Hands-on Science

Advancing Science. Improving Education

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

Hands-on Science
Advancing Science. Improving Education

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Foreword

Advancing Science. Improving Education

Back in 2004 the first annual Hands-on Science international conference was successfully organized in Ljubljana. The main theme of the conference was "Teaching and Learning Science in the XXI Century". We intended to draw a picture of the current situation of science education in Europe and in the world and to point out ways of improvement in line with the Hands-on Science Network rational. Along the years a large number of excellent, pedagogically and scientifically, papers support materials and remarkable and inspiring examples of good practices were presented at our conferences and published in the sixteen proceedings and books we edited.

Sadly in this XXI century many of us are noticing an unexpected civilizational regression hard to accept and to understand on view of all remarkable progress achieved on previous decades. Fortunately Science keeps evolving and opening new and better development ways to a better future to humankind.

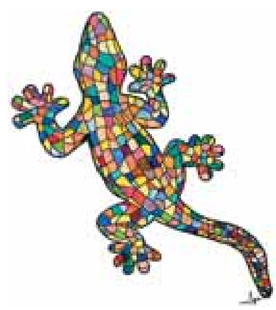
The book herein aims to contribute to the advancement of Science to the improvement of Science Education and to an effective implementation of a sound widespread scientific literacy at all levels of society. Its chapters reunite a variety of diverse and valuable works presented in this line of thought at the 15th International Conference on Hands-on Science "Advancing Science. Improving Education" held in Barcelona, July 16 to 20, 2018.

Vila Verde, Portugal, June 11, 2018.

Manuel Filipe Pereira da Cunha Martins Costa
Editor in-chief

Hands-on Science

Advancing Science. Improving Education



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FOREWORD

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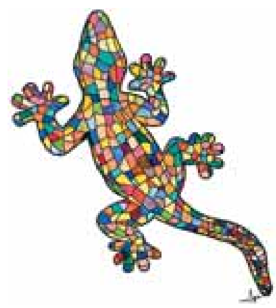

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Crazy about Biomedicine: A Hands-on Initiative Run by a Research Centre to Nurture a Vocation for Science among Secondary School Students

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Abstract. The Institute for Research in Biomedicine (IRB Barcelona) is a world-class research centre devoted to understanding fundamental questions about human health and disease. In addition to conducting multidisciplinary research of excellence, IRB Barcelona is committed to maintaining an open dialogue with the public about our work. In this regard, one of our flagship programmes is the Crazy About Biomedicine course. Aimed at secondary school students in their first year of baccalaureate, this mentoring programme seeks to foster passion for science and promote science as a vocation. Over the year-long course, students participate in a series of workshops and hands-on sessions in which IRB Barcelona researchers serve as mentors in the lab and provide training on state-of-the-art research.

Keywords. Education, Engaging teenagers, Scientific Vocations, Young Talent.

1. Introduction

The Institute for Research in Biomedicine (IRB Barcelona) is a world-class research centre devoted to understanding fundamental questions about human health and disease. Founded in October 2005 by the Government of Catalonia and the University of Barcelona, IRB Barcelona belongs to the Barcelona Institute of Science and Technology (BIST).

One of the missions of IRB Barcelona, besides conducting multidisciplinary research of excellence, is to maintain an open dialogue with the public about our work. In this regard, since its very beginning, the Institute has designed and implemented a wide variety of engagement and education activities [1].

We believe that it is paramount that research institutes like ours organise activities for the public. This approach serves a double purpose. First, it allows us to be open about the research we do (in part financed by public funds). And second, it allows us to foster scientific culture in society and a vocation for science among its youngest members.

Figure 1. A PhD student from IRB Barcelona explaining her research to secondary school students

As a high-level training institute, we provide young researchers with the tools and training opportunities to empower them to effectively communicate their research (Figure 1). Beyond communication to scientific audiences, we also seek to instill the importance of public outreach in our young researcher community. Our science engagement and educational programmes are aimed at different segments of the public, ranging from primary school students and secondary school students and teachers, to general adult audiences.

IRB Barcelona has its own in-house outreach programmes but also partners with a number of institutions, including the Barcelona Science Park, the Fundació Catalunya-La Pedrera, The Barcelona Institute of Science and Technology, and the Barcelona City Council, among others.

IRB Barcelona firmly believes that interactions between researchers and society are mutually beneficial. Consistent with this stance, we channel considerable efforts into maintaining an open dialogue with the public, thereby strengthening the bonds between science and citizens with the aim to contribute to a more informed society.

2. The Crazy About Biomedicine Course

Aware of the need to provide secondary school students interested in life science with hands-on experience, IRB Barcelona devised a tailor-made course to fill this need.

In 2013, we launched the first edition of the Crazy About Biomedicine course [2], a training initiative that is now in its sixth year. Aimed at secondary school students in their first year of baccalaureate (around 17 years old), it is given exclusively in English and it is held on IRB Barcelona premises on Saturdays over 12 months. The course provides a series of lectures (Figure 2) and sessions in research labs (Figure 3) in which participants are guided by PhD students and postdoctoral fellows.

Figure 2. Crazy About Biomedicine students attending a lecture on cancer research by a PhD student from IRB Barcelona

Each year this course receives around 400 applications from all over Catalonia. Applicants are required to provide a letter of motivation and a letter of recommendation from their science teacher. A short-list of about 80 candidates is drawn up and the selected students are invited to an interview, which is also held in English. Of these, 24 students - some from as far away as 200 km- are offered a place on the course.

About half the participants go on to medical school, while a similar number move into fields of basic molecular life sciences, such as biochemistry, biomedicine, and human biology. A few others enter chemistry, physics, and engineering.

In addition to providing secondary school students with a learning opportunity, the course allows IRB Barcelona PhD students and postdoctoral fellows to gain teaching experience and awaken a vocation for education.

Figure 3. Crazy About Biomedicine students in two hands-on workshops held in IRB Barcelona laboratories

3. Beyond Crazy About Biomedicine

The success of the first Crazy about Biomedicine course launched by IRB Barcelona six years ago has led to its format being adopted for other disciplines, such as biochemistry, physics, mathematics, and even economics, which are now included in the “Crazy about Science” Programme run by the Fundació Catalunya-La Pedrera [3].

It is hoped that this programme will continue expanding so as to give budding young scientists in all disciplines the opportunity to explore real research.

In parallel to the Crazy About Biomedicine course, IRB Barcelona also gives students the opportunity to do their secondary school science project ("Treball de Recerca") under the tutelage of an IRB Barcelona researcher. These researchers work alongside the students throughout the planning, experimental design and execution of the project, and teach them the importance of the scientific method as the backbone of all rigorous scientific inquiry.

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Furthermore, IRB Barcelona has launched the Crazy Club, a new initiative to give former participants in the course the chance to keep in touch. Regular meetings are organised by a committee (formed by students from different years) to foster a network of young people interested in developing a career related to biomedicine. The meetings also include training sessions on new skills, such as time management, public speaking, team working and research integrity. Furthermore, senior alumni mentor younger ones throughout their university studies. The Crazy Club already has more than 140 members and will continue to grow as more students complete the course and sign up to join a big family of crazy contacts.

4. Acknowledgements

IRB Barcelona acknowledges the Fundació Catalunya-La Pedrera for funding the Crazy About Biomedicine Course and for its commitment to promoting scientific vocations among young people.

Special thanks go to the IRB Barcelona researchers who participate in the public engagement activities organised by the Institute, and in particular to the tutors of the Crazy About Biomedicine course.

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[3] http://www.bojos-ciencia.fundaciocatalunya-lapedrera.com/

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Socio-Environmental Science Investigations: Hands-on Active Learning with Geospatial Technologies

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Abstract. We have developed, implemented, and evaluated a series of innovative socio-environmental science investigations (SESI) using a geospatial curriculum approach that has provided economically disadvantaged secondary students with technology-rich, spatial learning experiences to develop science data gathering and analysis skills. SESI are based on the pedagogical frameworks of place-based education and socioscientific issues-based instruction. Place-based education focuses on local or regional investigations, is designed around engaging students in examining local issues [1] and utilizes field-work to gather evidence in that local setting [2]. Place-based education connects learners to their immediate environment and can provide opportunities to empower students to address important socio-scientific issues in their communities. Socio-scientific issues are socially relevant, real-world problems that are informed by science and often include an ethical component [3]. They are sometimes controversial in nature, but have the added element of requiring a degree of moral reasoning or the evaluation of ethical concerns in the process of arriving at decisions regarding possible issue resolution [4]. These issues require the use of evidence-based reasoning, and provide a context for understanding scientific information using an active approach to learning, placing science content within a social context in a way that supplies both motivation to and the ownership of learning by the student [4].

With SESI, students explore local issues through a sequence of inquiry investigations. During the investigations, students use iPads with built-in GPS utilizing a map-based data collection app (Esri's Collector app) to gather data outside their school. The student-collected data is then shared into a Cloud-based map service over the Internet. The collaboratively created data set is displayed in ArcGIS.com, an interactive Web-based GIS (or Web GIS), along with other important contextual georeferenced data for each investigation (for example land use type, tree density, ground surface type, city tree planted species, personal and property crime, and others). The Web GIS includes a suite of tools that students use to manage, query, and analyze the geospatial data. They use geospatial thinking and analysis skills for exploring spatial relationships in the data, and also critical thinking skills to synthesize, compare, and interpret georeferenced data to investigate problems in their local environment. Here we present two SESI investigations: (1) Trees and Ecological Services, and (2) Urban Heat Islands.

In the Trees and Ecological Services investigation, students observe the different types of vegetation around their school and throughout the city to understand the environmental and societal benefits that trees provide to their community. In the first step of this investigation, students explore with iPads to identify and collect data on the trees that surround the school. Students use a tree dichotomous key iBook that they are presented with a series of choices about the characteristics of trees. Using the iBook, students characterize the main features of the trees (such as leaf shape, vein arrangement, types of fruits, etc.) by reading through a series of questions accompanied by displayed sample images. They use these features to identify the tree species and learn if trees are native or exotic species. Students also measure the tree circumference and estimate the tree height. Students' data are entered into a map-based data collection app (Esri's Collector app). After returning to the classroom, students view all collected data and compare their findings with a data layer of planted city trees provided by the local shade tree commission. Drawing on both sets of data, they are tasked with identifying tree planting patterns and thinking about benefits of planting shorter trees in certain city locations, for example, under power lines and other obstructions. The investigation then requires exploring the ecological services provided by trees (energy savings, air pollution removal, storm water catchment, carbon dioxide reduction, and aesthetics), and calculating a monetary value for these services

for the trees surrounding their school.

Next, students examine neighborhoods in their own city—what social benefits do trees appear to provide? To simplify the task, we set up specific areas for investigation in the GIS maps used for the analysis: combinations of three city census blocks that contain variation in key factors, such as tree canopy cover and crime rate, to allow students to see how these factors are interrelated. Students are assigned a specific area on the interactive Web GIS map and must identify patterns in the percent of tree canopy cover (whether high or low), and personal and property crime rates (whether high or low) in that selected area. To investigate the relationship among trees and personal and property crime in their city, the entire class combines their collected tree data from across the student groups into a shared data table. Using these data, students identify the relationship between tree canopy and personal and property crime. While some students are able to detect the pattern immediately, we arranged the data table to allow the teacher to scaffold the process for identifying patterns and relationships among the different data layers. The pattern observed in this investigation is similar to those reported in Baltimore, USA and other cities where greener neighborhoods have significantly fewer crimes than non-vegetated areas [5]. However, correlation may not reflect causation, as there may be other mitigating factors at work.

A final motivating feature of the SESI activities is their social relevance to the students. At the end of the Trees and Ecological Services investigation, students apply their new knowledge to their local neighborhoods: How can you improve your local neighborhood using the information you learned in this investigation? Students are invited to take pictures to document their neighborhood and annotate the GIS map to suggest changes that will enhance the environmental and/or societal health in their community. Thus, the SESI investigations involve decision-making that is based on the analysis of scientific data connected to relevant social science content, and include implications for social equity and advocacy.

In the Urban Heat Islands SESI activity, students learn about heat absorption and re-radiation from different parts of the natural and built environment, culminating in proposed changes to neighborhoods that would reduce the heat island effect. The first step in the lesson is a presentation from the teacher about the scientific concepts involved: What is temperature and how do we measure it? What is the difference between air temperature and ground surface temperature, and what are the sources of heating and cooling effects on both? What is a heat island, and why is it an urban phenomenon rather than a rural phenomenon?

After the content background presentation, students download a map of a sampling area to the Esri Collector app. Next, they move outside with GPS-enabled iPads and infrared surface temperature thermometers. Working in pairs or trios, students orienteer to an assigned zone on the school property where they obtain temperature readings from various surfaces found within their zone, including grass, dark and light asphalt, concrete, bare soil, and other surfaces they may observe.

Once back in the classroom, the data from the individual iPads are synced into a aggegated dataset. Next, the students work in groups to examine the collected data using ArcGIS.com and observe the patterns in temperatures recorded on different surfaces (for example, dark asphalt vs. light asphalt or concrete vs. grass), and under different conditions (shaded vs. unshaded or morning vs. afternoon). Using the Web GIS, students observe the contrasts between shaded areas, such as tree-lined areas along sidewalks, versus the hotter temperatures recorded in the middle of the parking lot. Students analyze data to understand temperature differences from sunlight absorbed and retained in dark asphalt surfaces over the course of the day. This analysis is used to reinforce concepts about heat absorption and re-radiation, and how albedo and shaded areas can reduce this effect.

In the next step of the investigation, students deepen their analysis using a GIS map of the land cover in their city. This map displays both built environment features (e.g., structures, roads, impervious surfaces such as parking lots) and natural features (e.g., vegetation and tree canopy, particularly trees that shade structures and roads) that help reduce the urban heat island effect. Working in groups, students focus on an assigned neighborhood in their city to examine the land cover and discuss how it contributes to the urban heat island effect.

After considering possible mitigation strategies, students propose several changes for their assigned neighborhood. For example, students have suggested creating shade by adding rows of trees within parking lots, converting dark rooftops to light-colored rooftops, modifying large commercial structures such as office buildings to incorporate green roofs, and have offered other recommendations that increase albedo and decrease solar energy absorption by a surface. Students then use the suite of draw tools to make these changes on their ArcGIS.com map and submit their recommendation electronically to their teacher.

Keywords. Web GIS, socio-environmental science, place-based education.

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Feynman: Nobel, Drums, Topless and Didactics

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Abstract. In 2018, the scientific community commemorates the centenary of the birth of Richard Phillips Feynman, who won the Nobel Prize in Physics in 1965, Feynman has been considered the most important physicist of the 20th century after Einstein, but his fame comes not only from his research. The conference presents the life and facts of Richard Feynman, and his particular desire to make science to students understandable. We will discuss the use of analogies from Feynman and the author, and the advantages and limitations of the use of that tool on teaching.

Keywords. Analogies, Feynman, history of science.

1. Introduction

There are not many scientists identified as icons by the general public. In Figure 1 are shown some of them, along with some related scientific icons. Richard Feynman is not yet known to the public, although he is considered the second physicist of the 20th century after Einstein, and his life and facts would justify a more extensive fame. Figure 2 shows one of his typical poses, as well as the diagrams that have given him fame among the physicists.

2. Life and facts

Figure 3 summarizes the main moments of Feynman's life. His work starts at a plastic company, and his interest in the research in physics at Princeton, from which his participation in the Manhattan project in Los Alamos would be derived, for the development of the American atomic bomb. This allowed him to be in contact with the most important American and European physicists fleeing from Nazism. Later he moved to Cornell University and then finally moved to Caltech due to his interest in teaching.

Throughout his life he developed basic research in different fields, such as quantum electrodynamics (QED), for which he received the Nobel Prize in 1965, together with Schwinger and Tomonaga (Figure 5). The weak interaction between atomic nucleus particles and the superfluidity of liquid helium were other issues that he developed.

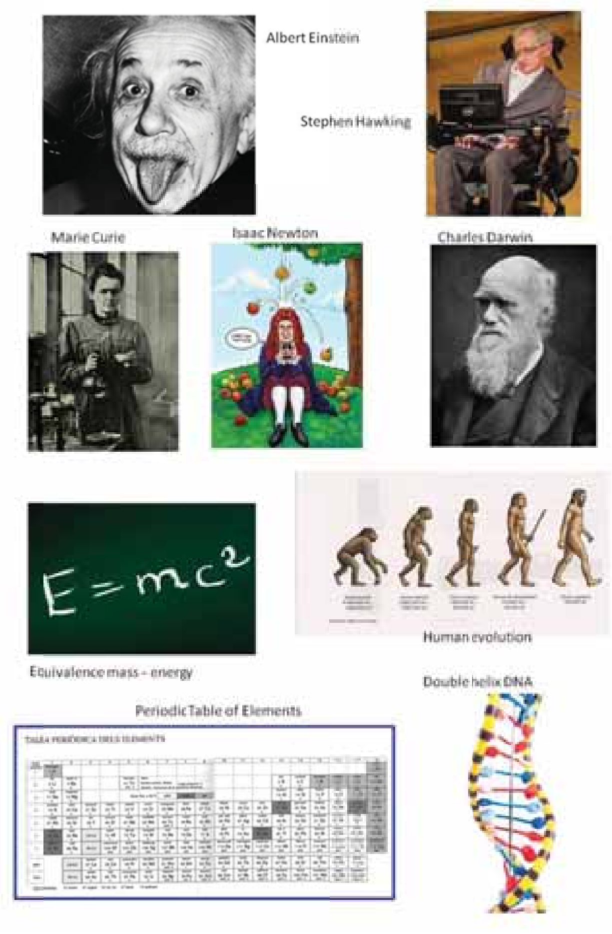

Figure 1. Some famous scientists and scientific icons

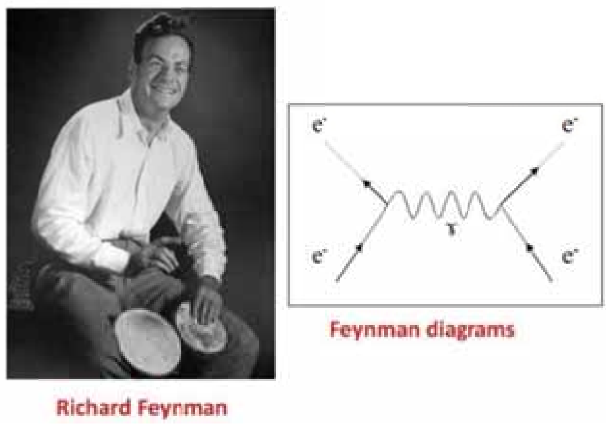

Figure 2. Feynman and one of their diagrams

He received several awards and recognitions throughout his life. Feynman did not work in nanoscience, but one of their visionary conferences is considered the beginning of this science and the nanotechnology related, which today have great development (Figure 4).

3. Personality

Feynman's personality was very versatile. Its main feature was creativity in all fields of life, including private life, and the obsession with transmitting information clearly. He was very skilled in calculating and encrypting, fixing radios, opening safes and inventing mathematical games, which he resolved easily.

1918 Born in New York
1939 Graduated atl Massachussets Institute of Technology (MIT)
1940 Work at Metaplast Corporation
1941 First wedding Arlene Greenbaum (+1946 tuberculose)
1942 Ph.D. at Princeton (director Wheeler, quantum mechanics)
Project Manhattan at Los Alamos. Oppenheimer, Fermi, Bohr, Teller, von Neumann.
1946-1951 Cornell University with Bethe i Gibbs
1950 Brasil: paint, samba, bongos, prostitution, topless, cannabis and LSD
1950 to 1988 Caltech (professor of Theoretical Physics). He preferred Caltech to Princeton because of having contact with pupils

- quantum electrodynamics. Quantum gravity
- helium superfluidity
- weak interaction
- Feynman diagrams (useful for strings theory)
- *Lectures on Physics* (***Oersted*** *award*)

1952 Second wedding, with Mary Louise Bell. Short and fiasco. Third wedding with Gweneth Howart (UK). 1 son and 1 adopted daughter
1954 ***Albert Einstein award***, Princeton
1959 Lecture ***There's plenty of room at the bottom***
1961 Lectures on Physics to undergraduates, Caltech
1962 ***Lawrence award***
1965 ***Nobel Prize*** on Physics, with Tomonaga i Schwinger
1986 Comission ***Rogers*** project Challenger
1987 Cancer
1988 Die at Los Angeles, 69.

Figure 3. Some facts of the Feynman's life

He married three times with a different fortune. His first wife died of tuberculosis while he worked in Los Alamos. He divorced shortly after marrying his second wife. His third marriage was lasting, and structured on the basis of broad freedom of movement. That allowed him to travel and have friendships that went beyond what was considered orthodox in his environment. His stay in Brazil during a period of depression and personal difficulties led him to learn to play bongos and other musical instruments, and to parade with a samba school.

4. Didactics and analogies

He had a great concern to explain clearly in his classes and in his lectures. To facilitate the visualization of his theorem of quantum electrodynamics (QED) he developed the diagrams that now bear his name, which summarize complex complicated visual theoretical equations. Figure 6 shows some of these diagrams, which have appeared on television series such as *The Big Bang Theory*. This led him to raise the design of a physics course for newcomers in Caltech.

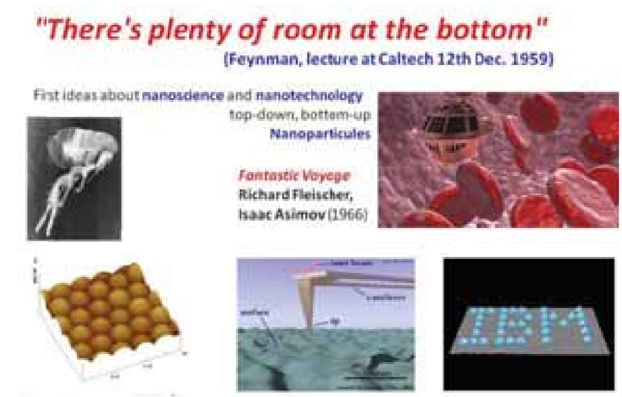

Figure 4. The beginning of nanoscience

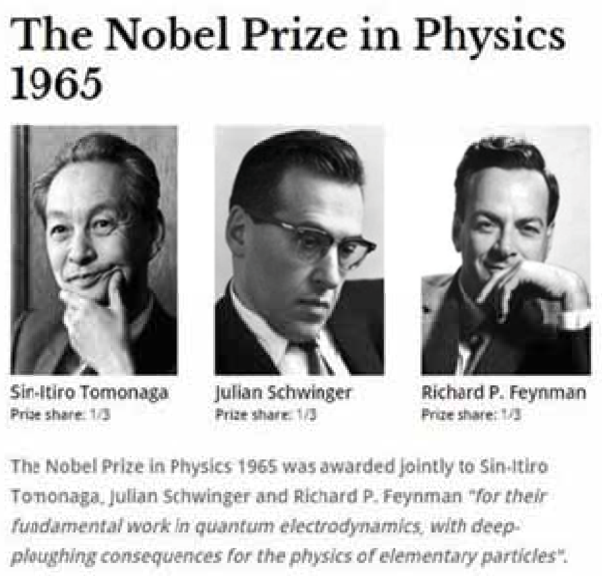

Figure 5. Nobel Prize 1965

His course consisted of conferences Master lectures given by himself, and by seminars of problems given by his assistants, along with laboratory classes. All the documentation was collected in three manuals that continue to be published and that probably were the teaching books of physics most appreciated by the teachers, but not so much by the students. The purchase and study of one of these manuals in bilingual edition has been for the author one of

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their sources of inspiration (Figure 7).

In that text [1], Feynman posed different analogies between the physical world and everyday life. The first of them is the analogy between the principle of energy conservation and the conservation of the number of pieces of a child building game (Figure 8). In the text it indicates that each block weighs 3 ounces, and that when it is thrown into the tank, the water rises to 0.25 in. It suffices to weigh the box and measure the height of the water to see that the number of blocks is conserved.

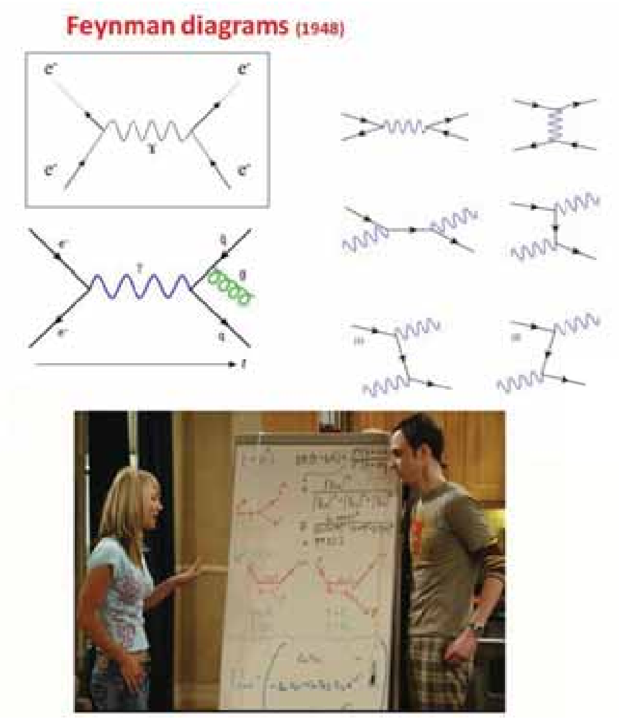

Figure 6. The Feynman diagrams

The prudent use of analogies is an effective resource in teaching, provided that ideas that the analogy does not allow are not extrapolated. The author has developed several analogies for the teaching of chemistry which is shown in Figure 9. It is about explaining the difference between thermodynamics and kinetic in chemical reactions, using the analogy with an exam. The students often complain that they lack time to finish it, because they have a "thermodynamic" vision of an exam: they assume that in infinite time all the students could obtain the maximum note. Instead, teachers usually have a vision that combines thermodynamics and kinetics: with more time maybe some students could get better grades, but many others could not because they could not get never at 100%.

Figure 7. The Feynman Lectures on Physics Vol I, bilingual edition

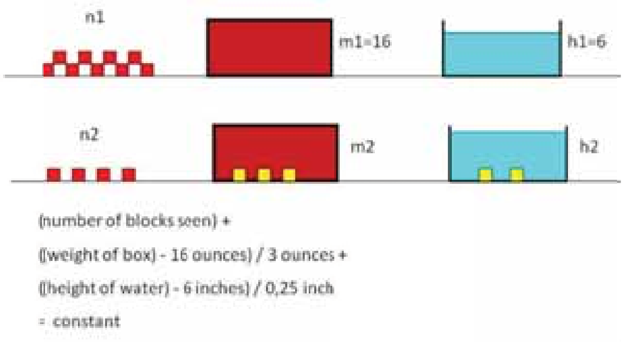

Figure 8. Analogy between the energy conservation and the conservation of blocks

Figure 9 graphically shows the two visions. An infinite time test would show if the final results are grouped around 100% (view of the students) or if they continue to distribute the results across the range of values (teacher's vision). At the department of the author, some years ago, an experiment was performed in such conditions, meaning "infinite time" the time that students required (up to 8 hours the student who resisted more) and the result gave reason to the teacher's vision, as expected: the distribution of marks extended between 0 and 100%, as in other exams with a limited time.

5. Some quotations

Feynman has been famous due to the big number of quotations included in their books and speeches. Some of the most known are the following:

- It you though that the science was certain - well, it is just an error on your part.

- I think it's much more interesting to live not knowing that to have answers which might be wrong.
- Religion is a culture of faith; science is a culture of doubt.
- Study hard what interests you the most in the most undisciplined, irreverent and original manner possible
- I learned very early the difference between knowing the name of something and knowing something.

I wonder why. I wonder why
I wonder why i wonder
I wonder why I wonder why
I wonder why I wonder !

Ref. [5] is just devoted to list hundreds of quotations by Feynman.

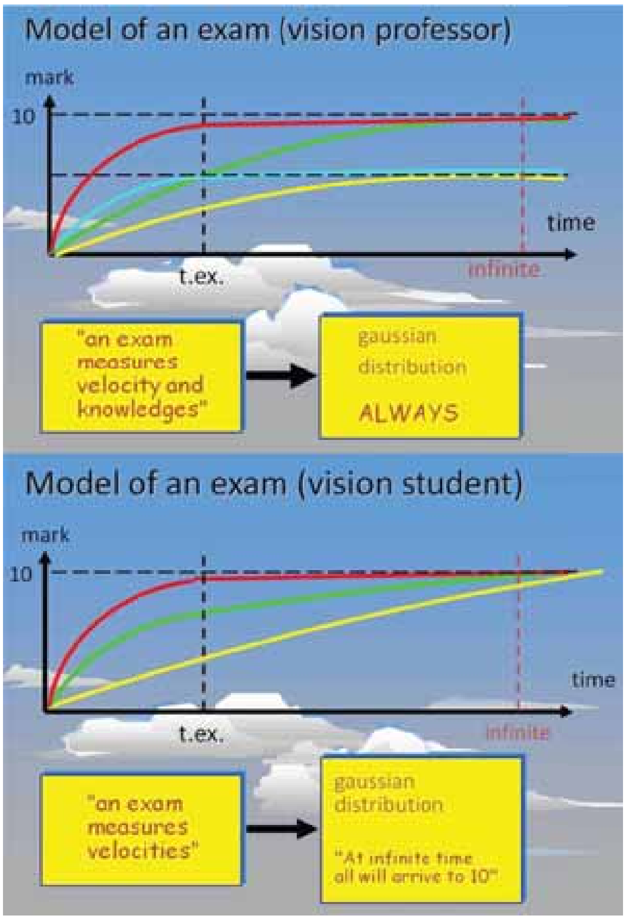

Figure 9. Analogy between the principle of energy conservation and an exam

6. Popular physics

The popular recognition of the figure of Richard Feynman was due to a set of factors such as his personality. Certain public performances gave him media fame. Probably the most important was a TV performance. On January 28, 1986, the Challenger shuttle exploded 73 seconds after its takeoff and its 7 crew died. Many U.S. schools were watching the operation because a school teacher was one of the crew, and many activities had been planned in the classes.

The social impact of the accident was very important, and an official commission was created to determine the cause of the accident. Feynman was asked to participate, but he preferred to work from outside the commission. He disagreed with the results of NASA in a public demonstration on television. He showed in a home experiment with a glass of water ans some ice that an O-ring of one of the tanks lost flexibility at low temperatures.

Figure 10. Covers of the books [2-4] in Spanish, Italian and Spanish translations

He also devoted himself to the art world, collaborating with plastic artists. For example, he helped Jeff Koons in the design of his "One Ball Total Equilibrium Tank" (1985), where a basket ball floats in equilibrium in the center of a water box.

Feynman wrote several books about their ideas about science and its methodology [2], and his sense of life [3]. A very clever biography as a comic book [4] (Figure10) has been written.

Richard Feynman died of cancer in Los Angeles in 1988.

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Making Simplified Professional Wind-Turbines by Using Mould Method

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Abstract. In most of popular science education activities, the wind-turbines, which are made by participants, are oversimplified. In the past two decades the author has been emphasizing importance of teaching the scientific principles of professional wind-turbine in science activities. The author also has been advocating the science education of professional wind-turbines in order to teach the related precious fluid mechanics knowledge. However, the process of making professional wind-turbines, which were made of wood, is rather complicated and not conducive to promotion of teaching professional wind turbine. In this article, the author presents a quasi mould method to make professional wind-turbines in more convenient way. However, the simplified wind turbines, which possess the vital features of professional wind-turbines, still conform to the principles of modern wind-turbines. Such a wind-turbine still has the performance of a professional wind-turbine and can still be used to carry out the scientific education of wind-turbines, which highlights the principle of modern wind-turbines. This alternative approach has broken through the bottleneck of previous professional wind-turbine science education. The costs and manpower requirements of these activities, and problems of polluted the site have been limited to a fully viable range.

Keywords. Wind-turbine, lifting force, angle of attack, airfoil.

1. Introduction

Many popular science education activities are related to wind turbines. In most of science education activity, wind-turbines are often made from cut espresso bottles or balsa wood thin plate. Because the shape of the blade and the airfoil of the blade cannot be modified to meet the scientific principle of modern mature wind-turbine, it is not easy to incorporate concepts such as angle of attack, lifting force, drag force, stall, relative speed, and work in the wind-turbine science education activities. In fact, among these science education activities of wind-turbines, some of the most interesting and valuable science and education priorities can all be enriched, if participants can have a chance to make a modern wind-turbine.

The author advocates that the professional wind turbines, which expound the basic principles of commonly used horizontal axis lifting-force type wind-turbines, can be made by participants [1]. From the perspective of the lifting force and the angle of attack of an aircraft wing, the most important function of the wind-turbine is to let the wind do positive work on the wind-turbine. Therefore, the angle of attack in each section of the wind turbine blade must be reasonable in order to generate adequate lifting forces exerted in each section of the blade and make the wind-turbine run normally.

Using wood as a raw material, the author produced wooden wind turbine with relevant appropriate pitch angles in every sections of the turbine blade. However, in the process of making wood wind-turbine blades, water-jet cutting, jigsaws, and sand grinders are used. The procedures are complicated and expensive and generate a lot of dust and sawdust. Furthermore, the annoying noises can not be avoided.

Figure 1. The person with red clothes is a teacher

Even in the situation, many hobby teachers unwaveringly put their full energy into the wind-turbine science education and disregard the fact that the teaching activities make them-self (Figure 1) and the classroom messy and dirty. Although the wooden wind-turbine blade can truly conform to the scientific principles in the two aspects: the airfoil of the turbine blade and various pitch angles in various sections of the blade, dust is harmful to health and also causes difficulty in site cleaning. This problem became a major obstacle in promotion for the wind-turbine science education in the past several years.

After doing a lot of preparatory works and practices, the author can produce a wooden windmill turbine, of which the length is 70 centimeters, in about 20 minutes at the final stage. Many teachers continuously have put them-self into practice with enthusiasm and vitality. However, we have not been able to break through the bottleneck of popularization.

In this article, the author developed a wind-turbine making procedure. Through the procedure, in which the mould technique has been partially utilized, people can make a wind turbine that possess the vital features of modern wind turbine and therefore learn the relevant principles of professional wind-turbine. Although the airfoil of the turbine can not be satisfied completely, the pollution in the making process can be ruled out.

Although the airfoil of the turbine is not perfect, the effect of this disadvantage can be ignored when the size of the turbines is limited. The wind-turbine made through the innovative process retains the knowledge content of most professional wind-turbines. The making procedure, which significantly reduces the cost and manpower for preparation, greatly reduces waste pollution on the site and makes professional wind-turbine scientific education popularized easily in the near future.

2. The principles of modern wind turbine

At present, the most commonly used wind turbines for producing electricity are called horizontal axis lifting-force type wind-turbines. Why is it called a lifting-force type wind-turbine? It is because of how this wind-turbines work. In fact, the principle of the modern wind turbine is consistent with the principles of the aircraft wing and also of sailboat.

There are various airfoils with different performances. Due to various flight requirements, the wing of an airplane has a suitable airfoil. The airfoil also affects the relationship between attack angle and lifting force. On the other hand, in most of the time sailboats also utilize the lifting force of the sail to propel forward the boat. Figure 2 shows that when wind comes from left side how the lifting force of the sail propels the boat. As the speed of the ship increases, the angle of sails needs to be adjusted to take full advantage of the lifting force of the sail (Figure 2).

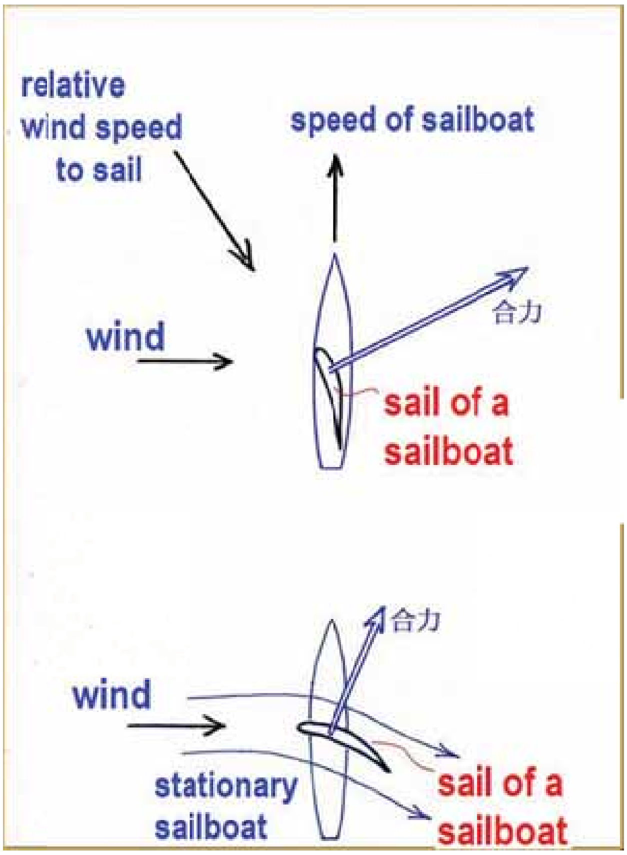

Figure 2. A sailboat is driven by the lifting force

Because the wind-turbine is a rigid body, the speed of the tip of the turbine blade is faster and the speed of the blade root is slower. However, the speed of wind could be assumed to be constant in the space occupied by the wind turbine. Therefore, in order to provide sufficient lifting force for each section of the blade with a proper angle of attack, the shape of the wind turbine blade shall be carved in a reasonable manner [2] (Figure 3). The key issue is that the pitch angles of every sections of the turbine shall be changed gradually and then the angle of attack of each section shall be within a reasonable range when the turbine is rotating.

The performance of modern wind-turbines is mainly determined by four factors:

1) The pitch angle of each section of the

turbine should make the angle of attack within a reasonable range while wind turbine is rotating. When the wind-turbine rotates, no stall or negative angle of attack can occur in each section of the wind turbine blade.

2) The airfoil should generate as much the rate between lifting force and the drag force as possible in favor of guiding the air current smoothly and efficiently. However, when the turbine is carved, some compromises will be made between ideal designing and structural safety.
3) The ratio between the total area of the blades them-self and the area swept by the blades should be appropriate. This requirement, in principle, is for avoiding airflow disturbances between the blades. This appropriate ratio can be determined according to existing empirical values.
4) The shape of the front face of the turbine is also related to the turbine's performance. The influence of this factor is relatively insignificant, so most of the blades are only made of long strips with wider roots.

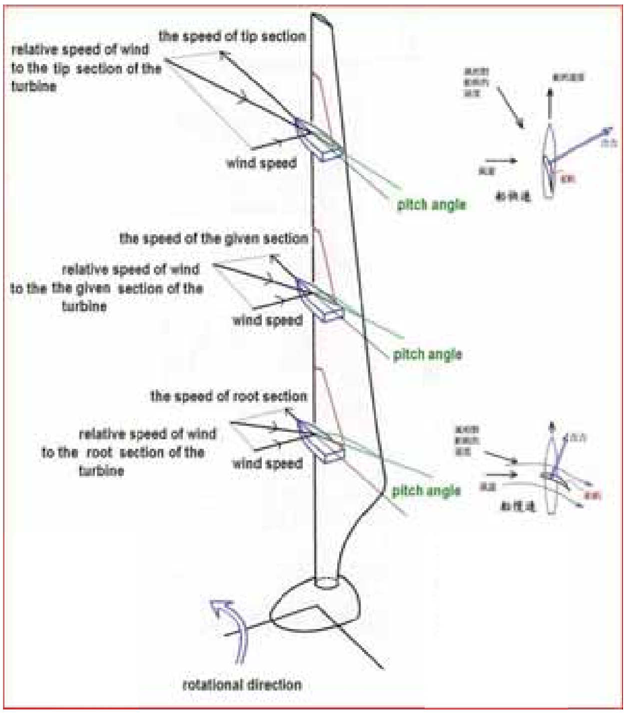

Figure 3. Pitch angles of every sections shall be reasonable

It is not difficult to make a wooden wind-turbine blade that meets the above conditions. The modern wind-turbine's performance is better than that of wind-turbines in current popular science activities in Taiwan. The author cooperated with Taichung Chulu Junior High School which was led by the headmaster Zhuo. He successfully held the Tai Dong County's Wooden Wind-turbine Production (Wind Power Generator [3-4]) Competition three times. Most of the county's schools participated in this wonderful competition. It is observable that every representative teams had made great progress year by year.

3. The new procedure of making a professional wind turbine

First of all, it shall be emphasized that a wind-turbine differs from a propeller. To replace a wind turbine by a propeller is obviously a scientific mistake. The new procedure is related to the common used mould technique. A PVC plate, of which shape is made as that of a turbine, is soften and deform in a mould-like instrument by heat. And then it was cooled and shaped. The new process is described as follows.

Firstly the shape and size of the blade shall be designed. Use a 1mm thick PVC plate as the material of the turbine blade. The size and shape are shown in Figure 4. In order to decrease costs and take into account the practical conditions of the science education activities along with the effect of the demonstration, the diameter of the wind-turbine is usually not more than 45 cm. Because of the smaller size of the wind-turbines, they can be rotate at high speed even with the breeze from ordinary fans.

Figure 4. The 1mm thick PVC plate is cut into turbine shapes

Then a wooden mould is made. The shape of the mould matches the shape of the PVC plate roughly. On the one hand, pay attention to the pitch angle of various sections, which affects the angle of attack of each section of the turbine during operation. From the root to the tip of the turbines, the width of various sections of the mould gradually becomes smaller. On the other hand it is also very important to make the approximate shape of

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upper part of the airfoil. For these purposes, the sloping line relating to the trailing edge of the wind turbine blade is plotted on the mould. (Figure 5.a). And then gradually engrave and polish the profile of upper surface of the turbine on the mould (Figure 5.b). Of course, for the sake of convenience, the original shapes of PVC plate and that of wooden mould are cut out with a water jet cutter.

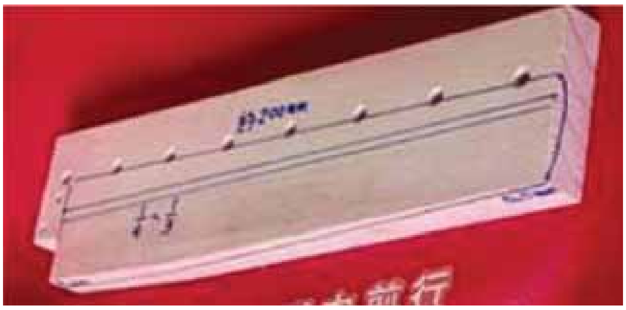

Figure 5.a. The oblique line below the picture is the trailing edge

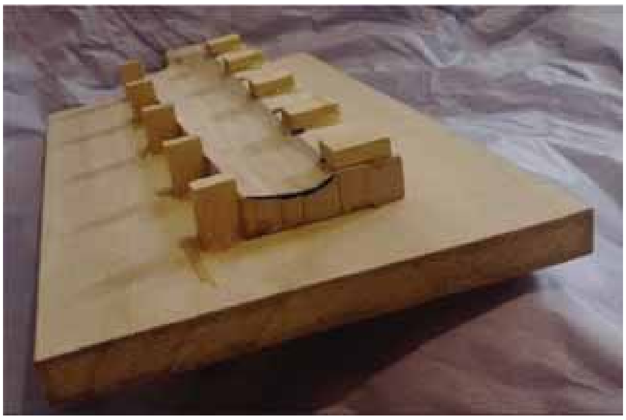

Figure 5.b. The mold regulates the curved surface of the wind-turbine

There are two small holes on the mould and there are two relevant small holes in the root of the blade of the PVC plate, so that both can be locked with screws to be combined together.

Firstly, the PVC plate is fixed on the mold with screws. Several small wooden blocks are installed around the mould to make the PVC plate more firmly placed in the mold to facilitate the subsequent extrusion process (Figure 6).

Then use a hot air gun to heat the PVC plate (Figure 7). The temperature of the hot air that blows out is much higher than that of a hair dryer. After about 15 seconds the PVC plate is softened. Under the circumstances, the PVC plate still maintains a generally flat surface, and it must be pressurized to fit to the mould.

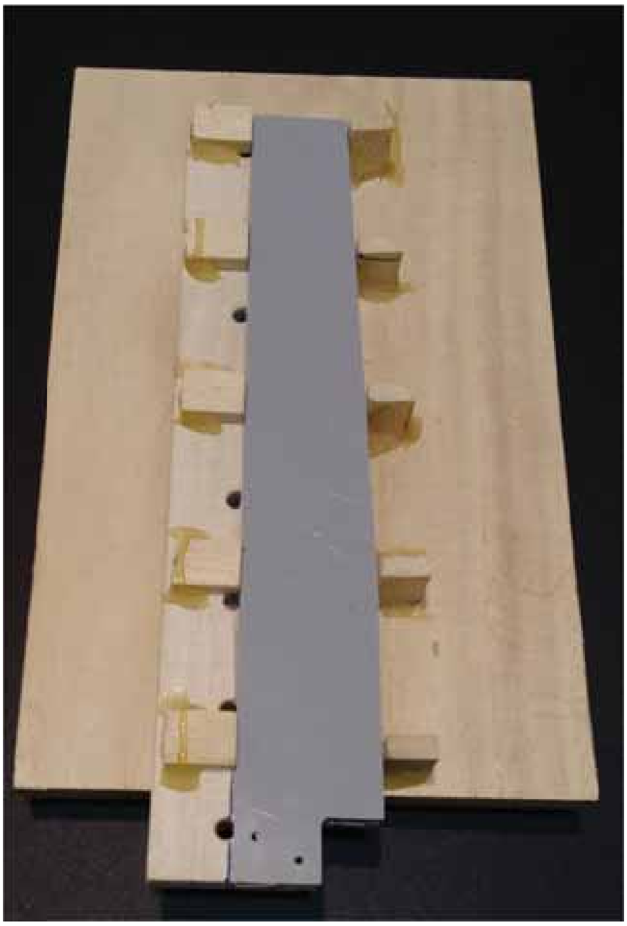

Figure 6. The PVC plate is fixed on the mold

Then use a hot air gun to heat the PVC plate (Figure 7). The temperature of the hot air that blows out is much higher than that of a hair dryer. After about 15 seconds the PVC plate is softened. Under the circumstances, the PVC plate still maintains a generally flat surface, and it must be pressurized to fit to the mould.

Figure 7. Heat the PVC plate on the mold with a hot air gun. The tool that looks like a hair dryer is a hot air gun

However, the soft PVC plate still tends to return to the shape of the flat board. Therefore, the pressure, exerted by gloved fingers, must be continuously applied. The PVC plate gradually cools and does not return to shape of the flat panel. If some parts of the PVC plate do not fit to the mould perfectly and do not form the desired shape of the design, the PVC plate can be reheated to soften and repeat the process. The author first squeezed the PVC plate with a toothbrush or a gloved finger to make it close to the mould below (Figure 8) to form the final shape of the wind turbine blade. During the continuous extrusion process, the PVC plate cools down gradually and is hardened (Figure 9). Finally remove the screws and cool the PVC turbine further with cold water to completely harden the shape.

Figure 8. The soften PVC turbine plate is squeezed

Finally, four screws were used to combine two blades with the middle hub of the wind turbine (Figure 10) to create a wind turbine that possesses features of modern wind turbine. And making and operating it, participants can learn rich knowledge of modern wind turbine.

Due to the simplicity of the process, that will not produce dust and sawdust, it took about 10 minutes to complete one (Figure 11). However, it takes less than 10 minutes to make the turbine blades. Therefore, only 10 sets of moulds are required for 40 people science education activities. For combining a micro-generator with the wind turbine, the activity time is slightly increased to three hours and it is already abundant. From the point of view of preparation, as long as NT$1,000, 12 wind turbine components can be produced. And if the components are mass produced, the cost per item should be further reduced. Gloves, screwdrivers, moulds and hot air guns can be reused.

Figure 9. The shape of the modern wind turbine basically is formed after the PVC plate gradually cools and hardens

Figure 10. Combine two blades with the middle hub of the wind turbine

Figure 11. It takes much shorter time to make the wind turbines

4. Performance of wind turbines made with the hand on mould

The completed wind turbine, shown in Figure 12, can rotate quickly in the wind, of which the speed is approximately 3-4 meters per second, blown by a typical family fan. In outdoor breeze it also has a good performance. The experimental result shows that modern wind turbines are better than general windmills that are made of flat wooden plate or cut bottles. Of course, such wind turbines, driven by lifting force, suffer from relatively slow start-up characteristics. Because the tiny wind turbines, that meet the modern wind turbines, are amazingly speedy (Figure 12), they can often arouse people's curiosity and then inspire them to explore the scientific principles. Perhaps this is the essence of inquiry and practical course!

Figure 12. The rotational speed can be nearly 600 rpm under the blow of a larger fan

5. Conclusion

The work in the paper is just a good beginning for wind turbine science education. The author still can further improve the making process, in which a quasi mould technique has been utilized in a simplified manner. The corresponding mold above the mould is produced. When hardening and setting the PVD plate, it is not necessary to continuously extrude the softened PVC plate. Directly cover the upper mold, and then the wind turbine can be done. It is a feasible way to press the softened PVC plate with other deformable weights. One blade can be composed of multiple layers of PVC plates, that is, one layer plus other layers to strengthen the strength of the blade and slightly improve the airfoil of the turbine blade. The wind turbine is different from the propeller of the aircraft. Scientific education is about seeking truth and seeking truth. Therefore, it is not reasonable to replace the wind turbine with the propeller of a toy aircraft.

The science education for wind power technique is intrinsically very exciting. The content includes: the relationship between lift and drag to angle of attack, which is an important knowledge of aviation engineering [5], the principle of sailboat driving (this part has its ancient history of development and the amazing of modern high-speed hydrofoil sailing); as well as the relative speed, the principle of work, etc.. All the content, which has a certain depth and breadth, yet is also closely related to life, is an excellent part of the inquiry and practice course. However, as many teaching aids have remained relatively simple, the enthusiasm of participants has gradually declined in the past several years. The successful development of this teaching aid will help bring back the wind turbine related fluid mechanics back to domestic science education activities.

6. Acknowledgements

Thanks to the Ministry of Science and Technology for the implementation of the project (ID: MOST 106-2511-S-238-001-MY2).

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Bertalanffy Project at COS Heidelberg: Bringing Cutting-Edge Science Close to Pupils

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Abstract. The „Bertalanffy at COS“ project started in 2012 with the “Bertalanffy Lecture”. The Centre for Organismal Studies (COS) in Heidelberg is hosting twice a year a lecture given by a wide-known researcher. This event would not be special except for the fact that the audience is not only other researchers but also students and teachers from high school. The Bertalanffy Lecture Series was installed with the aim to provide a better understanding of integrative approaches in systems oriented biology both to pupils from the Heidelberg region and to scientists on campus.

After more and more pupils asked about working in the lab, the initiative went one step further in 2014: eleven high school students interested in developmental biology were selected for the Bertalanffy practical course at COS during summer holidays. For two weeks, the students had the opportunity to step on research laboratories and discover the functioning and the everyday techniques. During this time, they also had the chance to talk to scientists doing research in these labs and learn some skills in science communication.

In 2016 COS expanded its contacts with schools in the Heidelberg region. Not only the pupils come to COS anymore. Things were turned around and some scientists (PhD students) went to high schools to explain their research. The program was named “Science Goes School”. The scientists gave a lecture in front of a biology class. The students attending this class were mainly in their last year of school. The lecture not only focused on the biological questions addressed in their research and the techniques applied in the lab but the scientists also talked about their scientific careers including what did they study and why. After the talk, there was some time for questions and discussion with the students.

In conclusion the “Bertalanffy at COS“ project is a great way to bring cutting-edge sience to those who will shape the future – the pupils. Therefore, the Bertalanffy project will continue running in the coming years and we are open to new ideas as well as new international partners willing to join this successful and ambitious initiative.

Keywords. High school, university, public outreach, science communication.

1. Introduction

Science communication is increasingly recognised as a duty of scientists. It is very important that the general public understands basic scientific principles. This understanding can help the society to make informed decisions, which can influence not only science policy and funding but also the quality of life. However, scientists are not trained in science communication [1]. For this reason, the participation of scientists in science communication events will help them to develop these skills and the society will also benefit from this. Those events can be addressed to different audiences. In this article, we will focus on an initiative to bring science to secondary school pupils.

The Centre for Organismal Studies (COS) in Heidelberg organizes the Bertalanffy activities for high school students since 2012. This initiative consists of two lectures, one summer practical per year and Phd scientist who give a biology class in secondary schools [2-4]. The Klaus Tschira Stiftung, a foundation that organizes scientific activities for children and young people as well as science communication activities, supports the Bertalanffy activities at COS [5].

2. Bertalanffy Lecture

COS invites twice a year a wide-known researcher who gives a lecture for the general public. Mainly high school students and teachers attend it. The lecture is not only focused on the research of the presenting scientist but also on his or her career. With this, the students can learn from his or her experience. The talk might also trigger their interest in science and inspire them to follow a scientific career. After the talk, the students are divided into working groups of 10-15 students together with a tutor (normally a PhD student or

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postdoc from COS). In these groups, they discuss about the talk and solve the questions that the students ask. Finally, all students get together again with the speaker. A short final discussion takes place to wrap up what the students learnt and discussed. With these lectures, the students and teachers leave the classrooms and lessons for one day and get in contact with the ongoing cutting-edge science [2].

Table 1a. Speakers of the Bertalanffy Lectures

Speaker	University/ Research Centre	Title of lecture for student	Title of lecture for scientist
Alfonso Martínez Arias	Department of Genetics, University of Cambridge, UK	Genetic alchemy and the making of animal embryos	Cell fate choice and decisions: an embryonic stem cell perspective
Enrico Coen	Cell and developmental biology, John Innes Centre, UK	Leaves, loops and Leonardo: the generation of biological forms	Hidden signposts of developments: tissue polarity and its role in morphogenesis
Russel Foster	Chair of Circadian Neuroscience, Brasenose College, University of Oxford, UK	Do you take sleep and your body clock seriously?	Light and time – a new look at the eye
Hannah Monyer	Klinische Neurobiologie, Universitäts-klinikum/ Deutsches Krebsforschungsz entrum, Heidelberg	Brain plasticity, learning and memory	Can studies in mice help us understand how memory functions in humans?
Benjamin Prud'homme	Institut de Biolgie du Développement de Marseille-Luminy	How did the fly get its spot?	The regulatory mechanism of morphological pattern evolution
Andreas Trumpp	Stammzellen und Krebs, Deutsches Krebsforschungsz entrum, Heidelberg	Cancer stem cells – the root of all evil in cancer and metastasis?	Cancer and metastasis stem Cells in hematopoietic and solid tumors
Martin Wikelski	Max-Planck Institute for Ornithology, Dept. of Migration and Immuno-Ecology, 'Vogelwarte Radolfzell'	Animals as our eyes and ears in the world	Intelligent environmental sensing via the study of global movement patterns of animals

The speakers are always, apart from outstanding scientists, great lecturers able to break down complex concepts into an understandable way to reach their young and challenging audience. The invited speakers as well as their university or research centre of origin and the topic of their lectures are listed in Table 1. The main topics of the talks are development, neurobiology and cancer. The fact that the scientists that came use different model organisms also gives a broader image of the scientific fields.

