	M – M	48	35	47	31	13	12	16	14	124	92
E12 – C8	6º B – 6º B	F – F	26	26	37	42	15	7	14	15	92	90
E13 – C9	6º B – 6º B	F – F	25	43	35	41	12	13	12	15	84	112
E14 – C10	6º A – 6º A	F – F	26	39	31	33	15	12	13	11	85	95
E15 – C11	6º A – 6º A	M – M	28	32	35	38	18	18	9	12	90	100
Media			33,47	32,20	35,93	35,80	14,00	13,93	12,13	13,60	95,53	95,53
Des. Estándar			7,520	5,710	4,183	4,195	3,525	3,150	2,295	1,298	10,643	7,060
Z (Mann-Whitney)			-,291		-,146		-,126		-1,954		-,771	
Sig.			,771		,884		,900		,051		,441	

***The same control is used for different experiments.**

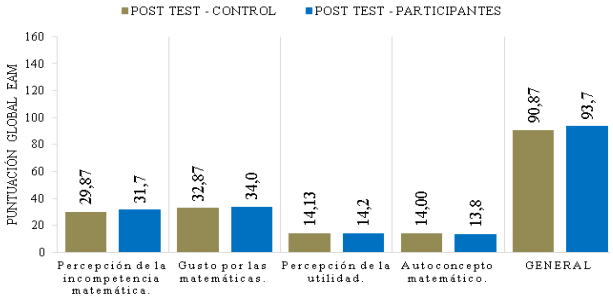
2. Project objectives

The objectives of the intervention project are the following:

- To improve the attitude towards mathematics through the STEM work proposal.

3. Results and conclusions

Based on the information collected through the instruments described in the method section, the results obtained when analyzing the variable attitude towards mathematics are presented (Figure 1).

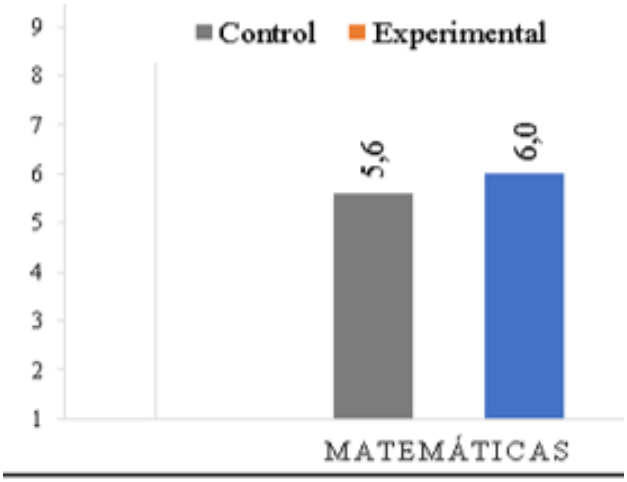


Z (Mann-Whitney)	-,270	-,940	-,063	-,064	**-,562**
Sig.	,787	,347	,949	,949	**,574**
TE	,275	,334	,028	-,084	**,382**

Figure 1. Results of the EAM questionnaire grouped by dimensions. Cohen (1988) establishes interpretation values for Effect Size (ES); low < 0.2, medium between 0.2 and 0.5 and high > 0.8

Regarding attitudes towards mathematics, a slight negative variation can be observed in both groups (control and experimental) in relation to the initial assessment (95.53 each), which would indicate that the intervention has not had the expected impact on this variable. Likewise, there is no significant variation (p= ,574) between the control and experimental groups; however, the effect size (TE= ,382) is in the medium range, which would indicate the existence of a greater variation in attitudes towards mathematics in the experimental group than in the control group.

Figure 2. Post - Test Results (Scores)



Z (Mann-Whitney)	-,916
Sig.	,360
TE	,386

Finally, in relation to the grades of both groups, it is observed that, in the case of grades in the subject of mathematics, practically no variations are observed between measures, both for the experimental group (+0.07) and for the control group (-0.4). In this case it is not possible to show that the differences between the two groups are not significant, however, a greater effect size is observed (TE= ,386), which is categorized in the medium range according to Cohen's classification.

In view of the results obtained, it becomes essential to value the enriching work developed with robotics in elementary school students. Bearing in mind these results, we can point out that our main objective has contrasted a positive change in the attitude of the students and their valuation of mathematics, revealing positive values in the evaluation of competencies that have, achieving success in learning on the part of the students. In this way, our results are close to those obtained by. [8] Who highlights in his research developed with robots the generation of significantly high scores in students from 9 to 14 years old, stating that the learning obtained is fundamental for success in STEM areas of higher order, professional success and innovations that are expected to be achieved. Therefore, awakening these capabilities in children are important to provide tools with which to face the different technological challenges we face as a society, being fundamental the incorporation and practice of technology and robotics in school from the early years of schooling [9].

In view of the results, it is possible to conclude that working with robotics through a STEM proposal has a positive impact on students' attitudes towards science and mathematics.

It can be affirmed, by means of quantitative evidence, that the students of the experimental group, who have actively participated in the 12 sessions show relatively high values compared to the control group, likewise the results of the pretest - post-test show statistically significant values. [10] describe based on the existing empirical evidence, that the use of robotics has aroused the interest of teachers, and education professionals as an alternative to support learning strategies.

4. References

[1] Barak M, Zadok Y. Robotics projects and learning concepts in science, technology and problema solving. International Journal of Technology and Design Education, 19(3), 289–307, 2009.

[2] Kim S, Lee C. Effects of robot for teaching geometry to fourth graders. International Journal of Innovation in Science and Mathematics Education, 24(2), 52-70, 2016.

[3] Taylor MS, Vasquez E, Donehower C. Computer Programming with Early Elementary Students with Down Syndrome. Journal of Special Education Technology, 32(3), 149–159, 2017.

[4] García Y, Burgos F, Reyes D. STEM activities in initial teacher education: new didactic approaches for the challenges of the 21st century. Educational Dialogues,17(33), 37–48, 2017.

[5] Cohen L, Manion L, Morrison K. Research Methods in Education. London: Routledge Falmer, 2000.

[6] Palacios A, Arias V, Arias B. Attitudes towards mathematics: construction and validation of an instrument for its measurement. Journal of Psychodidactics, 19(1), 67-91, 2014.

[7] Austin PC. A critical appraisal of propensity-score matching in the medical literature between 1996 and 2003. Statistics in Medicine, 27(12), 2037–2049, 2008.

[8] Coxon S. The malleability of spatial ability under treatment of a first lego league-based Robotics simulation. Journal for the Education of the Gifted, 35(3), 291–316, 2012.

[9] Ortiz-Revilla J, Greca IM, Arriassecq I. Construction of a theoretical framework for the STEAM approach in Primary Education. Paper presented at the 28 Encuentros de Didáctica de las Ciencias Experimentales, A Coruña, Spain, 2018.

[10] Spolaôr N, Benitti, FBV. Robotics applications grounded in learning theories

on tertiary education: A systematic review. Computers & Education, 112(12), 97–107, 2017.

ISBN 978-84-8158-937-5

Open Schools with STEM Projects

C Díez
Scientix Ambassador
INTEF Trainer, Spain
mdiez125@gmail.com

Abstract. The world requires an open society. Horizon 2020 encourage citizens to engage in science through formal and no-formal science education. Enterprises and civil society are necessary to build a new education dimension. To be part of the Scientix Community made it easy to discover this perspective and to develope opportunities to witch we refer Open School experience with STEM Projects.

The subject is collaborative interaction between Schools and Institutions, Organizations, Business, Security Bodies, Universities, Researchers, Research Centers Museums. This identifies Open Schools and guarantees the universality and training of citizens of the 21st.

We present 2 experiences in Spain that incorporate the Open School dimension that adds the collaboration of entities to educational action. In formal Education the Creations project, currently Global Science Opera, which started in 2015 between the Scientix projects; a European Schoolnet project, which adds the creation of STEAM scenes from countries on the 5 continents, with interdisciplinary work and the Inquiry Methodology. In non-formal education, the "STEM Family Library All we are Scientists" project started in 2013; this develops Science workshops in libraries with a triple objective: to increase the cultural offer of Libraries with a STEM project, to develop STEM skills and vocations within families, and to promote collaborative actions with companies and organizations.

Corporate Social Responsibility (CSR), opens a debate on the way of directing companies based on the management of the impacts that their activity produces and establishes to carry out concrete actions witch that enterprises leave a mark of a collaborative impact on society. The OpenSchool dimension with a design that complite the interests of business and education finds in RSC a projection for the future and Company Society feedback.

Keywords. Community Science, Company Society Feedback, Corporate Social Responsibility, Global Science Opera, IBSE, STEM Projects, Open School.

1. Introduction

To ensure that students are well prepared for the future on we built recurring questions are: What knowledge, skills, attitudes and values will today's students need to thrive and shape their world?, How can instructional systems develop these knowledge, skills, attitudes and values effectively?.

The OECD conducted Projects with answers. DeSeCo research published 2001 [1] identifying categories of competencies with the goals to: boosting productivity and market competitiveness, minimizing unemployment through developing an adaptive and qualified labor force and creating an environment for innovation in a world dominated by global competition. A Renewed pedagogy [2], 2007, values Inquiry-based science education (IBSE) with proven efficacy at both primary and secondary levels; their proposals combine the acquisition of traditional knowledge with the 21st century skills of creativity, critical thinking, communication and collaboration; At the same time, it highlights that enterprises and civil society are necessary to build a new education dimension. This is stated by Recommendation 4 "Measures should be introduced to promote the participation of cities and the local community in the renewal of science education in collaborative actions at the European level aimed at accelerating the pace of change through the sharing of know-how" and Recommendation 5 "The articulation between national activities and those funded at the European level must be improved and the opportunities for enhanced support through the instruments of the Framework". And framework OECD The Future of Education and Skills 2030 aims to help education systems determine the knowledge, skills, attitudes and values students need to thrive in and shape their future, and develop a common language for teaching and learning. The focus is not so much on what we are learning but on how we are learning.

The authors pay attention to the aforementioned recommendations and the OECD research, take on the challenge of implementing them in STEM education, look for

ISBN 978-84-8158-937-5

projects to develop scientific topics in today's society with the IBS methodology (Inquiry Based Science Education) [3], and discover the Creations [4] European Project. Creations project develop creative art-based approaches based on connecting Art with Science and transforming classroom training into STEAM education. Being part of the Scientix Community [5] has made it possible and facilitated the development of this perspective that we present as an Open School experience with STEAM Projects.

This framework is completed with the collaboration and participation of society and entities in developing projects and learning in the classroom aim this work.

2. Open Schools

The Open School dimension refers to the collaboration of the entities of society in educational activity, establishing a vision in schools to create learning experiences that provide tools and support in and from society.

The OSOS project designs, at the local level, the transformation of schools into science and learning ecosystems in which teachers, students and the local community share responsibility for learning science [6].