Table 1b. Speakers of the Bertalanffy Lectures

Speaker	University/ Research Centre	Title of lecture for student	Title of lecture for scientist
Alejandro Sánchez Alvarado	Howard Hughes Medical Institute & Stowers Institute for Medical Research	Hypothesis- and curiosity-driven inquiry: the importance of discovery research	The developmental plasticity of planarians and what they teach us about living, dynamic systems
Ottoline Leyser	Sainsbury Laboratory, University of Cambridge	Thinking without a brain - how plants decide what to do	Auxin and the self-organisation of plant form
Marcos Gonzalez-Gaitan	Department of Biochemistry, University of Geneva	How do stem cells divide? The physics of asymmetric division	Asymmetric endosomes in asymmetric division
Henrik Kaessmann	Zentrum für Molekulare Biologie, Universität Heidelberg	Dawn Of The Mammals - Revealing Molecular Secrets...	The molecular foundations of mammalian phenotypic evolution
Miguel L. Allende	Center for Genome Regulation, Universidad de Chile	Looking for fish in the wrong places: from salt pans to dried up ponds	Exploring the genomes of South American cypridontiform fish displaying unique life histories
Kristin Tessmar-Raible	MFPL/Centre for Molecular Biology/ Platform Rhythms of Life, University of Vienna	Right timing is crucial in life: investigating rhythms and clocks in biology	Light and time: how aquatic animals can inform human biology

In addition to the talk for students, the invited speaker also gives a lecture for the scientific community in Heidelberg the day after. The titles of these talks are also in Table 1.

Figure 1. Bertalanffy Lecture posters for the last Bertalanffy Lecture in April 2018 [2-3]

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In order to advertise the lectures and reach as many students, teachers and scientist as possible, posters are designed for every lecture (Figure 1). Those posters are distributed to schools in the region. Moreover, letters and emails advertising the events are also sent to the schools.

3. Bertalanffy Practical at COS

The second part of the initiative is a summer practical for high school students in laboratories from COS. With this course, they have the chance to learn some of the techniques that are used every day in research laboratories and, what is even more important, to discover the functioning in a developmental biology laboratory [3].

This practical course took place for the first time in August 2014. The course is advertised with a poster, which is sent to the schools (Figure 2). It is also announced in the Bertalanffy lecture previous to the course.

Figure 2. Bertalanffy Practical poster for summer 2018

To apply for the course, the students need to write a brief description of their interests in science and especially in biology. They also have to state what they want to study. Moreover, they have to explain why are they interested in the practical and what are their motivations to take part in it. In addition, they have to present a recommendation letter from their teacher [3]. All the applications are revised in COS, the best applicants are interviewed and the final participants are selected according to their motivation and interest.

But not only German students are able to be part of the Bertalanffy Practical. Since 2015 students from the Spanish Youth & Science Program of Catalunya La Pedrera Foundation can attend the practical. As well as exchange students from Heidelberg's partner cities (as part of the International Summer Science School Programm [6]).

Eleven applicants were selected for the first Bertalanffy practical. The number of participants in the following years were between 14 and 12 but the number of applications increased from 12 in the first year to over 30 in 2017.

3.1. Practical content

As a preparation for the practical, the students have to read some scientific articles, which will give them some background and basic knowledge for the course. This is completed by some introductory talks the first two days. Principal Investigators (PIs) and researchers working at COS give these lectures. They present the model organisms used in research at COS (fish, fly, hydra, plants and yeast). In these first days, the students also visit the different laboratories in COS and get a first contact with the ongoing research.

After this introduction, the students are divided into small working groups (2 pupils per group). Each student takes part into two projects of 3 days each. There are projects with each model organism COS is working with for example *Arabidopsis thaliana,* medaka (*Oryzias latipes*), hydra, fly and yeast.

At the end of the course, the students have to prepare a short talk presenting the results obtained. In order to learn how to prepare a presentation, they have a one day workshop with a science communication expert. For the presentation all COS scientists, teachers and parents are invited.

4. Science Goes School

In 2016 a new initiative was added to the Bertalanffy activities: scientists (PhD students) went to schools. The new program was named "Science Goes School" and it is coordinated by Michaela Bollen and Jochen Wittbrodt [4]. Michaela is a secondary school teacher, who attends with her pupils since 2012 the Bertalanffy lectures and works together with COS as a link between the schools.

Previous to the lecture, with the help of a high school teacher (M. Bollen) and other presenters, the PhD students adapted their talks to the knowledge of a high school student. Concepts which are unknown by the students must be identified by the speaker and introduced clearly and well explained in the talk. With this preparatory seminar the scientist learn to simplify and break down complex concepts. This experience also helps the scientists to improve their communication skills.

Eight PhD students and four different schools participated in this innovative activity in the first round. In all the schools, the speakers had two teaching hours, which is equivalent to 90 minutes. In these 90 minutes, the PhD students introduced themselves describing their scientific career, explained their research project and did the practical activity with the samples they brought.

After all the presentations have taken place, there is always a final meeting with the organizers and the speakers to evaluate the "Science Goes School" round.

"Science Goes School" was a success from the first edition. Not only pupils but also scientists benefit from it: pupils learn about science and research and, at the same time, scientists improve their communication skills, which are also very valuable for their career. "Science Goes School" is constantly growing with more and more schools and COS PhD Students joining the programm.

5. Conclusion

Initiatives to introduce scientific research to secondary school pupils are key to bring science to the society. Moreover, it also helps students with a strong interest in science to taste scientific research and decide whether they would like to work as scientific researcher in their future career.

These kinds of programs also benefit the scientific community: the "Bertalanffy Practical" and "Science Goes School" help scientists to improve their communication skills. Additionally, those activities are a great strategy to recruit young promising pupils keen on science, which will potentially be outstanding scientists in the future.

Furthermore, science is an international network of knowledge and introducing international exchanges into these practical courses for pupils is a great opportunity for the students to get to know the research world as it is. The experience not only at scientific level but also at personal level that pupils live with such exchanges might be key on their decision making about their future and their career.

With the support of the Klaus-Tschira-Stiftung, Bertalanffy at COS will continue running in the coming years and we are open to new ideas as well as new international partners willing to join this successful and ambitious initiative.

6. Acknowledgements

The authors would like to thank everyone who took part in any of the initiatives described here. All the pupils and teachers, who attended the Bertalanffy Lectures, everyone who attended the Bertalanffy Practical, all the tutors from COS who were volunteering at the lectures and with the practicals, all the PhD students who presented their work in "Science Goes School". We would also like to thank all the speakers of the Bertalanffy Lectures who came to Heidelberg for this event. Finally we would like to acknowledge the financial support from the Klaus Tschira Foundation.

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Lively and Exciting Hand-on Experiments: Electromagnetics

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Abstract. I discuss the roles of simple and essential hand-made experiments play in classes of Electromagnetics. I have shown the characteristics of simple and essential hand-made experiments in HSci2017. One was taking students out of the world of the textbook to the world they live, the other was helping students understand Physics concepts. In electromagnetism, physics quantities and lows are more abstract and phenomena are invisible in comparison with that used in Mechanics etc. We found that hand-made experiments using the materials around us are useful because they give students images of physics quantities and make them feel reality to the invisible electromagnetic phenomena easily. Furthermore, these experiments are easy to be used for students' hand-on experiments.

Keywords. Simple and essential experiments, hand-on experiments, electromagnetics.

1. Introduction

I presented some simple and essential hand-made experiments in Mechanics, and discussed their roles they play in enjoyable and fruitful Physics classes in HSci2017 at Braga in Portugal [1] following to the presentation in HSci2016 [2]. Students' recognition of the concepts is sometimes superficial if the classes are done without experiments or with only typical experiments. I showed that students' understanding of concepts becomes deeper and deeper by repeating processes between hypothesis and test using simple and essential experiments in HSci2017 [1].

Here, I introduce some simple and essential hand-made experiments in Electromagnetics we invented and discuss their roles in the classes. Because electromagnetic phenomena are usually invisible, experiments that visualize the phenomena or make students feel them visible are needed for students' understanding. I also show some examples how we used for hand-on experiments.

2. Experiments concerning to "Electromagnetic induction"

The first example is experiments of electromagnetic induction including mutual induction, self-induction and LC resonance. In addition to the popular experiments using commercial made equipment hand-made experiments are expected to be done to impress the universality of the laws. One of the suitable examples for Faraday's law is Umbrella Coil (Figure 1) which I have shown in HSci2016 [2]. This is the equipment using big coil fixed at the end of the ribs of the umbrella. By using the equipment, we can get induced current in the coil by opening or closing it in the geomagnetic field. Furthermore, we can do the experiment of mutual induction dynamically using the umbrella coil and another big coil that is made by winding code about 10 times. When we connect the big coil to the speaker terminal of the amplifier or the radio, alternative magnetic field is created by the audio current that flows in the coil.

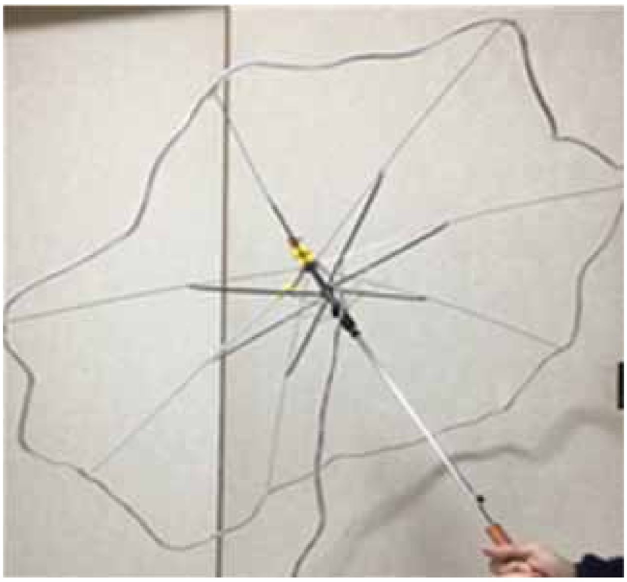


Figure 1. Area of the coil is changeable by opening or closing the umbrella

If we put umbrella coil connected to the amplifier just above the big coil, we can hear the sound from the amplifier because of the induced current in the umbrella coil. The amount of the sound depends on a location or a tilt of the coil. This experiment can be used as a hands-on experiment. Give students wires, earphones, nails etc. instead of umbrella coil, and give them such an assignment as "Pick up a signal from the magnetic field using given materials". We can see students research actively. [3] For a hand-made experiment of self-induction, experiment of "Light communication" [4] is recommended. I show the diagram of the experiment in Figure 2.

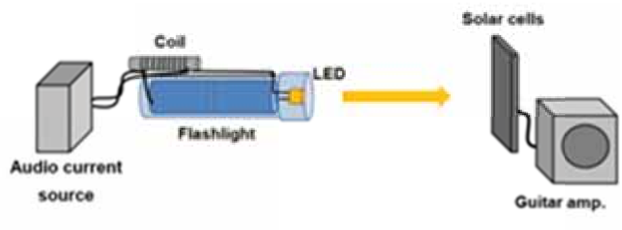


Figure 2. Diagram of the light communication apparatus. Light emitted from LED is modulated by th electromotive force induced in the coil

A coil is inserted in the circuit of torch light and audio signal is applied to the both end of it. Self-induction voltage occurred in the coil modulates the current in the circuit, that leads to the modulation of light. Though "Light communication" told here is very primitive one in comparison with cutting edge "Light communication", the experiment is significant because it explains the principle of the modulation well.

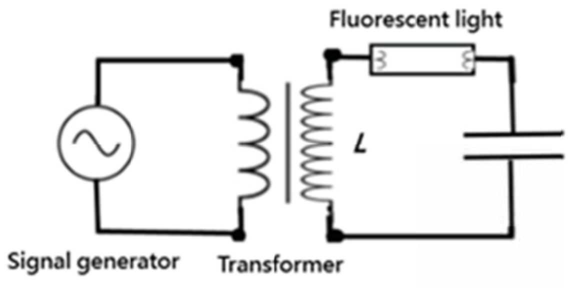


Figure 3. Diagram of the LC resonance apparatus. Light from the fluorescent light and sound from the capacitor appeal the resonance point to students

Figure 3 is a diagram of the experiment of LC resonance. We use simple capacitor using two aluminum sheets and a plastic sheet. By rising the voltage using transformer, we can show the resonating point visually with the light from the fluorescence light and the sound from the simple capacitor [5].

3. Experiments concerning to "Static Electricity"

The second example is experiments of static electricity. We usually use leaf electroscope for the experiments of the static electricity. We propose to use simple hand-made electrometer invented by Eiji Tanaka, Stray Cats member, in addition to the experiment of classical electroscope. It detects the polarity of the charged body by the polarity of the charge induced at one of the plate of the capacitor in the electrometer. This equipment enables us to do almost all experiments we do using leaf electroscope with information of the polarity of the charge. Furthermore, we can show movement of the charge dynamically using electrometer and galvanometer with DC amplifier. I show a diagram of the experiment in Figure 4. The aluminum sheet A is connected to the electrometer via the galvanometer to measure the polarity of the charge induced on A. The ground of the electrometer is connected to the aluminum sheet B. If we bring the negatively charged body near the aluminum sheet A, the indicator of the galvanometer indicates the current flows from B to A. And at the same time, the indicator of the electrometer indicates A is positively charged. On contrarily, if we bring the negatively charged body near the aluminum sheet B, the galvanometer and the electrometer indicate the current flow from A to B and A is negatively charged, respectively. Students realize what takes place in the process of the electrostatic induction.

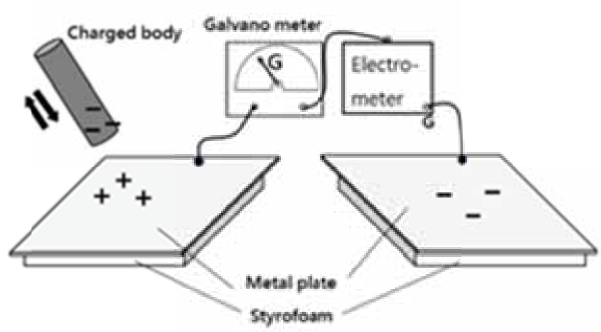
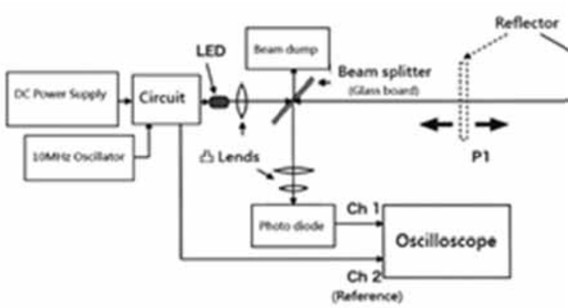


Figure 4. Diagram of the experiment of the electrostatic induction. The electrometer measures the polarity of the aluminum sheet A and the galvanometer measures the movement of the charge

4. Experiments concerning to "Measurement of Light speed"

The last example is equipment of measurement of light speed which Mr. Hirotaka Hayashi, Stray Cats member, invented recently. Fundamental principle of the measurement is almost the same as that of

Fizeau's experiment. Fizeau modulated light using teethed wheel and observed the delay of the phase of light because of the transmitting time. In this experiment, light is modulated by applying sine voltage of 10MHz to LED light and monitor a delay of the phase on the display of the oscilloscope. Recently, this experiment was adapted to the introductory experiment for freshman of faculty of science in Nagoya University.



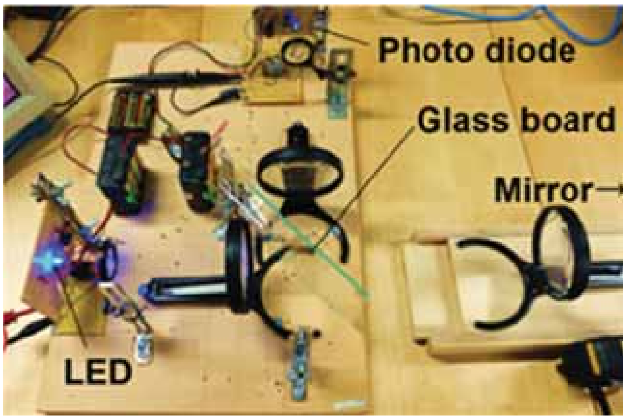


Figure 5. Block diagram of Mr. Hayashi's apparatus for measurement of light speed. Cat-eye reflector or cat-eye system using lends and mirror is used for the reflector (up) and picture of the apparatus. Optical system is fixed on the board except the reflector (down)

5. Conclusion

As I told through the examples in 4 to 6 above, simple and essential hand-made experiments not only fascinate students but also play important roles in classes of Electromagnetics because physics quantities and lows in Electromagnetics are abstract and invisible. They are sure to help students make image of physical quantities and help them understand the concepts and lows. However, it is regrettable that simple and essential hand-made experiments have not well penetrated in Physics classes even in Japan. Continuous effort for the popularization of them is expected to be made by researchers and teachers.

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Simple Physics Experiments Worth Thinking about

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Abstract. In our contribution we will show interesting and surprising physics experiments that are not demanding for equipment. Some of these experiments are often not properly and correctly explained. There are also many misconceptions connected with presented phenomena.

We will focus on experiments dealing with surface tension, thermal expansion and heat conduction. We will also deal with Newton's laws, especially with problems of internal and external forces. Experiments demonstrating weightlessness will be shown too and misconceptions connected with this phenomenon will be discussed. We will also present a simple, unconventional vacuum pump for school experimentation and experiments with it.

Keywords. Simple physics experiments, correct explanation, misconceptions.

1. Introduction

In the paper we will focus only on a few selected experiments. We specify what tools are needed to implement them, how to proceed with the demonstration and what`s the physical explanation. We draw attention to various technical details and focus on the misconceptions associated with the demonstrated phenomena. This paper is a free continuation of our previous HSCI contributions [1-2].

2. Experiments with aluminium coins

2.1. Strange electrostatic behaviour of aluminium coin

Tools: Aluminium coin or small flat aluminium circle (diameter of 20 mm and thickness of 2 mm approximately), plastic straw, paper tissue, glass bowl, small piece of modelling clay, thin thread.

Procedure: The experiment will be performed in two steps. First, we glue the Al coin to a thin thread with the length of approximately 30 cm. Small piece of modelling clay can be used for this purpose. Then we charge a plastic straw (wipe it with a paper tissue). The coin is hanging on the thread, which we hold in one hand and the charged straw is slowly approaching to the coin. The attractive force between these two objects can be observed – the coin swings to the straw (Figure 1). There will be probably no surprise – this is a subsequence of well-known phenomenon called electrostatic induction.

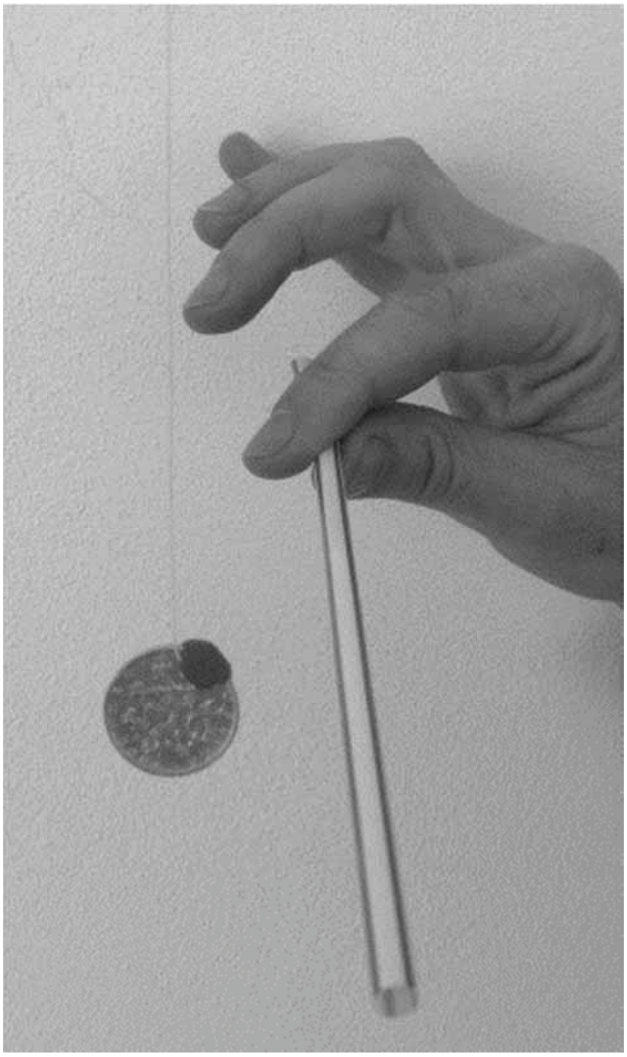

Figure 1. The coin on the thread - attraction

In the second part of this experiment we put the coin on the water level in glass bowl carefully. The coin lies on the water surface, which is also not very surprising. But… We charge the plastic straw again and slowly approach it to the coin by one hand (Figure 2). The coin moves away from the straw, surprisingly. It seems there is some repulsive force, but what is the reason for it? The electrostatic induction must cause attraction, as everybody knows!

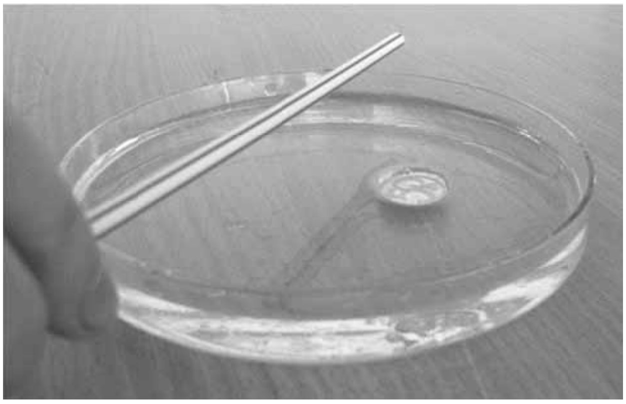

Figure 2. The coin on the water surface - repulsion

Explanation: The first part of the experiment (coin on the thread) is possible to explain by electrostatic induction. The negative charge of plastic straw causes regrouping of the electric charge in the coin - this is the electrostatic induction. Free electrons move to the part of the coin which is more distant from the straw and as a result of this charge rearrangement there is an attractive force between the straw and the coin.

The same charge rearrangement occurs if the coin lies on the water surface. But there is an additional effect of great importance. The permanent electric dipole moment of H_2O molecules causes the raising of the water surface in the vicinity of the charged plastic straw. So, there are two effects – electric induction, that cause the attraction between coin and straw and arise of the water surface under the straw. Simply said, the gravitational force wins over the electric force and the coin descends downward from the raised water level.

Pedagogical and technical notes: Aluminium coins are not very widespread. Such coins were a common part of the Czech currency, but recently these coins were canceled. (Of course - Czech physics teachers have a great reserve of these coins.) Aluminium coins are still in use for instance in Japan.

2.2. Why does a coin lie on the water surface?

Tools: Aluminium coin or small flat aluminium circle (the same as in the previous experiment), sensitive scale (digital one, optimally), plastic ruler, glass bowl with water.

Procedure: Pour water into the glass bowl. Measure mass, diameter and thickness of aluminium coin and then put the coin carefully on the water surface in the bowl. The coin lies on the water surface. This experiment is usually explained by the surface force. But, is the surface force sufficiently large? Is it the only force that holds the coin on the water level? If we know the mass of the coin, we can calculate its weight (the force by which the coin is pulled down). We can easily determine this force as $F_g = mg$, where m is the mass of the coin and g the gravitational acceleration near the Earth surface (9.81 ms^{-2} approximately). We can also calculate the surface force as $F_s = l\sigma$, where l is the circumference of the coin and σ is the surface tension (water-air). After calculations we can see, that the surface force is lower than the weight of the coin. For the former Czech coin "50 hal" the surface force represents approximately one half of the coin weight. So, how is it possible that the coin stays on the water surface?

Explanation: Observe carefully the coin that is floating on the water level. It can be seen that the water surface is bent under the coin. The lower surface of the coin is several millimeters under the water level. It means, that the bottom of the coin is in the depth where the hydrostatic pressure has a value of $p_h = h\rho g$, where ρ represents the density of water and h the depth. Because of the bottom of the coin has the area of $A = \pi r^2$ (r is the radius of the coin), the hydrostatic force $F_h = Ap_h$ pushes the coin up. So, we can see at the end, that there are tree forces acting on the coin: weight (acts down), surface force (acts up) and hydrostatic force (acts up). There is balance of these three forces and that is, why the coin floats.

This explanation can be verified by measurement of the depth h (using ruler) and calculating the hydrostatic force F_h. Then we can easily verify whether $F_h = F_g - F_s$.

2.3. Jumping coin

2.3.1. "Magnetic jump"

Tools: Aluminium coin or flat Al circle (the same as in the previous experiment), strong magnet (so called neodymium magnet).

Figure 3. Neodymium magnet and various aluminium coins

Procedure: First try whether the neodymium magnet attracts aluminium coin (of course – it doesn't). Put the coin on the table and hold the magnet just above it. Rapidly yank the magnet upward. The coin will jump upward too (Figure 4).

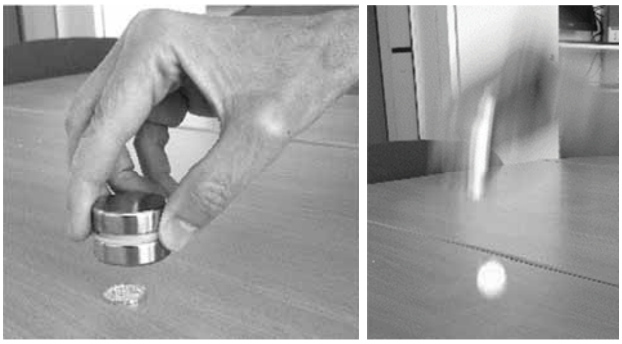

Figure 4. Jumping coin

Explanation: There is very strong magnetic field at the vicinity of the neodymium magnet. Once you move the magnet up, the coin is in a decreasing magnetic field which induces eddy currents in it. Magnetic field created by the eddy currents in this situation has such orientation, that the coin jumps up.

2.3.2. "Air flow induced jump"

Procedure: Put the aluminium coin on the table or hold it on the palm. Blow shortly above the coin. Although you blow parallel to the coin surface, it jumps upward.

Explanation: It is well known, that in flowing air the pressure decreases (so called "Bernoulli principle"). As soon as you blow above the coin, the air flowing above the coin causes the decrease of air pressure above it. The coin also tilts a little bit in the air stream. Together, these two effects cause the jump of the coin.

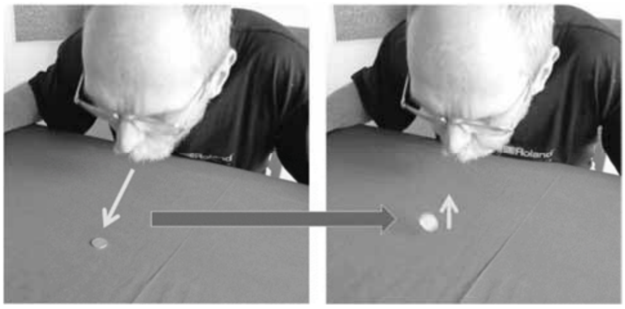

Figure 5. Air flow induced jump

3. Special pendulum

Tools: Pendulum – it is formed by a rigid rod ending with a flexible U-shaped bend strip, the ends of the strip are adapted to be bound to each other with a piece of thread (see Figure 6); weight; stand; thread; matches.

Figure 6. Details of the pendulum

Procedures: Fix the stand firmly to the table, so it can`t move and hang on it the pendulum. We will do the experiment in three steps. In the first step we bind the ends of the arms of pendulum together with a piece of thread. Then we ask whether the pendulum will swing after overburning the thread. We can vote on the result.

In the second step we firmly attach the weight to the arm of the pendulum. We again bind the ends of pendulum to each other and repeat the procedure.

In the third step we only put the weight on the arm of the pendulum, don`t fasten it and do the same as in previous steps.

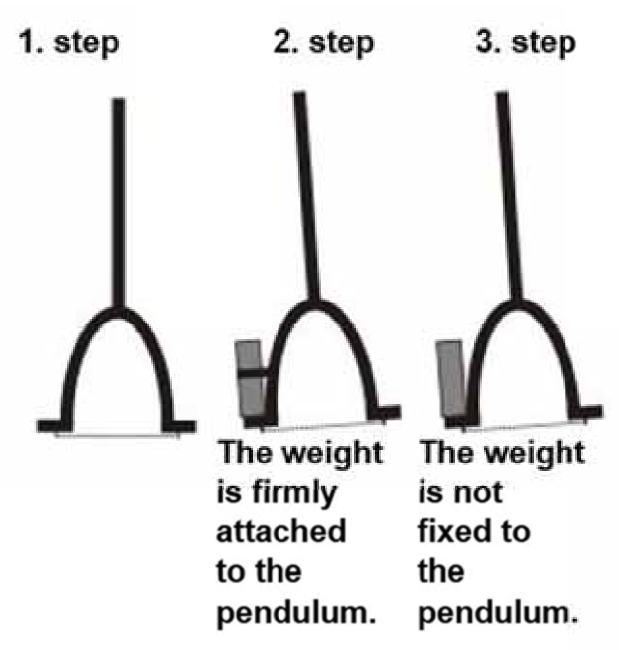

Figure 7. The scheme of the experiment

Explanation: In the first step the pendulum will not swing. There is no external force that would act on the pendulum and set it in motion. The ends of the pendulum bound to one another with a thread act on each other, but it is an internal force, which is not able to set the pendulum in motion. It`s like if we grab our ears and want to lift up ourselves.

In the second step the pendulum will also not swing. The weight is firmly attached to the pendulum and form one body. So it`s the same situation as in the first step.

A different situation is in the third step. After overburning the thread, the arm of the pendulum pushes the weight which falls down and at the same time the weight pushes the pendulum, which begins to swing.

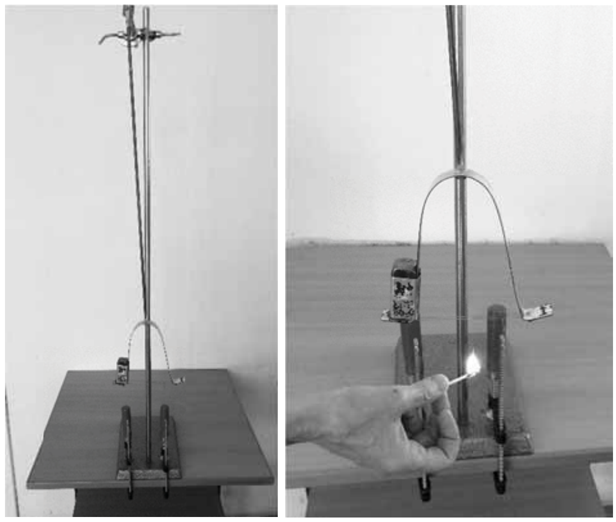

Figure 8. Experimental details

Pedagogical and technical notes: It`s better to overburn the thread instead of cutting it, because it prevents you pushing the pendulum.

In the third step it is good to note beforehand that swinging means a really significant movement rather than shifting the pendulum to the equilibrium position after the weight falls.

If you let the students vote on the result in each step, it is good to point out finally that nature behaves according its own laws and not by our vote.

4. Magic can

Tools: Cylindrical can, rubber fiber, metal nut.

Preparation: Drill two holes into the bottom and two into the lid of the can. Thread the rubber fiber through drilled holes and attach metal nut to it (using strong string etc. – see photograph). Disguise the outer parts of the top and bottom, so that the rubber cannot be seen.

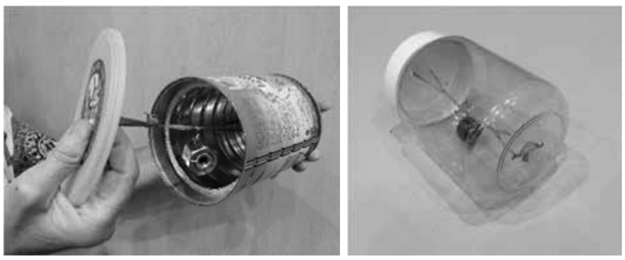

Figure 9. Magic can - details

Procedure: Spin the can in your hands before the demonstration (rubber fiber should be tangled a little bit). Send the can across the table in such manner to make it spin in the same direction as you previously spin it in hands. The tin will stop and start to roll backward. You can label the starting point of the can movement – the can will stop, than it will start to roll back and surprisingly it will overcome the starting label. It seems to be a perpetuum mobile… But this is not the only problem. The can evidently violate Newton's laws. It accelerates itself. No external force is applied on it.

Explanation: The first problem (if we have perpetuum mobile or not) will be briefly clarified. There is some stored energy in the tangled rubber fibre. The second problem (whether the Newton's laws are still valid) seems to be more complicated. Evidently there are only inner forces and torques. But this is not true. Imagine a situation of a very slippery table surface. The can is not able to move in this case – it only rotates. But in fact the table surface is not so slippery – some friction occurs between the can and the table. We can say that the can pushes to the table with a certain force and as a reaction the table pushes to the can in the opposite direction. So there is external force acting on the can and this force causes its acceleration.

5. Weightless state

5.1. Jump with a tennis ball, "astronaut" in the bottle

Tools: Higher table, tennis ball, plastic bottle, pencil.

Procedure: Stand up on the table and hold the tennis ball in front of your nose. Jump down and at the same time release the ball. During the fall, the ball stays in front of your nose.

Repeat it once more and before the jump say the students to imagine, that you are closed in a big box standing on the roof of very high building. You are playing with the tennis ball and in the moment when you have the ball in front of your nose someone drop the box down. Jump down and ask: What have you seen during the fall? – A tennis ball floating in the air before you.

Ask then, if the students have ever seen something like that. Usually someone says that it is like in a spaceship in weightless state.

You can model the astronaut floating in spaceship using a transparent plastic bottle with a pencil inside. When tossing the bottle from hand to hand, the pencil is floating inside.

Explanation: During the fall you and the ball or the bottle and the pencil fall down the same way with the same acceleration. The air resistance isn`t necessary to be taken into account because of the short distance of the fall.

Pedagogical and technical notes: There are a lot of misconceptions connected with the weightless state. If you ask students what is the reason of weightless state in spaceships, they usually answer wrongly, that there isn`t gravitational force acting on the spaceship, because it is very far from the Earth. It`s good to draw a picture of the Earth and the spaceship. The spaceships with astronauts fly at about 400 km above the ground. So if you take a scale where 1 cm corresponds to 100 km, the Earth will have diameter approximately 1,3 m and the spaceship is only 4 cm above it. The reason of weightless state in the spaceship is that the spaceship and astronauts are constantly falling.

5.2. Weightless cage

Tools: Metal cage with a weight on a spring (Figure 10).

Procedure: Hold the weight so that the spring is not extended. Then throw up the cage in the air or you can throw it to your colleague. During the flight the spring remains not extended. After that, you can throw the cage with extended spring, it will contract and remain so during the flight.

Explanation: If you let fall or throw up the cage, it`s in weightless state. The cage, the weight, the spring fall together. The weight stops to pull the spring and the spring contracts.

Pedagogical and technical notes: Students often confuse the weightless state for a state without gravitational force. In the weightless state the gravitational force still acts, but the weight disappears – objects stop to push on the pad and pull the springs. You can recommend students to take a heavy book, lay it on the palm of stretched hand, climb on a chair and jump down. During the fall, they are in weightless state and the book stops pushing on their hand.

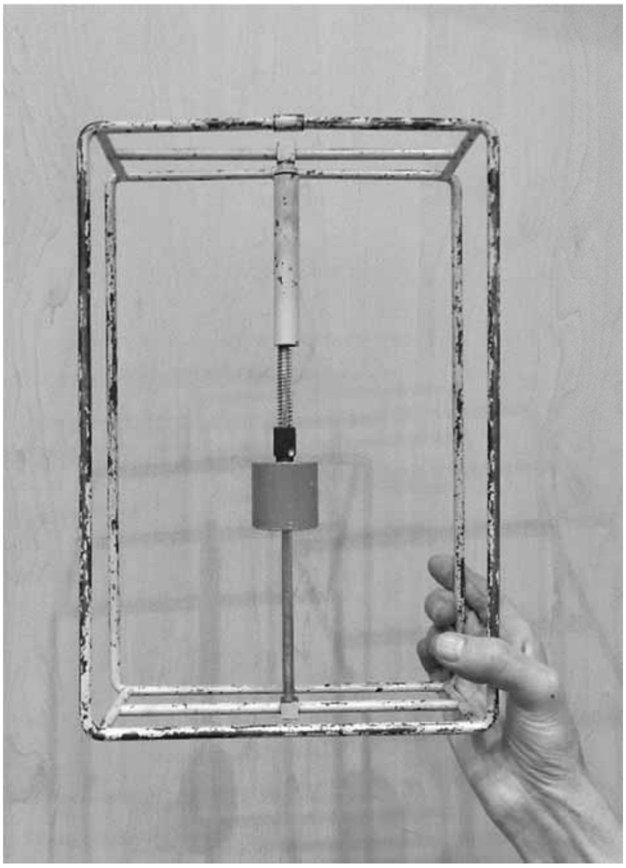

Figure 10. Weightless cage

5.3. Friction in the weightless state

Tools: Wooden board with glued sandpaper, two wooden blocks with hooks, spring or rubber.

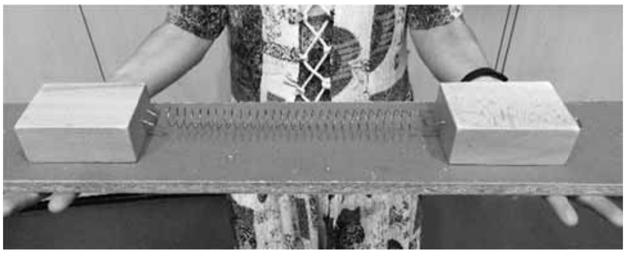

Figure 11. The blocks on the board with sandpaper connected with the spring

Procedure: First, put the blocks on a smooth table, connect them with the spring and push them a little apart. After you release them, they will come together because of friction between the blocks and the pad is small. Then put the blocks on the board with sandpaper and get them again a little apart (Figure 11). This time they will stay after you release them, because the friction is bigger and equalizes the tension of the spring.

Take the board into your hands and ask what happens with the blocks, if you release the board and let it fall. In this situation, the board with blocks will be in weightless state. Then release the board.

Explanation: After releasing the board, the blocks stop to push into the board and the frictional force between the blocks and sandpaper disappears. The blocks will come together. The frictional force is directly proportionate to the weight of the block.

5.4. Hydrostatic pressure in the weightless stat

Tools: Plastic bottle with holes, water.

Procedure: Take a pin and make several holes into a plastic bottle. Fill the bottle with water and only slightly close the cap. The water flows out of the bottle (Figure 12 left). Then throw up the bottle in the air or you can throw it to your colleague. During the flight the water stops to flow out of the bottle (Figure 12 rigth).

Figure 12. Water flows out (left) and water stops to flow out (right)

Explanation: The bottle is in weightless state when it falls. In this situation, the hydrostatic pressure disappears, because it is caused by the weight of the water. The water stops to push into the bottom and walls of the bottle.

Pedagogical and technical notes: It's better to do this experiment outdoors.

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5.5. Archimed's law in the weightless state

Tools: Plastic bottle with wider neck, plastic or cork plug, water.

Procedure: Fill the bottle with water and put a plastic or cork plug inside. It will float on the surface thanks the effect of buoyancy force. Turn the bottle upside down. The plug will rise to the surface. Then turn the bottle upside down again and at the same time either drop the bottle or throw it up. Observe the behaviour of the plug during the fall. It stops to rise and remains in place.

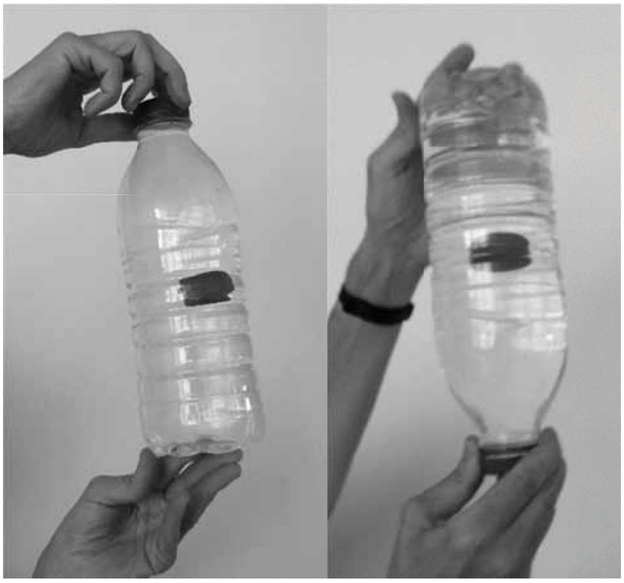

Figure 13. The bottle with plastic plug

Explanation: The bottle is in weightless state, when it falls. In this situation, the buyoancy force disappears. The bottle, water and plug fall together, so the water stops to push onto the surface of the plug and there is no hydrostatic pressure force.

6. Unconventional vacuum pump for school experimentation

The vacuum pump is used for keeping the food fresh and it is possible to buy it in the shop with household goods. It can be used for school experimentation, too. Ideas for experiments are captured in the photos (Figure 14).

7. Conclusion remarks

Physics could be studied using various tools. We can use sophisticated and complicated devices as well as simple ordinary things. In this contribution we tried to introduce several hands-on experiments which are connected with very interesting physics problems. We would like to recommend also other works deal with similar topics [3-6]. We hope that you will enjoy some of them in your physics lessons.

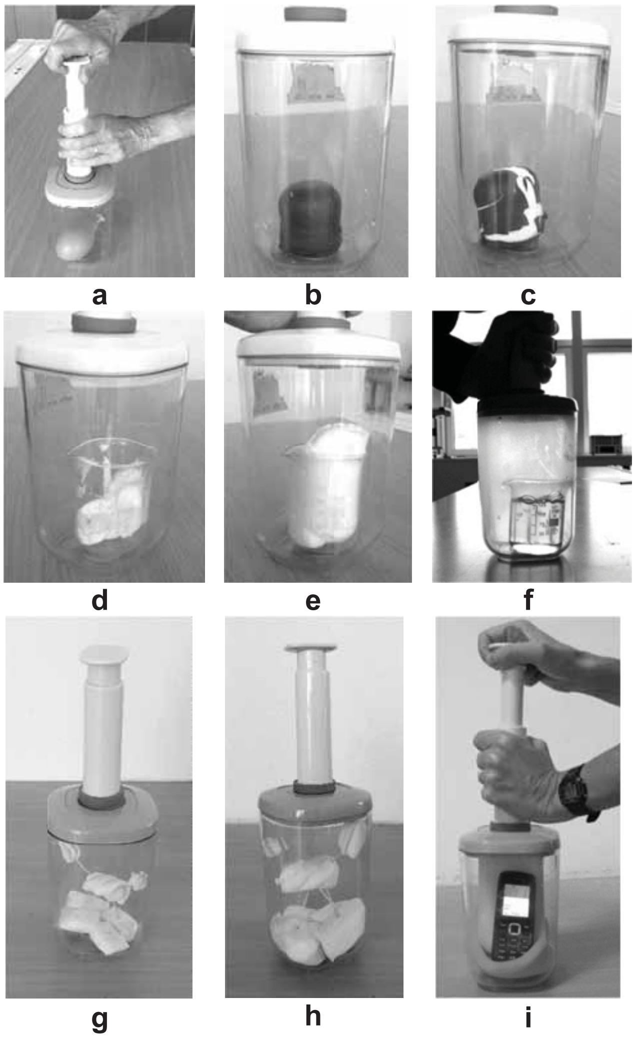

Figure 14. Experiments with low pressure: inflatable balloon (a); sweets (b, c); shaving foam (d, e); boiling water (f); marshmallows (g, h); sound propagation (i)

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Visual Presentations and Science. They Show More than You Can See

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Abstract. Visual presentations, pictures, schemes, diagrams, etc. play crucial roles in scientific processes and presentations. They help, for example, to communicate hypotheses or present research results to scientific peers as well as to the non scientific audience. Despite their important roles in scientific world some science teachers and scientists have more or less neglected visual representations in their classes or presentations.

We propose in this work to have a glance on different science fields throughout several pictures that we use as tools of reasoning in science at different educational levels.

Keywords. Drawings, pictures, science learning.

1. Introduction

Visual representations, photographs, tables, diagrams, charts, and drawings, can be a very powerful tool to enhance the impact of science.

They help, for example, to communicate hypotheses or present research results to scientific peers as well as to the non scientific audience. Notwithstanding their important roles in scientific world some science teachers and scientists have more or less neglected visual representations.

Scientists can examine a phenomenon and represent it visually using a picture or scheme.

You can observe in Figure 1 [1] results from a research paper; rat hepatocytes were analyzed by confocal microscope, it clearly appears the nucleus, the cytoplasm and the cytoplasmic membrane.

Here we will not study representations of scientific investigations. Primary and secondary science education can bring a new focus on how visualization contribute to knowledge formation in science from the young students' perspective.

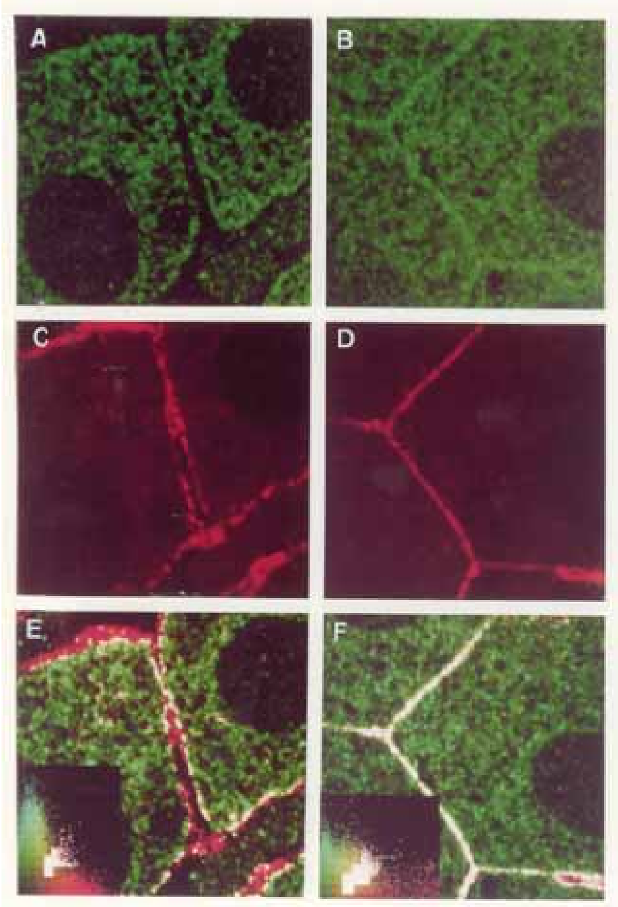

Figure 1 shows molecular biology results

We first present a study about two astronomy points: a Maasai father passing his knowledge about sky to his son and solar eclipses. The second case study focuses on science women contributions. The third case is a study about northern lights. Finally we study pictures obtained into a Science Museum and focusing on the experimental practices.

Students have to open their mind and find at least three several scientific fields that are related with each picture/image. Words and images presented can appeal directly to students' imagination.

2. Some images to taste it

2.1. Astronomy pictures

2.1.1. Maasai People

The Maasai people are semi-nomadic, using the stars to navigate across the East African plains. The moment when a father passes his knowledge of the stars down to his son was observed in a Figure 2 [2]. In addition, how to use the Milky Way and their hut as compositional elements.

Figure 2 shows a Maasai father passing his knowledge about sky to his son

As far as human history has been recorded, people have been observing the skies. What this picture reminds you is that you do not need a powerful telescope or electronic gadgets to enjoy stargazing. It tenderly expresses "the knowledge passed on from generation to generation".

Science teachers can use this picture to talk about:

- Astronomy.
- Mathematics
- Origin of life
- Social sciences

2.1.2. Solar eclipses

Solar eclipses occur when the moon comes between the sun and the Earth and spreads the darkest part of its shadow, the umbra, on Earth as you can see in Figure 3.

In August 2017, there will be a total solar eclipse, which is only visible from a small area on Earth. There are about 240 solar eclipses in a century, in Figure 4 you can see a partial solar eclipse.

The moon's shadow projected on the Earth is quite small. This means that solar eclipses are visible from only a small area on Earth. The people who see the total eclipse are in the centre of the moon's shadow when it hits Earth. The sky becomes very dark, as if it were night.

For a total eclipse to take place, the sun, moon and Earth must be in a direct line. Total solar eclipses occur when the dark silhouette of the moon totally obscures the bright light of the sun, allowing the solar corona to be visible.

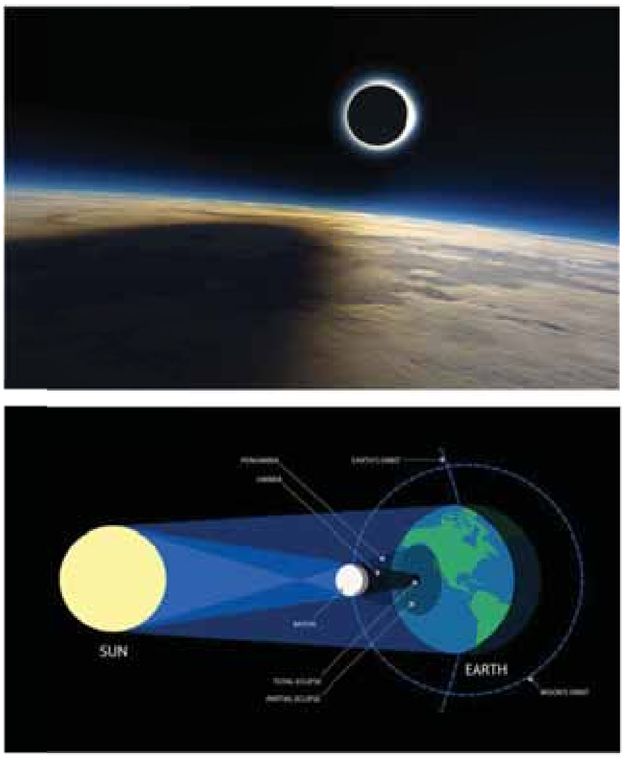

Figure 3 shows a total solar eclipse obtained from NASA network [3-4] and an illustration of this phenomenon

Figure 4 shows a partial solar eclipse

These pictures could be a way of thinking or teaching on mathematics, astronomy and:

- A space trip to planets or galaxies
- Evolution of the chemical elements
- Human evolution
- Geography

2.2. Women's Contributions

The history of women's contributions to science, technology, engineering, and maths (STEM) is long and varied, but it has also often been underrepresented [5].

Here we can highlights only three of the women who have made important discoveries and have had a crucial impact on STEM fields, Melba Roy, Marie Curie, and Florence Nightingale. Today, women are in every STEM discipline, in every type of job, and represent the widest range of background and experiences.

2.2.1. Melba Roy

Melba Roy Mouton, (1929, Fairfax, Virginia - 1990, Silver Spring, Maryland) was a mathematician and computer programmer in NASA's Trajectory and Geodynamics Division (Figure 5).

She worked up to being a Head Computer Programmer and then Program Production Section Chief at Goddard Space Flight Center. Melba worked also coding computer programs to calculate the trajectories and locations of various aircraft, and she was head mathematician for Echo Satellites 1 and 2 [6].

Science teachers can use Melba Roy's picture to talk about:

- Computer science
- Technology
- Mathematics
- Speed of rockets
- Stereotypes and glass ceilings

2.2.2. Marie Sklodowska Curie

Marie Curie (1867, Warsow, Poland- 1934 Haute-Savoie, France) was a Polish physicist and chemist who worked on radio-activity. She was the first woman to win a Nobel Prize (Figure 6), in 1903 she shared the Nobel Prize in Physics with Pierre Curie and Henri Becquerel in recognition of the extraordinary services they have rendered by their joint researches on the radiation phenomena.

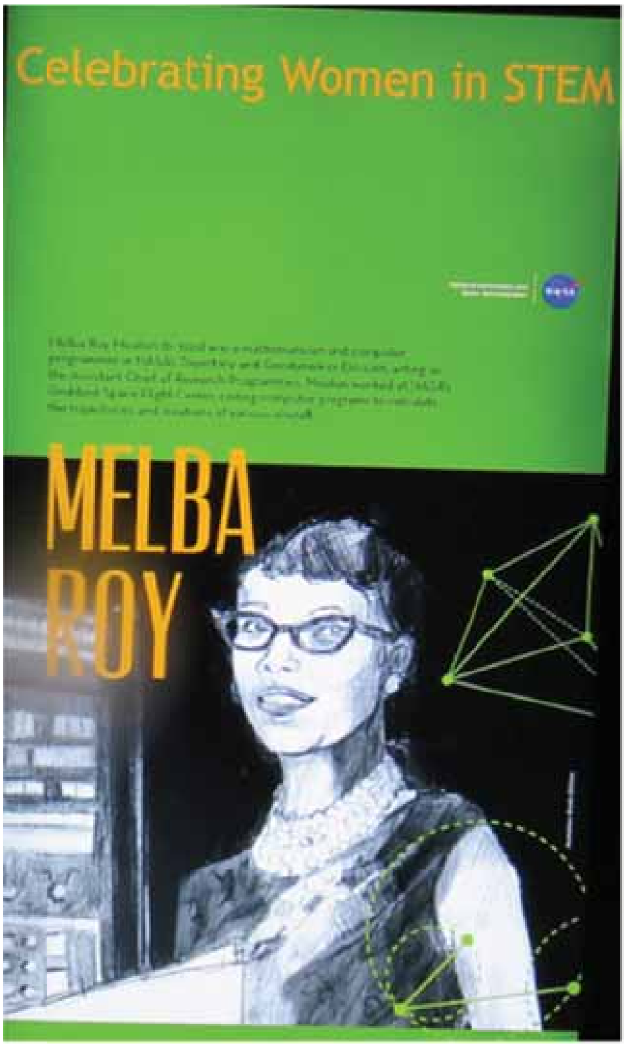

Figure 5 shows the Melba Roy's image on a poster (Celebrating women in STEM)

She was the only person to win a Nobel Prize in two different sciences. Marie Sklodowska Curie [7] won the 1911 Nobel Prize in Chemistry in recognition of her services to the advancement of chemistry by the discovery of the elements radium and polonium, by the isolation of radium and the study of the nature and compounds of this remarkable element.

She was also the first woman to become a professor at the University of Sorbonne, Professor of General Physics in the Faculty of Sciences. She was also appointed Director of the Curie Laboratory in the Radium Institute of the University of Paris, founded in 1914. In the course of World War I, she developed mobile radiography units to provide X-ray services to hospitals and in 1995 became the first woman to be entombed on her own merits in the

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Pantheon in Paris.