This perspective builts and to develope opportunities to witch we refer with Open Schools with STEM Projects. In an open environment, both the content and the process by which content is constructed are equally visible, enabling a new kind of critical learning. Fig.1 inspire the idea.

The subject is collaborative interaction between Schools and Institutions, Organizations, Business, Security Bodies, Universities, Researchers, Research Centers Museums. This identifies Open Schools and guarantees the universality and training of citizens of the 21st. Currently a new value prevails in the company: Corporate Social Responsibility (CSR). CRS opens a debate on how to manage companies based on the management of the impacts that their activity produces and establishes, and carry out specific actions so that companies leave a mark of collaborative impact on society. The OpenSchool dimension with a design that combines the interests of business and education finds in CSR a space of opportunities to develop feedback from the Business Society with the School and makes a crucial contribution to society. As well as to face the challenges and priorities of society in the field of science defined by the European Commission. The primary source of results from EU-funded projects [6] H2020-EU.5.d makes in value “Encourage citizens to engage in science through formal and informal science education, and promote the diffusion of science-based activities, namely in science centres and through other appropriate channels”.

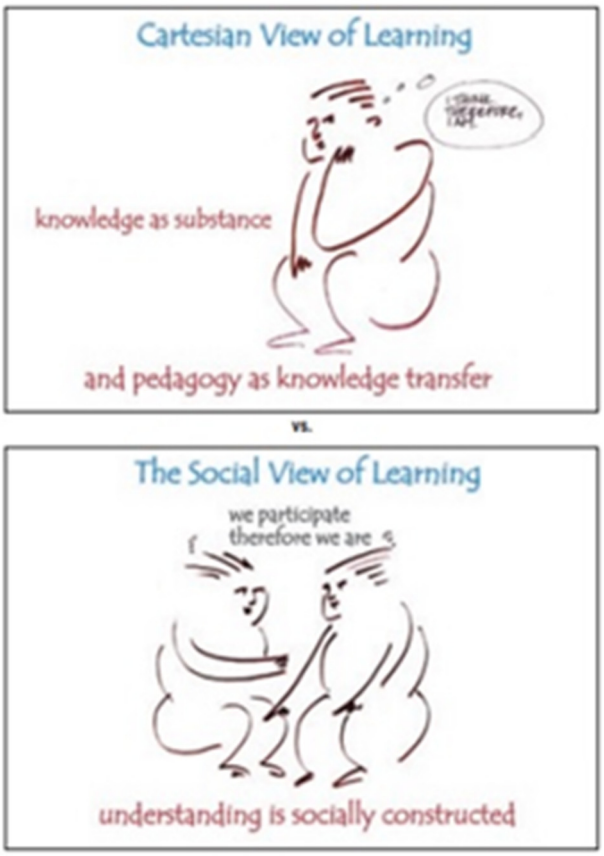


Figure 1. From Polanyi Michael [6]

The main objective of this work is to promote science, research and innovation as important elements for the lives of young people, motivate them to choose professions related to these elements and become more responsible citizens. The projects and works of the students here included respond to this contents and the real needs of the society. Interaction social could be built from instructional design that considers participation in and with society]. This pattern prepares the citizen of tomorrow from a constructivism that provides a broader horizon than regulated instructivism. From the

consideration that the student is closer and immersed in the structures of society. This work presents Open School as a constructive factor and learning in currently timely.

3. STEM Projects for Open School

3.1. Creations STEAM project

A project funded by the European Union Was launched in October 2015 an European Schoolnet project, which adds the creation of STEAM scenes from countries on the 5 continents, with interdisciplinary work and the Inquiry Methodology. Develop creative approaches based on art for an engaging science classroom. The portal on Open Discovery Space [8] extend the implementation to larger and more diverse settings.

Successive editions of the project that began Creations, consolida the Global Science Ópera in formal School with aims at improving the skills of young people in STEM (science, technology, engineering, mathematics) and at attracting talent to scientific careers. complete a Scientific Opera with the participation of scenes from countries from all continents, united through the Booklet. Each edition, guided by a Booklet, sequences the participation of the countries. Each country adds a Scene. Each scene lasting around 3 minutes.

The work carried out in Spain, in different schools of different autonomous communities of the country, throughout the first four editions is collected in 2019 [9]. The operas are guided by inquiry-based learning and are referenced in the Guide to Writing a Scientific Opera [10].

The scenes created by Spain in successive editions are: Skylight 2015 - World's first Global Science Opera [11], Ghost Particles 2016 - Quarks and Leptons [12], Village on the Moon 2017 – A school is needed for children [13], One Ocean 2018 – Three generations serch health for oceans [14], Gravity 2019 – A journey through the Universe brings Gravity closer [15], Energize 2020 - The awareness of the energy of the body itself, music production with the Theremin, and the clamor for renewable energies [16], Thrive 2021 Recover Nature and its species on the Camino de Santiago [17] Creavolution 2022 is in progress.

3.2. STEM Family Library all we are Scientists

Non-formal education project develops Science workshops in libraries with a triple objective: to increase the cultural offer of Libraries with a STEM project, to develop STEM skills and vocations within families, and to promote collaborative actions in society.

The product on which an Open School design is completed in STEM Family Library is a family workshop with students adressed to 8 to 12 years old. Workshops refered are: Eggs surprise us [18], Fire in Restaurant Health Detectives [19], Giants we cannot see DNA[20], Starlight explain us sun protection [24], The color of the universe [25], Trapping water molecules [26], Mistery in the Botanic Garden [27], Cooking with the sun [28], Little Archaeologists[29], Learning trades from bees [30] [31].