Figure 6 shows an image of Marie Curie on a poster at the Nobel Museum entrance in Stockholm

The Curies' daughter, Irene, was also jointly awarded the Nobel Prize in Chemistry in 1935 alongside her husband, Frederic Joliot in recognition of their synthesis of new radioactive elements.

Science teachers can use Marie Curie picture to talk about:

- Radioactivity
- Technology
- Physics
- Chemical elements
- Stereotypes and glass ceilings

2.2.3. Florence Nightingale

Florence Nightingale (1820 Florence, Italy – 1910 London, United Kingdom) was an English social reformer and statistician, and the founder of modern nursing. She worked on professionalising nursing roles for women. She was also a pioneer in the use of infographics and statistical data.

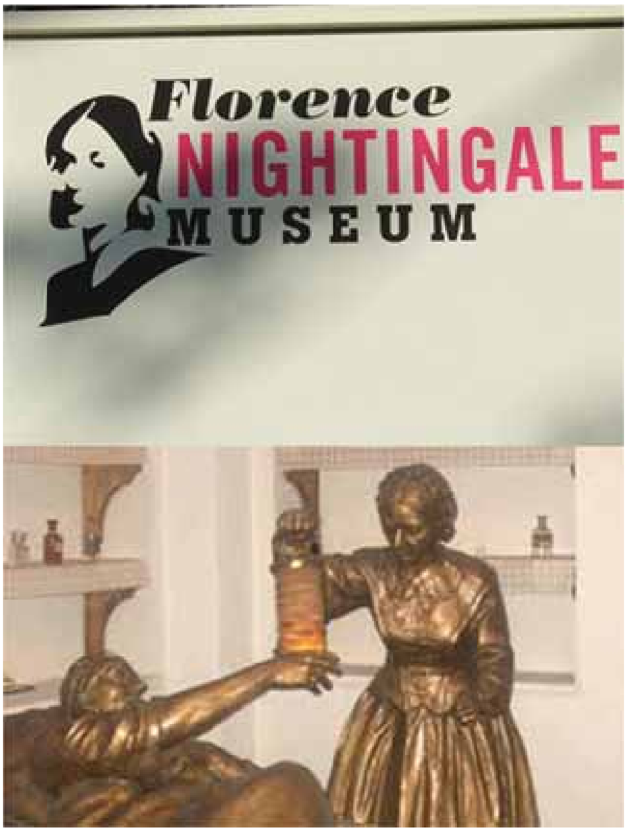

Figure 7 shows an sculpture of Florence Nightingale at the Florence Nightingale Museum entrance in London

Florence Nightingale (Figure 7) came to prominence while serving as a manager and trainer of nurses during the Crimea War, in which she organised care for wounded soldiers. She gave nursing a favourable reputation and became an icon of Victorian culture, especially in the persona of "The Lady with the Lamp" making rounds of wounded soldiers at night [8].

Science teachers can use Marie Curie picture to talk about:

- Nursing
- Statistics
- Stereotypes and glass ceilings

2.3. Northern Lights

The Northern Lights are the result of collisions between gaseous particles in the Earth's atmosphere with charged particles released from the sun's atmosphere.

The lights appear in many colours although pale green and pink are the most common. They are seen above the magnetic poles of the northern and southern hemispheres. They are known as 'Aurora borealis' in the north and

'Aurora australis' in the south.

Figure 8 shows Aurora Borealis or Northern Lights, obtained by the authors in Iceland

Variations in colour are due to the type of gas particles (chemical element) that are colliding. The most common, a yellowish-green, is produced by "excited" oxygen molecules (O_2) located about 60 - 150 miles above the earth. Blue or purplish-red colour is produced by nitrogen molecules (N_2) located at an altitude of 60 miles or less.

It could be a way of thinking or teaching on:

- Physics
- Light-Electromagnetism
- Spectrophotometer
- Origin of life
- Social sciences

2.4. Others Figures

A few visuals, illustrations and pictures, pertaining to science are shown. First of all, you can teach and learn about vaccination using a drawing clearly designed for children (Figure 9). Authors obtained this cartoon from a pharmacy in Canada. Secondly, visiting a science museum is an excellent opportunity to obtain many pictures, as in Figure 10, that science teachers can use them as a new educational approach.

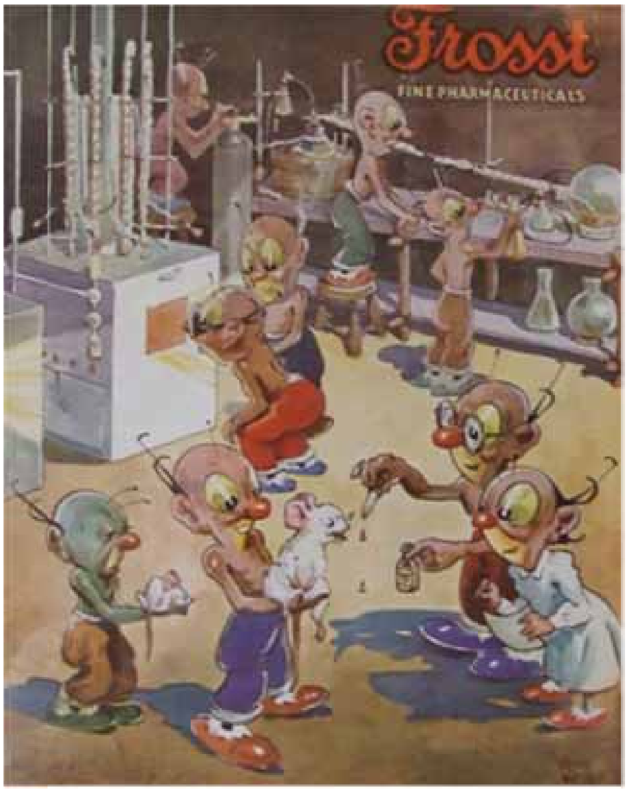

Figure 9 shows a cartoon with vaccination history for children

Science teachers can use both pictures to talk about:

- Vaccination
- Biotechnology
- Soap bubbles Physics

- Soap bubbles Chemistry
- Science Museum visits

Figure 10 shows a secondary school teacher into a giant soap bubble [2]

3. Conclusions

Science visual presentations, illustrations and pictures have contributed to:

Understanding vaccinations don't cause autism; GMO corn is as safe as every other crop that has been genetically modified by other means for thousands of years; and Earth is warming past dangerous levels.

Bringing a renewed focus on how visualization contributes to increase knowledge formation in science from the students' perspective.

In teaching science, the emphasis in visualization should shift from cognitive understanding—using the products of science to understand the content—to engaging in the processes of visualization.

Designing curriculum materials to inviting students to engage in the practice of visualization.

Reducing class size because since visual presentation activities take time, class size should be reduced.

Teachers should bring various visual to the classrooms, in addition to the textbook. Material needs should be fulfilled.

Finally, some questions for science school teachers:

1. What kinds of activities teachers perform for visual reading skill in the classroom?
2. What are the problems teachers encounter while applying in-class activities related with visual reading and visual presentation areas?

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Some Reflexions about Teaching and Learning Science

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Abstract. When teachers and scientists try to teach and transmit science, both to the society and to students at different levels of education, it is commonly described the importance of the scientific method and the great science triumphs during its history that they are using in their explanations.

However, despite its success, science is not free of criticisms. For this, some do not have confidence in science due to the weakness or unethical behaviours of some members of the scientific community. As scientists, we have to tackle and answer questions like "What are pseudo-science? What is the reason for scientific fraud?" among others. We have to prepare children for science, "Science is a resource that helps everyone in everywhere".

Keywords. Enjoy experiments, kids, primary school, science critics, and science education.

1. Introduction

When teachers and scientists try to teach and increase science knowledge to the society and students at different levels of education, Primary and Secondary schools, it is commonly explained the importance of the scientific method. In addition, teachers in their explanations use the great science achievements during its history.

On the other hand, despite its success, science is not free of criticisms, detractors, problems, and lacks the confidence of some people and social sectors.

Some of the attitudes that put science in doubt are due to the weakness or unethical behaviours of some members of the scientific community. Furthermore, some mistakes when scientific papers were rejected before going on to win a Nobel Prize increase this lack of confidence.

As a result, it is common that non-scientists people feel rejection towards science and ignore the positive effects of research in our society.

As scientists, we have to tackle and answer some questions posed by our society.

- What are "pseudosciences"?
- What are "pseudosciences" based on?
- What is the reason for scientific fraud?
- Why does the scientific system not take care of women and men equally?
- Which limits should be determined to start to publish scientific activity? Among others.

To answer these questions and make science such a vital subject for students we propose define science and scientific method and, enjoy with students through some laboratory experiments designed specially at primary school.

2. Questioning science and scientific method

Science [1] is the intellectual and practical activity encompassing the systematic study of the structure and behaviour of the physical and natural world through observation and experimentation.

Scientific Method [2] is a method of procedure that has characterized natural science since the 17th century, consisting in systematic observation, measurement, and experiment, and the formulation, testing, and modification of hypotheses.

Some science problems and mistakes are exposed at this point. Solutions will be explained in next point of the main text.

2.1. Pseudoscience

The word *pseudoscience* is derived from the Greek root *pseudo* meaning false and the Latin word *scientia*, meaning "knowledge".

Pseudoscience does not recognize scientific standards, such as the scientific method and falsifiability of claims. These are the differences between pseudoscience and science.

Astrology, creationism, esoterism, flat earth, geocentrism, graphology, homeo-pathy,

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intelligent design, naturopathy or paranormal plant perception are some pseudoscientific concepts among others.

"Belief in pseudoscience is widespread" [3]. "Pseudoscientific beliefs" are related to extrasensory perception, ghosts, telepathy, communicate mentally with someone who has died, reincarnation, witches,... Such beliefs in pseudoscience represent a lack of knowledge of how science works.

2.2. Scientific fraud

Scientific fraud has always been existing. There are doubts about some Ptolomeo, Galileo, Mendel or Millikan's results. Steling ideas and results or inventing results or erasing some specially bad results or falsify results.

2.3. Science Gender Equality

Gender equality means that women and men, and girls and boys, enjoy the same rights, resources, opportunities, income and protections [4].

In science, as in many areas of life, bias against women exists. Why are women underrepresented in many areas of science, technology, engineering, and mathematics (STEM)? [5]. It seems that it does not require that girls and boys, or women and men, be the same, or that they be treated exactly alike.

2.4. Mistakes rejecting papers

Peer review is the evaluation of work by people of analogous competency to the "peers" or makers of the work. It is a form of self-regulation by qualified members of a profession. The rejection process is part of good, healthy peer-review.

Some important scientific papers were refused before authors won the Nobel Prize [6] for their discoveries:

- Enrico Fermi's decisive paper on weak interaction was rejected in 1933. He won the Nobel Prize in Physics in 1938
- Hans Krebs' paper on the citric acid cycle was rejected in 1937. In 1953 Krebs won the Nobel Prize in Medicine
- Richard Ernst's paper on nuclear magnetic resonance (NMR) spectroscopy was rejected in 1966. He received the Nobel Prize in Chemistry in 1991.
- Kary Mullis's first paper on polymerase chain reaction (PCR) was rejected in 1983. He won the Nobel Prize in Chemistry in 1993.

Fermi, Krebs, Ernst and Mullis are examples, among others, of scientific papers that were rejected before to win a Nobel Prize.

3. What can be done? (I)

It seems that in nowadays, almost everyone at least accepts the value of science. Very few people so doubt the findings of neuroscience, chemistry or aeronautics, who will not to use analgesics, vaccines or board an airplane. However, a significant portion of the public still finds science mysterious, secret or inexplicable.

To take action with science questioning we propose fight against pseudoscience, science frauds, scientific mistakes and science gender equality and, denounce its presence.

3.1. Pseudoscience

The following indicators suggest a possible presence of pseudoscience:

- Lack specific measurements
- Use of obscurantist and apparently technical language
- Lack of effective controls, such as placebo and double-blind, in experimental design
- Lack of understanding of basic and established principles of science

3.2. Scientific fraud

There are many cases well documented about all kind of frauds:

- Sabotage competitors' experiments.
- Make up results.
- Falsify results.
- Copy a paragraph or a full article.
- Steal ideas.
- Make hypothesis after results.
- Choose the best results.
- Forget some especially bad results.

Giving no credit to some work that deserve it.

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Scientists must to fight against some bad practices that are detected in a few laboratories in our XXI Century

3.3. Scientific Gender Equality

Some researchers agree that gender differences are more important. However, it is likely impossible to disentangle the effects of societal bias and individual preferences, because people understand of gender differences shape their preferences.

One route to more equal representation across academic fields might be convincing both women and men that this is true.

The presence of women as laboratory teachers is very important and can help to normalize gender equality.

3.4. Scientific Mistakes rejecting papers

Peer review methods have to maintain standards of quality, improve performance, and provide credibility. In university, it is often used to determine an academic paper or a scientific article is accepted for publication in a scientific journal.

The rejection process is part of good, healthy peer-review. Following rejection, the end product is usually better than it would have been originally - or it at least, ends up in a more appropriate journal. It is a human activity and some mistakes can take place.

4. What can be done? (II): Children and experimentation

Children, 10-11 years old, learn about life through hands-on exploration and trial and error. Through asking questions, seeking answers, and feeding their curiosity through play. This is what makes science such a vital subject for children to learn [7].

The Department of Biochemistry and Molecular Biomedicine (DBMB) [8] at the University of Barcelona (UB) [9] makes available to the young students of primary school education some experiments using the scientific method [10].

The one-day event was organized to encourage an interest in science and foster science vocations among young people [11]. The aim was to introduce children to the world of science in a fun and entertaining way, without abandoning scientific rigor.

4.1. Teaching Science to young students

At all educational levels, motivation, learning and paying attention are the three columns of education [12], both in theoretical classes and laboratory practices.

Figure 1. Children playing with science

Teaching science to young students must to bring enthusiasm (motivation) to them and, more important, give children time to play and to explore science.

Figure 2. Student's paying attention

Thinking about something carefully implies to do interactive exercises that are a key component for maximizing students' motivation and then to bring together some questions. It is a good challenge.

The activities of obtaining science knowledge (learning science) involves teachers, parents and children who must find the answers together.

Figure 3. Teacher's picking up students' questions

Figure 4. Students doing Interactive exercises

Figure 5. Students asking questions

After experiments, a few students were asked about what science is. Three children gave us their definitions of science; their opinions about science were very edifying:

"Science is everything".

"With the help of science, we are able to know about new things, new medicines, and new materials".

"Thanks to science, we reached the Moon and now scientists are preparing themselves for Mars. Thanks to science, we found our “lost” planet. Pluto".

Children love to play, children love challenge, and children love to learn.

Figure 6. Teacher and students answering those questions

4.2. Students experiments

Motivation, learning and paying attention are the three pillars of experimentation [13].

Classroom attention is going to be a vital challenge for teachers and professors alike to prevent students from losing their ability to concentrate. Science laboratory experiments maintain children’s attention.

Students have also obtained the methodology to perform some experiments at school and at home:

- Choose a topic.
- Ask a question.
- Make a Hypothesis.
- Design a test and experiment for that question (Procedures).
- Test their answer by doing the experiment (Results).

- Look at results and draw a conclusion and you can suggest what students would do for further exploration of their question.

As you can see, the scientific method is on this methodology.

5. Conclusion

Scientific knowledge has been inaccessible for most of the population for centuries, and our generations are the first ones in receiving education on it massively.

We believe that it is vital promote scientific culture in young students to increase their scientific vocation.

In this context, teachers play a key role in stimulating curiosity about science from a young age. However, they need professional development, resources and support.

For this, the Department of Biochemistry and Molecular Biomedicine at the University of Barcelona had designed several courses [14] to updating primary school science teachers.

Science teachers have to maintain an open dialogue with children, their young students, about experiments. To conclude this point, authors can confirm children love experiments and they love science.

We strongly believe the possibility of using this educational approach to increase interest in science to our society [15]. Education is influencing social, economic and cultural changes.

"Science for all" [16-17] remains an educational priority because science and technology affect our everyday life. There must be more dissemination of science, at the level of the whole society. To do this, the civic centers are ideal places to hold lectures on scientific topics for young and no young (old) people.

6. Acknowledgements

Authors acknowledge the children and their teachers who have participated in our activities organised by the Department of Biochemistry and Molecular Biomedicine at University of Barcelona.

Special thanks go to the DBMB researchers who have collaborated in the practical sessions. Particularly, we want to thanks Josep Tarragó Celades his collaboration and contribution.

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Pinhole Photography. From the Box Camera to Digital Camera

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Abstract. Pinhole photography is a topic that can be proposed at different levels in both primary and secondary schools and at university level. It is a fun and surprising activity done with different devices such as a simple box camera loaded with photographic paper or a digital camera. In some cases it could be the introduction to a geometrical or physical optical course, while in others the first lesson in a photography course. The pinhole camera is the oldest and simplest device that can reproduce images with acceptable quality. In this paper we present different optical aspects related with pinhole photography, like the pinhole camera and its components, different types of cameras, image formation, image focusing and optimum pinhole, perspective, field of view, depth of field, exposure, vignetting, resolution, image quality and image processing.

Keywords. Pinhole camera, image formation, field of view, depth of field, exposure, vignetting, resolution, image quality, image processing.

1. Introduction

The pinhole camera is the oldest and simplest optical instrument known to man [1-2]. If we want to take advantage of this device to obtain photographs, we need to assure that its body is light-tight with a pinhole in a face and light sensitive material on the opposite side. Pinhole photography is a fun activity that could be proposed to students in primary, secondary or grade studies. The typology of cameras can be diverse: from a simple box camera loaded with photographic paper to a commonly used digital camera. Depending on the age of the students the subject could be addressed in greater or lesser depth, but at all levels of education, image formation by means of a little hole in a light sensitive device is both fascinating and instructive.

Pinhole photography can be also a good introduction to different topics of photography and is a good chance to address issues related to optics. In most cases geometrical optics is enough to understand image formation but, if we want to take our knowledge a step further, geometrical optics is insufficient and physical optics are needed, especially when dealing with optimal pinhole or image focusing. Surprisingly, a pinhole camera needs to be focused like a lens camera and the relation between object and image distances is the same as described for thin lenses [3-6]. However, despite this, pinhole images always appear blurry. Other drawbacks are optical aberrations such as chromatic, curvature of field and astigmatism.

On the other hand, this device offers several advantages over a lens camera. These are long depth of field, wide angular field and freedom from linear distortion. The main disadvantage is, in some cases, its poor resolution and long exposures. In this paper we present, first, the basic principles of image formation in a pinhole camera, related principally with the size of the pinhole. To do this we recommend the optimal pinhole for each situation. Thereafter we show different optical aspects of pinhole photography such as the pinhole camera components, different types of cameras and accessories, field of view, depth of field, exposure, resolution, image quality and image processing.

2. Some topics about pinhole photography

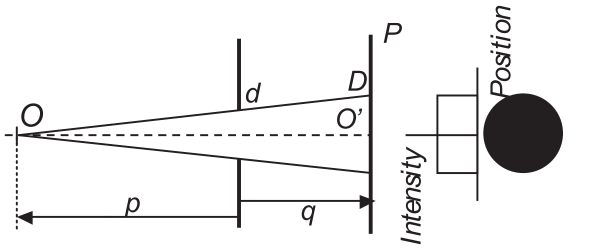
In this section some topics related to pinhole photography such as image formation, camera components and accessories, will be discussed, angular field, depth of field and exposure and resolution will be treated.

2.1. Image formation by a pinhole camera

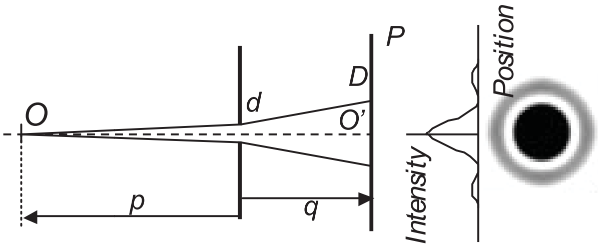
Image formation by means of a pinhole is described in many optics books [7-9], photographic books [10-12], specific pinhole photographic books and websites [13-14] but not in many general physics books [15]. We describe image formation in a pinhole camera paying attention to the diffraction effect.

Let's consider a camera with a circular pinhole of diameter *d* that forms the image *O'* of a point object *O* on a screen *P*. Consider *p* and *q*, respectively, object and image distances (Figure 1). Geometrical optics says that this image is a circular spot of diameter D proportional to d (Figure 1(a)).

Looking at Figure 1(a) sharpness of the image will improve when d decreases, although this is true if diffraction effects are not taken into account. When pinhole diameter d is small enough, diffraction appears and when d decreases D increases and the sharpness of the image worsens (Figure 1(b)). An extended object of size y can be considered as a set of points and its image of size y' is therefore a set of spots of diameter D (Figure 2).



(a)



(b)

Figure 1. (a) Image formation *O'* of a point object *O* by means of a pinhole. (a) Geometrical spot. (b) Diffractive spot

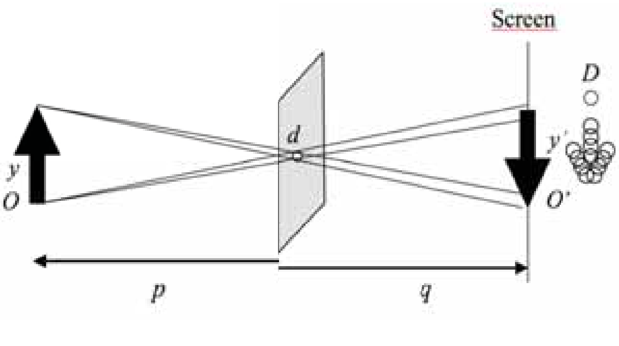


Figure 2. Image formation of an extended object by a pinhole camera

Lateral magnification or magnification m is defined as:

$$m = \frac{y'}{y} \qquad (1)$$

From Figure 2:

$$m = \frac{y'}{y} = \frac{q}{p} \qquad (2)$$

Taking into account Young's experiments related to resolution in pinhole cameras [5], spot diameter D can be computed as:

$$D = \begin{cases} d\left(1+\frac{q}{p}\right) \quad if \ q \le \frac{d^2}{8\lambda} & (1) \\ 2{,}44\frac{\lambda q}{d} \quad if \ q > \frac{d^2}{4\lambda} & (2) \end{cases} \qquad (3)$$

Where λ is the wavelength of light.

Eq. (3.1) corresponds to Geometrical Optics and Eq. (3.2) is due to far−field diffraction or Fraunhofer diffraction.

In the case that $\frac{d^2}{8\lambda} < q < \frac{d^2}{4\lambda}$ Fresnel diffraction or near−field diffraction needs to be applied. The shape of the spot image is circular, with multiple rings, and we have not an analytical formula that describes its diameter. Numerical methods must be applied, in this case, to obtain D. If a certain degree of continuity in the process is accepted, we can assume that in this interval D varies as:

$$d\left(1+\frac{q}{p}\right) < D < 2{,}44\frac{\lambda q}{d} \qquad (4)$$

There has been much theoretical work to find the optimal pinhole diameter d that minimizes the spot diameter image D [3-5] in order to obtain the best sharpness. The smallest diameter occurs roughly where the geometrical and Fraunhofer diffraction give the same result. That is:

$$d\left(1+\frac{q}{p}\right) = 2{,}44\frac{\lambda q}{d} \qquad (5)$$

In this work we take as the optimal pinhole the one that covers the first Fresnel zone plate [5-6]. In this case, the diameter of the pinhole fulfils the condition:

$$d^2 = 4\lambda f \qquad (6)$$

Where f is the focal of the pinhole camera.

Value obtained by Eq. (6) is indicative. Experience shows that we would not noticeably lose definition if we were to make the hole 20 to 30% larger than the size indicated in Eq. (6).

In zone plates, as is our case, distances p, q and f are related by the same equation as the thin lens:

$$\frac{1}{f}=\frac{1}{p}+\frac{1}{q} \tag{7}$$

This indicates that images obtained by the pinhole camera must be focused if we want to obtain a sharp image.

Most photographs are taken at distances that satisfy the relation $p >> q$. In this case Eq. (7) is reduced to $q \approx f$.

It is worth noting that if a lens formed the image of point O instead of a pinhole, the spot diameter D is about two orders of magnitude smaller. This is the reason why images obtained with lenses are in focus as opposed to pinhole images that are slightly blurred.

2.2. Cameras: Basic components, accessories and typologies

The basic components of a pinhole photographic camera are the light-tight box, the pinhole, the shutter and the element that records the image. This element can be analogic like photographic film or photographic paper or digital like an electronic detector (CMOS/CCD).

It is crucial to know the diameter of the pinhole since its value affects the sharpness of the image as well as its illumination. The f−number of the camera is defined as:

$$f\,/\,\# = \frac{f}{d} \tag{8}$$

Pinhole diameter d can be measured in several ways. There are a lot of measurement methods and we will briefly explain three of them. The first one is with the aid of a magnifying glass or a microscope, the second is by scanning the pinhole at high resolution and measuring its diameter with image processing software. The third consists of projecting the Fraunhofer diffraction spot onto a screen and measuring it from the value of the diameter of the Airy disk.

Box cameras with photographic paper are the simplest. In this case the shutter can be a small piece of cardboard that covers the pinhole. This has the drawback that for each photo the camera needs be loaded in darkness or with a laboratory safety light. In all cases, the final image is obtained after a development process in the laboratory.

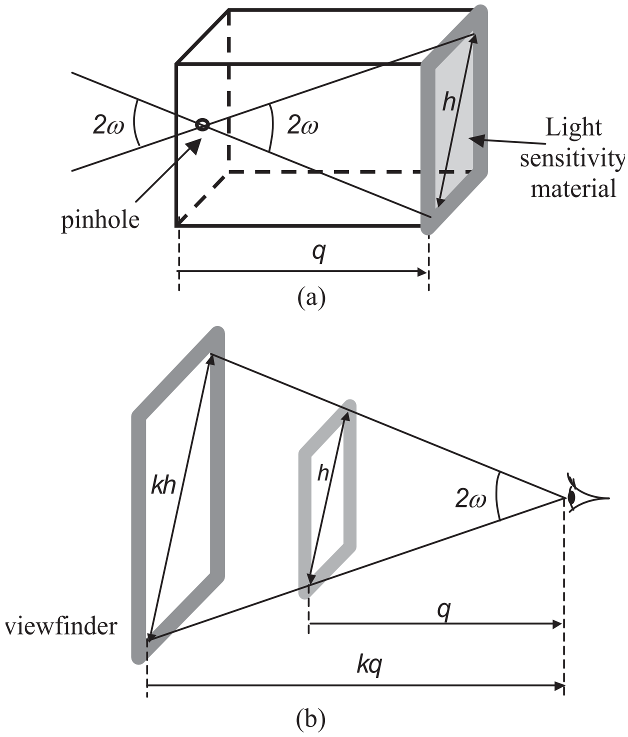


Figure 3. (a) Box pinhole camera. Angular field. (b) Sportive viewfinder

A complement to this camera is the viewfinder. The viewfinder allows us to see the part of the scene that will appear in the photograph. The simplest is the sportive viewfinder that is a window of the same dimension, or proportional to the size of the photographic paper. When the photographer looks through it at the distance q, or at distance proportional to q, the field that he views is the same that the camera photographs (Figure 3).

Nowadays the best and direct viewfinder for a pinhole camera is the image that appears on the screen of a smart phone when this camera focuses on the scene.

Other cameras that could be considered are old 35 or 120 mm analog cameras with removable lenses. These can be transformed in to pinhole cameras changing the lens for a pinhole attached to a photographic cap. Loading it with a photographic reel we have a device that can shoot a certain number of photographs before developing the reel.

Some enterprises commercialize analog pinhole cameras that work with 35 mm or 120 mm film [16-17].

However, the easiest and most direct way to introduce students to pinhole photography is with digital cameras with removable lenses. A pinhole camera is obtained, as in the case of oldest analog cameras, by changing the lens for a pinhole attached to a photographic cap. Images obtained in this case can be displayed immediately on the screen of the camera and, after visualization, it allows for quick correction of frame defects and exposure.

2.3. Angular field

Angular field is that part of the scene that is recorded through the camera at a particular position and orientation. In a pinhole camera the angular field is the angle 2ω that appears in Figure 2(a) and its value is:

$$2\omega = 2\tan^{-1}\left(\frac{h}{2q}\right). \tag{9}$$

According to this, angular field increases when h increases or q decreases and cameras could be classified as wide lens ($2\omega > 50^o$), normal ($2\omega \approx 50^o$) or tele lens. ($2\omega < 50^o$).

2.4. Depth of field

Depth of field is the axial distance that is focused in a photographic image. It is due to the inability of the eye to distinguish between a true point and a tiny blurred circle if the circle diameter subtends an angle less than 1/1000 rad [12]. Photographic images are visualized as copies in paper or pictures on a digital screen. Assuming that they are observed at 400 mm the size of the blur circle is c = 0,4 mm. In pinhole photography, in most cases, the scene is far from the camera ($q \approx f$) and the blurred spot is approximately the same size, independently of the axial position of the object. For this reason photographs taken with a pinhole camera with values of its optimal diameter lower than $d \approx 0{,}4$ mm and visualized with little magnification appears with a slight blur in its entire axial axis. Figure 4 shows a snapshot obtained with a 135 mm Zenith analog camera with d = 0,28 mm and f/144. In this image near and far terms of the scene are focused.

Figure 4. Snapshot taken with 135 mm analog pinhole camera to show soft focus and large depth of field

In addition, amateur photographers know that photographs shot with a high f−number, as is the case of pinhole camera, have larger depth of field.

2.5. Exposure

Exposure measures the quantity of light that arrives to the sensor of the camera. Its formula is [12]:

$$H = \frac{\pi B t}{4\left(f/\#\right)^2\left(1+m\right)}\cos^4\theta \tag{10}$$

Where B is the luminance (brightness) of the scene, $f/\#$ the f−number of the camera, t the exposure time, m the magnification (In in most photographs $m \approx 0$) and θ the angle that subtends the centre of the pinhole to an non-axial point image.

In the centre of the sensor $\theta = 0^o$ and $\cos^4\theta = 1$, but in the corner, $\theta = w$ and for a wide-angle camera, for example $w = 45^o$, $\cos^4\theta = 0{,}25$. This means that, in this case, exposure in the corner is four times lower that in the centre and vignetting appears.

Another parameter to consider in the exposure is sensor sensitivity S. More sensitive sensors need less light quantity to be sensitized than those sensors whose sensibility is lower. Sensitization is ranged in ISO scale from low to high values corresponding to low to high sensitivity.

In photography *S, t* and *f/#* make up the three sides of the exposure triangle. They work together to produce a photograph that is properly exposed.

The law of reciprocity says that if a photograph has a correct exposure with the parameters S_1, t_1 and $(f/\#)_1$ a change of these parameters to S_2, t_2 and $(f/\#)_2$ that does not vary exposure, satisfies the equation:

$$\frac{S_1 t_1}{(f/\#)_1^2} = \frac{S_2 t_2}{(f/\#)_2^2} \qquad (11)$$

The law of reciprocity is accomplished in photographic papers and electronic sensors but may fail in some films, especially when exposure time is greater than 1/10 s. Manufacturers deliver tables with the correction that will be applied to exposure time when the reciprocity law fails.

Exposure meters give us the three previous parameters that assure a correct exposure. There are different typologies of these devices and the most widely used are hand held exposure meters. Another exposure meter that can be used is the exposure meter of an auxiliary camera. In all cases *f*–number does not achieve values as high as the pinhole camera has and Eq. (11) must be applied in order to obtain the desired exposure time.

There are some apps that measure exposure in pinhole photography. Examples of this are the applications Pinhole Assist [18], Pinhole Master [19] or Pinhole Meter [20] for IOS and beeCam Light Meter [21] for Android. All of them give a reliable measurement of exposure and are conveniently incorporated into the mobile phone. With this gadget, a smart phone becomes an indispensable tool in pinhole photography because we are able to view the image on its screen. In addition the app measures exposure parameters of the scene and the chronometer measures the time that the photograph must be exposed.

2.6 Resolution

Resolution is the smallest discernible separation y_{min} between two image points. A pinhole camera has poor resolution in relation to a lens camera. In this paper we assume that resolution, in image space y'_{min}, of pinhole camera is:

$$y'_{\min} = \frac{D}{2} \qquad (12)$$

And resolution in object space is:

$$y_{\min} = \frac{y'_{\min}}{m} = \frac{D}{2m} \qquad (13)$$

Resolving power is the number of line pairs per millimetre that are just clearly discerned by the camera. Their values in image and object space are:

$$R' = \frac{1}{y'_{\min}} = \frac{2}{D}; \quad R = R'm = \frac{2}{D}m \qquad (14)$$

3. Image quality

Images obtained with a pinhole camera are always blurred but as we have just seen we can obtain images less blurred than others, it is a matter of focusing the camera with the right pinhole. Assuming that the camera works with the optimal pinhole there are two factors that influences image quality: Magnification of the image and tonal range of the sensitive material. Magnification is directly related with burring. Once the image is obtained in a photographic paper, in a film or in an electronic sensor, it can be visualized in a paper copy or in a screen. When this is done, in general, the image is magnified to be seen comfortably and consequently blurring increases. Images that require lower magnification look better because they have less blur.

Tonal range refers to the total number of tones (gray levels or number of colours) in the image. Films and CMOS/CCD detectors have a high tonal range while photographic paper has low.

Table 1 shows these characteristics in the cameras that we have used. Magnification required is that which would be necessary to obtain a copy of 13x18 cm.

The box camera with negative photographic paper of size 13x18 cm does not need magnification to obtain a final copy of the same

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size at it will look focused. The analog camera with sensor size of 60x90 mm needs little magnification and the final image will also look focused.

Table 1. Relationship between sensor size, tonal range and magnification required

Camera	Sensor size (mm)	Tonal range	Magnification required
Box (paper)	130x180 (big)	low	1x (low)
Analog (film)	24x36 (small)	high	5x (high)
Analog (film)	60x90 (big)	high	2x (low)
Digital	18x24 (small)	high	7,5x (high)

Analog and digital cameras with small sensors give us small size images. If we want to view them in 13x18 cm magnifications of 5x or 7,5x are needed and the final image will appear with high blur. Nevertheless, these images are suitable for sharing pictures in social networks like Instagram or Flickr as images appear reduced in mobile screens and blur is harder to see.

Analog cameras with a sensor of 60x90 mm work well because they have a high tonal range and their copies can be magnified without loss of quality.

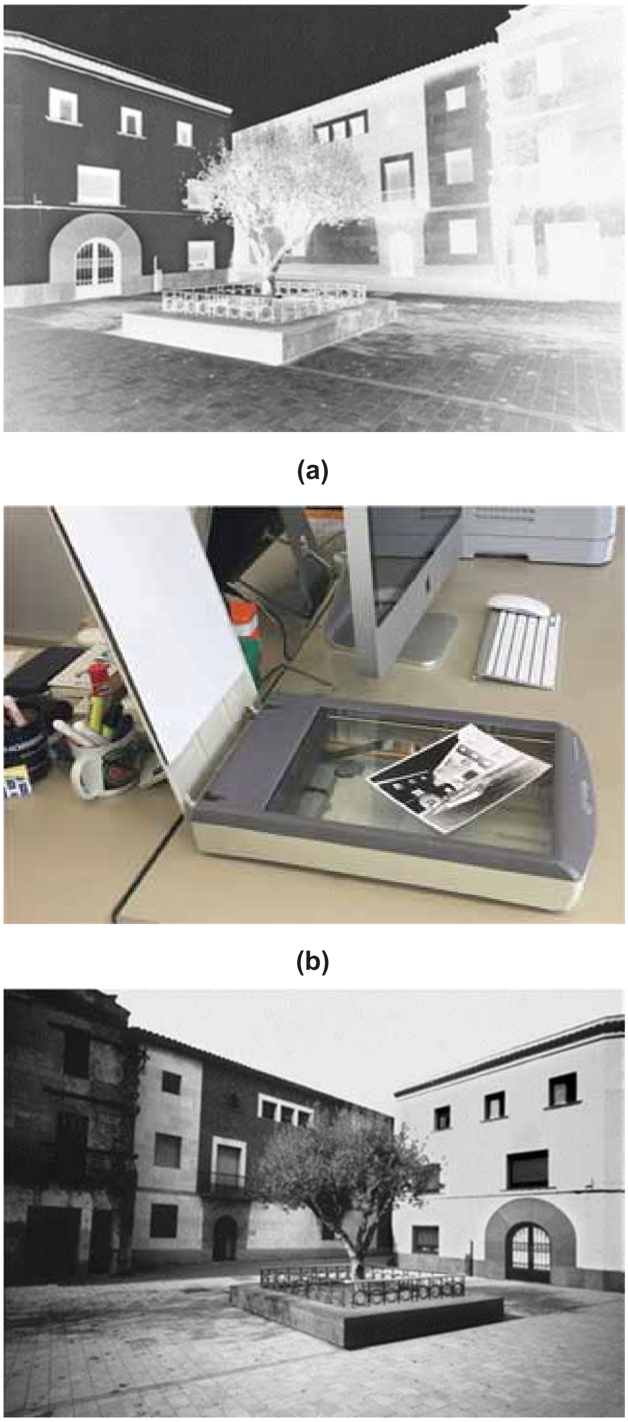
4. Image processing

Images obtained by analog cameras must be developed in a photographic laboratory.

The process is a bit different if the sensitive material is paper or film but in all cases developer, stop bath and fixer solutions must be applied to negatives. Once we have processed the negative we obtain the positive by digital methods such as scanning or photographing the negatives. Figure 5 shows the process of scanning a negative paper by means of a domestic scanner and Figure 6 the process of photographing the negative with a digital camera with a macro lens. The camera is attached to a column and the negative is trans illuminated with a uniform light source. In films of 24x36 mm a good option could be also to scan the negative with a negative scanner, but this has not been our choice.

Images obtained with digital cameras do not need a positive process.

Digital images, whether from analog or digital cameras need further processing before presenting the final image.



(a)

(b)

(c)

Figure 5. Digital positive process with a scanner. (a) Negative. (b) Scanner. (c) Positive

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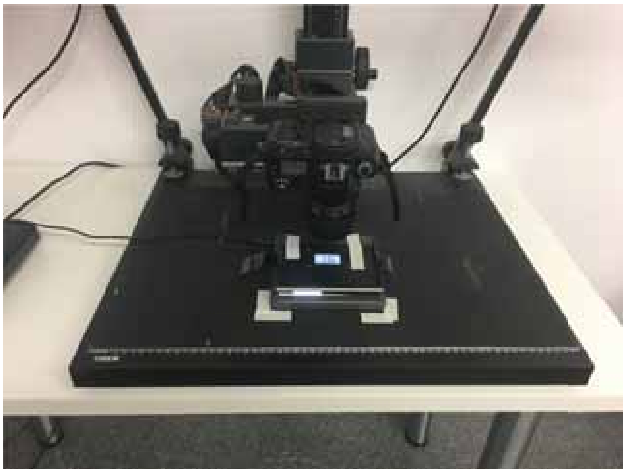

Figure 6. Digital positive process with a photographic camera and a macro lens

5. Results

(a)

(b)

Figure 7. (a) Analog box camera. (b) Image obtained with this camera

Next we show cameras, whose principal characteristics, have been used in this work. A picture obtained with each of these cameras is also displayed. In all cases optimum pinhole has been calculated taking into account that $q \approx f$. Figure 7(a) shows the box camera. Their principal characteristics are: $f = 105$ mm, $d = 0{,}51$ mm, $f/206$, $2\omega = 90º$, Negative size: 12,52x17,65 cm, Negative brand: Ildford MGIV Multigrade IV de luxe paper (S = 5 ASA). Figure 7(b) displays an image obtained with them.

Figure 8(a) shows analog camera Prak-tica. Their principal characteristics are: $f = 40$ mm, $d = 0{,}28$ mm, $f/143$, $2\omega = 57º$, Negative size: 24x36 mm, Negative brand: Ildford FP4 125 film. Figure 8(b) displays an image obtained with them.

(a)

(b)

Figure 8. (a) Analog Praktica camera. (b) Image obtained with this camera

Figure 9(a) shows analog camera Holga. Their principal characteristics are: $f = 40$ mm, $d = 0{,}30$ mm, $f/135$, $2\omega = 108º$, Negative size: 60x90 mm, Negative brand: Ildford FP4 125

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film. Figure 9(b) displays an image obtained with them.

Figure 10(a) shows digital camera Nikon D70S. Their principal characteristics are: f = 45 mm, d = 0,30 mm, f/150, 2ω = 36º, Sensor size: 60x90 mm, Figure 10(b) displays an image obtained with them.

(a)

(b)

Figure 9. (a) Analog Praktica camera. (b) Image obtained with this camera

We have tested resolution for the digital camera Nikon D70S (q = 55 mm) with Snellen near vision test situated at 110 mm from the pinhole (p = 110 mm). Figure 11 shows this test where visual acuity at 400 mm for each line appears in the left column, while in the right column resolving power is displayed.

Applying (7) the focal of the camera is f = 37 mm and by (6) the optimal pinhole diameter is d = 0,29 mm.

We have captured images of this test with a set of pinholes with different diameters. Table 2 presents the diameters of pinholes, the focal of the camera that best focuses the image (Eq. 7), the diameter of the blurred spot (Eq. 3), the resolution (Eq. 12) and the resolving power in image and object space (Eq 14). Shaded columns display cases where blurred spots are obtained by diffraction and unshaded columns show cases that are obtained by geometrical optics.

(a)

(b)

Figure 10. (a) Digital Nikon D70S camera. (b) Image obtained with this camera

Table 2. Diameters of pinholes, focals of the camera, diameter of blur spot, resolution in image space and resolving power in image and object space for a set of 5 pinholes

d (mm)	0,15	0,26	0,32	0,41	0,64
f (mm)	10,00	31,00	47,00	76,41	186,00
D (mm)	0,49	0,28	0,48	0,62	0,96
y'_{min}	0,25	0,14	0,24	0,31	0,48
R' (lp/mm)	4,06	7,05	4,17	3,25	2,08
R (lp/mm)	2,03	3,52	2,08	1,63	1,04

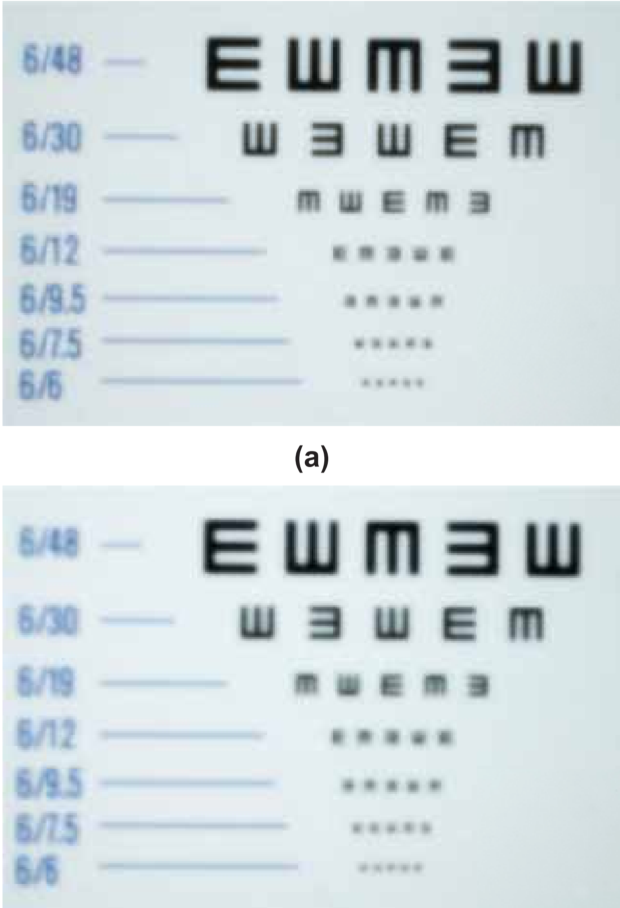
Figure 12. Snapshot taken with digital camera Nikon D70S attached with a pinhole with *d* = 0,26 mm (near optimal pinhole). Resolution reaches line 5

We have captured images of this test with a set of pinholes with different diameters. Table 2 presents the diameters of pinholes, the focal of the camera that best focuses the image (Eq. 7), the diameter of the blurred spot (Eq. 3), the resolution (Eq. 12) and the resolving power in image and object space (Eq 14). Shaded columns display cases where blurred spots are obtained by diffraction and unshaded columns show cases that are obtained by geometrical optics.

Figure 12 shows an image obtained with a pinhole that has a diameter near the optimal, $d = 0{,}26$ mm. The image exhibits minimum blurring and maximum resolving power. In addition resolving power matches the calculated and the camera can resolve until line 5.

Figures 13(a) and 13(b) display images obtained with pinholes of diameters $d = 0{,}15$ mm (diffraction limited) and $d = 0{,}32$ mm (geometrical limited). Resolving power is similar in both cases and is a little bit higher than calculated. In both cases resolution reaches line 4.

Finally, figures 14(a) and 14(b) display images obtained with pinholes of diameters $d = 0{,}41$ mm and $d = 0{,}64$ mm. In this case the size of blurred spot must be calculated geometrically and in both cases resolving power matches with calculated. Spurious resolution, described in [5], appears in lines 3 and 2 respectively. The image obtained with $d = 0{,}41$ mm reaches line 3 and the image obtained with $d = 0{,}64$ mm reaches line 2.



(a)

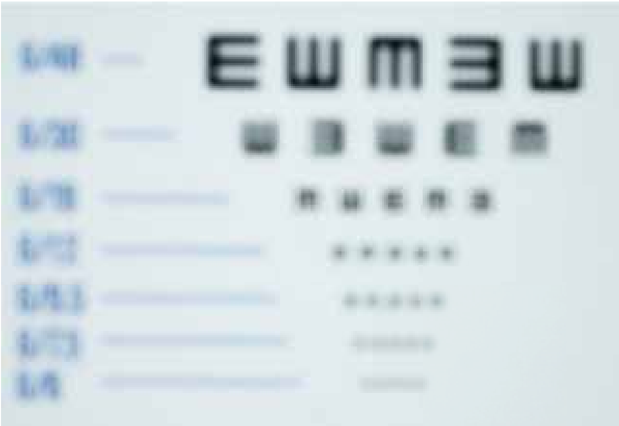
(b)

Figure 13. Snapshot taken with digital camera Nikon D70S attached with a pinhole with (a) *d* = 0,15 mm and (b) *d* = 0,32 mm. In both cases resolution reaches line 4

6. Conclusions

In this paper we have introduced different topics about pinhole photography. There are many activities related to it, some are which as follows: - Pinhole diameter measurement, obtaining the optimal pinhole, checking that pinhole camera focuses the image, proving what geometrical optics is unable to explain, in some cases, image formation, setting up a sportive viewfinder, measuring angular field of the camera, computing f/#, measuring scene exposure, managing exposure reciprocity law, computing and measuring resolving power, comparing images obtained with analog and digital cameras. Other activities derive from the photographic process such as developing photographic papers and films and the use of digital methods to produce a positive image and later process it.

However, the most exciting activity is obtaining images with this fun and old-fashioned device.



(a)

(b)

Figure 14. Snapshot taken with digital camera Nikon D70S attached with a pinhole with (a) *d* = 0,41 mm (resolution reaches line 3). (b) *d* = 0,64 mm (resolution reaches line 2)

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Virtual Tutoring

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Abstract. The project VIRTUAL TUTORING – the virtual tutor as learning mediating artifact in online university education, is an ongoing project, with the main goal of analyzing the pedagogic impact of an anthropomorphic user interface on a typical distance learning environment targeted to support online higher education. This demands the creation of animated avatars for virtual tutors, able to display intelligent behaviour while interacting with the students. A Virtual Tutor should be analogous to a real human one, being able to proactively understand, solve and intervene in different student learning situations. This paper gives an overview of the project present development status.

Keywords. Virtual pedagogic models, online distance learning, virtual tutor, embodied conversational agents.

1. Introduction

Virtual people have been populating our reality for several years. In business terms, their significance as player and non-player characters in videogames is uncontested. Research is being carried on in the academic world on advances for virtual people and related novel uses for them.

The Virtual Tutoring project aims to find out and answer some challenging questions such as: how should a virtual avatar look and/or act to achieve effective engagement with the student, what aspects and information in the online learning environment should be taken into account to model the avatar's behaviour; or what are the pedagogical implications that may arise.

At this moment, the project is entering into its first testing phase. Two different approaches were developed upon the Virtual Tutoring paradigm - one fully based on the desktop Moodle environment and another to work as a mobile Virtual Tutor companion.

The following sections give an overview on the present state-of-the art in the field of virtual tutoring, besides the present state of development and implementation of the project.

2. Background

Online learning (OL) has grown in importance as a direct consequence of the rapid development taking place in information and communication technology (ICT). This development has pushed OL agents into finding new methods of teaching and learning that could explore the technological media to the limits that ICT could actually offer. Due to the evolution of OL, it is difficult to find a precise and current definition. Nichols [1] describes OL as "education that occurs only through the Web", that is, it does not involve any physical learning materials issued to the students or an actual face to face contact. Pure online learning is essentially the use of eLearning tools in a distance education mode using the Web as the sole medium for all student learning and contact." Even though this statement is still valid, recent OL has evolved to include between others, aspects such as collaborative learning [2], connectivist learning [3], online participation, massive open online learning or serious games, virtual reality or digital storytelling [4-6].

To Universidade Aberta´s pedagogical modell this form of teaching and learning is based on several principles [7]: student-centered learning; learning flexibility (both spatial and temporal); and online interaction, in particular, asynchronous interaction, which blurs the temporal barriers imposed by communicational synchronism, and is consistent with the flexibility principle and digital inclusion. Interaction is absolutely fundamental for the teaching learning process so that students can effectively acquire the corresponding knowledge and skills. It occurs when students are actively participating in learning activities involving peer-to-peer and teacher communication, be it contributing in a discussion, solving an exercise, analyzing a result, simply exchanging views with their colleagues, or clarifying questions with the teacher [6-8]. In this pedagogical model some learning activities are moderate by a Virtual Tutor (Human).

One of the main research goals in online learning environments, according to Oncu & Cakir [9] is enhancing learner engagement and collaboration. In distance education, online interaction is one of the most important practices that influence engagement and collaboration in the learner community. Anderson [10] classifies interaction in 6 categories involving the teacher, student and content. Of these, the learner-learner and learner-teacher as well as the learner-content categories are essential to modern learner centered educational environments, being crucial to promote them in distance education, where the agents tend to become more centered educational environments, being crucial to promote them in distance education, where the agents tend to become more isolated and these types of interaction not commonplace or natural.

In distance OL, one of the most relevant roles the teacher/tutor is called to play, is that of "helping students develop as learners capable of managing their learning process" [7]. However, they also have tasks as motivators, clarifying ideas, defining learning paths, instruction, training, support, feedback, moderation and facilitation of interactions, among others. Supporting the student goes beyond cognitive support, to include a more organizational aspect, that is concerned with counselling and time management, which is critical to the students' success. Thus, the online teachers/tutors must master a set of competencies such as: the capacity to develop an adequate curriculum and to organize learning processes; competencies that relates to the various teaching/tutoring roles (giving feedback, motivating, training); and competencies that relates to reflection and evaluation. Within student support, they stress guiding the student, setting deadlines, and monitoring the students' progress, contacting them in cases of prolonged absence. All the contributions underline the relevance of the role played by the teacher/tutor in online distance learning, as well as its complexity. The challenge posed to this project is to investigate the potential of Virtual Tutors (digital tutors) as valuable teaching-learning tools in helping the human teacher/tutor fulfil his/her duties in OL.

On the other hand, ECAs are known to have important positive effects in the user interaction with technological devices; for instance visual speech can increase the intelligibility of audio speech; lessen the efforts required for understanding and; increase the satisfaction of user experience. However, the idea of synthetic companions capable of establishing meaningful relationships with humans remains far from being accomplished. To achieve this, synthetic companions must interact with people in natural ways, employing social mechanisms that people use while interacting with each other. One such mechanism is empathy, often seen as the basis of social cooperation and pro-social behaviour. Artificial companions capable of behaving in an empathic manner, which involves the capacity to recognise another's affect and respond appropriately, are more successful at establishing and maintaining a positive relationship with users [11-13].

The use of ECA as Virtual Tutors in real online teaching-learning scenarios is still a ground-breaking challenging since OL itself is still in its infancy. In spite of the achievements registered in the area of ECAs there is still a lack of virtual entities that can effectively give support to online teaching-learning. Very few experiments are referred in the literature. They have remained at a stage of limited demonstration and basic proof-of-concept, or expressive talking-heads where no actual pedagogic impact analysis has been carried on [14-15]. Most of the developments remain at a demonstration stage, with ECAs holding insufficient capabilities at level of natural language communication, artificial intelligence or emotional/affective interface. This leads to low levels of ECA's believability which implies their limited acceptance from users interested in more than playing with a nice demonstration. In this project we aim to advance one step further in the research of ECA integration support virtual tutoring in OL.

3. Methodology

The methodology chosen consisted in a multidisciplinary research team involved covering the distance education (e-learning), pedagogy and technology expertise needed for its implementation.

This is a multidisciplinary project. It is both about devising a new teaching-learning (pedagogy) tool and strategies as well as the application of novel technologies on ECAs. Its main aim is to evaluate the pedagogic impact and potentiality of ECAs for online teaching-learning. The research methodology is divided in four parts. The first has to do with the analysis and technological adaptation of current up to-date ECA technology, including written natural language communication, anthropomorphic interfaces regarding the special facial animation of avatars, knowledge modeling based on ontologies and emotion-based agent architecture and interfaces. A model and implementation of a virtual tutor will be realized and integrated in a LMS. The adopted LMS will be the e-learning platform of Universidade Aberta (Portuguese Open University) - UAb, the Portuguese leading public online university with more than 12.000 students from all over the world. In the second part of the project three trial scenarios will be prepared and implemented. These scenarios will be used to test the virtual tutor in three virtual classrooms in the context of three learning units taken from formal online courses (one graduation course and; two post-graduation courses). In the third part of the project we want to analyze the pedagogic impact of virtual tutoring in the context of three concrete trial scenarios (which are designed according to the virtual pedagogic model adopted in UAb) while devising how virtual tutors can be, or not, valuable artifacts to mediate between teachers, students and learning materials. The pedagogic impact analysis on the student side will be realized by means of online inquiries/questionnaires on student's satisfaction, virtual tutor usability, interaction and collaboration verified, among others, as well as monitoring observation focused in the incidence and quality of the teaching-learning results and student's behaviour. On the teacher side there will be additional ethnographic observations focused on the teacher's actions when configuring and using the virtual tutor as an extra and complementary teaching tool. Finally, we would like to design and propose a revised virtual pedagogic model (based on the virtual pedagogic model adopted in Universidade Aberta) that embraces virtual tutoring as a pedagogic strategy for online teaching-learning processes that are based on user-centred and collaborative learning.

4. Virtual Tutor Prototypes

4.1. Desktop Moodle environment

The virtual tutor window is superimposed over the Moodle's webpage of a discipline; it occupies a fixed position on the bottom right corner of the webpage, allowing students to scroll up and down over this page. The virtual tutor is an avatar (just head and shoulders) that was created based on photographs of real people.

The avatar delivers speech (text, lips' movements, but no sound yet) and exhibits facial expressions. Both speech and expressions are variable and depend on two factors: (i) the results of the student in the continuous evaluation components and also (ii) on his/her level of attendance in that Moodle's page.

Besides the avatar and the balloon with its speech, the window contains an area that lists the items with new information and also a set of buttons that guide the student in the navigation. The interface uses colour to highlight the novelties that appeared in the page since the last login of the student.

4.2. Mobile Virtual Coaches

To demonstrate empathic competence, a digital tutor should be able to: recognize, through the use theory of mind [16], the user's affective state within a particular context; possess a computational model allowing the simulation of the empathic process, and; being able to exhibit empathic behaviour [17]. In this work, we researched how two virtual tutors, Maria and João, working as coaches and inhabiting an Android application could provide empathic support to the student while interacting with a Learning Management System and going through an online course curriculum.

The virtual tutors perception is based on: (1) subjective factors such as the evolution of the perception of challenge by the student (i.e. how easy it has been to complete the course assignments over time), endogenous motivation (i.e. how much the student is enjoying the course over time) and exogenous motivation (i.e. the importance of the course for the student over time), as well as; (2) objective factors such as performance (i.e. grades obtained over time), effort (i.e. amount of time spent on the course over time) and engagement (i.e. amount of interaction with course materials over time). The evolution of these variables allows for the computation of an affective state using the "emotivector" model [18] that is associated with the student situation at this point in time (e.g. the student grades dropping more than expected).

This affective state is then used to select an empathic strategy based on all the objective and subjective context variables as well as the affective state itself. Empathic strategies are created based on the affective improvement strategies defined by Niven et al. in their interpersonal affect regulation strategies classification [19] and implemented as dialog trees. A dialog tree editor supports the development of strategies adequate in the context of a specific course and learning culture. To modulate the affective expression of the tutors while the dialogue occurs, the synthetic emotions "felt" by each one of the two tutors is computed by modulating the student's perceived emotion through a personality layer that allows for the tutors to express distinct and complementary personalities (e.g. in our case Maria is more understanding and caring, while João is stricter while encouraging).

The interaction with the tutors happens in real time through an interface inspired by the videogame “Oxenfree” (Night School Studio, 2016) using unlocked speech balloons to convey verbal information as well as providing non-verbal and back-channelling information through gaze, nods and animated speech balloons. The animation system controlling the agents, 3Motion [20] is inspired in 3-stages affective expression from principles of traditional animation [21].

We believe our approach is able capture the important elements of empathic behaviour creation: recognizing the student’s affect through the objective and subjective dimensions of the learning experience, integrating a computational model that supports perspective taking and the ability to express emotions and exhibit empathic verbal and non-verbal behaviour, through the interaction and dialog with the two virtual tutors: Maria and João.

5. Future

Customizing and attending individually are two of the essential elements of the elearning pedagogical perspective [22]. The Virtual Tutoring project prioritizes in one of its axes the service to the individualities with information and interaction intervening proactively in different situations of student learning. In this perspective, the artificial intelligence approach is established with its own elements and characteristics insofar as the interaction is valued and intensified. The trend is to facilitate more informative interaction processes that drive learning in virtual environments. It is significant to affirm this convergence of technological elements, artificial intelligence and pedagogical strategies for the contexts of elearning to break down the possible barriers of learning.

The pedagogical model of the Open University [7], permanent in its innovation and creation of solutions, especially in the new learning formats, prioritizes this innovation always thinking about the evolution of the quality of the educative process in elearning for the formation of people. The continuation of the development of projects that prioritize the quality of the interaction and attendance to the individualities of the elearning student is a growing line in the investigations of the area.

6. Acknowledgements

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11Towers. Didactic Geometric Game

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Abstract. 11Towers is the name of a didactic game created by the author. As a game, the essentials are very similar to the very popular "Tic-Tac-Toe" game, but instead of a 2-D square the table is a 3-D tetrahedron. There is a web page showing the different possible games to be played on it, as well as the instructions to get a model, even using recycled materials at zero cost. The participants at the presentation will have the opportunity to play the game in any of the different available structures and difficulty levels.

Keywords. Game, geometry, tetrahedron, tic-tac-toe.

1. Description

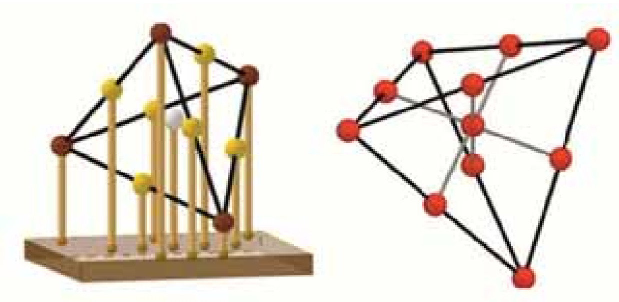

Figure 1. Geometric structure (left) and plane projection (right)

11Towers is the name of a didactic game created by the author. It consists basically in a structure with 11 points corresponding to the 4 vertexes, 6 side centres and the central point of a tetrahedron. The points are placed on their locations by a set of 11 rods or bars placed vertically on a horizontal platform. This is the reason for the game´s name. A set of 11 balls of three different colours can be placed on the tips of the bars to produce different geometric figures like lines, triangles of different shapes, quadrilaterals and even pyramids. This allows students to understand better the properties of these geometric figures.

2. Games

As a game, the essentials are very similar to the very popular "Tic-Tac-Toe" game, but instead of a 2-D square the table is a 3-D tetrahedron. The goal of every player is to be the first one to complete a certain figure. 11Towers can be played in different ways depending on the number of players and the complexity of the geometric figures.

2.1. Geometric figures

There are different games depending on the figure to get in order to win:

- Line
- Equilateral Triangle
- Other triangles (general, rectangular or isosceles)
- Quadrilateral
- Rhombus
- Pyramid

2.2. Types of Games

There are several possibilities to play on the 11Towers, depending on the number of players and the type of game. Two players can play with three or with four balls, to construct either a line or an equilateral triangle (with 3 balls) or a general, isosceles or rectangular triangle with 4 balls, which are also needed to build quadrilaterals, rhombuses or even pyramids.

Three players can compete to be the first to build a line or an equilateral triangle. The competition among three players adds the need to use basic strategies not only to win but also to keep others from winning. The three players can also agree in advance the type of figure each one has to complete to win, in this case the game resembles somehow the competition of gladiators using different weapons.

Four players can play any of the games for two players involving four balls. In this case, there are two pairs of players who share the balls of the same colour, which should be able to identify with a small mark on them. Cooperative games are also possible to play on the 11Towers. In this case, the purpose is not to defeat the adversaries, but to act in a coordinated way to reach a common goal. The goal is to build a set of previously decided geometric figures.

Even solitaires can be played by a single payer, in this case the goal is to take the greatest number of balls out of the rods by jumping over them with another ball. Additional games can be also presented in the future to play with the 11Towers because of its very simple geometric features.

3. Models

There are several possibilities to get a 11Towers game, depending on the visual appearance.as well as on the available budget or resources. A simple photocopy of Figure 1 (right) allows to play the game.

In this case, the game to play consists on the building of a line with three tokens. There are nine possible lines, marked in black on the figure. To play the other games involving more complex geometric figures, the players must have a good spatial vision. This is also a didactic way to get acquainted with the geometric notion of perspective. There is a possibility to build a three-dimensional structure using only recycled materials such as (used) plastic ball-pens and free CD boxes as shown in Figure 2.

Figure 2. Recycled materials (left) and Wooden structure (right)

A better aesthetic appearance can be got using wooden materials (Figure 2). There are several possibilities, from home-made structures to others that should be ordered to a carpenter.

4. On-line

There is a web page [1] showing the different possible games to be played on it, as well as the instructions to get a model, even using recycled materials at zero cost. The original web page [2] is in Galician language.

Figure 3. Week of Sciences

5. Presentation

The game 11Towers has been presented at the 3rd Week of Sciences organized in 2018 by the Ponteareas City Council in Galice (Spain). The principals of the 12 schools from the municipality got a copy of the model in wood. In this way, every student can learn basic geometry while playing with it. During the Week of Sciences, the general public had also the opportunity to know the game and its possibilities (Figure 3). Voluntary students from different schools used the models to present the game and to encourage visitors to learn how to play and effectively trying it by themselves.

The participants at the presentation in the HSCI 2018 Congress will have the opportunity to play the game in any of the different available structures and difficulty levels.

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DNA as Genetic Material: Didactic Experiments and Laboratory Practices

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Abstract. In life, concepts and things which could not see by ourselves are often the most difficult to understand and accept. Genetics is no different. Therefore, some biochemical concepts such as DNA, chromosomes or gens, are not easy to explain in a group of students. A great way to understand such distant concepts is by making the invisible visible, so this work introduces three didactic experiments related to DNA to make genetics a little more "tangible" and also easier to understanding.

These educational exercises, especially two of them, could be easily adapted to any educational level, from primary to high school. Moreover, through of these experiments, teachers could explain diverse relevant concepts about genetic material, which are normally included in the curriculum of science, such as DNA strands, chromosomes, genes, genetically modified organism, etc.

Furthermore, this work would encourage school science teachers to use practical experiments as pedagogical tools to consolidate and integrate the knowledge that students receive in theoretical classes.

Additionally, these laboratory experiments allow science teachers to introduce their students into the world of both chemistry and biology and also increase their interest in these sciences.

Keywords. Bacterial transformation, DNA extraction, educational experiments and pedagogical tools.

1. Introduction

Genetic information has been passed down and also refined for billions of years from parents to sons in all living beings. In fact, genetic material that contains cells regulates all life processes and procreative functions. There is an extreme multiplicity of life-forms around us, and even a simple unicellular organism is much more complex and purposefully designed than anything that human inventiveness could produce.

The human cell count in a body could get up to roughly 37.2 trillion cells, constantly doing work and then dying and being replaced with other cells to do that same work [1]. Most of those cells have a nucleus and in that nucleus is where DNA is found.

DNA is the macromolecule that carries all genetic information in the format of strings upon strings of genes. It is packed into structures called chromosomes. Humans have 46 chromosomes split up into 23 pairs; half from each parent [1].

It is worthy to mention that the emotional, behavioural, visual and all other differences between a person and another one else on Earth could be due to a slight variation in portions of DNA.

DNA is usually visualized as an elegant "twisted ladder" shape because it is how DNA is represented in not only Biology textbooks but also in advertising logos. This visual is actually a kind of artist's conception. It is a type of scientific model, useful in helping us understand how DNA functions, but in reality impossible to see. Moreover, students commonly bring ideas of genetics from 'folklore': ways in which families describe what and how certain characteristics are inherited. Their ideas could be further confused via popular reporting of genetics in the media. Thus, students have an abstract concept of DNA and many times find it difficult to understand. A fantastic way to understand such distant concepts is by making the invisible visible. Therefore, this work introduces three didactic experiments to make genetics and DNA a little more tangibles.

Moreover, didactic experiments are an effective pedagogical tool to offer evidence-based science instruction to students, and, at the same time, students could consolidate and integrate the knowledge received in theoretical classes and, besides, they could acquire a wide and profound theoretical knowledge base [2-6].

On top of that, there is growing interest among most scientist, science educators and

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teacher community to include practical lessons and laboratory experiments as active learning approaches, which allow students to observe the chemical properties by themselves, and even doing these didactic experiments in groups in order to discuss them in a pleasant atmosphere [7-10].

2. Strawberry DNA Extraction

This didactic experiment literally pulls the DNA out of strawberries. This practical could be performed using any vegetable (for instance, onions, beans, broccoli or spinach), sheets from several plants and also from chicken liver. In the case of strawberries, they are 'octoploid' which means they have eight copies of each chromosome, unlike humans who only got two copies of each one (diploid). Strawberries have more DNA than most other fruits.

2.1. Material

- Fruit (softer fruit works better)
- Water
- Clear dish soap
- Ice cold rubbing alcohol (at least 70%)
- Salt
- Coffee filter
- Toothpicks
- Clear glasses

2.2. Experimental Part

In this experiment rubbing alcohol (isopropyl alcohol or ethanol) has to be very cold so it could be keep in the freezer (at least 30 minutes before performing the experiment). 2-3 strawberries are cut in small pieces and placed in glass. Later the pieces of fruit are mashed into pulp with the help of a spoon because crushing them physically breaks apart the cell walls. Next, 1/2 cup of water with a bit of salt is added into the strawberry pulp. Later, 2 tsp. (teaspoons) of dish soap is added to the aqueous mixture that should be carefully mixed without making bubbles (Figure 1A).

After the cell walls have been disrupted during mechanical mashing of the fruit, the dish soap disrupts both the fruit cell and nuclear membranes because it dissolves lipids and proteins that hold the membranes together. This causes that the DNA could be released in the salt water. The salt has 3 functions in this experiment. Firstly, salt neutralizes the negative charges on the DNA and thus enables the DNA strands to stick together. Secondly, salt prevents that proteins could bind to DNA strands and degrade them (especially DNA proteases). Thirdly, salt also causes the precipitation of proteins and carbohydrates.

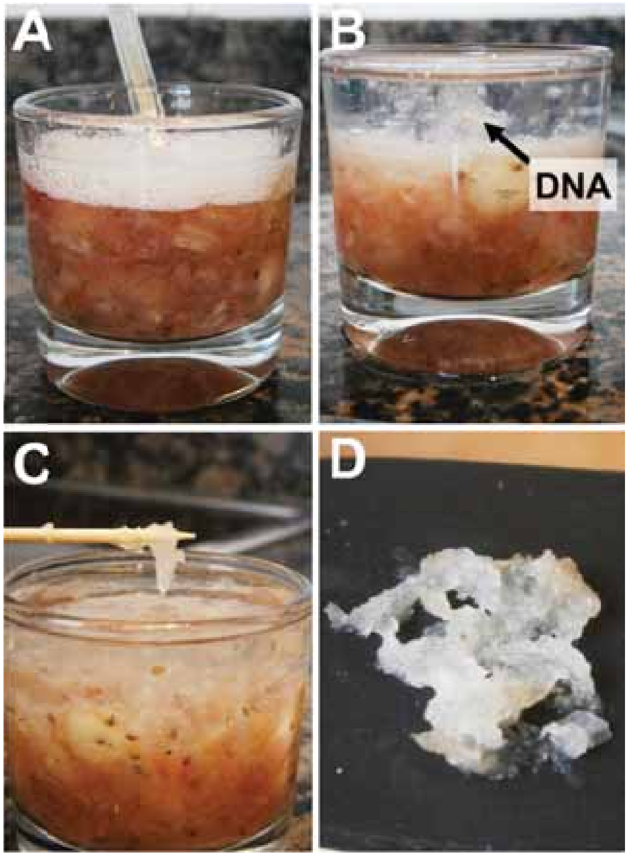

Figure 1. Strawberry DNA Extraction. (A) Strawberry pulp with salt water and dish soap is left to sit for 15 minutes. (B) Cold rubbing alcohol is carefully added to the fruit mixture to pull DNA from the juice in stringy white strands. (C) DNA strands could be removed with toothpicks. (D) Dried fibres of strawberry DNA

This experiment works best if the mixture is left to sit to react for fifteen minutes. In order to see more easily the DNA fibres, it is recommended to filter the mixture with a coffee filter. The juice is kept in a new glass and the rest of the fruit could be thrown away. Finally, 1/2 cup of cold rubbing alcohol is poured slowly down the side of the glass of the juice, allowing it to rest on top of the strawberry mixture and trying not to mix it. The alcohol forms a layer on top of the juice. Everything except the DNA is dissolved in isopropyl alcohol or ethanol. The alcohol pulls the DNA from the juice in stringy white strands (Figure 1B) because DNA molecules collapse in on themselves and precipitate. The DNA becomes visible as white mucous strands. They could be removed with toothpicks (Figure 1C) and even stored in a container full of alcohol. Therefore, millions of tiny strands of DNA from strawberries are extracted. If DNA strands are dried at room temperature, it is easily to observe that they are fibres (Figure 1D).

It is important to indicate that the colder the alcohol is, the greater the amount of DNA that is precipitated, because the extraction is best when the mixture is cold. There are proteins present in the cell's cytoplasm, such as DNases (also called restriction enzymes), which destroy DNA strands. The DNase proteins are there to protect the cell from invasion by viruses. Once the nuclear membrane is destroyed by the dish soap, the DNA is now susceptible to the DNases and could quickly be degraded. However, these enzymes are temperature sensitive and cooling the solution slows down the process of degradation.

3. Human DNA Extraction

This experiment allows students to get an inside look at themselves.

3.1. Material

- Water
- Clear dish soap
- Salt
- Ice cold rubbing alcohol (at least 70%)
- Clear cups
- Toothpicks

3.2. Experimental Part

1/4 tbsp (tablespoon) of salt is added in 100 mL of water that are into a cup. The mixture has to be stirred until all the salt is dissolved. The salt water is gargled for approximately 1-2 minutes and spited back into the cup. Before gargling the salt water, it is better to swallow saliva. Cheek cells are harvested. The greatest amount of harvesting cheek cells is after eating some food. 2 tsp. (teaspoons) of dish soap is added into the liquid which has previously been gargled. The dish soap breaks down both the cell and nuclear membranes and frees the DNA. The mixture is left to sit to react for 15-20 minutes (Figure 2A).

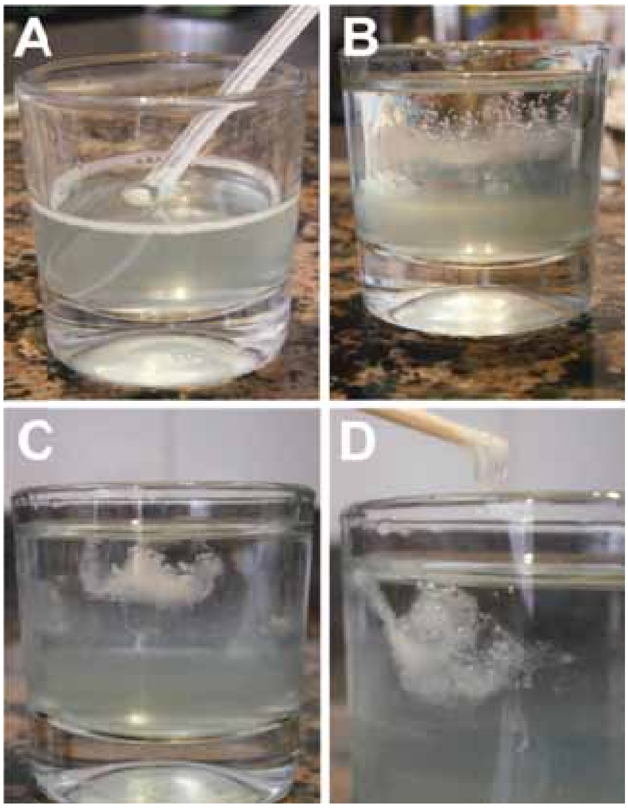

Figure 2. Extraction of Human DNA. (A) Dish soap is carefully added to salt water which has previously been gargled. (B) After adding the cold alcohol, white clumps and strings start to form in the interface, between the two layers. (C) DNA molecules are observed as white mucous strands. (D) DNA strands could be remove with toothpicks so that students could examine their own DNA

Next, cold rubbing alcohol is carefully added pouring it slowly down the side of the cup, taking care to avoid mixing the two layers (Figure 2B).

After allowing the new mixture to sit for approximately 3-4 minutes, white clumps and strings start to form. DNA molecules could be observed as white mucous strands (Figure 2C). Students could examine their own DNA and removed it with toothpicks to get a close-up look at the building blocks of their bodies (Figure 2D).

All theoretical explanations about the use of the products or ingredients in this experiment are described above in the section *Strawberry DNA Extraction*.

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It should point out that when students gargle the salt water, they are collecting not only cheek cells but also bacterial cells from the inside of their mouths. Thus, the DNA extracted is a mixture of human DNA and bacterial DNA.

4. Transformation of *E. coli* with a plasmid that encodes GFP protein

At the end of this practice, students could produce genetically modified organism (GMO), more concretely genetically modified bacteria. GMOs are organisms whose genome has been engineered in the laboratory to favour either the production of desired biological products or the expression of desired physiological traits. On one hand, in agriculture and livestock, especially in crop farming, and even pet breeding, certain individuals of a species are selected to breed to produce offspring that have desirable traits. Additionally, soy, corn or other crops also grown from seeds with genetically engineered DNA. On the other hand, GMOs could be obtained by genetic modification. These organisms are produced using recombinant genetic technologies. Genomes of these GMOs have been precisely altered at molecular level by the inclusion of genes from unrelated species of organism that code for traits that would not be obtained easily through conventional selective breeding. Genetically modified bacteria were the first organisms to be genetically modified in the laboratory because of their simple genetics [11]. Moreover, bacteria have other important advantages, for instance, they are haploid, new generations are produced every 20 minutes, they are easy to grow in high quantity and individual members of these large populations are genetically identical.

Concretely, genetically modified bacteria are produced through using scientific methods such as recombinant DNA technology that involves the insertion of one or more individual gens from an organism of one species into the DNA of another. There are 3 types of genetic transfer found in bacterial: transformation (bacteria can take up externally provided DNA by chemical method or electroporation), conjugation (DNA is transferred from one bacteria cell to another via “sex pilli”) and transduction (DNA is introduced into bacterial by injection from a bacteriophage). Genetically modified bacteria are used for several purposes such as the leaching of copper from ore [12], cleaning up mercury pollution [13] or detecting arsenic in drink water [14] but they are particularly important in producing large amounts of pure human proteins for use in medicine [15].

GMOs produced through genetic technologies have become an essential part of everyday human life, entering into society through medicine, research, environmental management but especially agriculture.

In this practice, *Escherichia coli* bacteria is transformed with a plasmid, called pGLO, that encodes green fluorescence (GFP) protein and gives resistance to ampicillin antibiotic. Plasmid is a circular DNA that carries a bacterial origin replication, foreign protein gene and an antibiotic resistance gene for use as a selectable marker in bacteria. Concretely, the pGLO plasmid contains an origin or replication (ori), a selectable marker (bla that is the gene that codes for β-lactamase, and is the selectable drug-resistant marker for the plasmid), the gene for Green Fluorescent Protein, araC (the gene coding for the arabinose C protein which is a protein that regulates expression from the arabinose BAD promoter), and BAD promoter (P_{BAD}) (Figure 3).

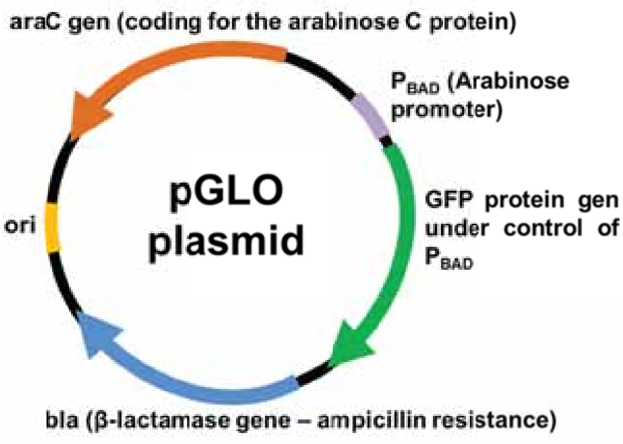


Figure 3. Scheme of the pGLO plasmid with its relevant parts

GFP protein is composed of 238 amino acid residues (26.9 kDa) and exhibits bright green fluorescence when exposed to light in the blue to ultraviolet range [16-17]. Scientists use GFP protein as a reporter of expression. In other words, GFP protein is used to make biosensors. Many organism have been created that express GFP, which demonstrates a proof of concept that a gene can be expressed throughout a given organism, in selected organs, or in cells of interest [18].

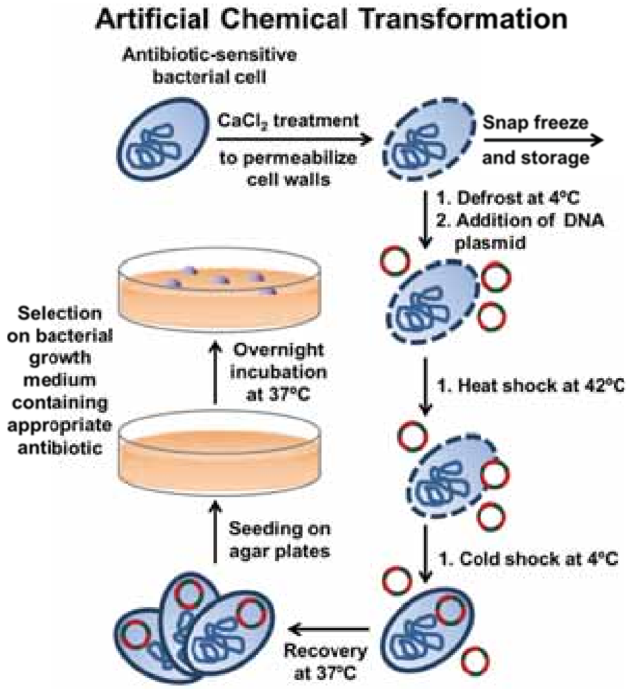
E. coli bacteria strains, which are used for transformation, are genetically modified to produce bacterial cells that can be more easily transformed and that will help to maintain the plasmid inside the bacteria. Moreover, specific treatments, such as CaCl2 treatment, increase the transformation efficiency and make bacteria more susceptible to transformation, generating cells that are commonly referred to as "competent cells".

4.1. Material

- Competent cells
- Plasmid that encodes GFP gene and gives ampicillin resistance (pGLO plasmid)
- Luria-Bertani (LB) media
- LB agar plates (10 cm of diameter) with ampicillin antibiotic (100 µg/mL)
- Arabinose solution of 4% w/v
- Incubator at 37 °C
- Water bath at 42 °C
- Ice bucket filled with ice
- Microcentrifuge tubes
- Sterile spreading device
- UV lamp

4.2. Experimental Part

It is necessary to remind that during all the experiment students have to wear laboratory coats, laboratory gloves and avoid touching their faces or clothes with their hands or with any material and product used in this practice. Competent cells are taken out of -80°C and thawed on ice (during 30 min). Agar plates that contain ampicillin (100 µg/mL) are storage at 4°C. Therefore, 2 plates per practice are warmed up to room temperature. In one of the agar plates, 1 mL of arabinose solution (4% w/v) is added and speared using some sterile spreading device. Later both agar plates are incubated in 37°C incubator. 1-5 µL of plasmid DNA (10-100 ng) are added into 20-50µL of competent cells in a microcentrifuge tube. The mixture is gently mix by flicking the bottom of the tube with one finger a few times and, later, is incubated on ice for 30 min. After this time, the mixture is heat shocked by placing the tube into a 42°C water bath for 45 secs. Tube is put back on ice for 2 min. 600 µL of LB media (without antibiotic) is added to the bacterial mixture and grow in 37°C incubator for 45 min (it is better to shake the sample during the incubation). 300 µL of transformation sample is plated onto LB agar plate containing ampicillin and arabinose and the other 300 µL of transformation sample is plated onto another LB agar plate that only contains ampicillin. Both plates are incubated at 37°C overnight (Scheme 1).



Scheme 1. Chemical transformation of *E. coli* competent cells with a DNA plasmid

The day after, colonies of bacteria could be observed in the surfaces of both plates. Only cells that contain the plasmid are able to grow, divide and form colonies. After 2 days of incubation, colonies are enough big to be easily observed with the naked eye (Figures 4A and 4B).

Both plates could be observed under ultraviolet light (Figures 4C and 4D). Only the colonies of the plate that contains arabinose are overexpressing GFP protein and, thus, they exhibit bright green fluorescence (Figure 4D). Arabinose is a sugar that induces the P_{BAD}

promoter. The plasmid used in this practice is the pGLO plasmid that contains GFP gen under the control of the P_{BAD} promoter, allowing GFP protein production to be induced by arabinose (Figure 4).

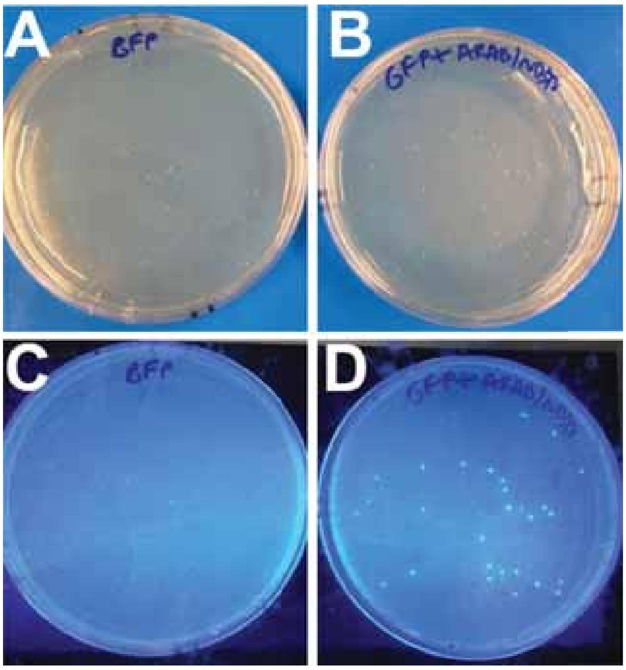


Figure 4. Agar plate with ampicillin (A) and agar plate with both ampicillin and arabinose (B) which have colonies of bacteria that contain the plasmid. Under ultra-violet light, colonies of agar plate with ampicillin are not practically observed (C) but colonies of agar plate with both ampicillin and arabinose are overexpressing GFP protein and exhibit bright green fluorescence

5. Conclusions

These experiments can be related, according to educational level, with: DNA, genetic material and genetically modified organisms. Moreover, the experiments titled "*Strawberry DNA Extraction*" and "*Human DNA Extraction*" can be done using both basic equipment and chemicals found in a normal laboratory, helping science teachers perform experiments that have all the characteristics of excellent classroom demonstrations because of their high degree of safety, ready availability of materials, visual interest and relative simplicity. The experiment titled "*Transformation of* E. coli *with a plasmid that encodes GFP protein*" is only recommended to be performed by high school students (16-18 year old). Furthermore, through this last practice, science teachers could demonstrate to students the importance of using safety personnel equipment and useful information on substance safe handling.

The benefits of using practical experiments as educational tools are diverse [2-6]. When science teacher explain experiments and help students to perform them, students improve their understanding of theoretical knowledge through experimentation and also gain confidence in their abilities [19-21]. Moreover, experiments become clear for students because scientific concepts and techniques are gradually introduced by their teachers.

On the other hand, an excellent way that science teachers have to increase knowledge of chemistry and biology among students is to include educational practice in their routine.

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Inquiry Based Science Education in National Technical University "Kharkiv Polytechnic Institute" as a Way to Increase the Popularity of Natural and Technical Sciences

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Abstract. The article analyses the problem of reducing the rating of natural sciences in youth. Possible options for solving this issue are considered. Based on the experience of young scientists of the National Technical University "Kharkiv Polytechnic Institute" (NTU KhPI), it is indicated on perspective directions of interaction between higher education and secondary school in order to increase the popularity of natural and technical sciences. One of the points of contact can be the foundation of a creative space for children, which will be the focus of STEM education, and promote a positive image of the natural and technical sciences.

Keywords. IBSE, NTU "KhPI", natural science, technical science, STEM education.

1. Introduction

In Ukraine, for several years now, there has been a system of admission to higher education institutions based on the results of an external independent assessment – a kind of a single state examination system. Taking into account that uniform requirements are applied to all entrants within the country, it is easy to use the test results as a relevant indicator for assessing the popularity of a particular profession or specialty.

For instance, in 2017, similar studies were conducted in the analytical centre of CEDOS [1]. Unfortunately, the conclusions are disappointing. Many technical specialties are not very popular among applicants. Thus, according to research, applicants who entered mechanical and electrical engineering in 2016 on average demonstrated one of the least levels of knowledge in the main subject field (in average amount of universities it was mathematics). That is, we personally witness a dilemma when students with low balls enter complicated and important for innovative development of the country's specialties.

Such a picture is not observed in all technical professions. For example, a degree in IT and biotechnology, on the contrary showed the highest exam results with mathematics. But IT specialties are now at the peak of popularity in Ukraine. Therefore, they among exceptions, which only confirms the rule, and detaches from the already “poor” engineering and technological specialties top-level school-leavers.

Naturally, each branch of knowledge has motivated entrants, with high rates of entrance examinations. But in general, the “average temperature in the hospital” is not comforting. Competition for most technical and natural specialties sciences is relatively low. What has been said above demonstrates the rapid decline in the rating of natural and technical sciences among young people. And this situation is quite usual not only in Ukraine, but also in the global context.

2. Heating up

Looking at the deteriorating positions of natural and technical sciences among those entering higher technical institutions, many faculties and departments of NTU “KhPI” began to gradually develop in the direction of career guidance for secondary school pupils. However, in most cases, the successes of these works were insignificant. In general, some of the chemical departments succeeded, on which interesting popular science programs were developed. Those were the combination of educational meet-ups with labs and “show” elements. Most of the events did not have a systematic nature. A turning point occurred after the opening in the university of a Space for children and young people creative development, that’s called “The Space of Ideas: Science & Museums / Arsenal of Ideas Ukraine“.

3. The Space of Ideas: Science & Museums

In 2013, a project of an inclusive educational space for children under the name “Arsenal of Ideas” arose in “Arsenal of Arts” (Kyiv, Ukraine). In 2017 it was decided to expand the project to the regions of Ukraine. Young scientists of NTU “KhPI” actively supported this idea. As a result of successful cooperation of both institutions, Kharkiv became the first regional city where a new creative space was opened. It was created on the basis of NTU “KhPI”. Later, similar locations were organized in Melitopol and Lviv. The main slogan of the space was “Accessibility. Equality. Inclusiveness“. The space was oriented to the leisure time of school-age children, and wholly adapted for children with disabilities. It included permanent interactive installations (like Sensoricum, Uncontrolled Painting), developing games (Kinetic sand, various of constructors), materials for creativity, several interactive lectures, etc.

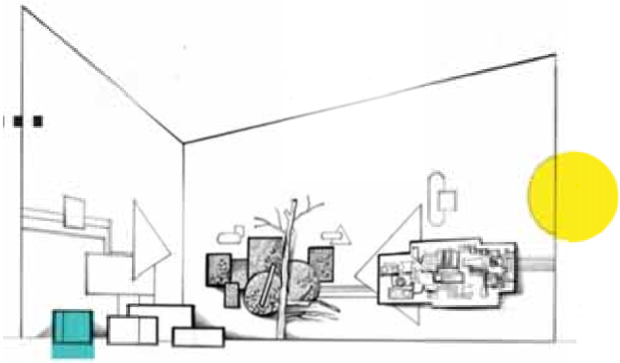

Figure 1. «Scetch of The “Space of Ideas: Science & Museums / Arsenal of Ideas Ukraine”»

It was assumed that “The Space of Ideas: Scince & Museums“ will become an interactive platform for joint learning and family intellectual pastime. Indeed, after the opening, which took place on September 7, 2017, there was a surge of visitors. Unfortunately, within a month the flow began to dry out.

One of the reasons why the original idea did not work, we see in that, in essential differences from the space that was in the Kiev Arsenal of Arts. Original “Arsenal of Ideas” covers an area more than 1000 square meters and has a significant amount of entertainment installations. Despite the fact that the space in Kiev also began its history in a relatively small room, it was established in the exhibition gallery with a significant flow of people, which provided a sufficient audience.

The space in NTU “KhPI” was only about 75 square meters. In addition, the location in the higher technical educational institution imposed its limitations: the students are already too old to attend such kind of the educational places. At the same time, they were too young for to be interested in the location like in the space for family leisure. The reasons mentioned did not allow the original concept to stay alive. It is demanded an immediate rethinking.

Figure 2. «Lecture in “The Space of Ideas: Science & Museums”»

Figure 3. «Meet Up: Edible Chemistry»

4. Holidays with “Polytech and Arsenal of Ideas”

The idea of possible solution to the imminent failure was brought by the approaching traditional autumn holidays in first and secondary schools. We communicate with quite big amount representatives of the scientific and educational departments of the university and received a significant number of agreements to participate in the creation of a non-stop weekly popular science lecture with the integration of workshops and masterclasses that would be based on the principles of STEM education.

Fortunately, the authors of the article, which were the initiators of the idea, already had a certain experience of holding similar events, as well as various developments for scientific and

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popular events. In our practice we also used some methodologies from world-wide practices [2-4].

Figure 4. STEM projects that appeared within the NTU "KhPI" and aimed to the increase of the Natural and Technical Sciences popularization

In general, during the 7 days (October 23 - October 29, 2017), 25 events were held with a total of 470 visitors. It was more than for the whole previous month. And it was the beginning.

5. Conclusions

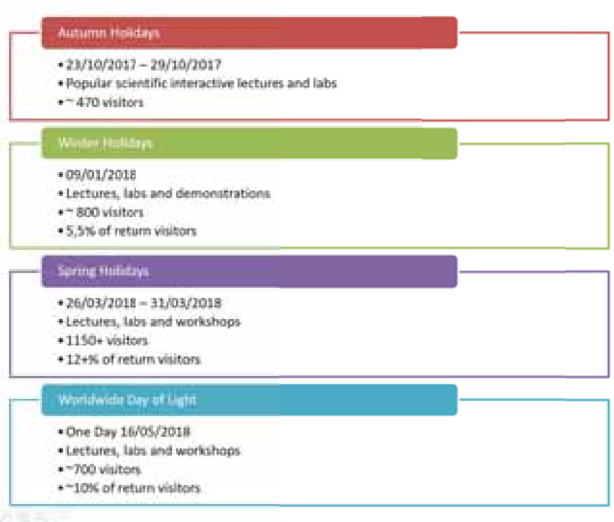

Figure 5. Analytical Data

Subsequent activities have shown that such a format works perfectly, as an opportunity to popularize technical sciences among young people. "The Space of Ideas: Science & Museums", has become a catalyst for active action in this direction. In addition, it allowed to coordinate the work of individuals and to give them a system.

During October 2017 - May 2018, 7 large-scale events were held, as well as a significant number of single small events. At the same time, it has been a positive trend in terms of total number of visitors as well as in the number of repeated visits.

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Assessing Learner Motivation and Academic Performance by Developing a Teaching Unit Using Roleplay-Based Gamification

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Abstract. This article presents a gamification experiment for a Year 1 Baccalaureate Teaching Unit in Physics and Chemistry. It seeks improved learning based on team work that has been optimized by using an interactive roleplay computer game. The methodology employed is compared with a control group for analysis. The results obtained for a small sample are similar to those found in the literature.

Keywords. Experimental science teaching gamification, game-based learning.

1. Introduction

There are many studies indicating that baccalaureate and secondary school pupils tend to reject STEM subjects. In the main, they find them authoritarian, boring, difficult, irrelevant to daily life and feel they are a cause of environmental problems, although it also true that they value the achievements that can be made by Science and Technology [1]. The fact is that most pupils do not opt for scientific or technological training at university level. It would appear to be around the age of 12 when a change takes place in their perception and pupils lose their interest in STEM—more noticeably among female learners [2]—which coincides with the move from primary to secondary education [3]. Several reasons for this have been analyzed and suggested causes include a lack of experimental work, the repetitive nature of the subject matter, and too much time spent practising for final exams [2]. ICTs, on the other hand, are at the top of the list when it comes to entertainment and education among this age group [4].

So the decision was taken to investigate how a change in methodology—one that gave ICTs a leading role and provided learners with access to them—could improve academic performance, some specific competences and learner satisfaction in a Teaching Unit (TU), by using gamification at the motivating factor.

Gamification is a relatively new term that is defined as “the application of game metaphores to real-life tasks in order to influence behaviour, improve motivation and increase commitment” [5], thus fostering three major aspects of personal development [6]: cognitive, emotional and social.

However, Game-Based-Learning (GBL), which is linked to some extent to gamification, is not a new concept as it has often been employed in infant education. However, as a child progresses through their education, GBL fades away to be replaced by a more serious and “cold” method, which leaves behind one of the learner’s main motivators: fun.

This work uses an interactive roleplay videogame as its gamification element in a TU for 1st year Baccalaureate Physics and Chemistry. Computer game players are usually persistent, take on risks and pay attention to details, all of which are are potentially recommendable ways of behaving at school [7] and can lead to many benefits, particularly among teenagers [8-9]:

- Cognitive: they develop attention, spatial awareness and mental processing such as in “Halo4” or “Grand Theft Auto IV”.
- Motivational: they give immediate, specific feedback, such as in “Clash of Clans” or “Candy Crush”.
- Emotional: they improve mood, and can relax and calm anxiety such as in “Angry Birds” or “Bejeweled II”.
- Social: they develop skills for belonging to a community and decision-making to favour the group such as in “World of Warcraft” or “Farmville”.

When it came to choosing a type of videogame to complement the TU methodology, it was decided that it should have some degree of complexity and a high level of social benefit because it was going to be used by pupils aged 16-17 in order to develop competences associated with team work and foster the learning of related concepts.

The games that meet such an aim are Shooter, Strategy or Massive Multiplayer Online Role-Playing Games (MMORPG). From this last group the “Classcraft” [10] software

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was chosen as an educational MORPG. It is multi-player but not massive as it only has a few players compared to the hundreds of thousands that typically play an MMORPG.

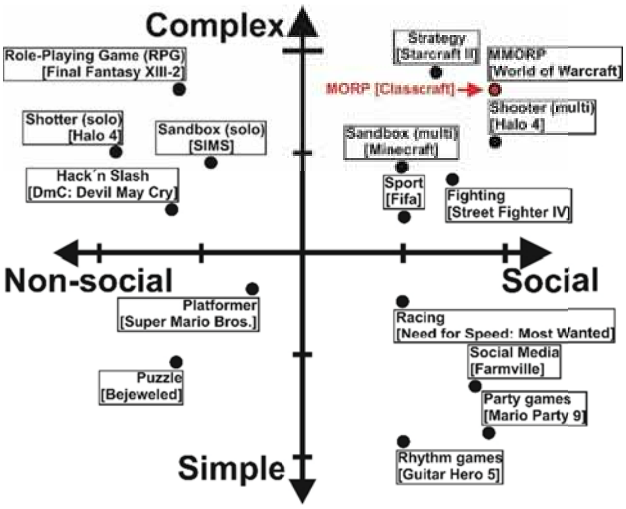

Figure 1. Chart showing the main computer game genres (with examples) organised along two major dimensions: complexity level (up and down) and interaction (left and right) (adapted from [8]). The game used is at the top/right

Thanks to the use of “Classcraft”, the pupils will be working throughout the whole TU in a team, as it is played in groups of four people and each person’s work is vital for the team to reach its goals. This will allow each member to develop their competences and define themselves as part of a complete group that is capable of carrying out the work. For example, while one team member is in charge of searching for information, another could be in charge of preparing how to communicate it, and another could act as leader. This would allow each one to develop what they are good at as part of a team.

The basic objectives established for this research was to assess the efficacy of gamification by means of a MORPG and detect the degree of improvement in academic performance caused by this change in methodology.

2. What is “Classcraft”?

“Classcraft” [10] is an free-to-access online educational platform that lets both teachers and learners take part in a MORPG that is developed simultaneously in the classroom.

“Classcraft” does not teach any curriculum contents – it is not contents development software like “Spore” [11], “Hakitzu” [12], or the fantastic “Anatomy”, “Chemistry”, “Geometry”, “Plants” or “Solar Sistem” by Arloon [13]. However, it does provide substantial help when developing the following core competences:

- linguistic communication: team members must communicate constantly with each other;
- mathematics and other science and technology basics: what defines a player and their abilities is based on points which must be managed critically.;
- learning to learn: it fosters curiosity and the motivation for individual learning.
- digital: it is based on an environment that uses ICT resources;
- social and civic: teamwork is fundamental, each team member collaborates in order to obtain a good result.

“Classcraft” is a tool that makes it possible to change how the classroom is run. By using it, each participant can take on a role in an interactive game between the teacher and the learners. The participant takes on a new identity and nothing that has happened previously is taken into account once they have a new persona. The player chooses their character according to their personality, and their new role enables them to exploit their strengths and hide their weaknesses.

In our case, the advantage of “Classcraft” as a gamifying element compared to others such as “Class Dojo” [14] lies in several factors: the level of maturity needed for the school year it is being developed with; a very appealing interface; a high degree of personalisation as the abilities, sentences and experience needed to go up a level are edited by the teacher; it takes up little class time; it is free.

The mechanics of the game, inherited from “World of Warcraft”, the MMORPG it is based on, is typical of any RPG. Each action considered as positive provides experience points (XP), which allow the learners to rise to the next level and gain power points so that they can acquire powers. Actions considered as negative takes away health points (HP) and are considered as attacks for the purposes of gamification, if they drop to zero the character or the whole group must carry out one of the "sentences" that the teacher has already established. In order to obtain powers, the players need ability points (AP) that are the characteristics of each persona. On going up a level, participants acquire gold points (GP), which let them acquire new accessories for each character.

The teachers manage the software and are in charge of designing the game, establishing the powers, the sentences and the XPs needed to move up a level. They assign the XPs to each player during the session – and take away the HPs. The teachers also have the job of driving the dynamics of the game and presenting it. That is, they are the equivalent of the Game Master is any RPG and their role in developing the effectiveness of the "Classcraft" game is key [15].

There are three types of character in "Classcraft", each with clearly different abilities. Each participant must choose one of them and they cannot change them during the game. The warriors have a high HP score, which makes them ideal for people who tend towards negative behaviour, and a low AP score, which stops them from using too many skills. Mages have very few HPs and are ideal for people who are normally well behaved. They have a lot of APs, so they can use a lot of skills. Healers have a mid-range score for both HP and AP and specific skills for healing. According to [16] the choice of character is determined by the participant's personality, so it is advisable (although not compulsory) to let the participants themselves choose the character they will play during the game, given that there are no pure profiles. If the teacher chooses, then it could be more complex and, in many cases, unsuitable.

There are four player types [17]:

- Competitor: Their aim is to complete levels and achieve goals that make them stand out.
- Explorer: Their aim is to discover the game's contents.
- Socializer: Their aim is to progress through the game in a collaborative way.
- Assassin: Their aim is to impose their will, even at the cost of all the others.

The player types are not pure ones because a user can present some of the features of each one [16]. Thus, 80% of people have characterists shared with the Socializer, 50% with the Explorer, 40% with the Competitor and 20% with the Assassin. However, only the competitor and explorer profiles are useful in the game [18]. This is due to the fact that someone with a more competitive profile will try at all costs to complete the game just for the sake of completing it. The person whose profile is more explorative will attempt to develop their character as much as possible and squeeze all they can out of it. Someone with a more socializing character will try to collaborate with the other participants, but may possibly not finish the game successfully. As for the Assassin, there is nothing in the game to provide a purpose that could motivate playing it.

3. Methodology

There is an initial test of previously covered ideas [19] on nomenclature in Organic Chemistry, adapted so that the starting point of the TU can be established. Then "Classcraft" is presented to the pupils of Group B. They are explained what the game comprises, how to use it and they are given registration sheets so that they can enter and create working teams. From this point on, "Classcraft" is initiated at the start of each session, for the first five minutes, in order to give an overview of the players/teams' situation.

The teacher gives a lecture to explain the priorities of functional groups when it comes to formulating organic compounds and then resolves exercises on formulation.

The four-member groups must write a document on a randomly chosen functional group. The document must reflect the characteristics of each group: physical and chemical properties, reactivity, nomenclature and examples from everyday life containing the compounds. A rubric is used for assessment. According to the curriculum, 6 groups are established in the subject: Alkanes, Alkenes and Alkynes (AAA); Alcohols and Ethers (AE); Aldehydes and Ketones (AC), Carboxylic acids and Esters (AcE); Amines and Amides (AA); and Carbon (C).

After that, the teacher chooses one person at random from each group to present their work on functional groups to the rest of the class. After the presentation the teacher and the other pupils have a short period to ask questions.

In order to quantify the improvement, results from the beginning and end of the TU are compared by means of the assessment test mentioned above [19] in the sixth and final TU session. Additonally, a satisfaction survey will be analyzed to assess the TU's qualitative aspects such as the level of satisfaction, materials used and performance. Finally, there will be a quiz on more advanced nomenclature exercises using online assessment the teacher has prepared on Kahoot! [20].

4. Gamification management

Once they are participating in the game the pupils in control group B receive a rules sheet that explains which actions increase XPs and which ones decrease HPs, what powers they have in each class, and how to gain Ability Points or Gold Points.

Given the TU's short duration (6 sessions), a large number of experience points were awarded, whereas the number needed to go up a level was very low.

After finishing the first level, all the pupils were given their first 100 XP for good behaviour and showing interest, this let them climb to level 2 and acquire a Power Point to gain a new skill.

During the second session, one person (a warrior) used their hunting skill to eat sweets during the class. Their good behaviour once again earned them 100 XP each at the end of the session, which allowed them to reach level 3 and gain a new power.

In the third session, two warriors used the hunting skill to eat during the class. The teams that handed in their work on functional groups on time were given 100XP, whereas the teams that missed the deadline were only given 30 XP. No team failed to hand in the work.

During the fourth session, when the assignments had to be presented, the people who did the presentation were given a 20-XP bonus. Any pupil actively taking part in the presentation with questions was given 60 extra XPs afterwards.

During the fifth session, when exercises were done, any pupil correctly resolving a formulation and nomenclature exercise on the class board was given 100 XPs.

Two days before assessment day, they were sent a "pre-exam encouragement potion" which gave the last 100 XPs needed by anyone who had already obtained all the points to reach the top level and unblock the most advanced abilities.

By the final session there were three level-nine mages, four level-11 mages, two level-9 warriors, six level-11 warriors, two level-9 healers and five level-11 healers.

The level-9 mages did not use any power, whereas the level-11 ones used "clairevoyance", which meant all the team members received a clue to a question in the Kahoot! quiz.

The level-9 warriors used the "counterattack" power, which allowed them to have a clue for a Kahoot! quiz question, whereas the level-11 ones had the secret weapon power, which allowed them to use a sheet of notes provided by the teacher.

Level-9 healers had the "ardent faith" power, which let them know whether an answer to a Kahoot! quiz question [20] was correct or not, while the level-11 healers used the "prayer" power which let them use their notes during the Kahoot! quiz.

5. Results and discussion

The individual learning results were obtained as the arithmetical mean between the group work, the post-test and the Kahoot! quiz. In this way the team members were co-responsible for the work they undertook. The assignment was assessed using a rubric and the multiple choice test was assessed by using the equation:

$$Mark_{10} = \left(Nº\ Correct\ answers - \frac{Nº\ Incorrect\ answers}{Nº\ Items-1}\right)\frac{10}{Nº\ Questions} \quad (1)$$

As for the work carried out, the average mark was 7.00 in Group A and 7.86 in Group B. Figure 2 shows how, in general, except for the work on carbon, the marks are better in the control Group B. As for the test on prior notions, it is worth noting that there was improvement in both cases compared to the initial TU pre-test, with an improvement of 0.39 in group A and 0.49 in group B. It was the same for normalized learning gain [21] or Hake gain [22], defined by the Equation (2):

$$g = \frac{\%Post-test-\%Pre-test}{100-\%Pre-test} \quad (2)$$

considering that *g* is high if it greater than 0.7; medium if *g* is between 0.3 and 0.7; and low if *g* is below 0.3. In our case, the gain was 0.39 in group A and 0.42 in group B.

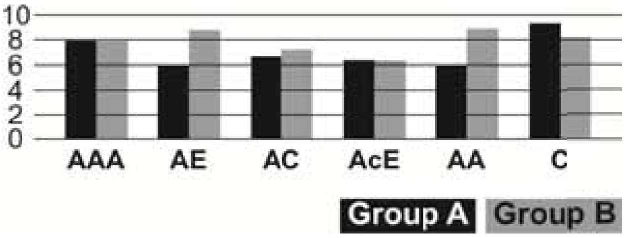

Figure 2. Mark obtained in the work on functional groups

Likewise, to evaluate perception and satisfaction of the pupils, a Likert-style questionnaire (on a 0 to 5 scale) was applied to each group during the last class session on post-TU satisfaction (adapted from [23]).

Regarding the aspects that influence satisfaction in the student (importance of the contents, methodology, infrastructure, teacher/pupil performance), no significant changes have been detected between the groups, with an average evaluation of 4.0 for group A and 4.6 for group B, although both state that the methodology and the performance of the teachers are both key to developing the TU successfully.

The results concerning the contents of the TU and the degree of fulfilment clearly show that the control group (3.1 compared to 2.9 in group A) met the objectives more closely and understood both the contents and the teaching material. Furthermore, this group considers the contents of the TU more relevant and more applicable in the syllabus. Despite all this, both groups agreed that more sessions would be needed to reach a greater degree of understanding of the TU.

By analyzing the responses regarding the effect of the activities and the teaching materials used (assignments, laboratory practical sessions and tasks, notebooks and exercise books, class discussions, audiovisual material, bibliography, etc.), it can be concluded that they were more useful for group B (3.5) than for group A (2.9), which was also true for the audiovisual material they developed.

As far as the section on teacher performance is concerned, group B (4.6 compared to 4.1 on average for group A) states that the teacher showed more knowledge and mastery of the subject, promoted discussion and dialogue that enriched the subjects, responded adequately to questions and kept the group interested and focused on the TU subjects, and made better use of the time than for group A. This could be interpreted as being the result of the MORPG constantly fostering in Group B the dynamics of participation, motivation and a pleasant working environment, which led to more dialogue and more questions. Thus, for example, when asked "if you could choose, would you do another TU with the same teacher?", 94% of group B said they would, compared to 70% in group A.

In terms of pupil performance, the evaluation of both groups is similar (3.9 in group A and 4.2 in group B). Only group B had the perception of having made better use of the effective class time and using ICTs more.

Finally, the pupils in Group B were given a questionnaire on the MORPG methodology, the results from which show (with margins between 85 and 100% of affirmative responses) that it motivated their learning (4.2); improved team work skills (4.3), as they formed part of a group in which the rewards for one person often favoured the whole group; they would like to apply it on a regular basis (4.6); they had fun (4.7); they liked it (4.8); and, above all, it improved the atmosphere in class (4.9).

6. Conclusions

After carrying out this work, it has been possible to assess satisfaction and quantify the improvement in the development of a Gamified TU by means of MORPG, as it presents several advantages when it comes to TU development: it improves performance and the atmosphere in the school; it motivates the pupils; it develops key skills; it encourages teamwork; and is fun.