4. Spain experience in Open School

An approach to Open School actions in Spain with Global Science Opera and STEM Family Library is completed on the sequence of activities that describes the Fig.2

Figure 2. Sequence of activities throughout Open School action

The achieving the collaboration described as Open School in the production designed to complete each project requires a sequence of actions that we describe below:

a) Product dessign. Analyze the STEAM content of the product for which we request the Open School action. Analize conection with society interest and

ISBN 978-84-8158-937-5

future projection.

b) Collaborator. Search for national and international collaborative action goals: companyes, cultural entities, institutions, museums, faires, bussinesse, universities, occupational centers, development agencies, technology organizations, audiovisual communication companies, small and medium-sized enterprises, health institutions, popular magazines, social agents, local businesses, small businesses, stores. Tracking opportunities to start a communication action and make a proposal. Study their activities, their position in society, their presence in the media and search CSR opportunities. Analyze the products they develop, current lines of research, educational outreach actions

c) Action. Design actions related to the content of each Project (Fig.3).

Figure 3. Collaborative Actions

Some are: direct connection and virtual visit, face-to-face conference and online, workshop, technical support, press conference, material transfer, images and music with authorization of copyright, webinar, fairs participation, Experimentation and use of museum objects. Technical and technological material., co-management, knowledge transfer. The actions never request economic financing.

d) Presentation Document. Prepare a document of the proposal, personalized highlighting national and international dimension, complete SWOT, include related national events. Carry out the communication action aimed at specific people in the entity. The means have been email@mail and telephone conversation targeting different departments and people with the information provided by the networks. In this phase it is interesting to know the profile and activities of the people with whom you contact.

e) Comunication and Agreement. This stage confirm OpenSchools collaboration and adapt action to the needs and common interest. The communication of the definitive content of the action must contain the previously discussed framework of action. Successful agreements are cited in the Credits and material referred to in this work: National and International Organizations of Astrophysics Astronomy and Space Agency, Research Centers, small (Pharmacy) medium (Nutrition) and large Company (Cosmetic Dermatology), local and national Institutions, Universities, professionals and artists, Museums, shops.

Figure 4. National and International Collaborations

National and International Collaborations in GSO Project (Fig.4): CERN. UAB. NASA. UCM Astrophysics Madrid. Hands on Universe Spain Astronomy. Municipal Archive of Bilbao City Council. IOE Oceanographic Institute Spain Malaga. CICEROM. UAB Audiovisual Communication. UBU, ESERO European Space Agency Office Resources Education.

UBU Burgos. MUDIC Interactive Science Museum. UMH Alicante. UMH Film School.

5. Conclusion

In recent years, many initiatives have tried to reduce the distance between science education and society; and in this sense the GSO and Family Scientist Library projects cover this need by developing Open Schools actions. This work provides achievements of establishing communication bridges that connect different social actors such as organizations and entities and schools. The STEAM content of each project worked on takes center stage in the collaboration. IBS work is a methodology that facilitates collaborative interaction. The objectives of unifying and giving open projection to the schools have been fulfilled; and different actions have been developed that ensure the purpose of promoting scientific vocations in boys and girls. The sequence of stages to design and complete an Open Schools action has been optimized over 8 years and the work related to the GSO "One Ocean" carried out by the IEO developing content "Oceans Health" in STEAM Creative Learning Spain Experiences [9] is a detailed reference. However, there is a lack of experience in this Open School perspective in the compulsory education environment, while university education has a long tradition of CSR [29]; The current concern and commitment of social responsibility companies extends to other areas of society and opens expectations to address the design of Open Schools from educational projects.

In summary, the benefit is clear in both directions, since it implies the improvement of the current educational process, providing citizens with skills and knowledge with a universal horizon The connection with public and private, national and international entities, satisfies the construction of values future for society: the professionals of the 21st century.

6. Acknowledgements

The enumeration of contributors in the projects under discussion may have been unintentionally left incomplete. So I close these lines with thanks for the Collaborative Return to Society of those who have been involved in the Open Schools dimension.

7. References

[1] Definition and Selection of Competencies (DeSeCo). Rychen DS, Salganik LH (Eds.), 2001.

[2] Rocard M, Csermely P, Jorde D, Lenzen D, Walberg-Henriksson H, Hemmo V. Science Education Now: a Renewed Pedagogy for the Future of Europe. OCDE, 2007.

[3] Minstrel J, van Zee EH. Inquiring into Inquiry Learning and Teaching in Science, Washington: American Association for the Advancement of Science, 2000.

[4] http://www.scientix.eu/projects/project-detail?articleId=593964

[5] http://www.scientix.eu/

[6] https://cordis.europa.eu/project/id/741572/en

[7] Polanyi M. The Tacit Dimension. Garden City, N.Y.: Doubleday, 1966.

[8] http://portal.opendiscoveryspace.eu/creations

[9] Díez C, Garcia-Martinez MC, Zurita S. Scenarios and Scenes of Opera for STEAM Creative Learning: Spain Experiences for Classroom Implementation. Journal of Modern Education Review., 9 (5), 385-397, 2019.

[10] Smegen I, Ben-Horin O. Inquiry-Based Learning – A Guidebook to Writing a Science Opera. Leiden: Brill, 2021.

[11] https://www.youtube.com/watch?v=jeGQqwxz2lQ

[12] https://www.youtube.com/watch?v=zG_wXPO7RuE&feature=youtu.be&t=2501

[13] https://www.youtube.com/watch?v=D3I6m8JZL0Y&feature=youtu.be&t=2418

[14] https://www.youtube.com/watch?v=sJUwzstTmJ8&feature=youtu.be&t=2162

[15] https://www.youtube.com/watch?v=tQVyogfaJ_w&feature=youtu.be&t=4158

[16] https://youtu.be/uwmyYtyxzeM?t=3493

[17] https://youtu.be/oRxegmnck-w

[18] https://www.pinterest.es/bibliotecavdm/tots-som-cient%C3%ADfics-i/

[19] https://www.pinterest.es/bibliotecavdm/tots-som-cient%C3%ADfics-ii/

[20] https://www.pinterest.es/bibliotecavdm/tots-som-cient%C3%ADfics-iii/

[21] https://www.pinterest.es/bibliotecavdm/tots-som-cient%C3%ADfics-iv/

[22] https://www.pinterest.es/bibliotecavdm/tots-som-cient%C3%ADfics-vi/

[23] https://www.pinterest.es/bibliotecavdm/tots-som-cient%C3%ADfics-vii/

[24] https://www.pinterest.es/bibliotecavdm/tots-som-cient%C3%ADfics-viii/

[25] https://www.pinterest.es/bibliotecavdm/tots-som-cient%C3%ADfics-xi/

[26] https://sdw-blog.eun.org/2020/04/22/learning-professions-with-bees-stem-family-library-project/

[27] Corporate Social Responsibility in Higher Education. Globalization ACME, 8 (3), 474-483, 2009.

ISBN 978-84-8158-937-5

Partnerships between Schools and Science Institutions: The Magnet Project Experience

S Zurita i Món
Departament d'Educació,
Generalitat de Catalunya, Spain
szurita@xtec.cat

Abstract. Partnership between schools and external institutions like scientific and technological centers is a way to create schools that are open and connected to their environment. A way to improve the quality of the education and to induce innovation in the educative system.

«Magnet, Aliances per a l'èxit educatiu» is an innovation program that is working in Catalonia since 2012. The program uses intensive partnership as one of the main levers to change the schools involved, and the present paper summarizes the learning of this decade about what's important to construct lasting successful partnerships that really improve educational centers.

Keywords. Educational Innovation, Open Schools, Partnerships.

1. Introduction

Our Society is increasingly demanding with respect to education. Schools are not only supposed to prepare its students to live as citizens in an increasingly complex and changing society. They are also asked to prepare them to change the world, to model an uncertain future that we know will be complicated [1].

In this context, schools must provide quality education, rich not only in content but also in skills and abilities to live and collaborate with different people in different contexts. And this is a task that isolated educational centers can hardly carry out. The need to create schools that are open and connected to their environment, that have access to more knowledge and experiences than those that can be provided by teachers and that address and solve real problems in their environment is raising. It is one of the directions in which current educational innovation is moving [2].

Intensive partnerships with prestigious external institutions is really useful strategy that induce change in schools. It incorporates some of the partner knowledge and, when properly implemented, embeds the culture of the center with the values and way of thinking of the institutions.

But overcoming the traditional activities, visits and trips of superficial collaborations and replacing them with truly active partnerships is not a simple task.

2. The "Magnet. Aliances per a l'èxit educatiu" program

"Magnet. Aliances per a l'èxit educatiu" [3] is an educational innovation program, inspired and adapted from the American Magnet Schools experience [4,5].

The shared main objective of the original program and of the catalan version is the fight against school segregation, that is an important challenge of our current educational system [6,7,8], producing a reduction of oportunities for all our students, a threat for the social cohesion and, in general, a more unequitable and unfair society.

Magnet project tries to attend this goal by creating an innovative and quality educational program in not very desired schools. If all schools in a specific zone are able to attract different types of families and guarantee the heterogeneity of all them the segregation problems will decrease and the global quality of the system will improve.

Figure 1. Webpage of "Magnet. Aliances per a l'èxit educatiu" project

The program was implemented and evaluated in five catalan educational centers as a pilot program from 2012 to 2017 by Fundació

ISBN 978-84-8158-937-5

Jaume Bofill [9]. Since 2017 the program has been driven by the Departament d'Educació de la Generalitat de Catalunya and the Fundació Jaume Bofill and has involved 33 more centers in four successive editions.

The current version of Magnet involves an intensive intervention in the educational center, and uses mainly four strategies to induce the change in the school project and in the school perception:

- A 3-years training for all the teachers aimed to construct and develop a renewed educational project and change classroom practices.
- A collaboration with the educative and local administration to support the school and change those institutional habits that contribute to maintain or worsen schools segregation.
- An improvement of the schools communication channels and abilities.
- And the one we are dealing with: the partnership with one prestigious cultural institutions during, at least, four years.

Using this four levers, and with the effort and collaboration of all the educational and local community, the program has managed to transform many of the schools and to induce changes:

- Initially, in the interest aroused among the families of their environment, reflected in an increase in visits during open-doors days.
- In a second stage, in the amount of families wanting to take their children to the schools
- And finally, in the variety of families that attend the center, which are more heterogeneous and have more varied cultural, geographical and socio-economic levels.

3. Description of the partnerships

Partnership is one of the main features of Magnet program. Institutions get involved in the program and commit themselves to collaborate with the school for, at least, 4 years. Their contribution is totally altruistic, based on their social commitment with education and their wish to spread their knowledge and work to society [10].

Currently, the list of Magnet partners include 7 institutions from arts or social fields, and 29 from scientific and technological fields.