These results coincide with those observed in other studies [24-27], where it has been concluded that using an RPG produces greater effects of change than those achieved without it.

Almost 100% of the pupils have liked the gamification experience. The academic results in the control group using gamification have been better and the TU aims have been met to a greater degree. Likewise, pupil motivation has increased by using “Classcraft”.

Any future such proposals should be implemented with longer-term monitoring and not just for six sessions. More groups should be used in order to assess the skills acquired during the process of working in a team by using, for example, one of the rubrics available online [28].

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A Study of Discrepant Events and Picture Books as the Integrated Design of Science Activities

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Abstract. This study aims to explore how to use discrepant events in conjunction with a picture book in scientific activities to enhance children's desire to learn. The study took the science fair in Pingtung County, Taiwan as an example, from handling teacher workshop to planning and implementing a series of activities. Research shows that the design of scientific activities will present a different phenomenon in different variables, and this can lead to cognitive imbalances (or inconsistencies) among learners.

The use of a picture book guides the problem of contrast, and hands-on action prompts the learner to think rationally in order to reach his new balanced mental model. Some small experiments triggered the concept conflict of students, which made them impressed and had higher motivation for learning. Give extended scientific activities to enable students to learn more through extended activities. Implications for teaching and learning of scientific thinking and future research were discussed.

Keywords. Discrepant events, picture books, science fair activities.

1. Introduction

Science teaching in Taiwan is usually limited by the factors of progression or quick success. Some past studies have pointed out that science teaching is often conducted in recipes experiments. Students are only a fixed step in completing the experiment. They rarely have the opportunity to experience the process of scientific exploration as a scientist.

In the science fair activity, there are a lot of students involved, but how to do it effectively is an important factor for our consideration. Therefore, we must collaborated with the theme of each activity to draw scientific electronic picture books and integrate scientific inquiry activities as a reminder to guide students in discovering and thinking about natural discrepant events.

So, this study aims to explore how to use discrepant events in conjunction with a picture book in scientific activities to enhance learner's desire. And the research questions include:

- How to plan teacher study and enhance teacher design science fair activities?
- How does an e-picture tell a discrete event?
- What are the results of the learner's desire?

2. Discrepant events and Picture Books

2.1. Discrepant events

What is discrepant event? Simply speaking, discrepant event is occurrences which defy our understanding of the world by presenting unexpected outcomes [1]. These phenomena are often used in science demonstrations to grab the attention of an audience and engage visual learners, particularly learner. The important method is to always encourage students to discuss what will happen before the experiment happens. Allow them to persuade themselves to know what will happen before they will have different events.

Discrepant events are often used by science educators to incite interest and excitement in learners, yet sometimes their results are farther-reaching [2]. In other words, a discrepant event is a phenomenon which has a surprising and paradoxical outcome that is not what the observer would normally expect.

Why use discrepant events? When teaching scientific concepts or principles, it is important that teachers inspire students' curiosity. The use of discrepancies is a method that can use student curiosity. When students have strong motivation, conditions are good for learning.

There was a study that outlines three general steps that may be used when utilizing discrepant events [3]:

- Set up the Discrepant Event
- Involve Students in Solving the Discrepancy
- Resolve Questions Posed by the Event and relate them to the body of Scientific

Knowledge

2.2. Picture Books

In addition, the question is how to allow students to perceive the existence of discrepancies and give tips or guidance at the most appropriate time, perhaps using a video or animation.

This study proposes a simpler method, using the tips of the electronic picture book. The way of electronic picture books is mainly to avoid the difficulties of video and editing. When it comes to macro and micro themes, it can be replaced by a picture book.

3. Research Tools

Before the county science fair, we hold a professional development workshop in order to regain the teachers' ability of designing suitable for junior high and elementary school students' hands-on science learning units.

3.1. Research Design

Based on previous research (Figure 2) a framework of science fair activity [4], and to enhance students' Learning effectiveness in science fair, first of all, this study hold a teacher professional development activities for 30 teachers to design the 10 set checkpoints scientific discrepant events activities (Figure 1).

Figure 1. An in-service teachers' professional development workshop

The Figure 2 is a Framework of Science Fair Activity. It showed that we hold a teacher's professional development workshop based on discrepant events. Simultaneously, developing the science fair activity unit refer the discrepant events. Students refer the discrepant events drew the picture books on General Education Course, then transfer to the soft. The e-picture books run on the computer are used to guide students to recognize discrepant events. Finally, the ultimate goal of the activity is to enhance the effectiveness of learning.

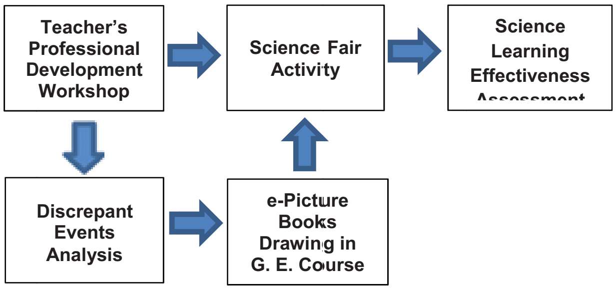

Figure 2. A Framework of Science Fair Activity. Modified from study [4]

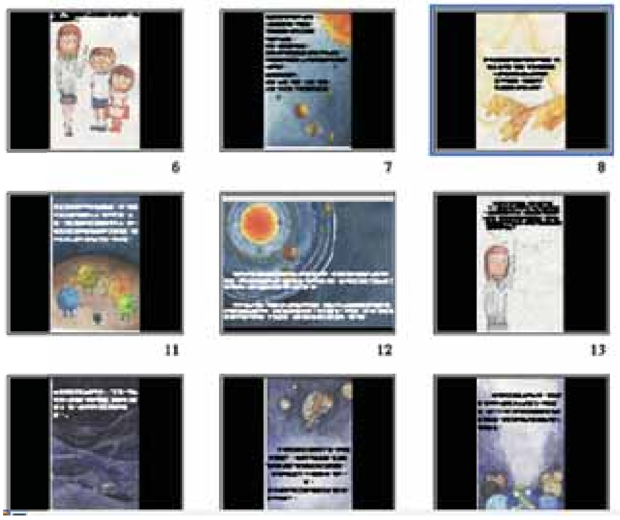

Figure 3. Science Picture book

There are 40 Fine Arts Department students design the picture books base on the scientific discrepant events. Finally, made into e-Picture books for a county science fair (Figure 3). It can be produced by Flip-PDF-Pro software and run on a mobile phones or tablets.

4. Results and Discussion

4.1. Results

The research shows that the design of scientific activities will present a discrepant events in different variables, and this can lead to cognitive imbalances (or inconsistencies) and curiosity among learners. The use of a e-picture book guides the problem of contrast, and hands-on action prompts the learner to think rationally in order to reach his new

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balanced mental model. Some small experiments triggered the concept conflict of students, which made them impressed and had higher motivation for learning.

Figure 4. Science fair activity

4.2. Activity Discussion

Implications for teaching and learning of scientific thinking and future research were discussed.

- Production of popular science picture books: Through the general education “Humanities and Technology” course of the university, teacher guide the art students to understand the discrepant events of science and make the scientific e-picture books in groups.
- Functions of e-picture books: The use of e-picture books helps students participating in science fairs to quickly understand the differences in natural phenomena and explore issues in scientific activities.

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Does the Irrigation Water Passed by the Microwave Oven Affect the Plant Growth?

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Abstract. There is a widespread belief that the substances heated in a microwave oven are affected by the radiation they receive. In the IES Val do Tea de Ponteareas, it was developed by the Department of Physics and Chemistry, with 4th year ESO students, an experience to find out if this belief is scientifically grounded.

The results obtained were presented at the Student Congress, held in the framework of the III Science Week, organized by the teaching centers and the City Council of Ponteareas.

The students that developed this project will outline the methodology used, the results obtained and will evaluate their experience, both in the scientific work and in the participation in the Student Congress.

Keywords. Microwave, plant growth, common believes, student congress, science week.

1. Introduction

Frequently new media outlets on the possible negative influence of electromagnetic radiation in the lives of human beings, and living beings in general appear.

Against the opinion of the companies of the branch, that deny any effect on the health, and even the one of the authorities that, in the same sense, argue that there are no studies that demonstrate a negative repercussion on the people, appears the opposite opinion of ecological groups and some scientist, who try to warn about a danger that we are not completely aware of.

Extended use of mobile telephony, microwave ovens, communications antennas in buildings, wifi networks in workplaces, homes and outdoor public spaces, high voltage lines, transformers near homes, etc., makes us live immersed in an intense tangle of Radiation of different frequencies that, at least, should make us reflect.

We will study the microwave radiation, very familiar, since in almost all kitchens there is an oven that uses this type of radiation to heat and cook food.

1.1. Bibliographic Research

We did a brief search to find out what had been done previously on this same subject, and we found an increasing number of references in the last years, with disparate results:

Some researchers found that microwaves had some observable effect on plant growth paramenters, which was considered sometimes as a negative one, as Sahin [1] did, and in others [2-3]) the effect was considered positive for the plant germination.

There were also results [4] where the effect varied according to the microwave frequency or the plant type, or even, as was the case of Roux et al. [5] where the effects depended on the time the plants were exposed to the radiation.

And finally, researchers like Senavirathna and Asaeda T [6] reported that microwaves had no observable effect on the parameters they measured.

From these results we concluded that this was an open issue even in the scientific literature.

1.2. Microwave radiation

Microwave radiation is a type of low frequency electromagnetic radiation and wavelength of the order of the centimeters, which are used in radars and ovens of the same name. It is a low energy radiation, much less dangerous than ultraviolet radiation or X-rays.

1.3. The operation of a microwave oven

An oven of this type consists of a device that emits microwave radiation that affects the food that we want to heat or bake. In order for a food to be cooked we must increase its temperature and this is nothing more than increasing the movement of the particles (molecules) that make it up. It turns out that the molecules of water and some fats are sensitive to microwave radiation, so that by affecting them, they vibrate much more intensely. This increase in vibration produces a lot of friction between the molecules, which translates into heat. Foods that are likely to be heated in the microwave are those that have a certain content in water, which occurs in virtually everyone.

Unlike a traditional oven, where the food is heated from the outside, a microwave oozes "from the inside".

2. The development of work

Our work will be to analyze the possible impact on plants when watered with water previously heated in the microwave oven.

2.1. The reason of the chosen subject

The real reason that made us choose this subject definitively was the possibility it offered us to be able to observe in a living being if the radiation has real consequences and, in the case of having them, what are they and how do they manifest themselves; since, as we have noted above, radiation is present in our days and we often forget, or simply ignore, the risks of it.

Searching on the Internet we discovered similar experiments of people who have watered during several weeks different plants with this water previously heated in the microwave oven. The results are contradictory, in some cases the plants died, in others they grew less and in other cases this apparently did not affect them.

2.2. The choice of plants

We decided to carry out the study on two types of plants: a flowering plant with slower growth, such as Primrose (*Primula vulgaris*) and Lettuce (*Lactuca sativa*), without flower and faster growth. Both are outdoor plants.

Primroses	Lettuces
Outdoor plants	
Easy care and affordable	
Slow-growing	Fast-growing

Figure 1. Characteristics of the plants

2.3. The plantation process

Once the plants were chosen, we proceeded to buy twelve samples of each type of plant, along with the necessary fertilizer. Likewise, we prepare twenty four containers to feed them in the same volume conditions, we sow them with the same amount of land and then they were located in the Physics Laboratory of our school.

Figure 2. Plants' location

2.4. Samples and methodology

We divided the twelve plants of each type into four groups. The first three vegetables were watered with water passed through the microwave and left to rest until it reached room temperature (Figure 3). For the following three plants, water was boiled to confirm that the possible variations in the development would be due to the radiation and not to the temperature acquired by the liquid (Figure 4). The following group received water directly from the tap after waiting for the decloration of it (Figure 5). Finally, we contemplated the possibility of being influensed by the information already known and the progress of the other plants, which is why we decided to add a last group, whose form of irrigation was only known to the professor until days before the Science Week. These plants were irrigated in the same order of the other groups, that is, the first with water passed through the microwave, the second with boiled water and the third with tap water (Figure 6).

During the course of the experiment, we went at the breaks between classes to the laboratory in question. In it, we watched the evolution, watered, prepared the water for the next occasion and wrote down in a notebook, along with the date, all those aspects and details that we considered relevant.

Figure 3. Plants from the first group

Figure 4. Plants from the second group

Figure 5. Plants from the third group

Figure 6. Plants from the forth group

2.5. The factors

To avoid any external factor that could vary the results, we submitted all samples to the same temperature conditions, always keeping them with the radiator off and with the windows closed; of light, rotating them after each watering and amount of water, determining a standard measure for each plant species, according to the needs observed in each review.

Taking this into account, we have achieved that the only determining factors in the study were radiation and heat on water.

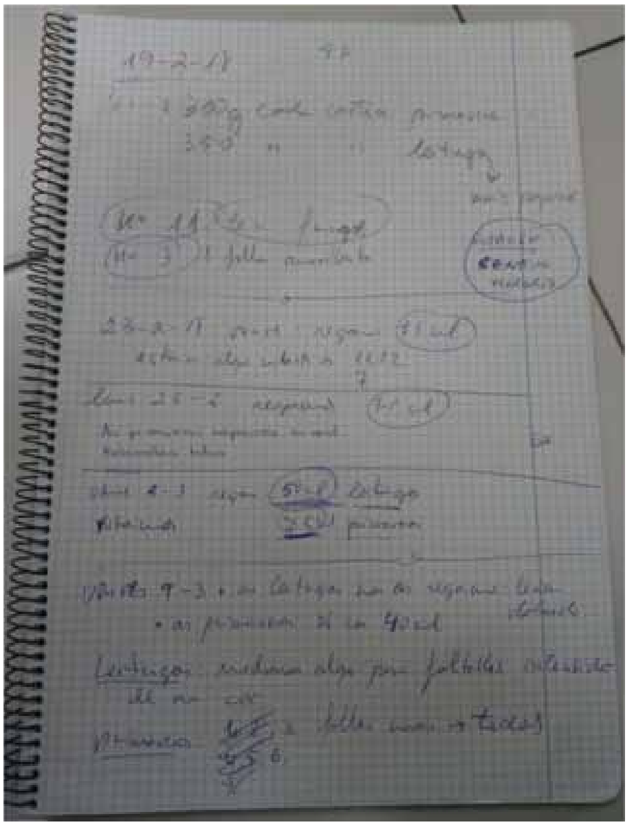

Figure 7. Notes

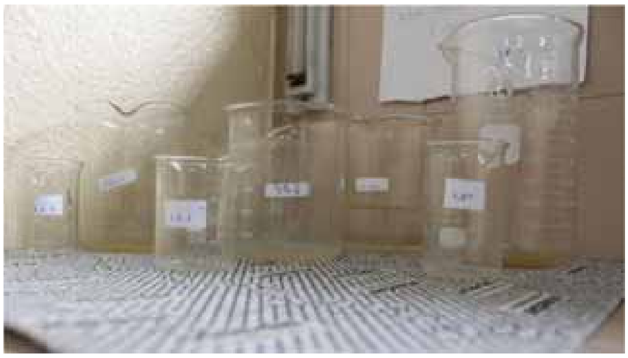

Figure 8. Measuring glasses

2.6. The duration of the study

The experiment lasted approximately eight weeks, from February 19 to March 23. During this time, the plants underwent the evolution shown in Fgures 9 and 10.

3. Conclusions

After the weeks of study, there was no difference between the different irrigation groups, so the results of the experiment can be interpreted in two directions: the first would imply that the study would not be conclusive, as there could have been an external factor that affected all the primroses alike, but not the lettuces; and the second possible interpretation would be the claim that the radiation conditions in the water did not affect the plants.

Figure 9. Primroses' evolution

Figure 10. Lettuces' evolution

4. Science Week and the Student Congress

This experiment and many others were included in the III Science Week of Ponteareas, an annual event that brings together many educational centers in the area to share the interest and scientific knowledge through fairs, exhibitions and talks.This edition had for the first time a Student Congress in its agenda. In that context, we presented our study to students and teachers from other educational centers.

5. Evaluation of the experience

In view of the results, there are certain aspects that we would take into account if we repeat this experiment again: we would take more samples, because in the end we considered them insufficient at the time of drawing conclusions; we would lengthen the period of study to try to observe long-term consequences, and we would adapt the type of plant chosen to the available location.

For us, as students, it was an opportunity to develop the scientific method in a real situation, where it was necessary to evaluate all the variables and work rigorously. It was an innovative and satisfying experience, different from the usual work of the classrooms.

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Learning Metabolism: The Key Concepts and Laboratory Experiences to Understand the Main Metabolic Reactions

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Abstract. What is the function of the chemical reactions that occur inside our cells? Which is the main substrate for our cells? Do all living beings need oxygen to survive? Why are plants so important for us? In this work, the basis of cell metabolism are explained through key questions at a primary and secondary school level. As a complement to this, laboratory experiences on photosynthesis and fermentation are also presented to help the students understand how important plants are, being the producers of both the organic matter and oxygen that we consume and how some unicellular organisms live without oxygen.

Keywords. Metabolism, energy, oxygen, electrons, respiration, fermentation, glucose.

1. Introduction

Teaching experimental sciences such as Biology or Chemistry is something that with no doubt implies experimental activities. It is considered that an effective education should create an environment where the students develop hands-on activities, as established by Maria Montessori more than a hundred years ago [1]. Observation and experimentation, as important parts of experimental sciences are thus important when teaching them. Furthermore, in order to motivate the students and arise their curiosity, teachers' questions are also crucial [2]. Therefore, this article presents key questions and laboratory experiences about metabolism, one of the main branches of the fascinating world of Biochemistry, in both a primary and secondary school levels.

In the first part of the article, the basis of metabolism are explained through different questions that would let the students understand how energy and matter are obtained, transported and stored in our cells, why glucose is the main substrate for metabolic reactions, what is the role of plants as producers of organic matter and oxygen, and so on. In the second part of the article, the laboratory experiences are presented: In the primary school level, students will observe photosynthesis. In the secondary school level, the students will observe the fermentation of glucose by yeast both qualitatively through the presence of CO_2 bubbles and quantitatively through spectrophotometric measurements of glucose concentration. Students are also asked to complete the experiment varying some parameters that they would like to study such as the effect of temperature, glucose concentration or presence of oxygen.

2. Key questions to understand metabolism

2.1. Primary school level: Why are plants so important for us?

In primary school, the concept of metabolism as metabolic reactions that take place inside the cells is difficult to introduce, as the concept of cell is not always well established. Therefore, it is simpler to focus the students' attention into the metabolic relationship between animals and plants.

In the next sections an hypothetical session is presented with four questions to understand the importance of metabolism in order to conclude with the main question of the session. Why are plants so important for us? This main question can be asked at the beginning and at the end of the session in order to see how different are the students' answers and they understand the key concepts presented.

2.1.1. Why do we eat?

It may seem a very simple question but it is a very good starting point to go in deep with the two main functions of metabolism, even though it is not necessary to mention the word metabolism or metabolic reactions. The possible answers that the students would give is "Because we are hungry" and then we can focus on why are we hungry and therefore why do we need to eat. We also can introduce it by asking what are we made from? or else from where do we obtain the energy to move? However, this second question may be more problematic for the concept of energy that may be not already introduced at that age. In the end, the students should realize that we eat in order to grow and realize that we are made from what we eat, although we transform it in order to make our own body. We can also introduce that the food give us energy to move and do all the main functions of living beings.

2.1.2. What do we eat?

Once it is clear that we need to eat in order to grow and obtain energy, the second focus may be on what we eat. It is clear that we have to make the students understand that all we eat is plants or animals (apart from water and mineral salts) but those animals at the same time ate plants or other animals that ate plants (Figure 1). Therefore, the students have to arrive to the conclusion that all what we eat comes from plants. Then, depending on the level, we can go in deep with the question of *how plants grow just from a seed and taking up water from the ground?* and *how are plants able to make their own food?* However, this concept may also be better discussed in the last question.

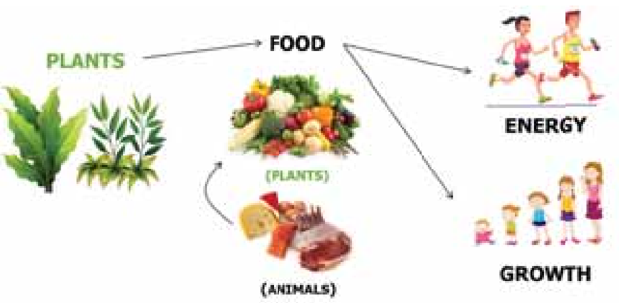

Figure 1. Plants produce all our food. Plants are the producers of our food, and the food from the animals that we eat. We need the food to have energy to live and matter to grow

2.1.3. Why do we breathe?

The answer to this question is a little bit more difficult than the others, and depending on what age we this is outlined it can be answered in different ways. Of course, the focus should be on oxygen, which we breathe in but not breathe out. The students have to come into the conclusion that oxygen is the element that we need to live, as well as we need the food.

2.1.4. From where do we obtain oxygen?

This is a key question where students realise that both the food and the oxygen we need to live come from plants. Here is where we can talk more about photosynthesis by asking why do plants produce oxygen? and explain that process that is related with the fact that plants also produce their own food, which is at the end the organic matter that also forms part of ourselves (Figure 2) [3]. This is also a good point to instil the students to take care of plants and, relating to our initial question, why are plants so important for us?, now they are at least convinced that they are important.

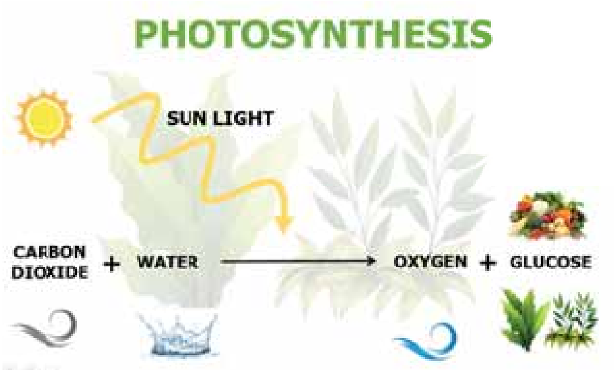

Figure 2. Photosynthesis allows obtaining oxygen and food. Plants take carbon dioxide from the air and water to transform thanks to the energy from sun light to oxygen, which we breath, and glucose, a molecule that is the base to form the plants itself and therefore food

2.2. Secondary school level: Is it possible to live without oxygen?

In secondary school level, we can introduce metabolism as chemical reactions that take place inside the cells. However, a way to really understand metabolism is to go through the following questions:

2.2.1. Why do we need metabolic reactions?

At this level, we can introduce metabolic reactions as reactions that are needed to maintain cells alive and reproduce if it is necessary. Some of the questions that can be made are: From where do we obtain the energy to live? or From where do we obtain the matter to grow? Of course, students may answer from food and we can make the same reflexion than in primary school, which is that plants are the main producers of organic matter. However, the idea is to introduce at this point that some metabolic reactions emit energy by breaking the molecules (obtain energy to live) while others build up molecules that we need from precursors (obtain matter to grow, a process that requires energy). At this point we can also introduce ATP, which is the molecule that

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allows the cell to take up and release energy to the metabolic reaction (Figure 3).

2.2.2. Which is the main substrate of our cells?

The aim of this question is to start introducing the main metabolic pathways such glycolysis, Krebs cycle, etc. In this case, we can address the question by making a parallelism between which is the main food for us. Bread or rice, which are cereals, and therefore carbohydrates formed by polysaccharides, mainly starch, would be the answer. Which is the main component of starch? Glucose is the main component of starch and carbohydrates, and it is the substrate that is most consumed by cells. It is the starting point of glycolysis, it is a tiny molecule, soluble in water, full of potential energy, easy to store (for example, in starch) and their carbons can be used to form other biomolecules like proteins and DNA (Figure 3).

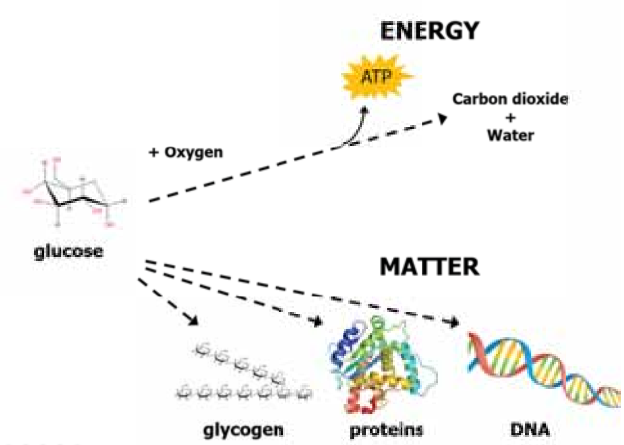

Figure 3. Main functions of metabolic reactions. The main functions of metabolic reactions are to obtain energy to live and matter to grow. Glucose is the main substrate for doing these reactions, although we need also other substrates

2.2.3. Why do we need oxygen to live?

We can start by understanding the role of oxygen in our body. It goes through the blood to all the cells of the body. Therefore, oxygen is needed for the cellular respiration, which takes place in the mitochondria. Then, we can introduce a question like what do we have in common with a battery? In metabolic reactions not only exchange energy through ATP but also electrons. Glucose is full of electrons that when it is metabolized (oxidized), the molecule of NADH will take up and carry on (Figure 4).

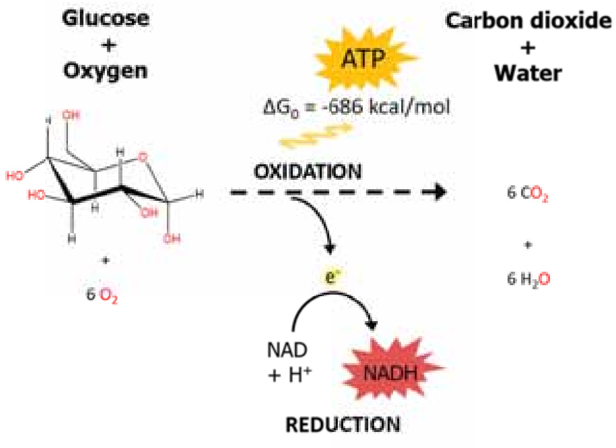

Figure 4. Glucose pass its electrons to NADH. Glucose oxidation can not take place without another molecule that takes its electrons. As ADP takes the energy becoming ATP, NAD takes the electrons and becomes NADH

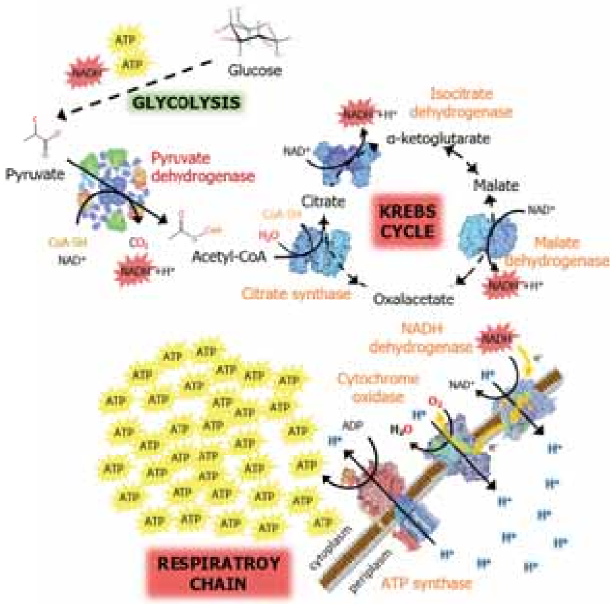

Figure 5. Simplified version of glucose catabolism. The respiratory chain allows obtaining 36 ATP from one single molecule of glucose, much more than the 2 ATP obtained from glycolysis

In glycolysis, we obtain 2 molecules of ATP and 2 molecules of NADH. However, if pyruvate from glycolysis goes to the mitochondria and passes through the Krebs cycle the oxidation of glucose is complete. We obtain 2 more ATP and 10 more NADH. Then, in the respiratory chain located in the mitochondrial respiration chain, each NADH is transformed to 3 ATP thanks to oxygen, which is the final acceptor of the electrons that carry on the NADH. This makes the complete metabolization and respiration of a molecule of glucose much more efficient (38 ATP) than only glycolysis (2 ATP) (Figure 5) [4]. It is believed that that great efficiency made possible the transition from unicellular organisms to pluricellular, an important step in evolution.

2.2.4. Do all living beings need oxygen to live?

Many unicellular organisms, both prokaryotic and eukaryotic are able to survive and reproduce without oxygen. They perform a metabolic process called fermentation, which consists on glycolysis and a final reaction that recovers NAD+ and accepts the electrons from glucose. Furthermore, we as society take profit of that process and use different organisms to produce wine, bread, yoghurt, and so on. These products come from the fermentation by bacteria or yeast of the glucose from the sugar of grape juice (wine), milk (yoghurt) or from the starch of flour (bread) or barley (beer), among other examples (Figure 6).

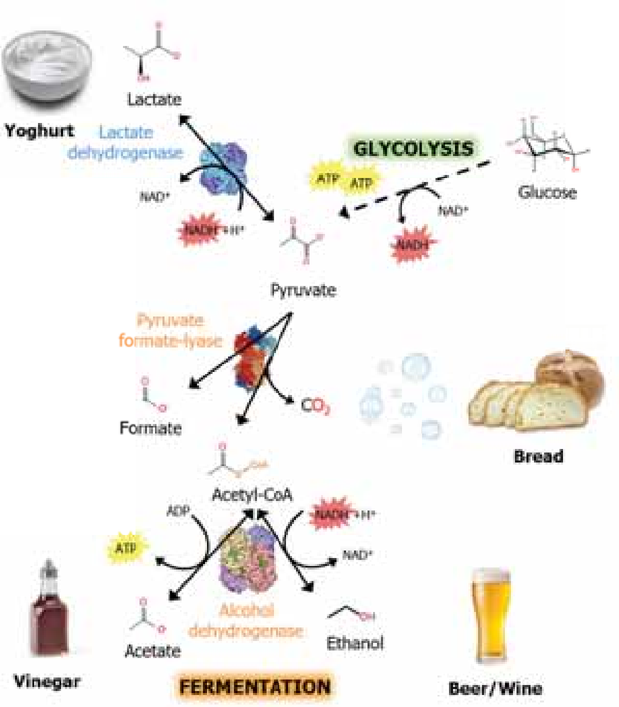

Figure 6. Simplified version of glucose fermentation. Without oxygen, glucose can undergo different metabolic reactions where the final electron acceptors are lactate, ethanol or acetate, products that we use for the production of many foods and drinks

3. Laboratory experiences

3.1. Primary school level: Observing photosynthesis

The following laboratory experience is a way to observe how algae make photosynthesis by exposing the algae beads into more or less light and observing the change on their density, in result to more or less oxygen production [5]. We can explain more about photosynthesis (depending on what we explained in the last question of the theoretical part) and students are ask to design the experiments, proposing the places where the containers with the beads can be in order to observe the different oxygen production depending on the light (Figure 7).

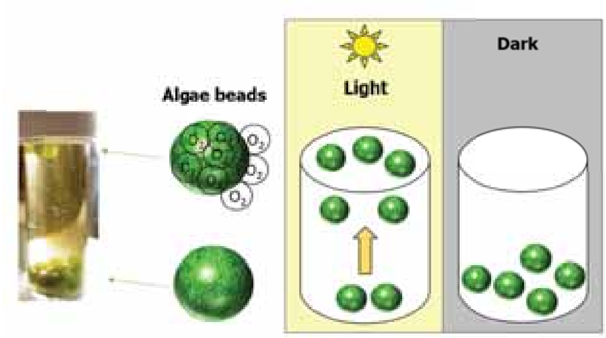

Figure 7. Photosynthesis laboratory experience. Observation of photosynthesis through the density of algae beads that produce oxygen when exposed to light

3.1.1. Material

- Green algae culture (for instance, from Chlorella gender)
- 2% w/v of sodium alginate solution.
- 3% w/v of calcium chloride solution.
- Distilled water.
- 15 mL tubes for the algae culture.
- Pasteur pipettes.
- Little glass containers.

3.1.2. Procedure

- Mix 5 mL of green algae culture with 2.5 mL of sodium alginate solution.
- With the Pasteur pipet, drop by drop release the algae mixture to the glass jar containing the calcium chloride solution, which should be cold.
- Change the calcium chloride solution to distilled water (2 washes)
- Now the students can think by themselves the places to perform the

experiment depending on how many glass jars they have. One can be always dark (with aluminium foil), others with natural light, in the shadow, with artificial light, etc.

- Observe every day until four days if the algae beads rise at the surface or not depending on the light they receive.

3.2. Secondary school level: Quantifying fermentation

In this laboratory experience students will observe metabolic reactions (specifically fermentation) both qualitatively (by observing the formation of bubbles) and quantitatively (by spectrophotometric measurement of glucose concentration). At the beginning of the practice, we can explain the reaction of fermentation (Figure 8) as an anaerobic metabolism (as we explained in the last point of the theoretical part). Students are asked to design the experiments as they want: They can choose the incubation conditions: Different temperatures, different glucose concentrations, and so on.

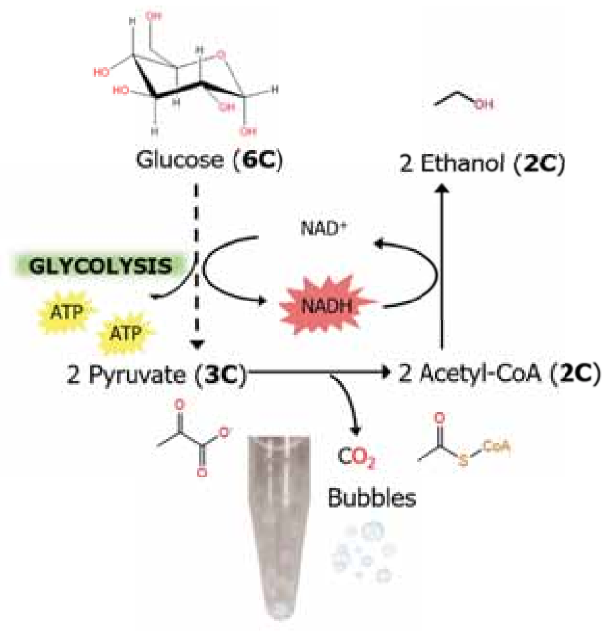

Figure 8. Fermentation laboratory experience. Observation of fermentation through the CO_2 bubbles after an incubation of yeast with glucose

3.2.1. Material

- Yeast culture (for example, Saccharomyces cerevisae)
- 100 mM glucose solution
- Enzymes solution: 80 mM Pipes buffer (pH 7.6), 3.04 mM NAD+, 1.76 mM ATP, 0.1% Sodium Azide, 4 mM Magnesium sulphate, 1.7 U/mL Gluocse 6-phosphate dehydrogenase (G6PD) and 1.7 U/mL Hexokinase (HK).
- Distilled water
- Eppendorf tubes
- Spectrophotometer cuvettes
- Pasteur pipettes
- Micropipettes (1 mL and 200 µL)
- 37ºC bath
- Centrifuge
- Spectrophotometer

3.2.2. Procedure

- Take up 1 mL of the yeast culture with the micropipette or a Pasteur pipette and release it in an Eppendorf tube.
- Centrifuge it 500 g (1.200 rpm in a MiniSpin) during 2 minutes.
- Discard the supernatant.
- Add 1 mL of glucose solution to the tube with the pellet of yeast (if the students want to study different concentrations of glucose, dilute the 100 mM before and add the different solutions).
- Resuspend with the micropipette.
- Place the tubes into the places that the students decide (if they want to study the effect of temperature, place some tubes to the fridge, some at room temperature and some at the 37ºC bath). Incubate for 45 minutes while doing the next steps:
- Perform a bank of glucose dilutions from 100 mM that will be the standard curve for the quantification of glucose concentrations. The dilutions can be 1/20 (5 mM), 1/10 (10 mM), 1/7,5 (15 mM) and 1/5 (20 mM) with distilled water.
- Add 1 mL of enzymes solution (HK+G6PD) to the cuvette and 5 µL of the standards, resuspend.
- Wait for 10 minutes while the reaction takes place.
- Read the standards in the spectrophotometer at 340 nm.
- Now observe the yeast incubations, observe if they have bubbles of CO2 as a subproduct of fermentation.
- Centrifuge the tubes of the incubations.
- Take the quantity of the supernatant to

make a dilution 1/10 in a new eppendorf.

- Take 5 μL of this dilution add it in a spectrophotometer cuvette with 1 mL of enzymes solution.
- Wait for 10 minutes while the reaction takes place.
- Read the samples at 340 nm.
- With the result of the standards and the samples, calculate the difference of glucose concentration between the beginning of the incubation (100 mM) and the end, in order to quantify the fermentation.

4. Conclusions

In this article, the principles of metabolism are explained at both primary and secondary levels with theoretical questions and practical experiments. When learning metabolism, as well as other fields of experimental sciences, it is very useful to question the students with some basic questions that can be answered in a very deep way depending on the level. Moreover, laboratory practices drive to a better learning experiences because the students can see with their eyes what was explained and they can think about what happened in the experiment and even, in this case, design the experiments [6].

5. Acknowledgements

I would like to thank the University of Barcelona and especially prof. Dr. Josep Maria Fernández for giving me the opportunity to participate in that congress and in other programs bringing university closer to secondary school. I would also like to thank my research group, Dr. Marta Cascante and all my laboratory mates for their support.

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Microscopy Images Are Not Worth a Thousand Words

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Abstract. Image analysis is a process used to gather quantitative information from images which can be applied to different fields, from traffic monitoring to optical microscopy. It is a crucial requirement in scientific publications as images alone are subjective and an ineffective way of communication. In this paper it is first shown how images can trick the eye. Then, several daily life applications of image analysis are described. Finally, the main steps of an image analysis protocol are summarized pointing out the difference between analysis and manipulation of images.

Keywords. Image analysis, image manipulation, optical illusions, optical microscopy.

1. Optical illusions

Optical microscopy is a technique that all laboratories in the field of live science use in a daily basis. It is routinely used, for instance, to check cell cultures, cell or organism phenotypes and specific staining performed on samples. Whatever is observed under the microscope can be recorded as pictures but is at the point of showing those images in a scientific paper that some issues arise because images are not an effective way of communication [1]. They are well known the many examples of optical illusions where different people see different things in the same image (Figure 1A) or where the perception of what is seen depends on the surrounding context (Figure 1B). Moreover, people tend to interpret what they see (Figure 1C) and to look for known things when searching for further details (Figure 1D). As a consequence, any scientific conclusion other than the simple description of what is shown is subjective and therefore, any quantitative result gathered from images should be obtained by means of image analysis.

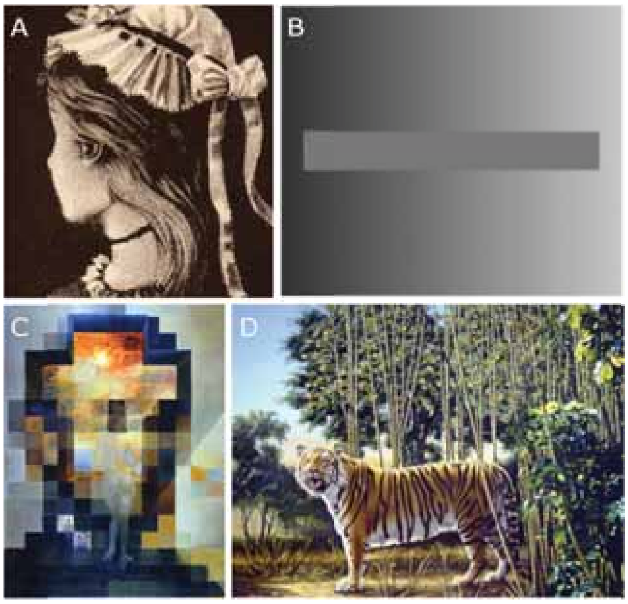

Figure 1. Optical illusions. A) A cartoon published in 1915 by W.E. Hill that shows, depending on the observed features, a young woman or an old hag. B) Horizontal homogenously grey rectangle inside a background with a grey gradient. C) The famous Dali's painting: "Gala nua mirant el mar que a 18 metres apareix el president Lincoln" (1975). At a certain distance one can infer the face of Abraham Lincoln. D) A brain challenge riddle showing one tiger and asking the observer to look for the hidden tiger [2]

2. Daily life applications of image analysis

Image analysis is not only designed for optical microscopy images and indeed it has several applications affecting the daily life. In recent years there has been an increasing interest in developing computer vision techniques to monitor different types of environments and use the results in urban planning, security, etc. This same year 2018, appeared in the news the Chinese project for facial recognition to be used for surveillance of people (Figure 2A) [3]. Moreover, it can also be used to monitor the road traffic (Figure 2B) [4] or the crowds (Figure 2C) [5] and to track passengers and their bags in airports (Figure 2D) [6].

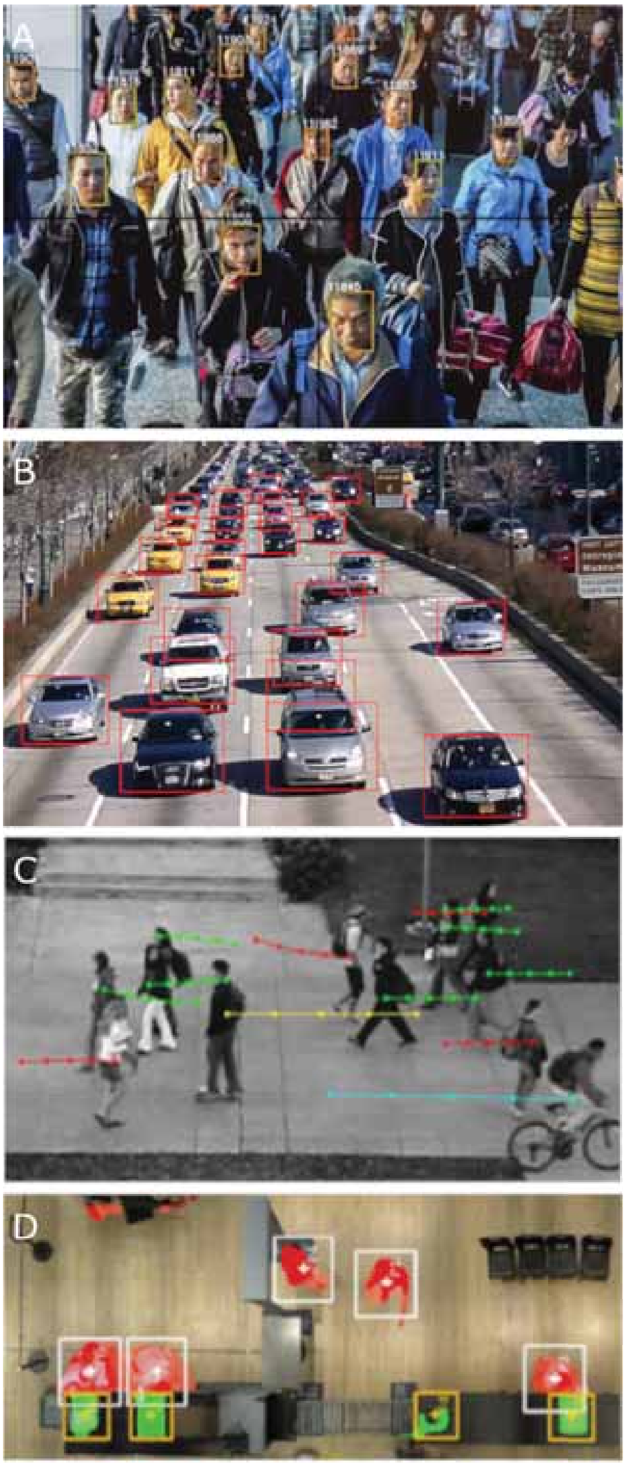

Figure 2. Image analysis applications affecting the daily life. A) Washington Post image used to illustrate the Chinese project for face recognition [3]. B) Image showing car detection used to monitoring the traffic [4]. C) Image illustrating human displacement monitoring [5]. D) Image of an airport security gate where passengers and bags are detected and tracked by means of image analysis [6].

Image processing in all cases is based on identifying the objects of interest from their background or surrounding environment and then extract meaningful information from them. The bottleneck of such processing is precisely that object identification which mainly depends on the quality and resolution of the images and videos to analyse.

3. Analysis and manipulation of images

The quality of images may be impaired by several factors. In fluorescence microscopy, the first step to grant a good image quality is the sample preparation, just before any observation is made [7]. In this step the objects of interest need to be somehow stained and the signal from the staining molecules should be bright enough to clearly discriminate from the background and from the autofluorescence. If several markers are required they need to be carefully selected to avoid any spectra crosstalk between them. Then, after sample preparation, the next step in assuring a good quality and resolution of images is their acquisition under the microscope. Here it is important to maximize the signal-to-noise ratio (SNR) while working at a resolution able to discriminate the objects of interest [8]. Images need to be acquired emphasizing those features that the image analysis will try to detect however, both the analysis and the quality and resolution of images need to be set together. In case that the objects cannot be accurately identified within the images either the acquisition settings or the sample preparation or both can be modified accordingly.

The process of image analysis typically involves three main steps: first, the images are pre-processed to reduce the noise and the background, correct uneven illuminations, etc. Second, the object are identified and distinguished from their surrounding background in a process known as segmentation. This step can be achieved in several ways: from setting intensity threshold levels to creating sophisticated machine learning algorithms [9]. Third, the analysis of the segmented objects is performed, extracting those morphometric and/or densitometric measurements required. An example of this protocol is showed in Figure 3 where it is measured the intensity of the staining of intercellular junction proteins [10]. First the image with the original staining is presented (Figure 3A).

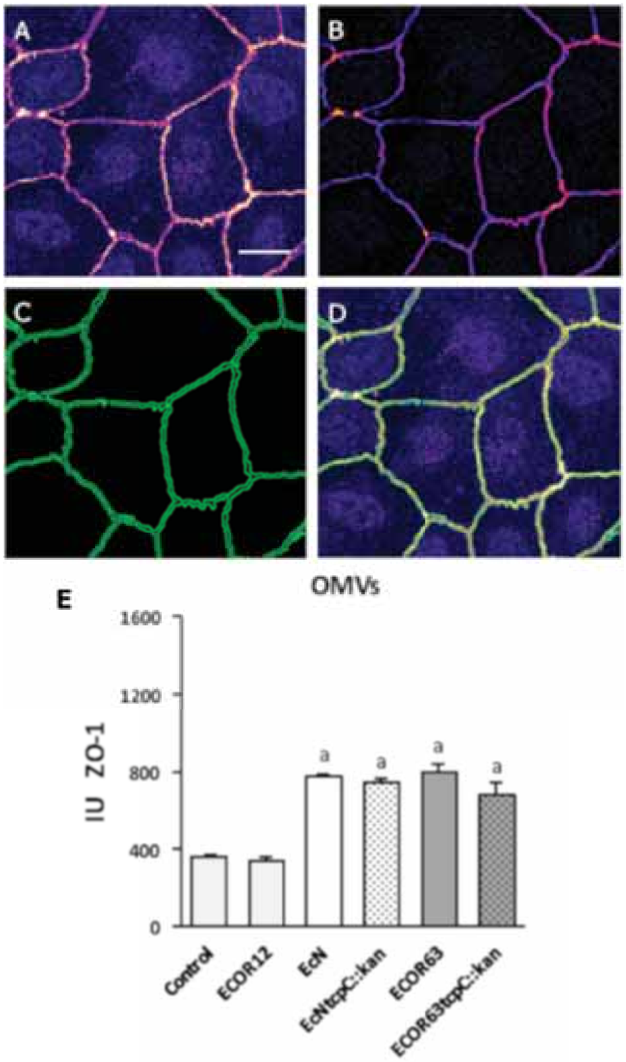

Figure 3. Example of an analysis protocol of optical microscopy images. A) Original image. B) Same image showed in A after processing. C) Image showing the ROI resulting from the segmentation of the image. D) Overlay of the ROI showed in C on the image in A. E) Graph showing the intensity measurements (Intensity Units, IU, y axis) of different treatments (x axis). Each column represents the mean intensity with its SD and the statistical significance is highlighted (a). Adapted from [10]

It is observed the fluorescent signal at the cell borders but also inside the cells. Then, images are processed to emphasize the staining at the cell borders over the noise and the intracellular signal (Figure 3B). After the processing step, images are segmented by setting an intensity threshold that divides the pixels in the images in two groups: 1) those above the threshold (bright pixels) which belong to the cell junction staining and 2) those below the threshold (dim pixels) which are discarded.

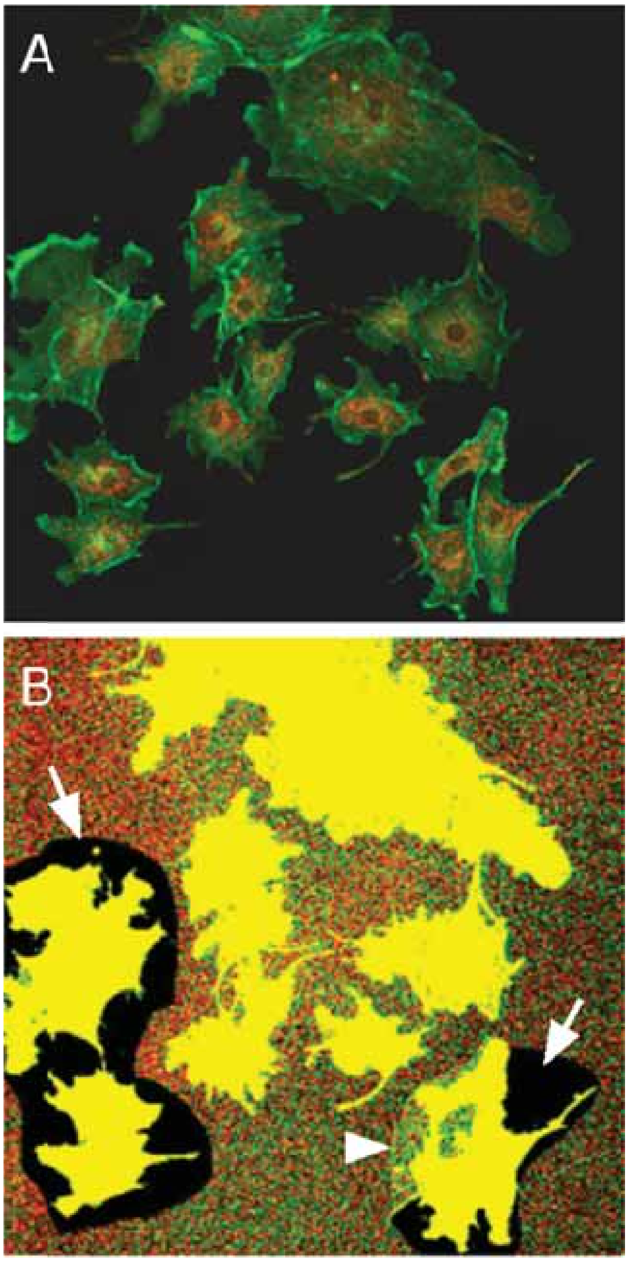

Figure 4. Example of image manipulation. A) Image showing several cells double stained on a black background. B) The same image in A after increasing the contrast. White arrows point out cells added digitally from a different image. White arrowhead points out intensity manipulation of cells. Adapted from [11]

Around the first group of pixels it is obtained the region of interest (ROI) thus surrounding the junction staining (Figure 3C). Finally, this ROI is superimposed on the original image to measure the intensity inside it (Figure 3D). Finally, in order to get statistics of this measurement, the described protocol has to be repeated on different fields of view and on different replicas of the same sample, and the same for the different cell treatments to compare. At the end, a graph can be generated with the average intensities and their standard deviation (Figure 3E).

At last it is worth to mention that many of the tools used for image analysis can also be used to manipulate the images. Most of the times this type of manipulations are performed for a matter of beautification of the images however the reviewer may interpret it differently. An example of this is showed in Figure 4 where an image with several cells spread in the field of view is shown before (Figure 4A) and after (Figure 4B) contrast enhancement. Increasing the contrast in the image shows that several of the cells were added digitally (white arrow) and even some of them were manipulated to increase their intensity (white arrowhead). This has nothing to do with a scientific analysis and should be avoided. Nowadays, several journals offer guidelines for image edition [11] and have started to ask for the original images trying to control this type of fraudulent procedures. In case some manipulations are performed on images it is highly recommended to describe them in the publication. Honesty is the best policy.

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New Results from Colliders and Accelerators for School Teachers and School Students

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Abstract. Our team from the Joint Institute for Nuclear Research (Dubna) and InterGraphics LLC more than 15 years has been involved in advancing of science education for school students and teachers as well as for universities students [1-2]. In this report we would like to present different interactive models and 3D visualizations for school teachers and students which explain basic principles of operation of colliders, accelerators, research reactors and modern particle detectors. We also discuss some new results obtained with the help of colliders to study early Universe in collisions of relativistic heavy nuclei and synthesis of new super heavy elements in experiments at heavy ion cyclotron. We also would like to present new educational materials on physics and engineering in format of massive open online courses.

Keywords. Colliders, accelerators, new superheavy elements, quark-gluon matter, neutrino, high-school education, nuclear physics, reactors, applied researches and engineering.

1. Introduction

Our team from the Joint Institute for Nuclear Research (Dubna) and InterGraphics LLC more than 15 years has been involved in advancing of science education for school students and teachers as well as for universities students.

JINR is an international research centre where unique basic facilities are being created and where scientists conduct research in the following up-to-date scientific fields:

- studies of a new quark-gluon state of matter at Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory (USA) within the international STAR collaboration and construction of the superconducting collider NICA in Dubna;
- search for new superheavy elements of Periodic Table in experiments at the cyclotron accelerator;
- neutrino physics research in deep underwater at Lake Baikal in Siberia;
- use of accelerators of protons and heavy ions for medical purposes;
- studies at the pulsed neutron research reactor IBR-2.

We have created attractive 3D models of an accelerator and a collider, a cyclotron and the physical facility for study of synthesis of new superheavy elements, models of the pulsed neutron reactor for researches in material sciences and ecology.

We are also developing series of online courses about modern science. In this report we will present online courses on physics and technology:

- “Relativistic Heavy Ion Collider – the Universe in Laboratory”,
- “Synthesis of New Super Heavy Elements”,
- “Engineering Is the Second History of Civilization”.

These courses are adopted for high-school students and physics teachers.

The implementation of results of modern research projects makes an invaluable contribution into such the fundamentally important problem as the raise of educational and cultural awareness of people. Educational support of such projects is aimed at attracting public attention (school and university students, science teachers and generally interested audience) to the scientific achievements.

The use of modern multimedia and communication technologies for the development of projects related to the science popularization opens up wide opportunities for explaining complicated things in a clear and understandable form.