5 of them are hospital or health institutions:

- Hospital de Tortosa Verge de la Cinta
- Serveis de Salut Integrats Baix Empordà
- Hospital de la Santa Creu i Sant Pau
- Althaia Xarxa Assistencial Universitària de Manresa
- Corporació Sanitària Parc Taulí, Sabadell

4 museums or private foundations:

- Museu del Ter,
- Museu de la Ciència, CosmoCaixa,
- Museu Nacional de la Ciència i la Tècnica de Catalunya, MNACTEC
- Fundació Naturgy

10 research centers:

- Institute of Space Sciences (ICE-CSIC)
- Centre d'Estudis Avançats Blanes (CEAB)
- CREAF
- Col·legi d'Arquitectes de Catalunya (COAC)
- Institut de Bioenginyeria de Catalunya (IBEC)
- Institut de Ciències del Mar ICM– CSIC
- CIM UPC
- Centre de Recerca Matemàtica
- Institut Català de Paleontologia Miquel Crusafon
- Institut de Recerca i Tecnologia Agroalimentàries (IRTA)

And 10 College or University centers

- UPC de Terrassa
- Escola Tècnica Superior d'Arquitectura de la URV
- UPC de Manresa – EPSEM
- Campus del Baix Llobregat de la UPC
- Escola Tècnica Superior d'Enginyeria de la URV
- Universitat de Barcelona
- Escola Tècnica Superior d'Enginyeria Agrària (ETSEA) de la UdL
- Fundació Tecnocampus
- Facultat de Veterinària – UAB

- EINA, Centre Universitari de Disseny i Art de Barcelona

Institutions commit to dedicate time and resources to their schools. Schools commit to create and introduce relevant and significant activities related to the field of expertise of the partner.

It's important to emphasize that the idea is to establish a mutual beneficial relationship. Not to have the partner "giving" resources and activities to the school, but to co-create them with the collaboration of people from both parts. Institutions are professionals in their field with a huge amount of knowledge, but teachers have to be professionals in their own field too, with a huge amount of knowledge about how to help young people to understand, develop and apply new ideas.

The specific structure in every case depends on the size and internal structure of every institutions, but the more efficient organization tends to have:

- A team of 4-5 people from the partner more involved in the project, with one of them being the main link between the partner and the school. Punctual collaborations of other professionals outside of this team are organized too.
- A team of teachers in the school that constitute the "driving force team". It includes the Principal or some other member of the administration of the school and the group of staff teachers more involved in the project.
- A clear institutional support to the project, stated by the direction of both the institution and the school.

During the first three years of collaboration the assessor of the center (who is in charge of the teacher training courses too) helps to coordinate and communicate both teams. Specific collaborations for one concrete activity tend to produce mixed working groups with the professionals involved in that activity (a project, an exhibition, a congress…). But it's important too to maintain general staff mixed meetings at the beginning and at the end of the school year to ensure the coherence of the project [11].

4. What we have learned: videos and infographic

The first thing we have learned, after one decade of fostering and nurturing strong collaborations, is that this type of alliance can bring important advantages, both to the educational center and to the research center [12,13].

But the second learning is that is not easy to do construct a strong effective partnership. Some preconditions are needed, together with a process of knowledge and collaboration that helps to overcome fears, resistance and differences in the operating cultures both environments. The culture, the working habits, the amount of resources and the time management are so different that difficulties are unavoidable [14].

The preconditions involve:

- The interest of a minimum amount of professionals on both sites. Not all the working force is needed, but a significant part of it have to be willing to collaborate.
- The explicit support of the directors (of school and of the institution), that communicate to their teams the importance of the Magnet project for the institutions.
- A shared vision of the project. That involves sharing the social compromise that induce each institution to participate in the project, but involves too a more specific shared vision of the type of school we are aiming at.

Previous experience in educational collaborations is not needed, and in some cases we have discovered that could be even a problem: the client-supplier mentality that tends to rule this short interactions between schools and external institutions (I "give you" a workshop, I "ask you" for this resources) is not easy to overcome.

When we took a time to analyze the shared features of those schools that have stablished really success partnerships, we arrived at a set of conclusions that were summarized in an infographic with an English version available [15].

ISBN 978-84-8158-937-5

Figure 2. Infographic generated by Magnet program about building partnerships

The infographic groups the observed behaviors and actions in successful partnerships for schools (in orange) and for institutions (in blue) under four categories.

4.1. We share culture

Behind the implementation of one or other classroom activity, sharing the vision, the values and stories that explain the reasons of what we are doing, is really important.

Schools have to integrate the partner's values into their educational approach and explicitly transmit them to the educational community and in the classroom activities.

To allow schools to do that, partners have to make the effort to reflect on the meaning and translation of the institution's values in an educational environment, be coherent with the social commitment of the institution and transmit the institution's values to the school through concrete and tangible proposals.

As examples, Escola Peramàs from Mataró, in partnership with the CREAF, has finished the Magnet project with a clear orientation towards curiosity, research and environmental care that are present in the projects they have implemented, but in many other aspects of the daily life of the center too [16]. School Marià Fortuny from Reus, in partnership with Escola Tècnica Superior d'Arquitectura de la URV and Col·legi d'Arquitectes de Catalunya, has not only transformed the vision of light and space in the center, but incorporated the projects and the interdisciplinary vision of architecture to their way of learning [17].

4.2. We reach out to and care for each other

Partnership is about learning, and science, and technology. But is about people, care and personal relationships too.

The school has to hosts the partner at their installations and constructively listen to its proposals and concerns. Teachers are not researchers, but can understand and get identified with their professional situation of researchers and offer the partner feedback on the impact of its proposals on students.

And personal from institutions can take an interest in learning about the school and its needs. They can keep the school in mind for more than just shared activities and show concern for the educational impact of its proposals.

The personal relationship and care between staff of Moises Broggi Institute and their artistic partner it's still alive, even if the program has officially finished more than four years ago. And the staff from CIM-UPC actively participates in weekend activities proposed by Escola Montessori from Rubi, and teachers clearly communicate their gratitude to the CIM for having helped them to became the STEAM school they are nowadays, even in published articles [18].

4.3. We co-create activities

As previously commented, it is crucial to avoid the client-supplier structure that kind of relationships where schools ask for, partners offer to and there is no more interactions. When limited to that, long partnerships don't work and tend to produce conflicts and misunderstanding. In order to get a real collaboration, schools and partners need to work together in co-creation projects.

Schools have to look for ways to apply the partner's ideas, resources or needs to classroom proposals. They have to find new and creative ways to adapt the partner's contributions to their teaching and collectively reflect about how to adopt a broad view of the partner's field of knowledge. This last point is especially important in high schools, where

teachers are specialist in a field and it is not easy for some of them to accept the partnership if the institution belongs to a field that they consider is far away from their own specialty.

On the other side, partners need to make an effort to listen and adapt to the school and its needs. It's important that researchers get involved in proposal planning or in task forces and training, and that they collaborate with teachers in the process to adapt their specialized knowledge to the educational reality of the school.

The Institut Rocagrossa, from Lloret de Mar, adapted the "plastic 0" project, that was one of the citizen science projects their partner CEAB had been leading for years [19]. But CEAB get involved too in the camping trip that older professional students of Institut Rocagrossa traditionally organize for 3r ESO students, collaborating with organizers so that they use the trip to do field work and sample collection in aquatic flood systems.

During pandemic lockdown, CREAF scientist and teachers from Escola Peramas from Mataró had the initiative to design and implement a birds mapping activity that students did from their homes [20].

4.4. We give visibility

Communication is one of the tools used by the project to attract any type of families to the Magnet center. And public image is important for partner institutions too. Magnet program emphasize the importance of sharing schools and partners activities and values with the local community around them.

Schools have to naturally give visibility to partner at their educational activities and communication channels. They have to explicitly and publicly share the input partners provide and the significance that holds for the school. Involves the educational community and the local environment in the activities proposed by the partner it's important too.

Partners have to consider Magnet as an own project, rather than just a series of one-off activities. They can help to broadcast Magnet activities in the media, and offer visibility of the Magnet alliance on the website, social media, and other channels.

At the beginning of COVID pandemic, Escola Sant Ignasi from Manresa, in partnership with the local Hospital, had the initiative to send and diffuse in the social networks the draws and letters created by their students supporting the doctors and nurses task. IBEC, partner of Escola Gayarre in Barcelona, presents Magnet as one of their projects to their visitors, even when they get visitors are the mayor of Barcelona city.

5. Conclusions

Partnerships between educative centers and external institutions are a really powerful tools to introduce innovation in schools and to foster a way to teach and understand science and technology and their vision of the world that is not easy to get by other means.

Anyway, long term collaborations are needed to get this objectives, as well as some previous conditions, personal resources and a proper framework for collaboration.

Schools and partners need to explicitly share their values and culture, look after personal relationships and reach out to care for one another, co-create educational activities and give visibility to each other.

When these conditions are fulfilled partnerships can make significant contributions, both to schools and to partner institutions.

6. Acknowledgements

We want to acknowledge all the communities of our Magnet schools and of our partner institutions for their generosity, their social compromise and their tireless professionality that make our schools and our students lives a bit better every day.

7. References

[1] International Commission on the Futures of Education. Reimagining our futures together: A new social contract for education. UNESCO, 2021. https://unesdoc.unesco.org/ark:/48223/pf0000379707.locale=en.

[2] https://www.openschools.eu/

[3] https://magnet.cat/

[4] Fullington GG. Magnet schools: What are they? Where are they going? Oregon School Study Council, 1977.

[5] https://magnet.edu/about/what-are-magnet-schools

[6] Síndic de Greuges. La segregació escolar a Catalunya. Informe extraordinari. Síndic de Greuges, Barcelona, 2008.

[7] Síndic de Greuges. La segregació escolar a Catalunya (I): La gestió del procés d'admissió de l'alumnat. Síndic de Greuges, Barcelona, 2016.

[8] Síndic de Greuges. La segregació escolar a Catalunya (II): Condicions d'escolarització. Síndic de Greuges, Barcelona, 2016.

[9] Tarabini A, Montes A, Parcerisa L. Les aliances Magnet: innovació per combatre la segregació escolar. Fundació Jaume Bofill i Bonalletra Alcompàs, 2018. https://fundaciobofill.cat/uploads/docs/i/v/m/2/z/k/d/b/e/ib_68_magnet_2019_070619.pdf

[10] https://magnet.cat/el-partenariat-com-desenvolupar-una-alianca-magnet/

[11] https://magnet.cat/com-comencar-una-alianca-magnet-primera-trobada-a-lescola/

[12] https://magnet.cat/oferim-oportunitats-educatives-per-a-tothom/

[13] https://magnet.cat/la-justicia-i-la-igualtat-doportunitats-son-dos-dels-valors-que-hem-compartit-amb-linstitut-del-ter/

[14] https://magnet.cat/lexperiencia-de-partenariat-del-macba/

[15] https://magnet.cat/wp-content/uploads/2018/05/Magnet-Infografia-partner-ENG-web.pdf

[16] https://magnet.cat/wp-content/uploads/2018/05/Magnet-Infografia-partner-ENG-web.pdf

[17] https://magnet.cat/projectes/construim-escola/

[18] Romero López S, Gimeno Sorribas C. Transformación metodológica de la Escola Montessori de Rubí desde una perspectiva STEAM y de género. Participación educativa, segunda época, 7(10), 123-134, 2020.