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2. Colliders – the Universe in the Laboratory

Modern scientific findings and technological solutions should be accompanied by educational, popular-science and outreach projects intended for a wider audience, including school students. In the future it will allow us to overcome a serious social problem — decline in young people's interest in scientific research and engineering professions.

One of the main goals of modern physics is to answer the questions: “How was our world created?”, “What are the building blocks of matter?”, “What was happening right after the Big Bang and further in the process of the Universe formation?” Experiments at modern colliders allow to answer these questions. We have prepared educational multimedia materials about modern colliders, principles of their work and the processes that took place at the very beginning of our Universe formation.

To study the Universe in the Laboratory we need to create high-density baryonic matter like it exists in neutron stars or matter at temperatures millions of times higher than the temperature at the surface of the sun. For experimental study it is necessary to create baryonic matter in the extreme conditions. Heavy ion colliders produce such matter in collisions of relativistic heavy ions (RHIC, LHC). With this purpose a new project NICA (Nuclotron-based Ion Collider fAcility) was started.

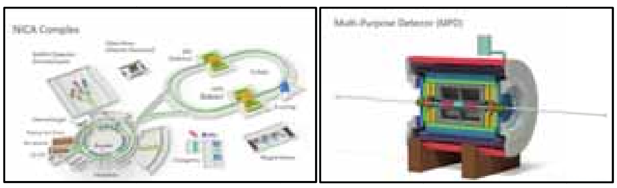

Figure 1. Multimedia educational resources: NICA Complex and multipurpose detector MPD

We also have developed the online-lesson for school students – “NICA – Universe in the Lab” [3]. In this video Academician Grigory Trubnikov speaks about the research that scientists from different countries will carry out at the NICA accelerator complex. This is an education material for school students and science teachers, which we tried to do interesting for all ages. It is a popular science movie, where we talk about the role of science in our life, how our Universe was created, about phase transitions of matter and quark-gluon plasma etc. We explain why we need particle accelerators and colliders and how they work.

Our experience of public presentations and workshops shows that teachers and school students take great interest in our multimedia presentations.

All results of this work are in the public domain and can be used in the educational process.

3. Synthesis of Super Heavy Elements (SHE) Factory

The Laboratory of Nuclear Reactions is world-known for the discoveries in the synthesis of superheavy elements. The element 105 in the Periodic Table is named “Dubnium” after the Russian town Dubna where this element was first synthesized. The element 114 was named “Flerovium” after the lab founder Georgi Flerov. At the end of 2016 two more elements obtained in Dubna were officially included into the Periodic Table. The first of them is the element 115 – Moscovium. It was named after the Moscow Region where the Joint Institute for Nuclear Research is located. The second – the element 118 – Oganesson is named after the academician Yuri Oganessian who works at the Joint Institute for Nuclear Research in Dubna. One of the key projects of JINR is the construction of the factory of superheavy elements (SHE Factory) in the Flerov Laboratory of Nuclear Reactions. SHE Factory is created on the basis of the new, the most powerful in the given region, accelerator of heavy ions DRIBs-III (Dubna Radioactive Ion Beams) with the intensity exceeding the world analogs 10 times. This will allow to solve the problem of synthesizing of new elements with atomic numbers 119, and 120, and beyond.

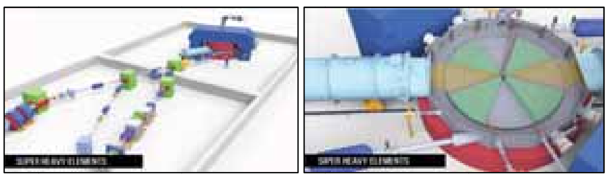

Figure 1. Multimedia educational resource: SHE Factory

We have developed 3D models of the heavy ion cyclotron and its detection system which we complemented with educational materials on synthesis of new elements of the Pereodic Table.

4. Baikal Neutrino Telescope

A neutriono is the most mysterious elementary particle. One of the main directions of JINR research activities is the development of methods for deep underwater elementary particles detection and construction of detectors using vast bulks of water of natural reservoirs as target and working substances. At the Baikal Neutrino Station an unique large telescope NT-200 is now being constructed for deep underwater neutrino research with an effective detection area of 2–11 thousand square meters (for atmospheric muons) and controlled water bulk of about 200 thousand cubic meters. The construction of this multipurpose setup will allow to search for new elementary particles and rare processes, and fulfill a large-scale experimental research program in the field of high-energy cosmic ray physics.

Figure 2. Multimedia educational resource: Baikal Neutrino Telescope

5. IBR-2 Reactor

IBR-2 is a fast neutron pulse reactor. Its main distinctive feature is the mechanical modulation of reactivity with a movable reflector. The reactor is located in the Laboratory of Neutron Physics and intended for studying the properties of condensed matter and nanostructures using neutron scattering.

6. Modern Physics and History of Engineering – Online Courses

We are also developing series of online courses about modern science. In this report we will present online courses on physics and technology [4-5]:

- “Relativistic Heavy Ion Collider – the Universe in Laboratory”,
- “Synthesis of New Super Heavy Elements”,
- “From Atoms to STARS: How Pysics Explains our World”,
- Engineering Is the Second History of Civilization”.

These courses are adopted for high-school students and physics teachers. We are developing the educational portal [2] where results of our educational projects are presented.

Figure 3. Multimedia educational resource: IBR-2 Reactor

Figure 4. Online courses at edX and Coursera platforms

7. References

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Nuclear Physics for Beginners: Hands-on Practicum

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Abstract. The project “Virtual Laboratory of Nuclear Physics” (VLab) for university students was presented at the HCsi Conferences in 2014 and 2017 [1-2]. Resources of this project are available at our website [3]. These resources are used by more than 15 countries at university level to add more value and understanding about educational teaching and learning [4]. In this report a discussion will be held about the adaptation of this project for high-school students and the creation of not only the virtual laboratory, but also the use of the traditional laboratory for studying the basics of experimental nuclear physics. The goal of this report is to present results of this project which was applied to the high school teaching community. The main focus is to make teachers at high schools aware of these resources which are available with the hope that they will implement this resource in high-school education teaching and learning, which will improve the understanding and development of nuclear physics at schools.

Keywords. Colliders, accelerators, new superheavy elements, quark-gluon matter, neutrino, high-school education, nuclear physics, reactors, applied researches and engineering.

1. Introduction

Experiments have always been an integral part of the experimental sciences, such as Physics, and are one of the most effective ways to get first-hand knowledge about certain concepts and principles in a study field such as nuclear physics. It is challenging for schools to set up an excellent practicum on nuclear physics, because they do not have enough knowledge, understanding, equipment or skills available.

At the Joint Institute for Nuclear Research (JINR), a new educational project, the Virtual Laboratory (VLab), was initiated.

2. Hands-on practicum on experimental nuclear physics for high-school students

Initially the target group of this project was students of different universities and young specialists who started their careers in experimental nuclear physics. This project was divided into 3 parts:

- Software complex (includes illustrated theory, quizzes, exercises and virtual practicum with data obtained from traditional experimental facilities)
- Hardware complex for student practices (the laboratory with experimental equipment at the JINR was used)
- Environments for performing nuclear experimental modeling (virtual tool for experiment modeling and for modeling elements of experimental equipment)

Several practices were successfully held for university students from all over the world. After these practices, a new decision was made to adapt this resources for high-school students. The aim was to help high-school teachers to set up nuclear physics practicums. It was quite a complicated task because it was taken into consideration that students at high schools have limited knowledge and access to nuclear physics resources.

This year under the project “Virtual Laboratory” the extensive “hands-on” practicum program for high-school students at the Joint Institute for Nuclear Research was initiated.

The first part of this practice includes lectures provided by the scientific stuff of the JINR. The main goal of these lectures was to do revision with students about the basic concepts of nuclear physics. It created opportunities to give new resources and explanations to the students about processes that happen inside matter and also the methods how to detect different types of radiation.

During the lectures students study the following:

- The basic concepts of nuclear physics
- Radiation sources
- Interaction of radiation with matter
- Different types of radiation detectors
- Experimental electronics
- Data acquisition and analysis

Students can test their knowledge and understanding by doing quizzes and exercises which are loaded on the VLab.

Figure 5. Work with VLab software complex

Most of the time students spend their time working with traditional experimental equipment. In this practicum, under the supervision of specialists, students get acquainted with the basics of electrical signal measurements, knowledge about operation of semiconductor, scintillation detectors and modern detectors for time-of-flight measurements and also study the vacuum system needed for the study of alpha particles. Students assemble and work with a scintillation telescope for registration of cosmic rays. Attention was given to the analysis of experimental data.

For this practicum methodological resources were used which include step-by-step instructions that guide the students to achieve the results needed, pictures of expected outcomes and opportunities were created to help students write their conclusions. This practicum runs for 3 weeks, but it is possible to set up practices for a shorter period of time.

Figure 6. Preliminary calculations before measurements

Figure 7. Basics of signal measurements

Figure 8. Work with the scintillation telescope of cosmic rays

In April 2018, the VLab team organized an intensive “hands-on” practicum for a selective group of high-school students from HEMDA-Center for Science Education, located in Tel Aviv, Israel. They run a special program aimed to gifted and highly motivated students. The students enter a two-year program in which they learn physics and mathematics at the university undergraduate level. Hands on experiments are also an important part of their program. The visit to the JINR represents the peak of their studies. The first experience has shown that students display heightened interest in nuclear physics experimental activities. No one was left behind. Everyone has passed all the stages of the practice successfully!

Of course, we should also note the very high level of students from Hemda Center in physics and mathematics.

Figure 9. Students are studying the vaacuum system for nuclear physics experiment

By analyzing the outcomes of this practice it has shown that the students passed the practicum at different stages. This project also cater for advanced students, who were recruited from universities.

Figure 10. Assembling of the detection system of the light ion spectrometer

3. Conclusion

The VLab project at the Joint Institute for Nuclear Research developed the hands-on practicum on experimental nuclear physics for high-school students.

All teachers and students from all over the world are invited to the Joint Institute for Nuclear Research to take part in the hands-on practicum on Nuclear Physics. Future plans for this project are to broaden this practicum by inviting teachers to take part as practicum developers and develop skills to achieve and teach more methodological approaches about nuclear physics.

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What's Inside Themselves? Young Children's Ideas Elicited through Analysis of Drawings

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Abstract. Scientists do not rely on words alone. Drawings of some form are an integral part of science education across the genre, physics, chemistry, biology, geology for example. Making drawings is an active 'hands-on' activity and integral part of scientific picturing or visualisation together with for examples diagrams, photographs, videos. These drawings provide evidence for educators of some of a child's understanding because drawings are but one instrument in an educator's assessment repertoire of obtaining data. The skills of accurate representations develop as a child matures but all involve hands on activity. Moreover, drawings are a universal form of communication, free of linguistic variation, hence transverse cultural and language barriers. Analysing such drawings executed by children is one method in science education of eliciting an expressed model of what they think about something be it of the exterior or internal organisation of an organism. This paper presents the results of a longitudinal study of children's understanding of what is inside themselves by following the same class from entry into their primary school aged 5 years and analysing the content of their drawings. As children aged they produced more realistic drawings gradually learning more but few developed an understanding of a system as defined in the rubric systems at the end of pre-secondary education when not all the members of the original intake were still at the school.

Keywords. Biology, drawings, children's understanding, research methods.

1. Introduction

Drawings have been created by humans from earliest times. The cave drawings of Europe and the more recently discovered ones in Indonesia inform us that drawings have been used by our species for literally centuries as a record of happenings such as hunts and in one instance of the night sky. Drawings are constructed for a variety of purposes in science education. They are particularly pertinent in biological learning as 2 D representations derived from obervation of organsims, external or internal structures, e.g Tunnicliffe and Litson [1] or the drawing of the outline of a process [2].

Ainsworth et al. [3] assert that students will deepen their understanding if they generate their own representations of a phenomenon or concept. However, drawings alone do not reveal all that a person understands about a phenomenon but are an indication of their mental model, as a form of expressed model [4]. These expressed models are generated from mental models which are considered the personal cognitive representations held by individual subjects. Using drawings in biology learning has both advantages and disadvantages in being used to elicit understanding through analysis of the expressed models. Drawings are a universal form of communication, free of linguistic variation, hence transverse cultural and language barriers. Thus enabling international comparisons to be made. However, children may be unable to draw all that they know. Hence interviewing the learner with their drawing is a more effective means of assessing their understanding, as for example, sometimes a child will confide in interview that they had not the technique to draw that which they aspired to or decided not to.

Children see objects and organisms from their earliest years and can begin making representations which become more 'accurate' as they acquire certain skills they can represent them. Drawing is easier than writing for many children, particularly very young children, and making representations on paper is a stage in the development of a normal child. Luquet (1921), (cited by Krampen [5]) felt children do not directly transmit the characteristics of objects, that is, they do not simply copy them, but rather they put on paper the features of objects that they observe. He recognised stages in this development, in which there is a gradual tendency toward realism. Thus, the final aim of drawing would be a realistic translation of the visual properties of objects into graphics. Luquet proposed five phases in drawing development [5]: (1) Scribbling (ages 2–3 years); (2) Fortuitous realism (the discovery of similarities between certain features of scribbles and objects in reality, which begins to emerge at ages 3–4 years); (3) Failed realism(synthetic incapacity, as seen in drawings by children of 4–5 years of age); (4) Intellectual realism(the child draws what is known about reality, a stage that is generally from 5–8 years); (5) Visual realism(in this stage, which occurs between ages 8–12, the child draws what is visible only from a certain point of view in reality, i.e., from a certain perspective). Alternatively, Symington et al. [6] suggested there are three stages in the dev elopement of children's drawings, a scribbling phase, followed by scribble symbolism culminating in visual realisms.

Figure 1. "Me' drawn by Luc, aged 4. A Welsh boy. One of many identical drawings he produced

Research on children´s ideas about internal organization of organs and organs system is more common in vertebrates as for example [7].This study was focused on the organisms with which a child is most familiar, themselves. From other work I have found that very young children scribble, they progress to scribbling in an outline and then develop 'Tadpole' man. The children in this study had largely entered the at least early stages of visual realism. Such concurs with the observations of Krampen [8] suggests that one way of looking and draws conclusions about the drawings of children is to focus on one figure, such as the human. He reports that it was soon discovered that such drawings change from the tadpole man to a realistic presentation.

2. Methodology

The study reported here shows and discusses what can be learnt from drawings and from interviews of 5-11 year-old English children in a one form entry primary school in a middle sized town in the Home Counties of England

Level	Definition of level of organ knowledge
1	No representation of internal structure.
2	One or more internal organs (e.g. bones and blood) placed at random
3	One internal organ (e.g. brain or heart) in appropriate position.
4	Two or more internal organs (e.g. stomach and a bone 'unit' such as the ribs) in appropriate positions but no extensive relationships indicated between them
5	One organ system indicated (e.g. gut connecting head to anus)
6	Two or three major organ systems indicated out of skeletal, gaseous exchange, nervous, digestive, endocrine, urinogenital, muscular and circulatory.
7	Comprehensive representation with four or more organ systems indicated out of skeletal, gaseous exchange, nervous, digestive, endocrine, urinogenital, muscular and circulatory

Table 1 The scoring of organs shown in drawing of the human body [9]. In analysis the organ is denoted by the small letter of the system to which it belongs. See Table 2 for system definitions

The children were given a A4 blank sheet of white paper and asked to draw what was inside themselves. They were not provided with an outline. The class was visited at the same time in the Spring Term (between The New Year and the Easter (Spring) holidays by the same researcher, English schools usually have 3 terms in the school year, Autumn, Spring and Summer, the next school year beginning in the September. After the whole class drawing session each child was interviewed separately, by the researcher, at the side of the classroom, with their drawing which we used as the cue for questions. The researcher asked them to talk about each organ they had drawn and where they had found out about it.

Code	Definitions
s	Skeletal system Skull, spine, ribs and limbs
r	Gaseous exchange Two lungs, two bronchi, windpipe system which joins to mouth and/or nose
n	Nervous system Brain, spinal cord, some peripheral nerve (e.g. optic nerve)
d	Digestive system Through tube from mouth to anus and indication of convolutions and/or compartmentalisation
e	Endocrine system Two endocrine organs (e.g. thyroid, adrenals, pituitary) other than pancreas [scored within digestive system] or gonads [scored within urinogenital system]
u	Urinogenital system Two kidneys, two ureters, bladder and urethra or two ovaries, two fallopian tubes and uterus or two testes, two epididymes and penis
m	Muscular system Two muscle groups (e.g. lower arm and thigh) with attached points of origin
c	Circulatory system Heart, arteries and veins into and/or leaving heart and, at least to some extent, all round the body

Table 2 Definitions used for the systems of the human body [9]

The collected drawings were analysed for content using the rubric of Reiss and Tunnicliffe [9]. In the analyses (Table 1) and 2) the small letter of the organ system to which the organ belonged indicated an organ whereas the capital letter represented the drawing of a whole system. For instance, if a bone were indicated it was scored an ‘ s’ for a component of the skeletal system, but if a representation of a whole skeleton with pelvis and pectoral girdles, limbs, ribs and skull together with vertebrate column were drawn it was denoted as an ‘S’.

The definitions for these rubrics were complied by two biologists who were also experienced school teachers.

The children’s responses to “What is this,?” when asked about their drawing were noted by hand on a proforma responses sheet by the researcher. The early year interviews were also audio recorded and transcribed.

3. Results

A series of drawings were obtained together with a record on the interview of the same child’s answers about their drawings throughout their primary school career.

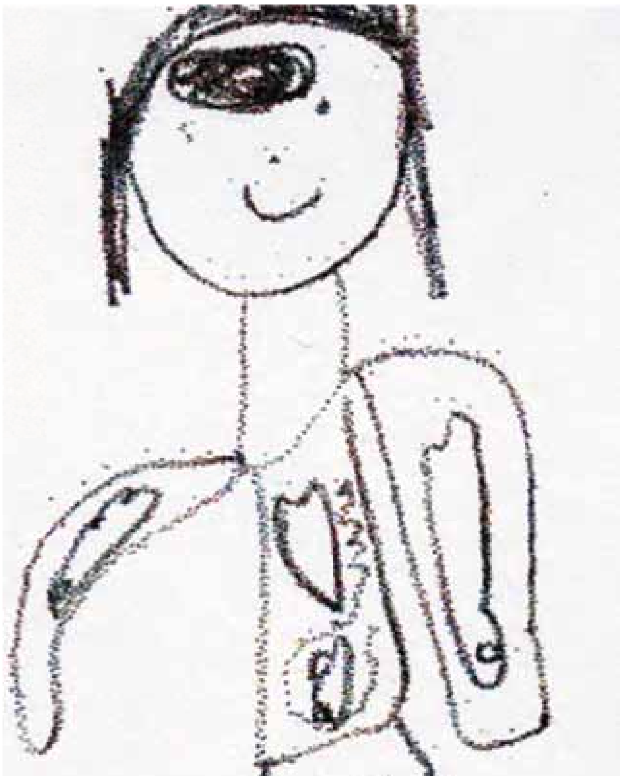

Figure 2 A year one girl scored cdsn (‘c’ for circulatory as a heart represented, ‘d’ for digestive as it appeared to be a stomach, ‘s’ for the bone representations and ‘n’ for the brain). According to Table 1 this was scored as a Level 4. The brain and heart were at approximately the appropriate place

Figure 3 Another year 1 child's drawings scored as level 4 as the indications are that they knew the appropriate place for three orgs, 's' bone, 'n' brain, 'd' stomach part of digestive system. It was decided that this was not a representation of the heart. Even young children drew the iconic 'love heart' as in Figure 2

Figure 4. This drawing from a year 2 girl shows many bones

The drawing in Figure 4 was assessed as level 4. This dog shape depicting bones is characteristic of early years in such drawings through the world. This girl had only inserted dog bones in her yr 1 drawing and was assessed as level 3 she is assessed as level 4 because she has both bones and a heart. In Year 3 she had acquired more organs belonging to more systems but was still at Level 4, ncdsu.

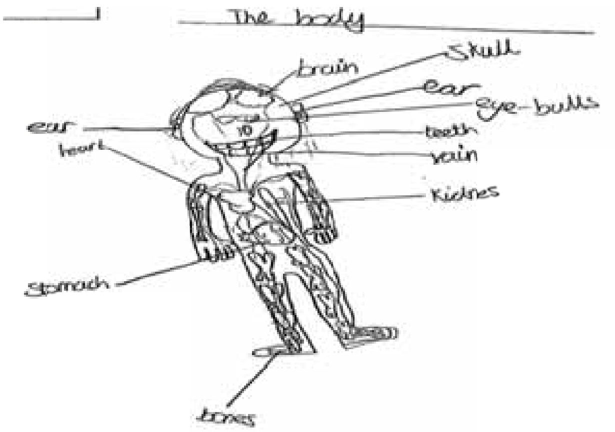

Figure 5

With reference to Figure 5, this girl in Year 5 she had added and organ but omitted kidney. She was absent in year 6 the respiratory system so had an 'r'.

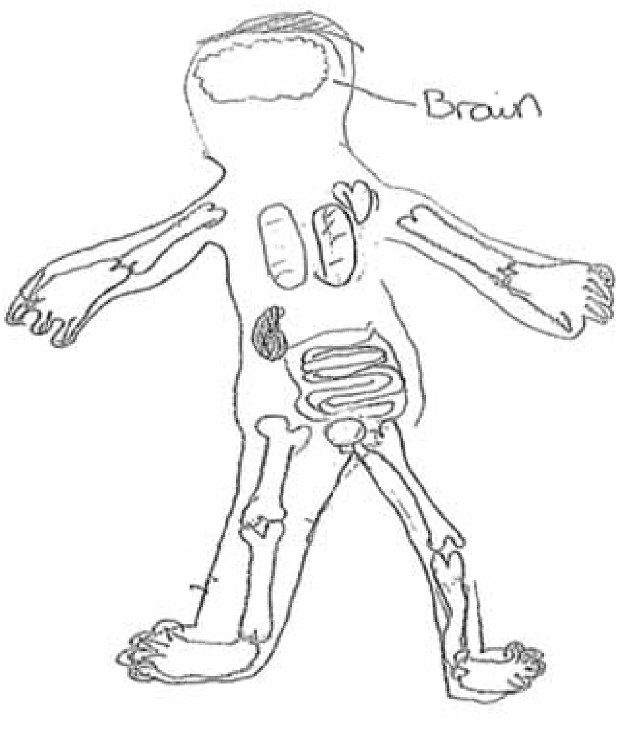

Figure 6

One girl who was present throughout the years began in years 1 with a level 3 indication of two organs forming the nervous system (brain) circulatory system (heart) and some bones, and at Year 6 was still, from her drawing, scoring level 4 but with an extended collection of organs of which she was aware. Namely nmcsrud.

Unusually she had indicated muscles from her year 4 drawings upwards but only included a digestive system organ and an excretory system organs (kidney) in year 6. However, on interview she was assessed as Level 5 systems (one) because she could explain the relationship between the kidney and the bladder and the urethra. Several children scored a higher score highly from the discussion using their drawings. A boy called M, for example from his transcript, was fully aware of the circulatory systems as we define it and the nervous system but only scored a level 4 from the drawings of year. He was one of the children who drew organs without a body outline at this stage as it became, he said, ‘too complicated’. Only 6 children remained present on the day of the interviews at Year 6 why has been present in year one. Other children had joined during the primary school stage. None of the original class members complied drawing scored at level 5 or 6.

Their learning source about their inside organs ranged from home, various media, seeing organs in model of a human torso at the local interactive science center, from books and from family members. In the earliest classes the children’s knowledge appeared to have been from conversations overheard or remarks made to them at home, particularly their care person. A number of children mentioned at year 4 (8 years) that they had learnt things in school that year.This was the age group where the then national curriculum recommended that the human body be studied.

4. Discussions

Over the six years, while there were periods of stasis, there was a tendency for children to know more about individual organ systems as they aged and for them to know about organs from a greater number of organ systems as they aged. In a number of cases, this growth in knowledge could be attributed to the influence of particular teachers and particular teaching approaches. Other sources of knowledge include family members, books, TV, personal experience and science museums/centres.

Form this work we conclude children learn incrementally from knowing of the existence of an organ and gradually learning of more organs and their approximate location gradually learning their reconnections to form systems, rather like finding end peace of jigsaw and gradually putting a picture together. It is common practice in drawing this anatomy topic of showing bone units in isolation. Hence provide them with cards for example, drawings of bones, the large limb bone, a rib case and have them build up the skeleton. From all the work I have carried out I assert that children learn one organ, and build up this understanding into bone units, i.e. the rib cage, the leg bones. Ultimately understanding the girdles and vertebrate column and skull. Children were very prone to personalise their drawing with a face as in Figure 2. External parts of the body for instance in Figure 5 where the ear and eye balls are modelled were not scored as we defined these as external features.

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The Development of a Scale on Co-Constructivism in Science Lessons

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Abstract. The aim of this study is to develop a scale measuring co-constructivist environment at Science lessons of secondary education. Scale has been applied to 238 students. Exploratory Factor Analysis has been carried out for 47 items. Remaining 27 items have been grouped into 5 factors. They explain 64.371 % of the total variance. Cronbach Alpha value of the scale is 0.950. According to findings, scale is reliable and valid. Item-total and item-remaining correlation values are significant ($p < 0.01$). Item discrimination obtained from the difference between mean points of bottom and top 27 % of the groups are significant, too.

Keywords. Co-constructivism, exploratory factor analysis, science lessons.

1. Introduction

Historical foundation of co-constructivist theory dates back to Baldwin, Piaget, Vygotsky and Stern. Co-constructivism is a kind of socio-genetic personology (examination of characteristic features) [1]. Thinkers of socio-genetics emphasize that humanbeings construct their all functions or at least high psychological functions socially [2]. Socio-genetic approach of this theory makes special emphasize on unique feature of individuals in terms of belonging to their culture. In other words, individuals are the part of macrolevel existence (collective culture) at microlevel (personal-cultural).

The relation between two levels can be defined as dual cultural conversion. This kind of cultural bond enhances the conceptualisation of cultural dialectic. On one hand, collective culture is located in common meanings of social group on the other hand, each individual constructs his/her own collective culture and co-constructs his/her own personal culture in an active way [1]. Personal culture and collective culture are in interaction with each other.

Learning is thought as active construction of knowledge. While students are trying to make sense of their worlds, they do not get passively stimulant knowledge which match with the independent physical constructions. They geniusly interpret their experiences through re-organizing cognitive constructions by increasingly complex ways. According to Piaget, this real constructivist process in cognitive, developmental and educational psychology is obtained through both biological based constructs (its strength and content have not been known) and existing pre-knowledge of the individual (concepts and functional schemas). How come individuals who construct independent personal knowledge have same or similar cognitive constructs? If individuals are thought as single learners, how will we share the knowledge of our culture? The answer can be driven from symbolic interactionist and socio-cultural theory. This theory claims that learning is a social activity.

Learning and acculturation cannot be restricted with the individual's brain or mind. It is hidden in society and knowledge of society, its point of view and beliefs. Individuals construct their knowledge not only through personal experiences but also through speaking with others. The basis of personal development and acculturation is not being alone socially for constructing knowledge, but is to co-construct in social and cultural areas. Many learning in most places are cultural sharing and social activity. Child cannot form his/her knowledge alone. He/she forms knowledge among other people who feel belonging to one culture. According to this point of view, knowledge does not exist alone in one's mind. It spreads to the people who have common interactions and agreements [3].

2. Aim and importance of the study

Co-constructivism is not a new theory in the literature but it needs more research on it. In Turkey, a study about this theory does not exist. This scale aims to measure the level of co-constructivist environment at Science lessons of secondary education. One of the main competencies of Science curriculum is cultural awareness and expression. According to this competency, students are expected to understand their own culture thoroughly, respect cultural differences and demonstrate positive attitudes towards them [4].

3. Method and sample of the study

In this study, general survey method has been used. Survey researches which have descriptive feature are used for describing objects, structures of societies, institutions and process of events. In survey researches, generalization is made in the light of data obtained from a sample towards the population which it represents [5]. The sample of this study is consisted of 238 secondary school students (female: 136, male: 102). The number of sample needed for factor analysis should be minimum 5 for each variable [6].

4. Development of scale

This scale is a five point scale. These types of scales are developed through using the approach of item analysis. In item analysis approach, a certain item is evaluated in terms of the differences between the items which have high points and low points [7].

4.1. Item pool

First of all, literature research has been carried out in order to understand co-constructivist theory and write related items. Theoretical information has been gathered through written sources. Key concepts which explain the features of co-constructivist theory have been determined. Each item has been based upon literature. Moreover, open-ended six questions have been asked to five secondary school students about co-constructivist theory at Science lessons in order to write more items. There have been 59 items in this item pool. These items have been presented to three experts and they have examined these items whether they have written according to the aims of the curriculum. 11 items have been omitted since they are not appropriate for 7^{th} and 8^{th} grade Science curriculum. 6 items have been rewritten in order to prevent misunderstanding. Remaining items have been ordered and scored as “I always do” (5 point), “I usually do” (4 point), “I sometimes do” (3 point), “I rarely do” (2 point) and “I never do” (1 point). 10 secondary school students have answered the items on the scale in order to find out any problems with regard to language and expression. After this pre-application of the scale, 1 item has been omitted. Lastly, 47 items have remained in the scale and 238 secondary school students from three different schools have answered the items on the scale.

5. Findings

In order to determine construct validity of this scale, exploratory factor analysis has been made. Exploratory factor analysis aims to find out the number of common factors which affect a group of measurements and value of relations between observed measurement and factor [8]. Before factor analysis, data have been examined in terms of normality. Values of skewness and kurtosis of data are between +2.0 and -2.0, which show that data have normal distribution [9]. For factor analysis, distribution in universe should be normal. Barlett test gives the result whether variances are homogeneous [10]. In order to determine whether data is suitable for factor analysis, Kaiser-Meyer-Olkin (KMO) coefficient and Barlett sphericity test have been obtained [11]. KMO coefficient’s result is 0.95 and Barlett test’s result is significant (0.00) (x^2: 7886; sd: 1081; $p < 0.01$). If the value of KMO is above 0.70, it shows that there are enough number of samples [12].

Factor loadings which are less than 0.30 are considered as low whereas factor loadings which are more than 0.40 are considered as high [12]. In this study, items whose factor loadings are less than 0.40 have been considered to be omitted but there aren’t any items whose factor loadings are less than 0.40. Therefore, items have not been omitted through this method. Items should have high factor loading in only one single factor while they should have low factor loading in the other. The difference between the two high factor loadings should be 0.10 at least [11]. In this study, this method has been applied while omitting the items. Accordingly, 20 items have been omitted. Rotation has been made through using varimax method. After omitting items, scale has 27 items that are grouped into 5 factors. These 5 factors explain 64.37 % of the total variance and eigen values whose higher than 1.00 are taken into consideration.

The first factor has 6 items; the second factor has 6 items; the third factor has 6 items; the fourth factor has 5 items and the fifth factor has 4 items. The factor loadings of 27 items are between 0.46 and 0.82. Cronbach Alpha value of the scale is 0.950. Cronbach Alpha value of the first factor is 0.850; of the second factor is 0.852; of the third factor is 0.856; of the fourth factor is 0.874 and of the fifth factor is 0.868. If this value is higher than 0.70, it means that scores of scale are reliable [11]. Item total correlation values are between 0.410 and 0.741 while item remaining correlation values are between 0.456 and 0.765. Accordingly, it can be said that items are significant because item total correlation coefficient is higher than 0.30 [11].

Another method in item analysis is to compare the mean points of bottom and top 27 % of the groups [13]. The difference between the mean points of bottom and top 27 % of the groups is significant ($p < 0.01$), which shows that scale has internal consistency [11].

In order to name the factors, the content of the items and literature have been considered. First factor is named as “co-constructivism”; second factor is named as “collaborative work”; third factor is named as “social experience and interaction”; fourth factor is named as “sharing culture” and fifth factor is named as “relating with real life”.

6. Conclusion

In this study, it is aimed to develop a scale which measures the level of co-constructivist environment in Science lessons at secondary schools. In order to determine construct validity of the scale, factor analysis has been carried out. As a result of exploratory factor analysis, scale has five factors. According to validity and reliability results of the scale, it can be said that items on the scale are valid and reliable.

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Scientix, the Community for Science Education in Europe

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Abstract. Scientix is an initiative for promoting scientific education and vocation in Europe. The Scientix Ambassadors promote and inform about Scientix to their peers - science and mathematics teachers across Europe. They present Scientix in schools and national teachers associations, on conferences and workshops, and can advise teachers how to get involved in European collaboration in STEM. They also assist in developing and testing various tools and services of Scientix and ensure the pedagogical quality of the Scientix repository. In this work the experience and results of the tasks performed as Scientix Ambassador in Galicia-Spain are presented.

Keywords. STEM, European Schoolnet, Scientix.

1. Introduction

Scientix [1] is an initiative for promoting scientific education and vocation in Europe that now brings together over 7000 teachers after seven years in operation. It is open to the education community in general and especially to teachers, researchers and policy makers. Its main aim is to promote and support collaboration between teachers, education researchers, policymakers and other education professionals in the areas of Science, Technology, Engineering and Mathematics (STEM subjects) and was recently recognised at the BETT 2017 Exhibition of Trends in Education Technology as one of the top 100 innovations worldwide in the field of education.

2. Structure, resources and activities

Coordinated by European Schoolnet [2], a non-profit organization and network of thirty-one European education ministries, Scientix receives funding from the European Commission through the 7th Framework Program and has contact points in every EU country. In Spain, this role is currently fulfilled by the Spanish Ministry of Education, Culture and Sports [3].

Figure 1. Scientix Ambassador Logo

Over the course of the project, Scientix (Figure 1) assigns a series of representatives or ambassadors in each country whose aim is to spread the word about its activities among the teaching community throughout Europe, help share knowledge and best practice in science education, and support and improve scientific education in general at a local level. The panel of Scientix ambassadors is one of the three main support groups for the implementation of Scientix activities and support STEM Education. Spain currently has 58 Scientix ambassadors for the 2016-2019 period, five of whom are linked to different Spanish universities while the others are mainly secondary school teachers. The main task of all Scientix Ambassadors is to support the dissemination of Scientix, to provide ad hoc help in surveys, feedback requests, etc. and to report back to Scientix on their actions. They participate, for example, in activities to raise awareness of the research going on in different science and technology centres not only among the general public but, particularly, among students undertaking training who are likely to find their vocation through direct interaction with labs and research teams. At the same time, the ambassadors present Scientix at education centres, national teachers' associations, congresses and workshops, and they advise other teachers on how to get involved in European STEM collaboration, in the belief that professional development of teachers should include active participation in cooperation and collaboration networks. The ambassadors can undertake assessment and monitoring tasks for projects/tools for teaching innovation at a European level and, at the same time, help not only to publicise the resources, projects and training Scientix offers

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but also to provide information about periodical events. Scientix Ambassadors are normally involved in the preparation of the Scientix Webinars [4], Scientix Moodle courses [5] and in the writing of Scientix blog articles [6]. In Scientix training actions participants receive a certificate of attendance (Figure 2).

Figure 2. Certificates of participation in Scientix Webinars

During this academic year, a post related with hands-on physics resources was written for the Scientix blog on the following topic: Where do I find hands-on Physics resources? (Figure 3) [7].

Figure 3. Hands-on Physics activities

Scientix currently provides free direct access to over four hundred European educational projects and almost two thousand teaching resources for the classroom, many translated into the 30 official languages of the EU or available for translation by Scientix on the specific request of teachers when the need arises. Around seven hundred resources have already been translated in this way. Scientix periodically offers online training, inviting users to freely access video conferencing programs in twenty-four languages and various formats: Massive Online Open Courses, seminars or workshops, etc.: spaces for learning that are also times and places for sharing and exchanging ideas. These presentations commonly involve up to 200 people at different sites all connecting for an hour with the possibility of interacting with the speaker in some way. Afterwards, a certificate of having participated is also an option. It is possible to subscribe to the online newsletter tailored for a specific topic which also gives information on news and events and reminders of upcoming activities, competitions, awards and training possibilities. Meet-ups are held nationally and internationally – meeting points in the form of seminars or congresses, although an important way of keeping up with Scientix initiatives is by following a project on social media, where the organisation has over twelve thousand followers on Twitter [8]/Facebook [9], , which are open to collaboration from anyone interested in STEM education.

Figure 4. Scientix web page with a banner related with a photo of our stand

Several Scientix Ambassadors we were selected to attend the 3rd Scientix Conference (Brussels, 4-6 May 2018), and event, which attracted around 350 teachers, policy makers, researchers and project managers involved in science, technology, engineering and mathematics (STEM) across Europe, offered participants a unique opportunity to network and explore different science education projects [10].

Gabriel Pinto [11] and I present different hands-on Physics and Chemistry activities in a demonstration stand on the following topic: Connecting science with the daily life via hands-on activities (Figure 4).

During academic year the strategies used to spread and share knowledge include face-to-face seminars with students, teachers and the management and departmental teams in centres. In our case we use a motivational talk packed with fun experimental material in the belief that practical experiments and activities can inspire and help the students to develop a conceptual understanding of the ideas in the curriculum and the competences associated with using the scientific method, such as critical thinking, group work, and so on [12].

Figure 5. Images of activities in secondary and pre-university centres during the 2017-2018 academic year

So the seminars aim to show experimentally the relationships between the contents of seconda0ry and pre-university Physics topics and the knowledge needed to study Engineering or a scientific degree – encouraging learners to lose their fear of science, technology, engineering and mathematics and to start seeing them as an appealing option they could dedicate their time to in the future (Figure 5). At the same time, this intervention on their own doorstop in schools means informal collaboration networks can be created with the teachers in the places where they work by providing information about the different tools and resources available through Scientix, encouraging them to take part in the activities, and providing them with updates and news about events.

Figure 6. Images of activities at Universidad San Marcos (Lima-Peru) and at the National Technical University "Kharkiv Polytechnic Institute"(Kharkiv-Ucraine) during the 2017-2018 academic year

During the 2017-2016 academic year, there have been 26 talks that have taken "Learning Physics by Doing Physics" and the Scientix project to around 1400 students and 125 teachers (Figure 5).

At the same time practical classes and workshops for teachers, education researchers, policymakers, and other education professionals in the areas of science were presented in different countries (Figure 6) [13-15].

Persons interested in obtaining quick information can subscribe to Scientix email updates to get all the latest news [16].

3. Disclaimer

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Spherification: A Practical Tool to Teach Biotechnological Concepts at Schools

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Abstract. The use of polymers to entrap cells, enzymes and organic molecules is a common procedure in chemical and pharmaceutical industries. These gelling agents permit certain molecular permeability allowing both substrate and product exchanges at appropriate rates that are suitable for the proper functioning and viability of cells or the activity of the enzymes. Alginate spherifications are widely used in molecular gastronomy, and are appealing to the student. Immobilization with sodium-alginate fulfils appropriately these requirements, in fact, immobilization by alginate is a simple, gentle and low toxicity method, suitable for immobilizing any type of cells, enzymes and a widely kind of chemical substances.

Keywords. Biotechnological practice, cell and enzymes immobilization, polymers, teaching.

1. Introduction

Alginate is a polysaccharide natural from brown algae. Sodium alginate is a soluble salt of alginate and is the common form of this polysaccharide. This salt is a linear polysaccharide chain solvated with sodium ions. If a calcium salt is mixed with sodium alginate in aqueous medium, the calcium ions substitute the sodium ions. The bivalence of the calcium ions makes possible the cross-linking of original sodium alginate linear polymers, generating an insoluble network that becomes a gel.

If a sodium alginate solution is poured drop by drop into a calcium chloride solution, the superficial tension of the droplet plus the rapid jellifying reaction generates almost perfect calcium alginate gel spheres.

2. Sodium Alginate in Gastronomy

Alginate spherifications are commonly known to be an *avantgarde cuisine* technique. Ferran Adrià was the first cook to use alginate polymerization reaction in gastronomy, in its restaurant *Bulli* on 2003 [1]. There are many kinds of spherification techniques, but the most common are the direct and the inverse spherification.

Direct involves mixing a liquid of interest (for example fruit juice, some alcoholic beverages…) with the sodium alginate and then pouring it drop by drop into a calcium chloride solution. Then, the spheres are washed in mineral water and finally are ready to use.

Inverse or reverse spherification is trickier, for the result is more fragile. Instead of mixing the liquid of interest with the sodium alginate, it must be mixed with the calcium chloride solution, and then introduced drop by drop into a sodium alginate solution. This generates a thin calcium alginate film on the surface of the droplet.

Direct spherification generate a more solid and tough sphere, while reverse spherification generates spheres that are liquid on the inside. The latter explodes in the mouth. For this reason, direct spherification is done with little droplets and inverse spherification is done to bigger drops.

This is easily done in the classroom. A brick of juice can be used as liquid of interest. Sodium alginate and calcium chloride can be obtained from gastronomic suppliers (it should be labelled as edible). Then, 3 bowls are needed. One for the sodium alginate plus flavoured liquid solution, which usually contains 1% of the salt (but this depends on the density of the liquid of interest); one for the calcium chloride solution, which usually contains 0,18% calcium (0,5% calcium chloride, but might be different for other salts); one for the washing water (which should not have much calcium).

Obviously, this is for direct spherification. For reverse spherification, the same should be prepared but calcium salt should be mixed with flavoured liquid and sodium alginate with distilled water (it can't contain any calcium or the solution would react).

It is important to note that sodium alginate might be difficult to dissolve and might create bubbles. You should wait until there are no bubbles if you want perfect spheres. For a more spherical result, the calcium bath can be increased on density by adding up to 20% of sugar. [2]

Interestingly, at pH<3.4, the reaction does not occur properly due to competition for the negative charges between protons and calcium. Also, the acidic groups (responsible for the crosslinking) are protonated in a higher proportion. For this reason, acidic liquids must be basified (sodium citrate is mainly used) [2].

Another consideration is that some liquids might have enough calcium to react with the alginate. For instance, a creamy yogurt can be used in reverse spherifications, without any supplementation of calcium. Just pour a spoonful of yogurt into the alginate bath. This was first done by the famous indian chef Gaggan.

3. Sodium Alginate in Biotechnology

Although sodium alginate has been popularized thanks to Ferran Adrià's inventions, it had been widely used before. Polymerization reactions are avidly used to entrap cells, enzymes or other molecules of interest. This makes easier the purification step of the process, since a simple centrifugation can separate the producers from the product. Not only that, but entrapment can sometimes protect the cells or molecules from a toxic product such as ethanol or inhibition by product.

Calcium alginate is specially used due to several perks:

- Low cost;
- Insoluble, non-biodegradable and without or low toxicity;
- Provide a sufficiently large surface area for cells to have access to metabolites;
- High mechanical and chemical stability and high diffusion under the operating conditions of the process;
- It does not affect the activity of the cells nor induces cell lysis;
- Easy to perform
- Safety of recycling and / or disposal;
- Enough matrix flexibility to accommodate new cells.

An easy fermentation assay can be used in the classrooms to explain basic concepts of biotechnology (such as entrapment) and biochemistry (such as fermentation and ethanol toxicity).

The objective of this practical is to obtain a time-course of a yeast fermentation with free yeast suspension and immobilized yeast. The following protocol was obtained from the guide for practical sessions of *Bioquímica I Microbiologia Industrial* subject in the Biochemistry degree of *Universitat de Barcelona* [3].

To immobilise the yeast, mix a 3% sodium alginate solution with 10 ml of 30% yeast suspension on proportion 1:2 v/v. The spheres are done in a 2% calcium chloride solution. Mix 3g of yeast with 50 mL of 8% glucose solution for the free yeast suspension and all the immobilised yeast spheres in 50 mL of 8% glucose for the immobilised yeast suspension. Prepare a structure like Figure 1 on constant mixing and measure the produced gas every 10 minutes.

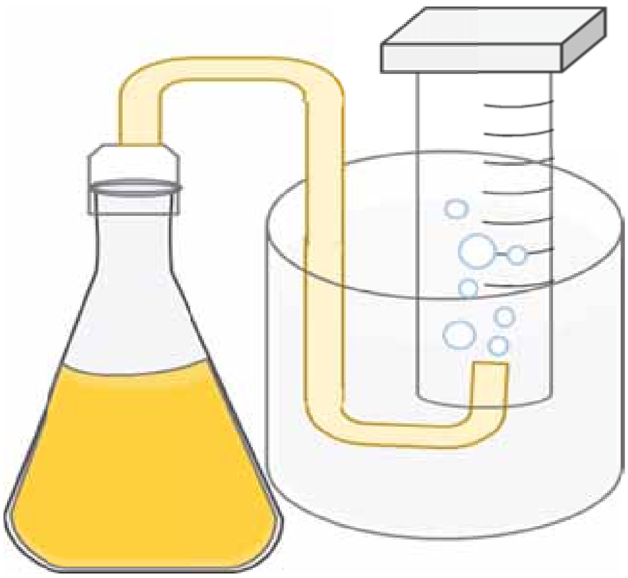

Figure 1. Scheme of the experiment structure

After one hour, represent gas volume vs time. You will see that free yeast presents a decrease in the ratio V/t but immobilised yeast does not. This is because calcium alginate protects the yeast from ethanol toxicity.

4. Conclusions

Two kinds of practical sessions can be used to explain jellifying agents such as calcium

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alginate. A friendlier approach is the molecular gastronomy approach. For bachelor students, though, the biotechnology approach might be more fulfilling, there are more concepts introduced.

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Scientific Software at Schools

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Abstract. It is said that technological devices, particularly computers, change every day. In an analogous way, Science is in full change, and this is one of several problems that educational community must face; as well as maintaining updated both scientific concepts and the classroom and laboratory equipment.

In recent years, we have witnessed the progress made in our educational system [1]. The use of ICT (Information and Communication Technology) in classrooms have involved a significant didactic aid, allowing teachers to accompany their explanation with the exhibition of a multitude of multimedia examples [2]. Despite the importance of ICT or the reduction of the computer equipment prices, renovating the software of a computer classroom tends to be difficult. Sometimes, due to the time that involves the necessary updates, or sometimes, due to the lack of financial resources. In these circumstances the use of free or open source software or cloud software could be useful in reducing license costs or because students can be involved in this process.

Traditionally, one of the reasons to explain the existing reticence in their use is the lack of information or the believe that software only run on free operating systems like GNU/Linux and these are difficult to use it. Even though their improvements in the ease of installation, the desktop environment and graphical interfaces, which have greatly reduced the learning curve. Fortunately, these circumstances are changing thanks to the wide introduction of Android software and apps in mobile phones and tablets.

In Spain, different autonomous communities to expand the deployment and the implantation of open source software in the Spanish educational system have promoted several projects. Most of them based on modified GNU/Linux distributions, usually based on Debian, such as Linex in Extremadura; Guadalinex in Andalusia; MoLinux in Castile–La Mancha; Linkat in Catalonia; MAX in Madrid; Galinux in Galicia or LliureX in the Valencian Community.

Even so, these work environments are less known by users than other operating systems considerably more used in personal computers. This would not be too important if it were not for the fact that this type of software and operative systems are widely used in scientific and supercomputing areas. For this reason, educational staff should to train secondary school science students in the handling of this type of software and operative systems.

In the present work, we have set ourselves the goal of presenting different scenarios of free software use, considering the needs of teachers and students. For example by means of Live-Distros, which allow their use booting them from a DVD or a USB flash memory or an external disk drive, or by using virtualization environments, which are the perfect candidates to be used routinely in computer rooms. In addition, how they can open us the access to an enormous collection of programs that can facilitate the teaching of sciences or are routinely used in scientific research field.

Keywords. Free/Open Source, scientific, software, teaching.

1. Before starting, some necessary definitions

1.1. Software licenses

It is one of the most important points for the user, since a software license is a contract between the licensor (author / holder of the exploitation rights / distributor) and the licensee of the software (consumer user / professional user or company), to use the software complying with a series of terms and conditions established within its clauses.

Next, are presented a comparison between the most used operative systems' licenses.

1.1.1. Windows

Restrictive end-user license agreement (EULA), one copy per license at one time, not allowed its simultaneous use by multiple users over a network, not allowed its sharing [3].

1.1.2. Mac OS

Restrictive EULA, one copy per license at one time, not allowed its simultaneous use by multiple users over a network, not allowed its sharing [4].

1.1.3. GNU/Linux derivates

Nonrestrictive end-user license (GNU GPL), non-restricted the number of copies per license at one time, not allowed its simultaneous use by multiple users over a network, not allowed its sharing [5].

1.1.4. BSD derivates

Practical nonrestrictive end-user license (BSD), non-restricted the number of copies per license at one time, not allowed its simultaneous use by multiple users over a network, not allowed its sharing [6]. Another point to consider is the responsibility acquired by the licensor for the licensee; even in pay per use software, the responsibility of the software developer is restricted. Sometimes limiting the change of the product during the warranty period or setting a limit of compensation. In addition, the end-user license agreement (EULA) does not always allow the execution of the operating system in a virtualization machine without the acquisition of as many licenses as virtual machines in which the operating system is executed.

1.2. Free software

The FSF (Free Software Foundation) [7] expresses its philosophy about free software as a matter of users' freedom to execute, copy, distribute, study, change and improve the software. Being access to the source code a necessary condition. More precisely, it means that program users have the four essential freedoms: Being able to run the program for any purpose; the freedom to study how the program works and modify it to adapt it to the needs of the user; the freedom to redistribute copies and the freedom to distribute copies of their modified versions to third parties [8].

1.3. Open Source

It refers to freely distributed and developed software [9]. Like free software, users have access to the source code to be able to adapt it to their needs and improve it. Although, from the practical point of view it is equivalent to the movement of free software. The licenses under which it is distributed may incorporate some restrictions such as the requirement to keep the name of the authors, the declaration of copyright in the code, allow the modification of the code only for personal uses or its redistribution for non-commercial uses.

1.4. Freeware

It does not mean that it is equivalent to free or open source software, since this type of software may include restrictions on its licenses. Many times, this software is offered by companies as software with limited capabilities or limitations of use (on a personal level); or, associated with counterparties such as the incorporation of advertising. Generally, it is compared as a free shareware.

1.5. Shareware

Shareware is a software distribution modality, which allows its free evaluation by the user, but with limitations in the time of use or in some of the forms of use or with restrictions in the final capacities. To acquire a software license that allows its use in a complete way, a payment is required, usually moderate, or less commonly a simply registration.

2. GNU/Linux – BSD distributions

A program is a set of instructions, which are found in the source code. This code is written in a language understandable to programmers, but cannot be executed directly on a computer without compiling it previously.

The compilation process can be long and tedious, so certain companies and user communities have created their own collections of software (distributions) already compiled.

Many of these applications are part of the operating system, which is a set of programs responsible for managing the basic processes of a computer system and allows the normal execution of the rest of the operations.

The choice of an operating system and its associated applications will depend on several factors: type of computers available, choice of applications to use and type and age of students. While the choice of operating systems based on free software may be convenient in the last years of primary school, merely, as an introduction for students. In secondary and higher education courses, especially in the scientific field, it can become mandatory, if we consider its use in research

[10] and the vast number of applications [11] developed.

In the case of free and open source software depending on the core of the system used, which is the software that constitutes the most important part of the operating system, among the more common there are Unix-like distributions based on GNU/Linux, BSD, GNU/Hurd or Solaris; windows-like distributions as ReactOS; and DOS-like systems as RDOS or FreeDOS.

The software is ordered within the collections in packages, managed by software that solves problems of dependencies and updates. Generally, the greater the number of packages in a collection the greater the number of applications. For example, Debian 9, a GNU/Linux distribution, comprises ca. 51,000 packages or the equivalent of more than 58 GB at a cost close to zero.

3. Live distros and virtualization

Some distributions are known as Live Distributions or Live Distros, which provide an operating system stored on a removable media, which can be used from the medium itself without the need to make changes or install it on the computer. Depending on the type of removable media, we have CD-DVD Live and USB Live distributions.

CD-DVD Live distros uses a CD or DVD as the boot medium. The user can download the disk image, usually an ISO image, from Internet and then burn it on an appropriate support. Except those distributions with the ability to save the user's preferences on the hard disk or other removable media, in general, changes in the whole program are not saved.

USB Live uses a USB flash memory as the boot medium. An important advantage over previous distributions is that USB Live allows you to store the desired configuration parameters and work files in one device. In the case of older computers that do not allow booting from the USB drive, a diskette or CD can be used as the start-up device. Furthermore, in newest computers read and write speeds achieves on USB media are further higher, particularly using USB 3.1 or thunderbolt ports, than the can be achieved on CD/DVD media.

On the other hand, there is the so-called virtualization software. Virtualization means the creation of an abstraction layer between the hardware of the physical machine (host) and the operating system of the virtual machine (guest). This layer manages and manages the main resources of the computer (CPU, Memory, Network, and Storage). As the guest operating system is developed within another operating system, there is a logical performance penalty. In current systems, this penalty is close to 10%.

If virtualization is complete, the virtual machine simulates sufficient hardware to allow the execution of an operating system that runs as if it were installed on a stand-alone hardware platform. Therefore, it is possible to run several virtual computers on the same physical computer. Although this concept was born in the 60s with mainframes, it was not until the 90s that it reached its development in personal computers.

Next, it is shown a comparison between Live-distros and virtualization.

3.1. CD/DVD Live distros

Free or with reduced cost based on licenses GLP/BSD. Commonly with high latency read/write times. Usually data recording on the support is disabled, and typically, the time to be ready to use in a computer once the image has been burned is ≤ 10 minutes.

3.2. USB Live distros

Free or with reduced cost based on licenses GLP/BSD. Commonly with medium-low latency read/write times. Usually data recording on the support is allowed, and typically, the time to be ready to use in a computer once the image has been burned is similar or a bit more than a normal boot. Hibernation mode is enabled for a fast boot. Noteworthy that there are some optimized distributions to use with removable media. In the specific case of USB Live distro, when the used USB port is version 1.0 and 1.1 they are not practical because of the long latency in reading and writing.

3.3. Virtualization

Free to high cost based on licenses GLP/BSD/Privative: Note:Xen, KVM, Virtualbox y VMware Player can be free download from

Internet. Hypervisor is enabled in Windows Pro/Enterprise versions.

Commonly with low latency read/write times. Data recording on the support is full enabled, and typically, the time to be ready to use in a computer once the image has been burned is more or less the same than a normal boot. Suspend mode is enabled for a fast boot.

Virtualization has the main drawback of the need to install the guest operating system and the chosen applications, but this step should only be done once. Since the virtual machine image can be copied to any compatible computer, even with a different hardware configuration. Virtualization machines can also be used to run Live distributions.

Noteworthy than under virtualization or using USB Live distro, the storage limit is the storage capacity of the machine/device.

4. Implementation in the classrooms

In many countries, an effort has been made to equip the classrooms with computers to offer to students the opportunity to learn computer science and be equipped with the computational thinking skills they need to be creators in the digital economy. Many computers come with an operating system pre-installed; almost all are Ethernet wired or have WI-FI connections and USB ports, and many have CD / DVD readers. This configuration is enough for testing both Live systems or virtualized machines.

Live systems based on removable media require shutdown, reboot the computers and loading the operating system on the guest machine. This process can consume up to 10 minutes of time, which shortens the time available for classes. In addition, these distributions are not always the most suitable, as we can find the lack of a program. In this case, only the distributions hosted in USB memories can solve this problem, allowing us to reconfigure the set of applications. In any case, students can save their work using an external device or in the case of writable systems in the same USB flash memory.

On the other hand, virtualization systems have the advantage that they can emulate and virtualize different operating systems within a single machine, providing the host operating system with access to the extractable and printing systems. Therefore, that for the user the host system behaves with total transparency.

In virtualized systems, the hardware abstraction layer provided by the virtualization machine simulates standard hardware. Virtual machines are stored as a disk images that can be copied and hosted on other computers or be accessed from a unique computer that acts as an image server (cloud servers are commonly used in High Performance Computing). The main advantage is that once the disk image is created it can be distributed to other computers because the hardware that is simulated into the virtual machine is always the same, independently of the real hardware of the school computers, thus only the creation of a single image is necessary.

Thus, it is possible to create a virtual machine with a base installation of the operating system, and later, to add the set of applications that the educator considers most appropriate. The students who can be involved in the process of creation of the virtual machines [12] can do that step [13-14]. Other advantage is students can freely operate and test without the fear of harm the computer, in case of failure image can be easily change the image disk without affecting the host computers' 'health'.

Nowadays, it is possible to download images from the Internet, most of them are systems based on free software, which could be used as a base installation.

Virtualization, therefore, implies a reduction of costs, if they opt for open solutions, saving time and facilitating the implementation and maintenance of the systems, but it requires enough disk space to house the virtualize image, which commonly requires several gigabits of space.

Another possibility is to create a virtualization hybrid system based on removable media with permanent storage capacity. These systems use a large USB flash memory (best newest memories) or an external disk drive where the portable virtualization system is housed; using part of the available space to host the image of the virtual machine and the rest is used as a storage space.

These hybrid systems have the intrinsic advantages of virtualization and portable systems. In this case, it is not even necessary to install the virtualization system. Any work can be saved in the same USB memory or disk drive. As diverse partitions can be hosted in the same memory or disk, a partition can be used as a storage partition, in case of total disaster of the operative image, storage data will no affected and continue to be accessible.

In addition, the system is portable to any computer and thanks to the recording of the state of the virtual machine. It can be continued from the same point where the virtualized operating system was left. In addition, students can use their own devices, which can be connected to any computer. Although the main drawbacks of this platform are the speed of reading and writing through the USB ports and the penalty when running applications under a virtualized system. However, the newest USB 3.0, 3.1 or using f Thunderbolt ports, this penalty can be neglected when high-speed storage devices are connected through these ports. The increase in storage capacity of the external devices together with the reduction in prices, augur a good future for this platform that presents obvious advantages due to its ease of use and implementation.

If we have decided to test the implementation of one of these systems, we just need to find the most appropriate type of distribution. A number of Web pages present a compilation of distributions. Among all of them, maybe Distrowatch is shown as one of the most appropriate to perform the search [15].

5. Examples of software distros for schools

Most distributions are from GNU/Linux world, which offers a vast variety of distributions. Some distros have a good and long maintenance, and they are fully supported by user communities; others have a short life and are unfortunately discontinued.

In this paper, a part of Spanish distributions that has been mentioned above, it will be shown the most common distributions used in STEM education. STEM is the acronym for Science, Technology, Engineering, and Mathematics, and encompasses a vast array of subjects that fall into each of those terms. Below, are presented the most commonly used distributions in schools. We strongly recommend a search for possible distributions through a browser engine or through the Distrowatch web page to appreciate the vast assortment of existing distributions.

5.1. Sugar

It is based on Fedora is a platform designed for young children (K–6), it is Sugar is available in a wide variety of forms: as part of GNU/Linux distributions; LiveUSB/CD; and in virtual machines or emulation [16].

5.2. Kano OS

It is an open-source OS for exploration, creation, and play to-free for Raspberry Pi 2 and 3, for kids (K-12) and it is designed to allow kids to assemble their own personal computer and learn to program [17].

5.3. Ubermix

It is an open-source-OS Linux-based built by educators, for young children and kids (K-7 and K-12. Ubermix is based on Ubuntu Linux combining a base operating system and a mix of applications under 8 GB, so that it would fit easily on the 8 GB system drive smaller flash-based devices [18].

5.4. Karoshi

It is a free and open source school server operating system based on Ubuntu. Karoshi provides a simple graphical interface that allows for quick installation, setup and maintenance of a network [19]

5.5. Debian Edu/Skolelinux

It is a customized the Debian distribution, which aim is to provide an out-of-the-box localized environment tailored for schools and universities. The out-of-the-box environment comes with 75 applications aimed at schools, as well as 15 network services pre-configured for a school environment [20].

5.6. Specific scientific distros

Although the teachers themselves would make the best choice of applications, another approximation is to use an already configured scientific distribution. The following would stand out for their collection of applications and simplicity of use, for example for chemistry subjects: Knochem, Bio-Linux or Ubuntu Science. Knochem would and be among the most recommended for the field of general chemistry teaching and Bio-Linux would be more oriented for researchers / students of biochemistry and biotechnology.

6. Scientific software apps: where to find them?

When sometimes it is not necessary to modify the operative system an appropriate alternative could be use free/open-source scientific software. This kind of software can be download from the Internet, but where can be find this software? The web page SOURCEFORGE could be one of the best sites for find it. In this Web there are indexed more than 200,000 software entrances for Windows, more than 150,000 for GNU/Linux and more than 130,000 for Mac.

For example, in internet [21] is possible to found more than 17,000 applications for science and engineering to run under Windows. This software is ordered by categories, type of licenses, user interfaces, etc. In addition, it is possible to carry out a search for a specific software on the web site.

For young children and secondary school students, exists another alternative and it is the use of portable apps. PortableApps.com [22] is an initiative that offer one of the most popular portable software solution providing a fully open source and free platform that can work from any synced cloud folder, from a local PC on an internal or external drive, or on any portable storage device (USB flash drive, memory card, portable hard drive, etc.) moved between PCs.

7. Scientific software in the cloud: how to use them?

Some Web sites provide scientific software that can be use via an Internet browser. This type of accessing is usual in research areas; on the contrary, almost all large public databases are hosted and accessed in the cloud.

This kind of scientific software are designed for the academic and research world, and for this reason are no suitable for students below the baccalaureate degree.

Next are listed the used Scientific resources available in Internet.

7.1. The National Center for Biotechnology Information

The National Center for Biotechnology Information (NCBI) Web site provides a vast access to biomedical and genomic information. Ranging from literature search in Pubmed [23], which comprises more than 28 million citations for biomedical literature; to a variety of educational products and events including courses, workshops, webinars, training materials and documentation [24], which are free and open that are available for anyone to re-use and distribute.

7.2. Research Collaboratory for Structural Bioinformatics: Rutgers and UCSD / SDSC. Protein Data Bank

RCSB PDB is a Web site dedicated to structural biology, that are built upon the data by creating tools and resources for research and education in molecular biology, structural biology and computational biology. Essential to access the PDB’s newsletter education corner [25] and the Educational portal of RCSB PDB [26], both provide useful resources for science high school teachers.

7.3. The European Molecular Biology Laboratory. European Bioinformatics Institute

The European Molecular Biology Laboratory. European Bioinformatics Institute (EMBL-EBI) site is a Web site for life sciences research [27]. Although the information provided by the site is for undergraduate students, it is possible to find diverse information suitable for high school students in the online training section [28].

8. Conclusions

As we mentioned before, the objective of this work was to present different alternatives that can be used in classrooms to facilitate the teaching of science subjects.

There are more and more free computer applications that can be used as teaching resources. Even considering that sometimes these applications could be not available for the operating system of the computers, that problem can be fixed using different strategies that eliminate or minimize these restrictions as have been presented above, some of them offer protected environments where students can freely experiment with these tools without compromising or damaging the proper functioning of the equipment

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Innovation on Synthetic Biology by University Students: The iGEM Competition

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Abstract. Synthetic Biology is the engineering of biology. It allows to build complex, biologically based systems, capable to perform specific functions. The most important event on the field is the iGEM competition, where multidisciplinary teams push the boundaries of synthetic biology designing and building a project, using a repository of interchangeable biological parts and standardized molecular biology techniques. In the present work, we introduce the project that the iGEM UPF-CRG team carry out for the 2018 iGEM competition. This project is based on building synthetic engineered bacteria capable to absorb palmitic acid, which is speculated to be a metastasis inducer.

Keywords. Cancer, dissemination, fatty acids, hexadecanoic acid, iGEM, metastasis, palmitic acid, probiotic, synthetic biology.

1. Introduction

The university environment is in continuous evolution. Since the first universities to nowadays, the objective of these institutions has remained unchanged over time: disseminate existing knowledge and discover the answers to the new paradigms that arise.

Scientific research has been the tool to access these answers. From physics, which aims to unravel the absolute rules that govern the universe, or the chemistry that studies the behaviour of particles, or the mathematics that studies the properties and relationships between abstract entities. All of them are part of a conglomerate called science.

While it is true that all provide useful knowledge for humanity, biology and biomedical sciences are of prominent relevance to our specie. Curing diseases, increasing longevity and improving the quality of life are the classic objectives of biomedicine. However, the incredible technological and scientific advances in different areas obtained in the last century have allowed us to go further and consider recently unimaginable possibilities.

One of the fields that define this revolution is the Synthetic Biology field. This field that has been rapidly expanding for the last decade. As a discipline residing at the intersection between genetic engineering, biotechnology, circuitry engineering and genetics, its main objective consists in re-designing and building novel biological systems and functions for research, engineering and medical applications. Also aims to create biological modules that, when combined following a simple protocol, more complex systems capable to execute a specific task can be obtained.

Promising solutions have been proposed across very diverse fields such as biofuel production, leather generation by yeasts, petrol digestion for cleaning, self-healing materials and also in biomedical applications, including cancer treatment with CAR-T cell therapy.

2. What is iGEM?

In the Synthetic Biology field, the most important event in the world is the iGEM competition. Having its origin at the MIT in Boston, the educational impact that the iGEM competition has had in the field and also in training talented undergraduate students is rather astonishing, especially for its multidisciplinary approach and international outreach.

The iGEM competition, in which students from universities all around the world form teams and join, is a collaborative approach to provide real solutions and solve environmental, health, energetical and other challenges using synthetic biology. It represents a “think-tank” which has brought huge innovations to the field both in research and in industry, creating start-ups.

iGEM is also an open database of biological parts. It is maintained by the contribution of all the teams that compete every year in an effort to build a standardized open source repository. A significant part of each team project is focused in the development of responsible innovation through biosafety, biosecurity and public outreach strategies. The projects developed by the participating teams are

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presented each year in a big congress hosted in Boston, the “Giant Jamboree”, where all teams gather to interchange and expose their ideas.

3. Outputs from iGEM Projects

The teams that enrol the iGEM, often, they have great ideas. This is reflected in the fact that many start-ups are created from these teams. Also, many participants end up being great researchers in prestigious research institutions.

Examples of highlighted companies that originated from iGEM projects are:

- Asimov [1], which is focused on the development of genetic circuits for intelligent therapeutics that respond to disease. The company combines synthetic biology, artificial intelligence, and design automation to program living cells.
- Ginkgo Bioworks [2], that is an organism designing tool for technological applications and high throughput tools design. They design microbes on demand, using software and hardware automation, to replace technology with biology.
- SynBioBeta [3], which is the principal innovation network in the field. Brings together entrepreneurs, investors, and biology enthusiasts to further develop synthetic biology applications.
- Benchling [4], a web-based platform for experimental design, data analysis, and results sharing between researchers. It offers tools for online note-taking, molecular biology modelling and sample tracking.

4. Our project

In the project that we are going to present on the iGEM competition, we aim to build synthetic engineered bacteria capable to absorb palmitic acid to help preventing metastasis.

Metastasis occurs when a cancer spreads from the original tumour to other parts of the body. Currently, controlling metastasis is still a challenge and causes up to 90% of deaths related to the presence of tumours. It has recently been shown that a fat component, called palmitic acid, can cause metastasis in tumour cells. A main problem here is that palmitic acid is found in many foods so dietary restriction is not possible.

On the other hand, in our gut we find millions of bacteria, which are known as the intestinal microbiota. These bacteria perform many beneficial functions. Then, we had the following idea: What if we could develop a gut microorganism, capable of up taking palmitic acid and acting as a fatty acid sponge? Achieving so would provide us with a potential mechanism for combating metastasis, and it could also be applied to treat other metabolic diseases.

The project in depth history comes from a recent publication in Nature: Targeting metastasis-initiating cells through the fatty acid receptor CD36 [5].

In this paper, led by two researchers from Institute for Research in Biomedicine (IRB) and CRG, it has been described that cancer cells expressing high levels CD36 receptor, a long chain fatty acid scavenger receptor, are more likely to initiate metastasis in the presence of an excess of dietary fat. Hence, overexpression of CD36 in cell lines increased their potential to metastasize. Besides, this study also showed that the presence of CD36+ metastasis-initiating cells correlates clinically with a poor prognosis.

With these recent findings, a CD36-based anti-metastatic therapy has been proposed, in which the use of anti-CD36 neutralizing antibodies would block fatty acid intake in cancer cells and thus its ability to develop metastasis.

5. Project Aims

In an attempt to propose an alternative approach to the already existing antibody, our project benefits from the presence of bacteria in our intestines. Thus, we aim to design a probiotic with an enhanced metabolism able to increase fatty acid absorption. Our goal is to reduce palmitic acid intestinal absorption, since its presence in most foods makes unfeasible its avoidance by dietary restriction. By decreasing palmitic acid concentration in the intestinal lumen and consequently its absorption and blood levels, we expect preventing it from being used as an energy source for metastatic cells.

We believe that our probiotic would serve as a complementary approach, with low cost and accessible in places where an infrastructure for administration of antibodies is not yet available. Once we develop our system, we plant to further optimize it for the use in the treatment of other metabolic diseases.

The probiotic may also have industrial applications, mainly in dietetics. by reducing the intake of fatty acids, it could reduce the problems associated with a diet with too many saturated fatty acids. In addition, the genetic circuit could be generalized to be more specific for other types of fats, thus creating a more specific probiotic for each case.

6. Social Impact

Apart from the scientific innovation of our project, we have also set focus in the social outreach of it since the field we are working is mostly unknown to the general public.

Disseminating scientific knowledge can be almost as important as the research itself. We owe the society knowledge about what is being done. Most researches got funding from taxes, we got part of our funding from a crowdfunding. For this reason, we are trying to disseminate our project, and science, as much as we can.

Our project aims to have social impact at three levels:

- Raise awareness of cancer and metastasis and how synthetic biology can prove itself useful as a treatment for metastasis among other health conditions.
- Promote an open and collaborative way of doing science.
- Inspire of future scientist generations.

7. Acknowledgements

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General Dissemination of Science: Should We Do It?

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Abstract. Explaining science to people takes time from researchers, but it must be done. We owe to the taxpaying people an explanation of what is done with their taxes. It should be done in order to avoid misinformation and stop the growth of pseudoscience. It can be also used to educate society and promote the critical thinking. Some initiatives already exist, but there still exists a bias. Disseminating behaves risk to criticism from colleagues, and the work on adapting science to general public still despised. The main problem is not a lack of initiatives and events, it is a social problem.

Keywords. Critical thinking, Famelab, iGEM, Pint of Science, dissemination.

1. Introduction

Scientific dissemination should be an important task for the scientific community. It could serve as a tool to fight misinformation, a global problem, which can lead to serious health and social problems [1]. It also can help scientists to learn about different fields and thus promote multidisciplinary teams.

Actually, there have already been dissemination events for many years. For example, “Royal Institution Christmas Lectures” are a series of lectures that have been held at the Royal Institution in London each year since 1825, with a stop during the Second World War. These lectures were created by Michel Faraday, who hosted the lectures in many occasions, and nowadays are being broadcasted on television. Every year, during the lectures, speakers introduce a scientific subject to a general audience, including young people, in an informative and entertaining manner. But this kind of acts are still quite unusual.

More formal activities, like project competitions, were more frequent. In these competitions, professionals or students were encouraged to make projects and present them to the competition. As a prize, the opportunity to present the project in front of an auditorium full of people is offered, and in some cases, also financial assistance for the project. This is still the most frequent way to try to get people interested in science.

2. Actual Dissemination

Times change, and we must adapt. Formal activities are still an effective manner to disseminate knowledge, but nowadays we need more informal alternatives. One popular and informal activity is "Pint of Science", an informal event which consists on annual talks in pubs around the world, free and open to the general public. But this is not new at all. In February 28, 1953 a client on The Eagle, a Cambridge pub, announced that he, with a colleague, discovered the “the secret of life”. The client was Francis Crick, the colleague James Watson and the discovery, the double-helix structure of DNA. This was also scientific dissemination in a pub.

At the present times, activities like "Pint of Science" [2] demonstrated that science truly interests the citizen and scientists also like to explain their daily work to people. Scientists are able to explain what they are doing in their daily job to many people, connecting with them and receiving questions from them. It is also important that, with events like this, people gets to know what is being done inside the laboratories. People are really interested in learning science, but many times it seems that they think that if they go to a scientific event, they will not understand anything, especially if the event is more formal. In more informal activities, people usually gets more involved, asks more questions and feels closer to the speaker. It is much easier for people to be encouraged to come and participate in activities like this.

Despite being very simple talks with little content, many scientists are interested in attending too. Most of them try to attend talks about topics completely different from their studies, so they can learn more about other fields of science. Knowing about other fields allows you to work better in a multidisciplinary team. Therefore, acts like this would also help to promote the creation of more multidisciplinary research groups in the long run.

Another novel scientific dissemination

activity is ¨FameLab¨ [3], a competition that consists in making a small scientific monologue about science for the general public. This is challenge for the scientists who get enrolled, but it is a good way to increase the creativity and the understanding of the presented theme, because without a deep understanding, it is difficult to explain meaningful concepts in just a short monologue. It is also educative and informative for the public. People are able to learn a lot of diverse concepts from many fields in a funny way and during very short time.

This kind of events are relatively new but also welcomed by the people. More events like the explained ones should be created, apart from the more traditional events that are being hosted nowadays. Also, it can be a preventive measure to build a society based on science and not in pseudoscience or misinformation.

3. Articles and Dissemination

Open Science is also important for scientific dissemination. Giving information with a referenced article not only gives more credibility to the information, it also gives the opportunity to the people to go deeper into the subject. Unfortunately, again, academic publishing is undergoing a crisis. Used to be common that discoveries only were available on paper, whether in books or journals, which few could afford or were almost exclusively found in university libraries. The cost was too high.

Things began to change when the internet was invented, but astonishingly slowly. Paper publications started to become less popular among readers because instant PDF downloads, availability anywhere and article indexing on search engines were a major benefit of online publications. Yet, to access an article, you still need a subscription to the journal or to be part of an institution with access, like university libraries.

Then something new happened: online journals and open-access journals started to arise. Contrary to what we can think, this kind of journals are not much cheaper than traditional ones, because most of the money that a journal spends it is intended to edit, format or peer review the articles. Neither was there much innovation in the way of funding the journals. Online journals tried the traditional subscription fee for access while open access journals charged the authors that publish. Either way, governmental science budget is spent paying for science publication and maintaining its access free.

Relatively recently, new journals tried a new funding approach: advertisements for the readers and relatively low taxes to publish for the authors. This approach is not perfect, but anyone with internet connection is able to access the new knowledge for free while authors can publish at relatively low cost. Also, advertisements, if not personal information is used, enable journals to obtain a decent amount of money without major drawbacks. Charging the authors is not perfect, but not doing it at the moment is not an option. Being able to send an article to publish for free could cause an increase in the number of poor quality articles that should be filtered. Despite this, an even lower, symbolic, tax would be preferable.

Things are changing and articles are starting to be more open, but it is not ideal. To improve, not only the journals need to change, we need support from society and collaboration among all the scientists.

4. Promoting Science in Youth

Great progress has been made in teaching science to children. Experiments have been adapted for them and workshops have been made. But the same does not happen with teenagers. Adolescents have a lot of pressure when they must choose which career they want to do, and often the choose is wrong. Therefore, it should be important to try to help them making this choice. There are already some initiatives that give the opportunity to a small number of students to feel similar experiences to those who will live in the university. The problem is that this opportunity cannot be offered for absolutely all students who want it.

A possible solution, although not ideal, would be to try to bring university students to do more talks at the High Schools, explaining their experiences and interacting more with the students. Although teachers can help their students a lot, sometimes it is better that a person with a similar age, who recently was in the same place where they are now, can help them decide what they wants to do in a near future. Another possible solution, this one outside the classrooms, would be making workshops or talks more focused on them. If more specific events are done, where the collaboration among teenagers is promoted, it would also help to ensure that in the future the community that forms is more aware that collaboration is important.

It can also be solved in a different way, promoting collaboration but at the same time creating competitiveness: creating a competition for teenagers. For example, there is a competition of synthetic biology called “iGEM” [4], in which university students around the world collaborate and compete, while carrying out their own project and doing research in the field of synthetic biology. This same competition has a division for High School students, but not all schools can afford it. Therefore, similar competitions could be created, at a local level, but with the same philosophy. Thus, students could do research, and even if it is very basic, would create a much more complete experience during their studies at the High School.

5. Conclusion

Congresses and other classical science events are beneficial and should not be neither replaced nor eliminated, but informal alternatives focusing more general public should also exist. We should take dissemination as an obligation, since society is very important for science. Money from the taxpaying people is one of the principal incomes for many researches. Therefore, people should have the opportunity to know what is being done at a level that they can understand.

The scientific society, increasingly, is concerned about having an impeccable curriculum, attending conferences and publishing articles. Instead, disclosure is disregarded, although it should be one of the main priorities. Initiatives are already beginning to give more importance to the dissemination of scientific projects, reaching a more general audience and making science more fun, but still lacks more involvement of society. We should take into account that these projects are also important to promote critical thinking in society and fight misinformation, they are an investment for the future.

Also, within the scientific community, the mentality should be changed and the data opened up for everyone. Since science is a collaborative activity, unhealthy competition between scientists can endanger science itself. In addition, the most recent findings should be available to everyone. But we must not forget that formatting articles and keeping them available on the internet has its cost. Therefore, if the journals use advertising in order to sustain (as long as advertising is ethical), it should be seen as a lesser evil, because in this way access to knowledge is more open to everyone.

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Engineering Manager: What Really Constitute This Profession?

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Abstract. On a sample of 358 students of engineering management and 195 engineering managers, using an ad hoc questionnaire, the paper examines the importance of professional ethics as a constitutive element of the profession in Serbia. The results indicate that professional ethics is an essential element of constituting this relatively young profession in Serbia.

Keywords. Engineering management, ethics, profession.

1. Introduction

Engineering management is a career that brings together technological problem-solving savvy of engineering and organizational, administrative, and planning abilities of management in order to oversee the operational performance of complex engineering driven enterprises. A Master of Engineering Management (MEM) is sometimes compared to a Master of Business Administration (MBA) for professionals seeking a graduate degree as a qualifying credential for a career in engineering management. Yet, history clearly shows that the best managers and leaders have always been technically minded individuals with some degree of formal engineering education [1]. A successful engineering manager should have the skills necessary to coach, mentor and motivate technical professionals, which are often very different from those that are required for individuals in other fields [2]. Engineering managers typically require training and experience in both general management and specific engineering disciplines that will be used by the engineering team to be managed [3].

Engineering Management Society of Serbia was founded in 2009 by a group of professional engineers, managers in engineering, academics, and industry leaders, whom have discovered an alarming trend in their midst. The transitional economy of Serbia, combined with the latest World economic crisis has had a profound effect on the society, particularly on its engineering segment. Engineering management has been slowly outdated by popular business management trends and began seriously haemorrhaging its population to more financially lucrative industries such as media, banking, trading and management consulting. Serbian society as a whole has slowly become devoid of professionals with a classical engineering education upon which general and financial skills are built. Engineering companies, manufacturing industry, telecommunications, energy producers, bioengineering, and all „producing“ industries have begun a period of hibernation under the leadership of poorly chosen and inadequately educated individuals which have little or no formal engineering education. New ideas of production, technical skills, project budgeting and challenges of the future have been replaced by ideas of „outsourcing” or rather buying readymade solutions. Engineering management profession in Serbia has de-facto become management of low-cost-cheap labour companies used for subcontracting in geographic regions difficult to access.

2. Literature review and research question

As an expression of the pronounced need for engineering managers, the mid-20th century has seen the constitution of Department of Engineering Management, first at universities in the United States, which is considered the cradle of the profession, after which the process spread to European and Asian countries, but here the development of study programs was of lower intensity than in the United States [4]. All this contributed to the rapid increase of a number of new profiles of managers, with different educational degrees, academic journals, research projects, and professional associations. This process was accompanied by discussions and controversies about whether engineering management is a profession similar to the profession of general management. The first study programs in engineering management in Serbia have been accredited in 2008. Study programs in engineering management at all levels of higher education with a number of modules were accredited only at the University of Novi Sad.

3. Research sample, procedure and instrument

The research was conducted over the period from January to June 2016. The sample consisted of 358 students of engineering management and 195 engineering managers. The research was conducted using an ad hoc questionnaire created specifically for this purpose, which was distributed online to the respondents. The response rate was fairly high (57%) and we can say that every second respondent replied, so that the final sample of respondents has been formed. The psychometric characteristics of the Questionnaire was good (Cronbach alpha = 0.89).

The study programs were conceptually structured in a way that allowed engineering managers to be trained to participate in fields of work which were the most important for the survival and development of modern companies: strategic planning, organizing, leading, managing, controlling. Also, one of the specifics of the study program is to train future engineering managers to solve managerial problems using engineering methods and tools. These study programs are aimed at providing managers with the capacity to respond to challenges of the global and dynamic market. This implies that future managers should be trained to build new products and services, integrate technologies in business organizations, and lead technologically well-established organizations. Engineering managers are expected to recognize new opportunities through the introduction of new technologies and be innovative in creating products and services, which are better, faster and cheaper than the existing ones, in order to achieve a continuous improvement in customer satisfaction. It is also essential for all managers, including engineering managers, to adopt the ethical principles of professional work and be able to cope with the complexity of ethical dilemmas in modern business operations, especially with regard to the neoliberal concept as a framework for all business activities [5]. When it comes to the profession of engineering manager, the available data indicate that it received formal and legal protection from the state. In the Ordinance on the list of professional academic and scientific titles issued by the Ministry of Education of the Republic of Serbia (2007, 2008, 2010) [6], the section of technical and technological sciences covers also the fields of industrial engineering and engineering management. Thus, by defining titles for this type of profession, as well as the identification codes of the profession, the state legally and formally recognizes the profession of engineering manager and in this sense one can say that this profession in Serbia is legally protected. However, in actual working conditions, it is unknown whether companies in their job systematizations have positions foreseen to be held by engineering managers and whether they announce a competition for this profession? It should be noted that it is a new profession that may not yet be sufficiently recognized in Serbian business environment.

As for the need for this new managerial profile, the Italian author Lo Storto [7] pointed out that in the late 20^{th} and early 21^{st} century, the increased competition at labour market and related need to improve productivity in manufacturing and services imposed a need for a more effective management in technical functions of companies. Attempting to increase flexibility and efficiency, many companies have created a more balanced organizational structure by combining engineering and managerial jobs. One can agree with Lo Storto [7] that in this context, the areas of work and responsibility has dramatically changed, so that engineers in modern companies began to perform many managerial activities beyond conventional, technical activities associated with the engineering job. In the opinion of this author, engineering managers are different from other managers in that they have the ability to apply engineering principles and skills in organizing and managing technical projects, and people in technical jobs. They are qualified for three types of activities: managing technical functions (such as production and design), managing a wide range of activities (such as marketing or top management in hi-tech companies), and managing organizations orientated towards engineering, technology or production. In his opinion, engineers can be particularly effective in general management of hi-tech companies because critical factors in these companies are often technical by nature and engineers are skilled to recognize and resolve them. Allain Bromley from the Yale University (according to Lo Storto [7]) believes that the first 10 percent of decisions in an average engineering project are made by the effective involvement of engineers, while for making the remaining 80 to 90 percent of decisions engineers are insufficiently trained, because instead of being purely technical decisions, these also include decisions of economic, ethical and political nature, assessing international affairs and other business dimensions [7]. Therefore, this author advocates creating a larger number of engineers who are competent in all these areas of decision-making. In the past, conventional engineering education included understanding and applying technical knowledge of employees in using and improving natural resources for human purposes. In actual conditions, the emphasis is on associating technical-engineering competencies with managerial, economic and other skills and competencies in order to achieve greater business success. Lo Storto [7] lists four reasons supporting his view that the main impetus for establishing study programs of engineering management comes from the market: the great oil crisis in the 1970's produced an awareness of the need for technically trained managers to manage technological systems with scarce resources; the demand expressed by the industry for engineers and scientists capable of performing technical - managerial roles; the high demand of industry for introducing changes in academic institutions necessary for the development of graduate courses in the field of management; and the awareness that technology alone is not enough to build industrial leadership, and that the critical power needed for obtaining competitive advantage in the market lies in the ability of managing technologies, that is engineering management.

Professional ethics is a set of norms, values and goals that members of a particular profession need to practice in their work. The essence of professional ethics is primarily in using professional knowledge for general welfare. This means that professionals should not deviate from standards of their professions regardless of the pressures. Professional ethics also prescribes behaviours in relationships in which professionals engage in performing their jobs, including relationships between the professional and the client, relationships between fellow professionals, relationships between the profession and the wider community (local or cosmopolitan), as well as relationships between professionals and organization as a whole. Norms which need to be complied with by members of a specific profession are usually formulated in the ordinance of professional conduct or code of ethics, delivered, supervised and implemented by the professional association. Why to insist that members of a profession should supervise their colleagues in terms of complying with the code of ethics or its implementation? Because members of a specific profession know exactly how their fellow professionals should be acting in specific situations. The very existence of code of ethics is of particular importance for each profession because it sends a message to the public that members of a given association will perform their professional activities in the interest of the public. These codes have several important functions [8]. So far, the profession of engineering manager has not yet been fully analysed from the perspective of all of its constituent elements. Numerous articles and textbooks whose title includes the term engineering management are mainly focused on individual functions of engineering management. Planning as one of the main functions of engineering management has been in the focus of a growing number of authors [4,8-12]. Also, a significant number of authors analyse the function of organizing [13-17]. Also, a number of authors take leadership as their main topic [14-15,18-20]. A handful of authors are focused on control as an important managerial function [21-23]. Engineering management as a specific type of management, but only from the aspect of the type of job and function, was analysed by a substantial number of authors [1,24-29]. Insight in domestic literature indicates a lack of research related to the level of development of constituent elements of the profession of engineering manager. This points to the need for studying the profession of engineering manager in a comprehensive manner, primarily by examining which of their constituent elements are well developed, which are partially developed or have not yet been developed at all, and investigating the factors that resulted in this situation [30]. Current economic processes in Serbia show that systems in the field of economy and other areas, regardless of whether they are newly

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established or renewed, need highly professional management teams. In these teams, contribution of the profession of engineering manager is of particular importance for organizing and managing the available resources efficiently. For these reasons, the following are the research question examined in this paper:

1) Is professional ethics an important constituent element of the profession of engineering manager?
2) What are the other important factors that constitute the engineering manager profession?

4. Research

Factors that influence the constituent elements of the engineering profession were examined using the structural model. Based on the review of literature, the following independent variables were assumed to influence the constituent elements of the profession of engineering management:

- KNOWLEDGE - theoretical knowledge, practical knowledge, currency of knowledge and degree of adaptation of the coursework to the objectives of study program;
- PILLARS of knowledge on which engineering management rests;
- ACTIVITIES of students ranging from creative thinking and problem solving in the subject area, through student teamwork and making plans for the own business, to plans for further professional development;
- PRACTICE, professional student practice from the perspective of adoption of techniques in the process of professional socialization;
- COMPETENCES - learning outcomes or competences of engineering management;
- CAPACITIES - developing entrepreneurial capacities in surveyed students of engineering management;
- RESPONSIBILITIES that engineering managers have in specific organizations;
- FACTORS that influenced engineering managers to take leadership positions;
- MOTIVATION of engineering managers for accepting leading positions;
- PROFESSIONAL ETHICS as an important factor of professionalism.

The independent and dependent variables were operationally defined by the Questionnaire. Validity of the defined structural model was tested using ten standard parameters of model fit and the indicators of quality of the model (Table 1).

Table 1. Basic parameters of the general structural model

Average path coefficient (APC)	0.124	P=0.006
Average R-squared (ARS)	0.412	P<0.001
Average adjusted R-squared (AARS)	0.393	P<0.001
Average block VIF (AVIF)	1.373	Ideal
Average full co linearity VIF (AFVIF)	1.483	Ideal
Tenenhaus GoF (GoF)	0.427	High
Sympson's paradox ratio (SPR)	1.000	Ideal
R-squared contribution ratio (RSCR)	1.000	Ideal
Nonlin biv direct ratio (NLBCDR)	0.750	Acceptable

The values and statistical significance (p) of all parameters are shown in Table. The significance of the created and obtained model is high (APC = 0.124, p = 0.006 and AARS = 0.393 p = 0.000). These results allow for interpreting the relation between the dependent variable of the study (constitutive elements of the profession) and the independent variables measured across the student population and the population of engineering managers.

Path coefficients corresponding to each independent variable, their significance, as well as their effect on the dependent variable are shown in Table 2. Based on the response of the student population, the following independent variables were found to be statistically significant in affecting the constituent elements of the engineering profession:

- Knowledge acquired during the studies
- Competences of engineering manager
- Activities of students of engineering management while studying
- Professional practice
- Capacities of students for entrepreneurial ventures influenced engineering managers to take leadership positions in organizations.

The variable *factors* have a negative path coefficient and a negligible or small effect on the dependent variable. On the other hand, *ethics* has a positive path coefficient and a medium effect on the dependent variable. Independent variables of *motivation* for accepting managerial positions, *responsibilities* that engineering managers have in their organizations, and *pillars of knowledge* on which the study programs of engineering management rest have no statistically significant influence on the dependent variable, as evidenced also by the negligible effect.

Table 2. Relation between the dependent variable and the independent variables in the obtained structural model

	Constituent elements of the profession Path coeffic.	Constituent elements of the profession Significance	Constituent elements of the profession Effect
KNOWLEDGE	0.115	0.019	0.038
ACTIVITIES	0.177	<0.001	0.081
PRACTICE	0.129	0.009	0.036
COMPETENCES	0.150	0.003	0.078
CAPACITIES	0.255	<0.001	0.126
MOTIVATION	0.026	0.324	0.001
FACTORS	-0.105	0.029	0.010
RESPONSIBILITIES	-0.084	0.066	0.008
PILLARS	0.056	0.156	0.007
PROFESS. ETHICS	0.139	0.006	0.027

5. Discussion

5.1. About the constituent elements of the profession

All constituent elements of the profession of engineering manager were evaluated by respondents with the average score of about three or slightly above it. In addition, the level of development of theories and techniques in the field of engineering management and the level of development of professional ethics were evaluated with an average score of 3.25. The data suggest that respondents perceive the constituent elements of the profession of engineering manager in Serbia as underdeveloped, which implies requirements for: greater involvement of the faculty in terms of further developing the theoretical and methodological knowledge required for the profession of engineering manager; significant involvement of the state in terms of legal protection of monopoly over professional expertise in the profession of engineering manager; higher and more serious activism of engineers themselves in the development of professional associations; and involvement of the faculty in adopting professional ethics by engineers of management and professional associations in the promotion and complying with professional ethical codes (Table 3).

Table 3. Assessment of constitutive elements of the profession

Constituent element	Total
CE1: development of theories and techniques in the field of engineering management	3.00
CE2: monopoly over professional expertise (regulated legally)	3.00
CE3: external recognisability of the profession of engineering manager	3.05
CE4: organizations of the profession of engineering manager (professional associations)	3.19
CE5: development of professional ethics (managerial ethics)	3.25

5.2. Factors that affect the constituent elements of the profession

Knowledge acquired in study programs of engineering management were assessed both by students of engineering management and engineering managers as too theoretical, while the practically applicable knowledge is under-represented (Table 4).

The respondents believe that the highest emphasis in the study program which they were studying was on the knowledge of management. All respondents agreed that study programs in engineering management lack the knowledge of engineering disciplines, but they also believe that knowledge of economy, as well as combinations of other disciplines with economy, are poorly represented in the study program. One can assume that this finding is associated with relatively modest knowledge of economics, much needed by engineering managers in their actual working process. Regarding the outcome of study programs, the general opinion is that the best results were achieved in developing presentation skills, communication skills, and the ability of creating effective teams. Respondents highly valued the degree to which study programs were realized from the standpoint of developing competencies related to communication skills. At the same time, respondents believe that the least has been achieved in developing skills of mentoring, designing and recognizing potential innovation in engineering management (Table 5).

Table 4. About the acquired knowledge

Contents	Total
Theoretical knowledge:	4.15
Practical knowledge:	2.64
Currency of knowledge	3.81
Adaptation of the structure to objectives	3.80
QUALITY OF TEACHING	3.77

Professional student practice (Table 7) as part of the study program received relatively low scores from surveyed students of engineering management.

Table 5. Competences

Competences	Total
Possibility of finding job in the company where professional practice was performed	3.41
Ability of relating theoretical knowledge with practical problems and their solution	3.54
Ability of researching in the field of engineering management	3.42
Leadership knowledge	3.75
Knowledge of strategic planning	3.53
Knowledge of operational planning	3.54
Organizational knowledge	3.89
Recognizing potential innovation in engineering management	3.41
Ability of transforming the ideas in projects and action	3.61
Communications skills	4.08
Presentation skills	4.18
Practical application of technologies in business	3.52
Ability of working on multiple jobs in parallel	3.61
Negotiating skills	3.62
Designing	3.34
Business evaluation	3.48
Setting objectives	3.90
Creative problem solving	3.91
Understanding the relation between the company and the market	3.50
Teaching / mentoring abilities	3.38
Working with different people and cultures	3.68
Extending the social network within the organization	3.53
Extending the social network beyond the organization	3.45
Creating efficient teams	3.91
Solving conflicts	3.83
Entrepreneurial knowledge	3.68
Knowledge in business economy	3.49

As for the characteristics of the teaching process, students are satisfied with the quality of teaching staff and the ability of teachers to encourage students to think and engage in dialogues.

However, students warn that laboratories should be better equipped and more attention is needed to prepare students for scientific research. The surveyed students believe that the capacity of educational contents and the commitment of teachers to encourage students to various activities have the most positive influence in enabling students for teamwork in research projects, as well as in enabling students for their further professional development (Table 6).

Table 6. Capacities

Capacities	Total
Professional knowledge (engineering and managerial)	3.58
Organizational abilities	3.99
Money-handling skills – accurately planning the investments	3.68
Ability of conceiving a business idea and develop the own business	3.51
Ability of foreseeing the market movements and developing new products and services	3.36
Problem solving as a challenge	3.85
Leadership knowledge	3.81
Ability of creating new business contacts	3.85
Capacity to take control over the business process	3.56

The only features of professional student practice with which the surveyed students were satisfied are those relating to the characteristics of mentors, i.e. engineers who were presenting the work in the organization to students.

Plans for the future of surveyed students are mainly related to their desire to find employment in the profession and continue with masters and doctoral studies in Serbia. Findings of the research relating to students' self-assessment regarding their capacity to start a private business of their own have shown that faculty programs and educational practice need to be more focused on developing entrepreneurial skills in students. As indicated by the results, identification with the profession was successfully accomplished in the process of socialization for the profession. In this sense, the findings show that students clearly see the underdeveloped nature of all constituent elements of the profession of engineering manager, which indicates that they perceive their future profession correctly. In an effort to examine the types of responsibilities engineering managers have in their organizations, respondents were offered a list of fifteen different types of responsibilities – from responsibility for the fulfilment of the budget and responsibility for the predefined annual profit growth, through the responsibility for lowering the employee turnover rate and the responsibility for the safety at work and environmental protection.

Table 7. Practice

Practice	Total
Length of the professional practice	2.86
Adequacy of the program of practice for the future professional work	2.85
Mastering the practical application of theoretical knowledge obtained an the faculty	2.82
Professional and creative challenge of jobs performed during the professional practice	2.86
Excitement with jobs performed during the professional practice in the company/institution	2.92
Level of responsibility in jobs performed during the professional practice	2.69
Professionalism of your mentor during the professional practice in the company/institution	3.15
Communications skills of your mentor during the professional practice	3.18
Creating a network of business contacts important for your future professional work	2.89
Possibility of finding job in the company where professional practice was performed	2.68

For each responsibility offered they were asked to indicate whether they perform it in their organization or not. The highest share of surveyed engineering managers was responsible for deadlines, the annual implementation of projects, quality and cost reduction. On the other hand, the smallest number of respondents was responsible for lowering the rates of employee turnover, environmental protection and safety at work. Characteristics of study programs in engineering management were examined by asking the respondents to assess the pillars of these academic programs. In this regard, engineering managers were given the task to evaluate the dominance of one kind of knowledge, or a combination of knowledge, from various fields contained in the basics of engineering management. Respondents were asked to evaluate the following pillars of knowledge of engineering management on the scale from 1 to 5: knowledge of engineering, knowledge of management, knowledge of economics, balance of the program, knowledge of engineering and management, knowledge of engineering and economics, and knowledge of management and economics. The resulting distribution of responses showed that the surveyed engineering managers think that the highest emphasis in their study program was on the knowledge of management. These respondents also highly valued the balanced study program in terms of the body of knowledge on which their study program was based. On the third place, in the opinion of respondents, was the emphasis on the combination of knowledge of engineering and management. The lowest score was received by the body of knowledge of engineering.

The results of the part of research relating to professional ethics and professional association of engineers as important elements of professionalization indicate the following: the overwhelming portion of respondents are aware of importance of business ethics, but in actual business processes they fail to always comply with these policies, that is, they only sometimes comply with, which negatively affects the process of professionalization of this kind of social activities. Despite the generally positive attitude of engineering managers towards business ethics, this research shows that they are more utilitarian-oriented in sense that they believe that the primary task of management is to maximize profit. At the same time, the surveyed engineering management expressed the lowest level of agreement with the statements referring to the obligation of managers to protect social justice, environment, and serve to the welfare of society.

6. Conclusion

All the previously presented and data-backed limiting factors in the development of the engineering profession also point to the possibilities for the professionalization of engineering management in Serbia. As the research of the professional ethics of respondents showed that this element of the profession is insufficiently developed, it is of special importance for professional associations to define the professional code of ethics and provide mechanisms for complying with the code in pursuing the professional activity. Using the method of structural model, and based on the unification of the two independent sets of results, it has been shown that at the level of studies of engineering management there are direct and indirect ways of affecting practical aspects of improving its constituent elements. This is primarily reflected in the creation of realistic ethical basis for managers during the study process, as well as teaching and applying it. In this way, the problem of constituent elements of the profession should be realized to the fullest. By accepting the actual professional competencies, engineering managers would be the real transmitters of and difference-makers in existing social relations. This estimate excludes the utilitarian political concept and includes a real willingness for the acceptance of educating the people and exploiting their knowledge for the benefit of society. The results clearly suggest that there is a need for developing knowledge and competence in future engineers of management at the level of studies of engineering management through appropriate extracurricular activities. It is also very important to provide them with adequate professional practice and develop capacities in them to perform this responsible and socially useful work. On the other hand, the results showed that in the process of socialization for the profession it is also possible to indirectly influence the ethical values, as well as motivation and critical factors that affect the decision of engineering managers to take leading positions. Only the synergy of all the above elements will enable all constituent elements of the profession to develop in a way in which they were operationally defined in this study. Thus, the brief conclusion is: Non scholae, sed vitae discimus.

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Scientific Illustration with BioIllustra

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Abstract. Scientific illustration is a powerful tool to communicate science since it visually represents aspects of science without the help of any word. Thus, illustration can be considered a universal language that anybody is able to understand.

BioIllustra is an emerging scientific illustration brand that firmly believes in communicating science through images. I would like to offer a science fair experiment where students and public in general could get a little bit closer to the world of scientific illustration. The idea is to create a scientific sketching environment and bring people the opportunity to turn themselves into scientific illustrators.

Keywords. Art and science, scientific communication, scientific illustration, visual information.

1. The origin of scientific illustration: three great examples

Throughout history and in our own time, many famous scientists have stood out not only for their wide scientific knowledge, but also for their artistic skills. The origin of scientific illustration is inextricably linked to scientific texts, because image and texts have been evolving in parallel with the advances of scientific and technological knowledge. In many cases, images are the best mode of transfer of knowledge, being necessary and even essential. Leonardo da Vinci, Galileo Galilei and Ernst Haeckel are some example of great scientific illustrators in our history [1].

Leonardo da Vinci (1452 – 1519) was a talented artist, scientist, engineer, inventor, anatomist, sculptor, naturalist, musician, poet, philosopher and writer. One of his most famous drawings is the Vitruvian Man (1509), a perfect analysis of the human body proportions. However, da Vinci was also the creator of the modern sketchnoting: he made hundreds of illustrations about human anatomy and the human foetus, which are undeniably beautiful and accurate [1-2].

Galileo Galilei (1564 – 1642), as well as Leonardo da Vinci, was an Italian polymath. Galileo published an astronomical treatise known as Sidereal Messenger (1610), the first scientific publication based on observations made through a telescope. He reported his discovery of four satellites of Jupiter and mountains on the Moon. Galileo lived during the Renaissance period when art stood out for sophisticate mathematical techniques for drawing, such as linear perspective and handling light and shadow. Contemporaries of Galileo without artistic training in perspective were not able to see the mountains of the Moon, even though they had similar telescopes. They only saw some dark spots in the surface of the Moon, while Galileo, thanks to his artistic knowledge, realised that those spots were actually mountains and craters. Galileo was the one who could see scientific phenomena with the eyes of an artist [1-3].

Ernst Haeckel (1834 – 1919) was also a multifaceted scientist and artist. Haeckel was a zoologist and an accomplished illustrator. He discovered and described thousands of species and mapped the phylogeny of the tree of life. Moreover, Heackel helped to popularize Darwin's theories to the lay public thanks to his illustrations. His most famous scientific illustrations were published in the book Art Forms of Nature (1899-1904) which consists in 100 illustrations of various organisms (many of them discovered by Haeckel). The main theme was mathematical encoded structures in nature, such as, the scale patterns of boxfishes, the spirals of ammonites and the symmetries of jellies [4].

2. The basis of scientific illustration

Usually, what captures your attention when you open a scientific book or magazine are the images you can see on it. Images can be the trigger to read an article or a book chapter, but they can also help to visualise the topics or understand difficult concepts. Examples are phenomena that are not visible to the human eye and elements that are impossible to photograph, like an extinct animal, historical reconstructions or elements of the universe.

The main goal of scientific illustration is to represent a complex reality in the clearest way as possible. For example, in human anatomy, while a photograph of an organ could be

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unclear, confusing, and even unpleasant, an illustration allows to penetrate beyond the photograph and appreciate all the anatomic details of the organ.

Sometimes an image can be considered only as a decorative element but scientific illustration demonstrate that this is not true at all. A good illustration may provide as many or more elements than a written text because it is easier to schematize and to visualise concepts through a drawing [5].

2.1. Why working with a scientific illustrator?

As a scientist, it is essential to communicate in order to achieve a higher impact for your work. A regular scientist is usually well-trained to communicate in a verbal way: writing and presenting orally, leaving visual communication on a second level. In consequence, most scientists never really learn how to communicate effectively through images. This is why the collaboration between a scientist and a scientific illustrator may be highly beneficial [5].

I believe a good scientific illustrator must merge artistic skills with a strong scientific background. A scientific illustrator is defined as an artist who serves science, so he or she must stick to the truth and not to subjective interpretations.

3. BioIllustra and its participation in HSci2018

I strongly believe in the quote “an image is worth a thousand words”, and from that idea is where BioIllustra was born. BioIllustra [6] is a young scientific illustration brand that works to communicate science through images, pictures and designs. An artistic representation of the clam *Ruditapes philippinarum* is shown in Figure 1.

In the 15th annual international conference on Hands-on Science (HSci2018) held in Barcelona, I would like to offer a science fair experiment where students and public in general could get a little bit closer to the beautiful world of scientific illustration. The idea is to create a scientific sketching environment and bring people the opportunity to turn into a scientific illustrator for an afternoon observing different samples under a microscope and drawing them as an artist.

Figure 1. ***Ruditapes phillipinarum*** **(Helena Ariño-Bassols, founder of BioIllustra; 2017)**

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Genomics Education: Update Core Concepts in High School

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Abstract. Genomics is benefiting from exciting technological advances, joining next generation sequencing platforms with bioinformatics solutions for data analysis. This paradigm cannot be disregarded when promoting genomic literacy among high school students. In this work we explored a bioinformatics-based approach designed to have a positive impact on students' knowledge about genomics' concepts and methods. Based on it, this study highlights the benefits and the adequacy of dedicated bioinformatics activities to foster students learning of core concepts in genomics, while contributing to enhance students' motivation, interest and scientific reasoning.

Keywords. Bioinformatics, conceptions, genomics, high school.

1. Introduction

Genomics can be briefly defined as a scientific field dedicated to the study of genomes [1]. In the last decade, it has had major developments, mainly due to technological advances of next generation sequencing platforms coupled with ingenious bioinformatics solutions for data analysis [2-4].

In this regard, it is widely acknowledged by educational stakeholders that genomics literacy, briefly defined as the knowledge of basic genetics and genomic concepts and processes, should be promoted in high school [5-6].

The integration of basic genomics concepts in the classroom should incorporate the use of bioinformatics and computational biology tools having in mind the importance of these resources to comprehensively address genomics studies [7-10].

The interdisciplinary character of bioinformatics is at a privileged position to foster citizenship education [11]. A bioinformatics-based approach increases students awareness of the decisive role of other disciplines, such as mathematics - through algorithms for data analysis - and computer science – capable to integrate large datasets - in genomics research (Table 1).

	Curricular framework	Learning Goals
Information and Communication Technology	• Information, knowledge and the world of technology: the evolution of information and communication technologies (ICT) and its role in the contemporary world. • Exploration of computing environments: creation of products, using tools and computing environments installed locally or available on the Internet, appropriate to the cognitive development of students.	• To develop knowledge and skills in the use of information and communication technologies that allow widespread digital literacy. • To foster the critical analysis of the role and power of information and communication technologies. • To develop a method of computational thinking, centered in the description and problem solving and in the logical organization of ideas. • To stimulate students as active users of computers, networks and Internet.
Chemistry	• Physical and chemical properties of materials: physical and chemical properties of substances. Justify from selected information, the importance of analytical chemistry in areas related to our quality of life, such as food security, environmental quality and disease diagnosis. • Chemistry and Industry: Control of industrial production; Effects of temperature and concentration in the equilibrium of a system.	• To understand that the manipulation of chemical reactions can promote a desired outcome. • To disclose the influence of factors that generally affect the equilibrium in a system, and their relevance in everyday situations, such as in the food industry.
Mathematics	• Measures of location: Represent, process and analyze data sets. • Solving problems involving functions and manipulating variables.	• To organize, analyze and design solutions for a problem by interpreting data displayed graphically.

Table 1. Potential of bioinformatics tools as a promoter of interdisciplinarity: In Information Technologies and Communication these tools can be used to understand the role of information technology in science development; in Chemistry, teachers can use these resources to manipulate the factors that influence chemical reactions; or in Mathematics as a source of graphs for students interpret

Genomics education is fundamental to build up informed students capable to engage judiciously into discussions about genomics solutions for a panoply of real-world problems (e.g. gene therapies, genetically modified organisms – GMOs -, cloning, genetic testing or genetically engineered vaccines) [12-16]. According to Kovarik et al. [17], discussing real-world problems with students and introducing them to the exploration of authentic science tools, contributes to increase their interest in Science, Technology, Engineering and Mathematics (STEM) contents, while promoting critical thinking. Moreover, these approaches involve ethical theory which help students to understand the relevance of the science, leading them to assume a position regarding society issues with impact in our daily lives. In fact, in the last decade we witnessed a burst of exciting findings and societal discussions related, for instance, with personalized medicine based on individual genomic information, preservation of biodiversity, and the promise of new molecules from comprehensive metagenomics studies. These scientific progresses are raising sensible questions regarding bioethics and political options, that will require educated citizens capable to take scientifically informed decisions.

By getting acquainted with bioinformatics, students will realize their applicability and foster their interest, which may ultimately contribute to pursue careers in STEM fields. For students who do not pursue careers in STEM, understanding the applications and limitations of bioinformatics tools will scaffold them in taking informed decisions [17].

Regardless the importance of this subject, school teachers generally feel uneasy to approach this issue and tend to centre their teaching practice in expository methods of manual contents [18-19]. In this regard, it is urgently needed to propose hands-on bioinformatics-based activities aiming to introduce a practical component to boost the learning outcomes [20-21]. To fully acknowledge the importance of the currently curricular required notions, an update of the science standards of high school education is required in order to include new core concepts to face the challenges of an era characterized by daily advances in genomics and metagenomics.

2. Genomics in high school curriculum

Nowadays, basic notions of genomics already integrate the high school science curriculum to address diverse issues, particularly those related with heredity, biological evolution, gene regulation and protein synthesis [22-23]. Some examples of the required notions high school students have to acquire are listed in Table 2.

Having as reference the Next generation Science Standards (NGSS) [22], recent studies have shown that despite the school/academic improvements of genetics and genomics content coverage, all the educational stakeholders, including scientist experts and policy-makers, are key players to contribute with recommendations to enhance students' literacy in genetics and genomics [24-25].

In this context, the present work focus on the identification of specific concepts, presently absent from the curricular contents, but which integration we believe is important to facilitate the understanding of issues addressed in classes, such as gene therapies and GMOs, leading to an engagement of students as citizens and boosting their motivation [26-27]. The proposed core concepts were chosen considering their importance for a clear comprehension of the current required notions and to understand up-to-date genomics issues and get acquainted with user-friendly bioinformatics tools:

- Open Reading Frame (ORF) is a hypothetical coding sequence with a start and a stop codon [26]. This is an absolutely essential concept to understand how raw genome sequences are assembled and annotated.
- Basic Local Alignment Search Tool (BLAST) is based on an algorithm which identifies similarities between the query sequence and the sequences deposit in gene banks [27-28]. BLAST leads to the comprehension of evolutionary relationships and the identification of genes and gene families [28].
- Intergenic regions are DNA sequences located between codifying sequences/genes [29]. By recognizing the existence of these regions, a better comprehension of how genes are organized in the chromosomes can be achieved while the understanding of gene regulation is improved.
- Synteny refers to the preservation of the blocks of genes on chromosomes across different taxa [30]. This concept is essential to evaluate if gene clusters are conserved, and therefore derived from an ancestral genomic region [31]. This notion is fundamental to approach comparative genomics studies within the scope of evolutionary biology.
- Comparative genomics is the scientific field that studies comparatively genomic regions of different taxa in order to disclose affinities among different organisms [32]. This notion allows to explore evolutionary reasoning which evokes the need to hypothesize the presence of identical genes clusters across different taxa.