[19] https://agora.xtec.cat/insrocagrossa/general/sortim-a-tv3/

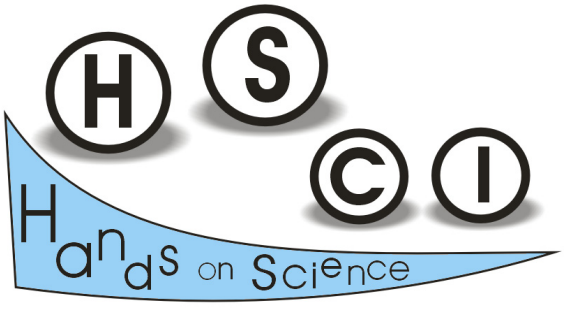
[20] https://magnet.cat/lescola-peramas-elabora-un-mapa-interactiu-dels-ocells-de-mataro/

AUTHOR INDEX

ISBN 978-84-8158-937-5

Z

This book is conformed of a set of selected works presented at the 19th International Conference on Hands-on Science held online July 25th to 29 th, 2022. The editors would like to acknowledge the efforts of the conference organizers and the members of the conference committees as well as the contributions of all authors and conference participants.



The Hands-on Science Network

19th International Conference on Hands-on Science

Rethinking STEAM education in times of uncertainty

25th-29th July 2022
University of Burgos, Spain

Honorary President

Manuel Pérez Mateos, The Rector at University of Burgos

Honorary Committee

Manuel Pérez Mateos, The Rector at University of Burgos
Daniel de la Rosa Villahoz, Mayor of the city of Burgos

Chairperson

Manuel Filipe Costa, University of Minho

Local Chair

María Diez Ojeda, University of Burgos, Spain
Miguel Ángel Queiruga Dios, University of Burgos, Spain

International Advisory Committee:

Abhay Kothari (India)
Alicia Fernandez Oliveras (Spain)
Amit Garg (India)
Anna Michniewska (Poland)
Angela Guzman (USA)
Ángel Manuel Vazquez-Dorrio (Spain)
Ann Torsted (Danmark)
António Carlos Pavão (Brazil)
António Fernando Ribeiro (Portugal)
Armando Dias Tavares Jr. (Brazil)
Bogdan Toma (Spain)
Carla Maria Medeiros y Araujo (Brazil)
Chien-Heng Chou (Taiwan)
Clementina Timus (Romania)
Dana Mandikova (Czech Republic)
George Kalkanis (Greece)
Elsa Fernandes (Portugal)
Erik Johansson (Sweden)
Eva Trnova (Czech Republic)
Guillermo Baldwin (Peru)
Francisco Sousa (Portugal)
Horst Bannwarth (Germany)
Iryna Berezovska, (Ukraine)
Jen-Chin Lin (Taiwan)
Joana Oliveira (Portugal)
Joaquim Carneiro (Portugal)
Jose Benito Vazquez-Dorrio (Spain)
Jose Luis Paz (Ecuador)
Kseniia Minakova (Ukraine)
Liu Xu (China)
Lucian Vladescu (Romania)
Luísa Neves (Portugal)
Manuel Filipe Costa (Portugal)
Maria Dulce Geraldo (Portugal)
Maria Inês Nogueira (Brazil)
Maria Teresa Malheiro (Portugal)
Marian Kires (Slovakia)
Miguel Ángel Queiruga-Dios (Spain)
Mikiya Muramatsu (Brasil)
Mohammed M. Shabat (Palestine)
Mustafa Erol (Turkey)
Nilgün Erentay (Turkey)
Norihiro Sugimoto (Japan)
Nuno Francisco (Portugal)
Panagiotis Michaelides (Greece)
Paulo Pereira (Portugal)
Pedro Membiela (Spain)
Pedro Pombo (Portugal)
Radu Chisleag (Romania)
Raquel Oliveira (Portugal)
Robert Worley (UK)
Roger Ferlet (France)
Samar Darwish Kirresh (Palestine)
Sandra Franco (Portugal)
Sonia Seixas (Portugal)
Stephen M. Pompea (USA)
Sue Dale Tunnicliffe (UK)
Teresa Kennedy (USA)
Toyohiko Yatagai (Japan)
Vasco Teixeira (Portugal)
Vasudevan Lakshminarayanan (Canada)
Victoria Belaga (Russia)
Walburga Bannwarth-Pabst (Germany)
William Stebniki Tabora (Uruguay)
Zdenek Drozd (Czech Republic)
Zuzana Ješková (Slovakia)

Local Organizing Committee:

Altamira López Gallego
Andrés González Santa Olalla
Antonio Jesús Canepa Oneto
Bárbara de Aymerich Vadillo
Bogdan Toma
Eva Maria López Perea
Isabel Soto Muñoz
Jesús Meneses Villagrá
Jordi Rovira Carballido
María Diez Ojeda
Marta Alarcón Orozco
Mercedes Saiz Ruiz
Miguel Ángel Queiruga Dios
Olga Segundo Mendoza
Patricia De La Fuente Gamero
Susana Jorge Villar
Vanesa Baños Martínez

ISBN 978-84-8158-937-5