In order to integrate these specific concepts in genomics teaching practices, a hands-on activity was explored to prospectively develop students' learning skills in genomics and bioinformatics.

Improving Genomics Education *Genomics Concepts*	
Current Required Notions	**Introducing New Core Concepts**
Genome Chromosomes Genes (structural, operator, repressor, regulator, promotor) Start and stop codons Operons Genetic code Taxonomic groups Evolutionary relations	Open reading frames (ORFs) Basic Local Alignment Tool (BLAST) Intergenic regions Synteny Comparative genomics

Table 2. Description of required notions which currently integrate the science standards for high school; and of the core concepts which would be important to add in the curriculum to improve scientific literacy in genomics

3. A hands-on approach to learn genomics core concepts

Previous studies showed that promoting genomics education through practical activities revealed to have a positive impact on students learning [33-35]. In this regard, several hands-on proposals for high-school can be found in the literature [36-39], most mainly centered on in silico approaches [40-43].

The current study addresses the potential of a hands-on bioinformatics-based activity, proposed by us [40], designated as "Mining the genome: using bioinformatics tools in the classroom to support student's discovery of genes" to promote the learning of the above-mentioned genomics concepts. It is important to emphasize that this activity was designed to provide teachers, generally uneasy with bioinformatics-based exercises, with a suitable didactic instrument which strongly contributes to improve students' knowledge about genomics' concepts and methods. While performing this research driven activity, it is expected for students to strengthen concepts related with protein synthesis and gene regulation (e.g. genome, genes, codons) and also learn new genomics core concepts currently dismissed from curricular contents.

Following detailed guidelines, students are driven to identify genes, disclose their genomic context, and hypothesize about their evolution, using up-to-date research platforms [40].

By accessing a comprehensive genebank database to obtain the specific DNA sequence such as the National Centre for Biotechnology Information (NCBI) database [44-45], students can understand that genomic information is freely accessible and realize that NCBI is an open access resource.

After retrieving the DNA sequence of interest, students are challenged to use the NCBI ORFfinder [46], which allows them to rapidly identify all possible ORFs of a given DNA sequence. This is an important step to understand how to deconstruct a DNA sequence, and identify all possible ORFs, start and stop codons, and getting a glimpse of the routines downstream of the outputs obtained from automatic sequencer machines to the identification and annotation of putative genes.

With all possible ORFs identified, students are asked to verify which of these ORFs might represent putative genes. In this regard, students are introduced to NCBI BLAST tool [47]. During this task students realize that not all DNA sequences bracketed by a start and a stop codon are coding sequences and that ORFs can be located in different reading frames and oriented in either directions.

To elucidate students about which of the OFRs are actually coding sequences, and also to provide information about the presence of similar putative genes in other taxonomic groups, a blast analysis is carried out.

Using the tool MaGe (Magnifying Genomes) of MicroScope (Microbial Genome Annotation & Analysis Platform), an open-access and user-friendly bioinformatics platform for microbial genomics analysis including comparative genomics [48-49], students can easily retrieve meaningful data namely the genomic coordinates of specific genes; characterize their flaking regions; access their full sequence; determine the reading frame and the coding strand. More importantly, with this in silico exercise students get acquainted with tools to comprehensively compare bacterial genomes belonging to different taxa, and intuitively comprehend fundamental concepts of evolution and phylogenomics such as homology and synteny.

4. Conclusion

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Understanding Aging: An Educative Way of Learning Science

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Abstract. The question about why we age and what we can do to keep ourselves young, is and has been a really recurring question in the history of humanity. The purpose of the article is to bring ideas about the principal study topics if you want to discover the process of aging, from why do we age to what we can do to slow down the process. Everything with a scientific base which includes biology, chemistry and physics.

Keywords. Telomers, telomerase, aging process, oxidative stress.

1. Introduction

The aim of this article is to bring ideas for answering questions about the aging topic and doing it by using concepts related to the different fields of sciences. It can be a really good way to motivate the students and link the different concepts studied during the academic course, especially for the ones who are cursing the last year of high school and next year will start university.

Throughout the history the concept of eternal youth has occupied a place in the humanity mind. We can find in the ancient civilizations from Aztecs to Egyptians to Greeks an amount of rituals related to the eternal youth, like the eternal youth fountain. It also appears several times in literature: the philosopher’s stone, The garden of Eden, the Holy Grail, Dracula or The picture of Dorian Gray are clear examples of it. Then, is it possible to become immortal, in terms of science? Let’s start from the beginning.

2. What is aging form the biological point of view?

We define aging like the combination of morphological and physiological modifications that manifest at the last period of life because of the course of time and are the cause of several functional errors. Most of the organs and systems of the organism develop some loss of function which increases the risk of developing diseases. The research in these area of science has the purpose of bringing tools in order to cope degenerative diseases like Alzheimer, arthrosis and cardiovascular illnesses, and therefore, improve the quality of life and increase the life expectancy.

2.1. Why do we age?

Nowadays is it known the loss of function related to aging is due a progressive loss of the repair and cellular renovation abilities. The organism cannot give an adequate response to damages and external stimuli.

Consequently, at the initial stages of life an organism has an equilibrium between degradation and reparation of the tissues that decreases with age. At the end of life, we have an organism with cells that have lost the regeneration capacity and moreover accumulate damage in DNA and toxic substances.

3. Live expectancy and longevity

If we want to study the aging process is important to know the differences between these two concepts: The longevity is something intrinsic of each specie and it is the maxim amount of time an individual may come to live if it lives in the best conditions. The longevity of a human being is 120 years. On the other hand, the life expectancy is the average time that an individual is expected to live according the region and population in which is living. The live expectancy of the first world is different of the live expectancy of the third word. The life expectancy in Spain is about 84 years. The most long-lived person in the world has been the Frenchwoman Jeanne Calment, who lived 122 years.

4. The second law of thermodynamics

The second law of thermodynamics states that all the molecules of the universe tend to the disorder, that is to say, the universe tends to an increase of entropy. Even so, life seems to challenge this concept: a living being is a set of molecules perfectly ordinates and linked, where each one knows the function that must develop.

A living being is an open system which exchanges matter and energy with its environment. The fact that it is never in equilibrium with the environment allows us to explain how they can create order at the same time that operate inside the second law of thermodynamics.

The secret of the living beings is that its metabolism consists in a chain of coupled reactions: this concept enables to carry out endergonic reactions with a Gibbs free energy positive, using the energy provided by the spontaneous reactions (with a negative Gibbs energy). The final balance always results with an exergonic and spontaneous global reaction.

5. Factors that influence the process of aging and health

A curious fact about aging is that it is a character which is not selected by the process of evolution. This is because the reproduction takes place before the start of the aging process. Therefore, the aging process do not influence the tax of reproduction and so is not selected neither favourably nor negatively.

5.1. The telomers

Everyone knows the famous letters ATCG which contain all the necessary information so that an organism develop itself and reproduce. In the case of humans (and eukaryote organisms) what we call the genetic information (3.200 million pb) is organized and packed in chromosomes. A characteristic of these structures is that in the end of each one, we find a sequence repeated in tandem without information coded in them and each time the cells divide these sequences shorten.

These sequences are the telomers and its function is to prevent the chromosomes to loss essential genetic information:

During the process of replication, the lagging strand requires the addition of primers for the okazaky fragments to be synthetized. The problem here is that when the last fragment is replicated, in the end 5’ there is no more DNA left to copy and the region which is placed the last primer used is impossible to copy. This is the reason why the telomers keep shorten each time a replication is done.

In fact, each cell has a limit of divisions from which the cells turn in senescence. This limit is known as the Hayflick limit. This theory exposes the cells would have a kind of molecular clock that indicates the moment they have to die.

Nevertheless, there are some cells which do not have a limit of divisions because its telomers never shorten, they have a mechanism that prolongs them. This mechanism is an enzyme called telomerase. Telomerase is a reverse transcriptase made up by protein and RNA. This RNA has a copy (a complementary sequence) of the telomer and is used to prolong it. In natural conditions, the living beings have the telomerase with little activity and paradoxally if we try to activate it we would develop cancer cells: cells which do not stop dividing and keep accumulating damage.

5.2. Cell damage

The principal cause of cell damage is ROS (reactive oxygen species) molecules. If they are produced in excessive way they cause oxidative stress. Free radicals can come from endogenous or exogenous sources.

In the case of endogenous sources, we talk about metabolism. Metabolism generates ROS as a subproduct in a natural way. ROS most predominant molecules are superoxide, hydrogen peroxide and hydroxy group. The organism has enzymes that interact with this kind of molecules and neutralize them. These enzymes are catalase, superoxide dismutase and peroxidase.

Which takes place during aging process is that this capacity of neutralization of these subproducts became each time less effective over the years. For this reason, the organism has less capacity to handle the cellular damage.

5.2.1. Why the oxygen is so reactive?

Oxygen is one of the elements more electronegative of the periodic table, so it has a huge tendency to react with other molecules, to take their electrons and reduce himself. ROS molecules are already chemically unstable because they have a lack of electrons. ROS react easily with other molecules and in consequence generate more ROS molecules. It triggers a chain of oxidations and reductions that leads to what we call oxidative stress.

6. Environmental influences

It has been shown the interaction which certain compounds increases the production of free radicals. These compounds are tobacco, alcohol, insecticides, hard detergents, environmental pollution, stress, processed meat and refined oils.

However, we can de something to low the free radicals in our organism and take care of our telomers: is absolutely recommended the consumption of food rich in Omega 3, blue fish, dry fruit and vegetables rich in antioxidant, green tea and coffee. It is also important to have an active life and practicing sport, and also to sleep well.

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Proteins, the Citizens That Live in the Cell City

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Abstract. What is a cell and a protein? A cell is the simplest unit that forms our body, and our body is composed of millions and millions of cells. If we imagine a cell as a city, we can imagine proteins as being the citizens that live in such city. Proteins are made of amino acids and they are much like us, they are born as small peptides or small chains of amino acids, they grow up, they study to get a job, they can feel stressed and sick, they can socialize and make a lot of friends, and most importantly, they allow the correct function of the cell. In this paper, we will use the citizen-protein analogy to learn more about proteins.

Keywords. Cell, growth, organelle, protein.

1. The birth and growth of proteins

Our cells have different compartments known as organelles, just as cities have different areas and buildings. It all starts in the hospital, the nucleus of the cell: the DNA is transcribed to mRNA[1]. Soon after, the mRNA exits the nucleus and reaches the cytosol, because proteins cannot be synthesized in the nucleus. The cytosol can be seen as the streets, the parks, the neighbourhoods, a place where everyone can be. Once in the cytosol, the mRNA is recognized by ribosomes that start linking amino acids one by one forming a short peptide that will elongate to eventually become a protein. This process is called translation. Ribosomes are like our parents, they make sure that the peptide grows up into a protein. Peptides can become proteins in two different compartments: the cytosol or the rough endoplasmic reticulum.

1.1. Growing in the cytosol and looking for a job

In our cells, peptides that grow up in the cytosol can find a job mainly in 3 different places: mitochondria, nucleus or they can remain in the cytosol. When peptides become proteins, they are still not mature and cannot perform their jobs, they need to be folded into their native structure, similar to us when we want a job, first we need to be educated and trained. These immature proteins are called preproteins or precursors, and they have a head called N-terminus and feet called C-terminus. The folding of preproteins can occur in the cytosol or when they reach their particular place. Preproteins that do not want to remain in the cytosol need an identification card that allow them to move to their respective working places (this movement is called translocation), whereas the proteins that will remain in the cytosol do not need any ID card. This ID is known as signal sequence, and it consists of a short amino acid sequence that vary depending on the destination of the protein. Once they reach their destination, most proteins cannot return to the cytosol. But how do proteins acquire the ID cards? They obtain their ID cards when they are growing up, these cards are intrinsically in their structure.

1.1.1. Mitochondria

Mitochondria are in charge of providing energy to the cell, we can imagine them as the electricity distribution companies that provide energy to cities. A mitochondrion has its very own compartments, from out- to inside they are: the outer mitochondrial membrane (OMM) which is in contact with the cytosol, the intermembrane space (IMS), the inner mitochondrial membrane (IMM) and the mitochondrial matrix (MM). These different compartments are like the different floors in an electricity distribution company, the OMM being the ground floor and the MM being the last floor. Precursors commute to the mitochondrion unfolded and acquire their native structure once they arrive at the organelle. During the commute, preproteins are nervous and are accompanied by assistants called chaperones that help them keep calm. Depending on the compartment they want to go, proteins will need different ID cards: for instance, if they want to go to the MM, they will need the matrix targeting signal (MTS) that is found in the N-terminus of the preprotein [2] (if the N-terminus is the head of the protein, the MTS is a hat) and cross the OMM and the IMM. There are security guards in each compartment, but preproteins can bypass them by showing them the MTS. Once preproteins reach the MM, their MTS is removed, they lose the ID card, but they will remain there forever. In the MM, preproteins are still not prepared to work and therefore feel a bit stressed, so there are other chaperones (we will call them instructors this time) that will help them fold into their native structure so that they are prepared to work.

1.1.2. Nucleus

The cell nucleus, as mentioned above, is the hospital of the cell, but a very special one, one that is only in charge of giving birth to mRNAs that will be used for protein synthesis. The nucleus also has different compartments, from out- to inside: the inner nuclear membrane (INM), the outer nuclear membrane (ONM) and the nucleoplasm (NP). The INM and the ONM form the nuclear envelope (NE). The NE serves as the entrance to the nucleus, and the NP is like the ground of the nucleus. Not everyone can go inside the nucleus, there is a security guard called nuclear pore complex (NPC) who will only let pass preproteins that have the right ID card. Preproteins that want to go to work in the nucleus are already folded, they receive their education and training in the cytosol by instructor chaperones. Proteins that commute to the nucleus have one compulsory ID card and may have a second optional ID card. The mandatory ID card is the nuclear localization signal[3] (NLS), which allows the entrance of proteins through the NPC. The optional ID card is the nuclear export signal [3] (NES), which allows the exit of proteins that were in the nucleus. Proteins with both ID cards have permission to work both in the nucleus and in the cytosol. The main duty of the proteins that work in the nucleus is to ensure the integrity of the DNA and its correct replication and transcription.

1.2. Growing in the rough endoplasmic reticulum and looking for a job

The rough endoplasmic reticulum is an organelle that is devoted to raising peptides that once they reach full maturity, will mostly leave the cell to work abroad. Peptides that grow in the rough endoplasmic reticulum (RER) also have an ID card, the RER signal sequence [4]. Peptides grow as they enter the RER, and once inside the RER they are folded with the help of chaperones. Unlike the other cases, folded proteins in the RER are still not mature and undergo what is called post-translational modifications, which consists of the addition of small molecules like sugars to the protein. We can imagine this process as going to the university: the RER is the university, proteins are the students and post-translational modifications are the knowledge proteins acquire. During this process, proteins can feel stressed much like students in real life, and even get sick but there are mechanisms to help them relax and to cure them which will be discussed later. Once proteins have obtained their bachelor's and master's degree, they need to study more, a PhD. To become PhD students, post-graduate proteins have to move to the Golgi Apparatus (GA), through a means of transport called vesicle trafficking. Basically, proteins take a bus (the vesicle) that drives to the GA. The GA is an organelle formed by several compartments named cisternae, they are structured one after another. Once in the GA, proteins travel through the different cisternae (first year, second year and third year of PhD). In the last cisterna, proteins decide where they would like to work: lysosome, plasma membrane or leave the cell. The lysosome is a compartment in charge of the degradation of old proteins and proteins that do not work properly, the cell membrane is the boundary of the cell and serves as a protection barrier. Proteins that decide to leave the cell can travel to other cells and work in new cities.

2. Getting sick and healed

Proteins can feel stressed during their education, training and in the work and consequently get sick. How do proteins get sick? Proteins get sick because of the presence of damaging factors. An example of these damaging factors is the reactive oxygen species (ROS) which are produced by the cell activity itself [5]. ROS are like air and water pollution caused by human activity in the city that is harmful for us. Another example of these factors is studying (post-translational modifications), as shown previously in section 1.2.

When proteins get sick, there is a slight change in their structure, a misfolding. We have seen in section 1.1. that when peptides grow into preproteins, there are chaperones that help them fold into their native structure, we called them instructor chaperones. In addition, there are chaperones who play the role of medical doctors that can cure sick proteins. These doctor chaperones can be found in the different compartments of the cell and can recognize the structural change in ill proteins (yes, they can also be found in the RER, the university). Sick proteins that are successfully cured refold into their native structure. However, if doctor chaperones cannot manage to cure them, they will eventually be sent to the proteasome. The proteasome is the graveyard of the cell, where sick and old proteins are degraded into amino acids that are recycled for new protein synthesis. This quality control of proteins is of great importance as the accumulation of misfolded proteins leads to protein aggregation, a common cause of human disease such as Alzheimer disease.

3. Making friends

Proteins also like socializing and they can do it by direct physical interaction. Proteins have interaction domains, which are specific amino acid sequences that allow them to interact. Protein-protein interactions are very important for the correct function of the cell. A very clear example of interaction is between misfolded proteins and doctor chaperones.

In the OMM there are two proteins called mitofusin 1 (MFN1) and mitofusin 2 (MFN2). These proteins can interact homotypically (MFN1-MFN1 and MFN2-MFN2) or heterotypically [6] (MFN1-MFN2). When cells are in a situation of high energy demands, two mitochondria can interact through the interaction of these two proteins and fuse into a larger mitochondrion to generate more energy, just like if two electricity distribution companies were working together.

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Motivation of University Students for Learning Chemistry

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Abstract. In recent years, important reforms have taken place in the European Higher Education System, as a result of the Bologna Process. Educational institutions face new challenges to enhance young people scientific literacy and their preparedness to accompany the rapid technological and social changes of today's world. One of the factors that influence the scientific literacy and the successful learning of students is motivation. This work meant to investigate the motivation for learning chemistry of university students enrolled in science degrees. More specifically, the study meant to investigate the eventual differences in the motivation between students from degrees that are closely related to chemistry (Biochemistry, Biotechnology) and students enrolled in degrees more faintly related with chemistry (Biomedic Eng., Marine Sciences). The results showed that the students were motivated for learning Chemistry, regardless the course that are enrolled in and the affinity with chemistry of their curricula. Although sharp distinctions among the different degrees where not observed, the results suggest that the relevance of the subject to the student's curriculum has a positive correlation to the respective motivation for learning chemistry. Further research is needed to better characterize the motivation of students and devise efficient strategies for students with different backgrounds and academic contexts.

Keywords. AMS, chemistry, learning, motivation, university students.

1. Introduction

The EU Research and Innovation programme Horizon 2020 is aimed at developing Europe's intellectual capital through the generation of key skills and innovation to allow Europe to maintain or increase a global competitiveness. The need to enhance student´s scientific literacy is well established not only in Europe [1-2] but also in the rest of the world. It has been recognized that the number of college graduates in science, technology, engineering and mathematics (STEM) should increase in the next decade [1-2]. Students need to be equipped "with highly codified, routine skills to empower them to confront and overcome complex, non-routine cognitive challenges" [2].

In the initial academic year of undergraduate curricula in STEM degrees, students have often modules in a broad range of foundational science disciplines so as to offer them the basic science knowledge in relevant science fields. However, students do not often see the necessity or the relevance of the other disciplines beyond their chosen core subject of study. As a consequence, they do not feel motivated to learn those basic science courses and they often disengage from learning and eventually drop out [3]. Henceforth it is important to characterize the motivation of students particularly when non-core courses of the curriculum are at stake.

1.1. Motivation

Motivation has been identified as one of the factors that influence the scientific literacy [4] and has been related to the successful learning of students [5-11]. Therefore, the effect of student motivation has been studied widely in academic research [6-15].

Most theories treat motivation as one-dimensional construct that varies in amount, but self determination theory (SDT) regards motivation as a multidimensional concept that varies not only in amount but also in type [15]. SDT makes a basic distinction between *intrinsic motivation (IM)*, *extrinsic motivation* and *amotivation*, placed in a continuum [15]. Intrinsic motivation has been linked to positive consequences to STEM college students [14]. Students who have intrinsic motivation tend to learn because of their inner curiosity and are more active in learning [15] and usually learn better [14]. Intrinsic motivation refers to the fact of doing an activity for itself and for the pleasure and satisfaction derived from participation. It can be further divided in three classes [17]: *IM to know*, that relates to constructs such as exploration, curiosity, learning goals, intrinsic intellectuality; *IM to accomplish* may be defined as the engagement in an activity for the pleasure and satisfaction of accomplishing something; *IM to experience* relates to the stimulation sensation derived from one's engagement in the activity.

1.2. Measuring Motivation

The motivation continuum means that students can have different types and degrees of motivation. The characterization of students' motivation may be useful to devise better learning contexts and strategies. Although the results of motivation tests may vary across student level, subject matter and social context, even when the same tool is used to evaluate motivation [16] a significant number of studies found a positive correlation between motivation and results of knowledge tests [10,18-19].

In the present case, motivation towards learning chemistry was the focus of interest. A few tools are currently available to measure student motivation that have scales adapted for college chemistry:

- Motivated Strategies and Learning Questionnaire (MSLQ), - a 81-item, self-report Likert-type questionnaire [20]. This instrument was used by Bauer and colleagues [21] in an entry-level general Chemistry course, and the researchers concluded that this could be used to identify at-risk students.
- Science Motivation Questionnaire (SMQ, SMQII), - a 25-item Likert-type questionnaire that was administrated to science and non-science majors to measure motivation toward science [22] and was modified to survey Organic Chemistry students [23].
- Academic Motivation Scale (AMS) – a 28-item questionnaire that has subscales to measure *amotivation*, three types of *extrinsic motivation* and three types of *intrinsic motivation* [18]. This questionnaire was adapted to Chemistry motivation and used in college chemistry courses [24-25].

The SMQ motivational components for science learning included *intrinsically motivated, extrinsically motivated, personal relevance*, *self-determination* (responsibility), *self-efficacy* (confidence) and *anxiety* [23] but lacks items measuring *amotivation*. Yet, amotivation seems relevant to college chemistry courses, which often feature quite high withdrawal rates, signaling that a student has decided that there is little hope for achieving a passing grade [14].

The Academic Motivation Scale (AMS) has subscales to measure three different types of *intrinsic motivation,* three different types of *extrinsic motivation*, and one subscale to measure *amotivation* [17], as displayed in Figure 1. Because *integrated regulation* and *identified regulation* are both classified as autonomous within the *extrinsic motivation* portion of the continuum [15], the authors of the AMS chose to keep only the identified regulation items. *Intrinsic motivation* was classified into three subcategories: *to know* - to engage in the activities that produce learning out of pleasure and satisfaction gained from seeking an understanding of something previously unknown; *to accomplish* - the choice to engage in behavior that will lead to learning because students enjoy the process of achieving, in and for itself; *to experience* - to choose doing the specific activities necessary to learn in order to experience stimulating sensations.

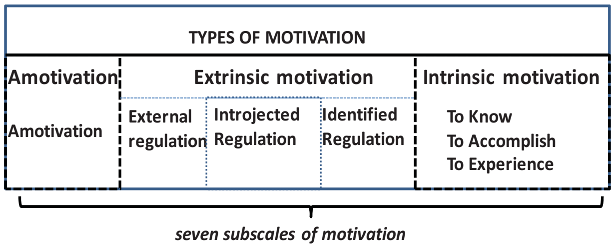

Figure 1. Academic motivation scale (adapted from [17])

The AMS aims to enable researchers to measure different types and degrees of motivation in detail. It was considered well aligned with a continuum based scale for SDT, has good psychometric evidence, and was adapted to measure discipline-specific motivation in several fields [24-25]. Particularly relevant was the work by Liu et al., that adapted and validated AMS in General Chemistry [24] and Organic Chemistry students (AMS-Chemistry) [25]. This questionnaire retained the 28 items from the original, but replaced "*college*" by "*chemistry*" and reworded some items when needed for the sake of clarity. As mentioned before, it has seven subscales and four items per subscale, and uses a 5-point Lickert scale. This instrument has been validated by interviewing the students

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about past experience in chemistry courses, reasons for enrolling the course and perceptions of the importance of chemistry in their future goals. Each of the four items per subscale should measure similar aspects of student motivation and elicit similar responses [24].

1.3. Scope of this Study

This work presents an exploratory study aiming at investigating the role of motivation for learning Chemistry in first-year university students. No such study has been carried out in Chemistry courses within the Portuguese universities. The results may help to bring a better understanding of the role of motivation in the learning processes. The purpose of the study is finding out if, which and why students lack motivation for learning chemistry. In particular it aims at comparing motivation of students from different chemistry backgrounds, that is, in degrees with high or low affinity with chemistry.

2. Methods

2.1. Instrument and achievements

No previous studies on motivation for learning chemistry were carried out in the Portuguese universities, so there was no instrument available for measuring motivation of Portuguese students. A tool had to be made from scratch or by translating an existing one. From the three questionnaires that have scales adapted for college chemistry (section 1.2) AMS-Chemistry was chosen since it measures different types and degrees of motivation in detail, as mentioned before. The 28-item AMS-Chemistry questionnaire was translated to Portuguese and an informal evaluation was made by a few non-participating students to adjust and improve wording.

The questionnaire was administered in regular classrooms (TP), and a period of 15-20 minutes was allowed to complete it. The students were informed orally that they were participating in a survey about the interest of studying chemistry in their curricula and that their participation was voluntary. It was pointed out that: it was not an achievement test; they would not get any marks and that their answers would be handled anonymously. Finally, the importance of being sincere was underlined.

2.2. Participants

Participants in this study were 1st year students from an university in Northern Portugal enrolled in mandatory courses of the respective curricula: i) an Introductory Physical Chemistry course (55) ii) a General Chemistry Lab course (56). The students attending the Physical Chemistry course belong to the heavily Chemistry-related (HCR) degrees, Biochemistry and Biotechnology, and to the lightly Chemistry-related (LCR) Biomedical Engineering degree. The students from the General Chemistry Lab course pertained to Biochemistry (HCR) and Marine Sciences (LCR).

3. Results and Discussion

3.1. AMS-Chemistry(Pt)

As mentioned above, the questionnaire used in this study was translated from the original AMS-Chemistry. Data analysis of AMS-Chemistry(Pt) was performed using IBM-SPSS, version 21.

Table 1. Internal consistency of AMS-Chemistry and AMS-Chemistry(Pt)

	Chronbach´s alpha	
	This study n=110	Ref.[24] n=208
Amotivation	0.87	0.74
External regulation	0.77	0.88
Introjected regulation	0.83	0.90
Identified regulation	0.71	0.79
To experience	0.65	0.88
To accomplish	0.78	0.91
To know	0.84	0.86

The internal structure validity was assumed also for the Portuguese version; confirmatory validity tests would not be valid since the number of respondents per item was not big enough. Nevertheless, the level of internal consistencies of the seven subscales was evaluated by computing the Crohnbach’s alpha coefficients. Those are a measure of how closely related a set of items are as a group and are considered to be a measure of a scale reliability. The results are presented in Table 1 as well as values from the use of the original English version AMS-Chemistry [24], for the sake of comparison. The coefficients obtained in this work for each of the 4-item groups of questions are between 0.7 and 0.9 and just slightly smaller than the ones from AMS-Chemistry. This corroborates an acceptable consistency of the items within each group. So motivation can be adequately characterized by the means of each subscale of the questionnaire.

3.2. Motivation characterization

The response scales of the questionnaire ranged from 1 (“not at all”) to 5 (“exactly”); a higher score in *amotivation* means that students lack any intention and motivation; a higher score on every other item means the students have motivation for learning chemistry. The respective motivation type may vary from the more controlled and less autonomous type (*external regulation*) to the high-quality autonomous motivation (*to know*) [17]. No significant differences were found between the participants of the two courses, so data from General Chemistry and Physical Chemistry was handled together.

The means of the seven motivation subscales of the questionnaire, along with the respective standard deviation are presented in Table 2. Subscales were approximately normally distributed, with skewness and kurtosis generally within ±1. As data shows, the score on *amotivation* is the lowest and, since it is below 2, it indicates that the students do not lack motivation. As for the type of motivation, the scores on intrinsic and extrinsic motivation were not much different although slightly higher for the latter. The means on extrinsic motivation subscales, i.e. relatively controlled types of motivation varied from 3.29 (*introjected regulation*) to 4.05 (*identified regulation*). The scores for the autonomous intrinsic motivation subscales ranged from 3.62 (*to experience*) to 3.99 (*to know).*

Table 2. Mean and standard deviation (SD) of the seven factors of AMS-Chemistry(Pt)

	This study n=110	Ref.[24] n=208
Amotivation	1.68 (0.66)	1.64 (0.74)
External regulation	3.54 (0.73)	3.81 (0.94)
Introjected regulation	3.29 (0.86)	3.39 (1.07)
Identified regulation	4.05 (0.58)	3.94 (0.82)
To experience	3.62 (0.62)	2.45 (1.00)
To accomplish	3.80 (0.57)	2.95 (1.04)
To know	3.99 (0.54)	3.00 (0.95)

These results indicate that the motivation of the students to learn chemistry has comparable grades of autonomous and controlled motivation. That is, in a learning situation, the students pursue performance related goals to demonstrate competence relative to others (*external regulation*) but they also have a purpose to develop competence by acquiring new knowledge and skills (*to experience, to accomplish, to know*). Autonomous motivational types are associated with cognitive, affective, and behavioral outcomes, which are all considered to be positive for both individuals and society [15,17]. The highest score observed for *identified regulation* means that the students have a relatively strong desire to perform activities in order to gain a sense of importance and personal value [15,17]. This feature was also observed in other studies using AMS-Chemistry [24-25].

As mentioned before, high scores of autonomous types of motivation were shown to correlate significantly and positively with the satisfaction of basic needs, experiences with meaning in education, and confidence. No direct and individual information on the previous academic background of the students was gathered, but indirect information could be inferred from the participants's high school academic scores that were needed for admission that were needed for admission to the chosen degree at the University. Using that general information, it could be questioned if students enrolled in EBM, Biochemistry and Biotechnology degrees (with high admission grading marks) would have more automous types of motivation than CM students whose admission required lower grading marks. However, no significant differences were observed in the motivational scores of students from CM degree and the other degrees. This finding does not mean that there is no such influence, but that the gathered data was not sufficient to eventually reveal the effect.

The goal of the study is to investigate motivation for learning chemistry, hence prior academic achievements in this discipline, and not global academic achievements are to be considered. Another important indicator of success in education is the development of interest in a topic or discipline. The courses in the first year of the degrees considered in this study are both mandatory. The enrolment in these courses does not mean that the students are interested in chemistry nor that they are motivated for learning the subject. Nonetheless, it may be assumed that the interest in Chemistry is related to the degree that students have chosen for their career.

To apply for a degree in Biochemistry or in Biotechnology, the students must have studied Chemistry at secondary school, contrariwise to an application in Biomedical Engineering or Marine Sciences Chemistry that do not have this pre-requisite. On top of it, the first have a core of Chemistry courses in the curricula whereas Chemistry is a lateral subject in Biomedical Engineering or in Marine Sciences. The motivation structure of the students from Biochemistry or Biotechnology, heavily Chemistry-related degrees (HCR), could then be different from the motivation of the students in Biomedical Engineering ou Marine Sciences, lightly Chemistry-related (LCR). The effect of the type of degree is presented in Table 3.

Table 3. Motivation scores of of AMS-Chemistry(Pt) from students of heavily chemistry-related (HCR) and lightly chemistry-related (LCR) degrees

	Mean and standard deviation	
	HCR n=60	LCR n=50
Amotivation	1.53 (0.63)	1.86 (0.65)
External regulation	3.68 (0.71)	3.37 (0.72)
Introjected regulation	3.36 (0.86)	3.21 (0.86)
Identified regulation	4.26 (0.50)	3.80 (0.57)
To experience	3.79 (0.58)	3.42 (0.61)
To accomplish	3.94 (0.46)	3.64 (0.64)
To know	4.10 (0. 94)	3.86 (0.57)

The motivational scores of the students from HCR degrees seem consistently higher than the corresponding values of students from LCR degrees – apart from *amotivation* that is agreeably lower. In fact, when analyzing the 28 items of the questionnaire, many of them displayed significant differences between the two types of degree.

However, when the subscale groups that characterize each type of motivation were considered, the differences were not significant, except for *identified regulation* at the 90% confidence level. The students from the degrees with a higher affinity with chemistry (HCR) who are also those with presumed better prior achievements in chemistry, scored better than the students from degrees with less affinity with chemistry. This type of motivation seems to discriminate the students according to the types of degree, that is, according to their previous experience and their interest in learning chemistry. The *identified regulation* subscale of motivation stemmed elsewhere as a type of motivation of no less quality than intrinsic motivation variables [26]. And was also found to be positively correlated with future academic achievements in a long-term longitudinal study [26].

4. Concluding remarks

The results suggest that the students are motivated for learning Chemistry, regardless the course that are enrolled in and the affinity with chemistry of their curricula. There were not sharp distinctions among the different degrees, contrariwise to what could be anticipated from the relevance of the subject to the respective curricula. Yet, a few significant differences were observed, which suggest that students with better previous achievements have higher levels of motivation for learning chemistry. That is, students with overall better achievements recognize more easily that a certain behavior (e.g. studying, attending classes) is beneficial toward their development and adopt that behavior as their own.

The study has some limitations, and its findings must be interpreted with caution. Further research is needed to better understand the role of motivation in the learning of chemistry and therefore help devising better learning contexts and teaching strategies.

The learning environment plays an important role in the formation of student motivation [11], and students exhibit different characteristics with different types of motivation. So, it may be useful to envisage different strategies for students with different backgrounds and academic contexts, so as to help them to become motivated self-learners, which is one important goal of introductory university science instructors.

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Inspiring Each Other

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Abstract. Inspiring each other means learning from students and teaching teachers. This paper discusses the method of Integrated Interdisciplinary Education, a method employed at the 1st Independent High School in Bratislava (1. sukromne gymnazium v Bratislave) every school year for 26 years and its evolution into its present form.

The aim, organisation and benefits of this method are introduced by teachers and alumni. In addition, there are examples of experiments carried out by students as their contribution to their final project presentations. This method is based on the peer-to-peer educational form, where groups of students study, explore and analyse a chosen theme. It is important for the authors – students – to get their hands on science through experiments and/or access to excellent scientific institutions such as the Slovak Academy of Science, state or private businesses, Bratislava Airport, the ISCARE Clinique for Reproductive Medicine and many others. Students then present their findings and teach their peers what they have learned.

The method is explained and introduced using specific examples of students' project themes, i.e. Water (2014), Vaccination (2017), Nuclear Physics (2018), Artificial Insemination (2017) and others. These students' projects inspire other authors as well as teachers, who work closely with the students as their consultants, in active learning and teaching.

Keywords. Active learning, communication and presentation skills, critical thinking, experiment, integrated interdisciplinary education.

1. Introduction

Our school is a modern alternative school offering general secondary education and preparing students for further university studies. Graduates of our school apply to prestigious universities in Europe, where they study different fields of the natural sciences, economics, medicine and law. They acquire high-quality secondary education and in their final two years can adapt their curriculum to their choice of further university studies by selecting special seminars (one- or two-year courses) in which they can develop their skills and knowledge.

What is our students' answer to the question of what they have used most from their secondary school education studies during their university studies? It is the skills acquired thanks to the integrated interdisciplinary education at our secondary school. The acquired competencies and skills go far beyond basic knowledge in the individual subjects taught at school, and they compensate for the fact that during individual classes there is usually no space and time to solve complex problems.

This specific method of teaching and learning was introduced at our school in 1992. Since then we have gone a long way in developing and adapting this system to our curriculum. Now it is an inseparable part of our school life.

2. The pillars of Integrated Interdisciplinary Education (IIE)

The main features of IIE are the interrelation of everything, teamwork and education.

2.1. Everything interrelates

The theme chosen by students has to be complex as they have to integrate pieces of knowledge, looking for connections beyond the limits of one subject. When looking at the problem, they do not limit themselves to just one school subject for a solution. The choice of theme is crucial for student motivation. They suggest themes and together with their teachers create the assignment for their work. The assignment is actually a set of very open problems and questions. The complete answer to these questions is often unknown to the teachers, who often do not even know whether an answer already exists. Topical themes and active work on the assignment can secure the students' interest in studying the problem and in preparing the project, which usually takes from 1.5 to 3 months.

Teamwork is a necessary component of a successful project, with the ideal team consisting of three students and three consultants (teachers or experts from outside of the school environment). The consultants' task is to guide the students in their search for answers, teaching them critical thinking in terms of the sources of information they want to use.

2.2. Education

Students become experts in their theme and are supposed to share their acquired knowledge with the rest of the class, presenting the theme in front of their schoolmates, leading a discussion and giving arguments. Presentations are a part of the educational process and the information gathered by the students becomes a part of their later tests. When preparing the tests, teachers are not narrow-mindedly focused on only the questions concerning just one subject.

2.3. Methodology of IIE

Project work is a method of education where students hone competencies which affect students': knowledge and critical thinking, communication, interpersonal skills – values and relationships, intrapersonal skills – responsibility and flexibility.

There are three main phases where these skills are refined. The first phase involves studying the topic and preparing a written work. Besides looking for information and studying materials, a practical part is also welcome (collecting and evaluating samples, preparing an experiment, preparing a tool or exhibit) as is contact with an expert from outside the school. The themes are discussed in April and May, and the assignment is set in June at the latest.

Each team finishes studying most of the theme by the end of September, the written work should be delivered by the middle of October. The written form of the work depends on the age of the students, ranging from a document through a website to a scientific contribution to a collection of abstracts.

The last phase includes the preparation of a presentation and an individual performance. Each team member has approximately 30 minutes to present, while the whole group together has a total of 120 minutes, but the length of the presentation can be prolonged according to the time needed for discussion. It is very valuable if not only students and teacher-consultants participate in the discussion, but also the experts who worked with the students on their theme.

3. Cooperation with experts and institutions

During the preparation phase, students search for information and study the problem not only at home, but also visit different institutions accompanied by their teachers where they can discuss the theme of their project with experts (external consultants) who are happy to help them. These experts introduce their workplace to the students so they can get an idea of different professional fields of interest. In order to visualize this form of cooperation, allow me to give you some examples of this excellent experience together with a brief description of the themes where this cooperation took place.

3.1. CERN

Students who are interested in physics, chemistry, mathematics and informatics can take part in a six-day excursion to Switzerland which we organize for them every two or three years. They spend two days at CERN. Besides the official half-day visit, Slovak scientists working at CERN take them for an excursion around different workplaces there and describe the problems they actually work on. This allows students and teachers to gain current first-hand information and gives them the opportunity to see state-of-the-art technology.

This kind of experience was used by two of our students, Alexandra Lesayova and Matus Hedera (aged 17), who were interested in the theme 'Nuclear Physics'. It is generally known that research at CERN is among the most demanding in the world and its results influence our view of physical reality. However, the fact that discoveries from CERN can be used e.g. in medicine is less known. Their choice of theme was also inspired by their participation in the Masterclass seminar held at the Faculty of Mathematics, Physics and Informatics of Comenius University.

During the preparation phase, these students cooperated with MUDr. Lucia Dzurillova from the National Oncological Institute and via on-line connection with Ms Michaela Mlynarikova from the MFF UK in Prague, who is working on her thesis at CERN.

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Not only did they get insight into the foundations of sub-nuclear physics, but they also gained a medical view on the problem of finding a cancerous tumour in a human body.

In the presentation, the students showed a Standard Model with the basic properties of particles. They dealt with questions like why it is necessary to accelerate the particles, why it is namely protons that accelerate or how a synchrotron works. They also explained what scientists working at CERN could see when analysing data. They talked about research into the b-quark and what a reverse search for it might look like in a detector. The chemical point of view for the theme Nuclear Physics was focused on notions like nucleus stability or radioactivity. In this way they wove together the importance of nuclear physics and contemporary medicine. They explained to their schoolmates how a tumour is pictured in a human body using marked glucose, explaining how this functions on the basis of the concentration of glucose in a human body. At the end they presented a device which can detect such a tumour. Their presentation ended with a lively discussion with MUDr. Dzurillova and all the students.

3.2. Energetics and distribution networks

Within the framework of power and transmission grid studies, we went for an excursion to the new seat of the Slovak Electroenergetic Central Control Room in Zilina, which is equipped with the most modern technology. We had an opportunity to tour it and students received the most current information on the dispatch control of electric energy transmission from the CEO, Ing. Frantisek Pech. The Slovak Electroenergetic Dispatch Control (SED) is the top operational manager of the Slovak Electricity Supply System and its reliability is closely monitored and evaluated at an international level. It is said among energy experts that SED is the brain of the Slovak power grid, covering the management of transmission from the power stations to the distribution network, big customers and other countries. The reliability of the whole power grid in Slovakia and the safe supply of electricity require a high level of expertise, reliability, accuracy, high-quality work, and the most modern information technology and control systems.

3.3. Bratislava Kamzik Transmitter

Within the framework of the ‘Signal and Noise (Buzz)’ project, we visited the Kamzik transmission tower, which serves Slovak radio and television broadcasting. Workers in the tower manage the broadcasting and look after all other Slovak transmitters. Besides their control function, they also communicate with foreign transmitters. It likewise serves the needs of the Slovak army, police and other telecommunication operators. During our visit of the premises, we were guided by Mr. Milan Herman, who works in the tower as a product specialist. We had the opportunity to see what lies behind the broadcasting of the signal to the surroundings of Bratislava and to the whole of Slovakia. Mr. Herman explained to us the technical details of the transmitters, the aerials, the differences between analogue and digital broadcasting and also the changes which have taken place in recent decades. Students studied the details of aerials which changed polarization from horizontal to vertical.

3.4. Slovak Academy of Sciences (SAV), Slovak Technical University (STU)

We have found a great willingness to cooperate amongst the researchers in many institutes of SAV. One of these examples was our visit to the Institute of Molecular Biology and Genetics, thanks to Mrs Alexandra Zahradnikova, DrSc. In the topic ‘Heart’, we studied different types of ion channels, their functions and the preparation of pharmaceuticals.

At the Institute of Physics and at the Faculty of Electronics and Informatics of STU, we were able to experience work in the field of nanotechnology, and understand their use and production by observing nanostructures. We saw top research laboratories, scanning electron microscopes, transmission electronic microscopes, an atomic force microscope and a scanning tunnel microscope.

4. Experiments in the preparation phase and in presentations

We are very much interested in improving not only the theoretical knowledge of our students, but also in improving their practical skills. Within the framework of school subjects like science, physics, biology and chemistry, our students are involved in work in the laboratory from the early age of 10. The first three years (10-13 years of age), they have four classes per week in the laboratory and in following years they have three classes per week. Experiments are a part of their project education (IIE).

One example is a project entitled ‘Water Pollution’. The students involved in this project collected many water samples from Slovakia and Germany during their summer holidays. In their project, they examined this problem from three points of view. From a geographical and geological point of view, they were looking at natural pollution such as, for example, hard water and soft water or the origin of karst formations. They did an analysis of the hard and soft water samples and looked for elements like iron (Fe). In terms of chemical pollution of the water samples, they examined some substances which can appear in the waters from industrial plants or from agricultural produce. They dealt with their influence on life in the water and on humans. In their samples, they tried to find simple organisms living in the water environment. They talked about the bio-purification station and the bacteria which are used in it. They evaluated each experiment and arrived at interesting conclusions.

Another example can be the project ‘Radio’. The students were so interested in this topic that they decided to build a simple radio receiver. They were familiar with the standard laboratory equipment used to set electric schemes in experiments, but not with electronics or etched printed wiring. They studied these activities on their own and found an external consultant, an amateur radio operator who they contacted via e-mail, and finally by trial and error, on the third try they successfully created a working radio receiver which they showed at their presentation.

5. Written output/Selection of information

As the development of this method continues, the phase of preparation has changed. In the ‘90s and early ‘00s, the most difficult thing for students was to obtain literature and up-to-date sources of information. Now the situation is different: Students have a great deal of information sources and are instead learning how to work with them. Some of the themes of our projects are so current that students can obtain a very wide spectrum of information all stating to be facts and/or scientific information, leaving high school students unable to decide what to believe and what to choose for their thesis and presentation. They use their intuition, as the majority of people would do in their place.

As an example, in the autumn of 2017, one group of students in their final year of creating projects who were interested in biochemistry chose the very challenging theme of vaccination and “antivax” movements. As described above, they visited specialists MUDr. Rams N. Mujica and MUDr. Azadeen Schunar of the Department of Infectology and Geographical Medicine of the Medical Department of the UK, SZU and UNB at the L. Dérera Hospital to obtain information, to see the actual work of physicians in hospitals and also to discuss their opinions on anti-vaccination movements in the world. The students prepared by studying about immunity and lymphocytes, essentially everything a biology teacher would explain in their biology class and beyond. Later the doctors informed us that the students were excellent in their knowledge, but what was more, they were adequate debaters in these fields and seemed to have a future in the study of biochemistry, medicine or similar fields.

The discussion ‘To vaccinate or not’ was a challenge for them. They decided to present their difficulties with such a huge amount of information to their peers as well. At the beginning of their presentation, they gave the audience two articles with opposing opinions and asked them to decide which one was telling the truth and which was misleading and, most importantly, why. Both articles had been written by physicians, both were current and from an online newspaper. The audience got to experience critical thinking themselves. Later on the authors of the project successfully explained what they had learned, including information about the immune system and vaccines, and how they had dealt with misleading information during their preparations.

During their study at our school, we teach students to be able to learn from experience as this skill is not only useful, but necessary throughout life. The concept is often misunderstood and replaced by the term ‘having experience’. Having experience does not mean effective learning, as experience alone does not guarantee flexible learning. Learning from experience happens in four steps which form a cycle. The first step is the actual experience (i.e. with an experiment, science or a scientist), the second step is reflecting on the experience, the third step is creating a new concept of the problem, the fourth step is planning the active experiment and again comes step one, actual experience. The second step, reflecting on the experience, means a systematic evaluation of the actual experience as students write their project either as a document, web page or as a paper for a conference, where the facts about the work are captured as well as one’s own feelings and an evaluation of the procedures. The third step, a new concept of the problem, represents the contextualization of the experience with a theory. During the fourth step, the previous steps are summed up and the knowledge gained is applied in planning a new project. A positive aspect of this method is the fact that mistakes and failures are considered instruments of learning.

6. Interdisciplinary education and critical thinking

The method of Integrated Interdisciplinary Education provides inspiration for the authors of the project but also for the teachers and consultants. One very important skill obtained during work on the project is the contextualization of facts and organisation of knowledge of different types and fields. A person’s knowledge is non-transferable; only information is transferable. Knowledge is created in the mind of the learner as an individual construction. The creation of this construction depends on a person’s common learning abilities (according to Bloom’s taxonomy). Offering space and time for this process leads to the skill of working with knowledge and recognizing original approaches and ideas.

At the beginning of the project preparation, the most important thing is creating the task to be accomplished in the project, respectively the problem to be solved in the project. A task can become problematic for students if the solution is not based on memorisation or the automatic repetition of learned steps and procedures or the mechanical usage of experience. A problem might become problematic if its answer is not known and the path to the answer is also unknown.

The first step is definition of the problem. The requirements are: precise knowledge of the information content in words, pictures, and situations used; adequate training in the skill of comprehensive reading of scientific or technical texts; understanding the rules of communication, dialogue, discussion, and task analysis; the ability to organize and hierarchize a data set, etc. The second step is giving students time to think. Students should be familiar with or learn their own personal method of thinking and type of intelligence. The third step is critical thinking. The prerequisites there are the ability to evaluate; make assumptions according to criteria; search for concepts; create structure, e.g., categorisation and argumentation of one’s own opinion; think actively, precisely and immersed in the problem without being affected by stereotypes. The last step is to have the courage to decide and create a solution.

Each of these steps should be practised and critical thinking is key to the selection of information as well as to its evaluation.

The training of critical thinking can be done during lessons. For example, during a chemistry lesson with up to 15 students, we can create a roleplaying game where two students are selling a real product, e.g., a machine to create super healthy water (this product is real, the lesson is based on an advertisement flyer taken from a café in 2016), while the rest of the students are potential customers with different occupations ranging from physician and scientist to alternative healer and sanipractor, etc. They must try to find mistakes in the flyer while the salesmen are trying to explain the information written there. The class is different from other chemistry classes and a great deal of fun. Students are very interested in the theory of argumentation, especially if it is shown in real life situations, so they receive information about arguments, proof and failures of argumentation.

Students often choose project themes based on what they see being presented in mass media or on social media as the opinions of others. The natural sciences are no longer only for scientists, instead many people of various backgrounds express their opinions on ecology, the energy industry, medicine, the food and drug industry or individual health. Students then want to study a theme from a perspective that agrees with their developing opinions; sometimes, however, their opinion is changed over the course of their work based on facts and their own critical thinking.

7. Presentation

The presentation of the project is essentially peer-to-peer education. Students learn how to create a presentation and how to step in front of an audience, their class. Each of them knows they are in the same position since everybody will have to present their own project. They even learn how to criticize other authors constructively and learn from their mistakes. Consultants are present during the presentations not only to evaluate, but also to help with understanding and to learn themselves. Students use all the didactic methods they are able to or want to, including improvisation and working with their intuition. During the many years of Integrated Interdisciplinary Education at our school, we have been able to see different approaches to experimentation. For example, extracting chlorophyll to describe the method of extraction because the project theme was ‘Perfume’, which integrated biology, chemistry and literature; showing what gluten is when the project was about bread and milk; or bringing equipment for an IVF embryo transfer when the project was about artificial insemination and problems with human conception.

8. Conclusion

The success of the IIE method at our school originates in the fact that students can choose their topic themselves, ensuring it is close to their interests and life and that their learning is well-phased and explicit.

We can see a plethora of benefits to our students: self-confidence, the ability to explain complex phenomena, the art of presentation, teamwork, exactness, and the ability to select basic information and knowledge.

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Food Allergy in Children and School Environment

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Abstract. Food allergy prevalence is increasing. Food allergy can cause of a severe systemic reaction, called anaphylaxis, even with a small amount of food. Sometimes, inhaled vapor from cooking or use kitchen utensils can cause a reaction like that. The first line approach is epinephrine injection. Doctors provide to this patients auto-injectors that can be used for anyone in case of an emergency attempt.

School age children, specially the younger ones, are not prepared to use them by themselves, and school staff needs to be prepared to face a situation like that.

Two schools that received 6 years old children with severe food allergy (one to milk, another to fish) were visited by an immunoallergist expert to improve the knowledge about the disease, how to prevent contacts with allergen protein and how to proceed in case of anaphylactic reactions. Four levels were instructed: administration, teachers, school assistants (that includes kitchen staff) and classmates. Several topics were approached: what is allergy in general, what is food allergy, what kind of reactions can be expected, how can be prevented and how should be each group behaviour in case of a reaction.

In this two schools, the knowledge about this disease and his treatment was very low. During the four years that the children attend the primary school, there was only one child with one episode of cutaneous reaction related with inhalation exposure, and the approach was appropriated. So, this kind of interventions appears to be useful in order to ensure the safety of children with food allergy.

Keywords. Anaphylaxis, epinephrine auto injector, food allergy, primary school children.

1. Introduction

Food allergy prevalence is estimated in 6% in all age groups in Europe, but prevalence among children (6,9%) was higher than among adults (5,1%) [1].

There was up to 10-fold difference between self-reported and medical diagnosis prevalence of food allergy in children [2]. In a study in Qatar, 23% of schools were not even informed by parents about their children anaphylaxis risk [3]. So, it`s very important not only schools ask for a full medical report concern child`s food allergy described by parents but also parents do not forget to give schools all medical information crucial to child safety.

Cow's milk, egg, wheat, soy, peanut, tree nuts, fish, and shellfish are the most usually foods responsible for allergic reactions [4]. In younger children, allergy to cow's milk and eggs are the more common ones [4] and tends to disappear with the growth in mostly of the cases. Allergy to peanut, tree nuts, fish, and shellfish are more common among the older children and adults [4] and tends to persist throughout life.

Sometimes, there is co-factors necessary to have a food allergic reaction. For example, eating the allergic food protein can not cause any reaction, but if the intake was accompanied with alcohol or followed by exercise, then an allergic reaction developed, and can be a life threating one. These problems and the solutions found for each one can be illustrated by two clinical cases that will be described above.

2. Clinical cases

2.1. Child number 1: “Ana”

Female child, with milk allergy with anaphylaxis, confirmed by history, skin prick test and blood analysis.

She was breastfeed since birth until nine months old. At four months old, after the first formuled milk intake, she had developed immediately generalized urticaria.

Skin prick tests and specific blood IgE was performed and positive to cow milk, so, the parents was advised to keep her without any contact with another milk than the human one.

From nine to 26 months she avoid cow and human milk proteins.

At 26 months, her mother was breastfeeding her baby brother and gave her a human milk glass (200cc) and she developed immediately an anaphylactic reaction (cough, urticaria, angioedema, vomiting, shortness of breath and stridor) that was treated in the emergency room with epinephrine, inhaled beta agonist, cortisone and antihistamine.

Since then, she strictly avoids all kinds of milk.

2.2. Child number 2: "Sara"

Female child, with fish food allergy, confirmed by skin prick test and oral challenge.

At eight months old 6 hours after the first hake intake she developed generalized angioedema and vomiting. She needed endovenouse corticosteroid and anti-histamine in emergency room. After that episode she have two more, one after salmon and another after horse mackerel.

At one year old she start visit the immunoallergologist doctor.

Skin prick test with several fishes were positive in an atypical way, with swelling of all arm about 2 hours after.

Oral challenge with tuna fish was performed and positive, with vomiting and angioedema more than two hours after the intake.

At four years old she as a new episode, thirty minutes after inhalation of cooking vapor at home.

2.3. Aproach

To both children was prescribe epinephrine autoinjector, corticoid and antihistamine to use in case of emergency. The family learn how avoid allergens. They have a full report explain all situation and what to do in an emergency situation.

The children were screened (skin and blood tests) once a year to access an eventually tolerance acquirement, that not happen in none of the cases.

3. Elementary school

At six years old both children begins elementary school and left the kindergarten safer environment.

Although both have a full medical report, the families ask for an immunoallergologist visit to the schools.

3.1. Schools characterization

Both schools are public, belong to Lisbon district, having a city environment and attended mostly middle class. They are exclusively for kids between 6 and 10 years old. Each class has 25 to 30 students and one teacher. Usually the teacher stays four years with the same class.

Additional staff was responsible for cleaning and ensure the children safety in several school places: playground, toilets, canteen and gymnasium.

The school provide lunch and an afternoon snack to about 400 children.

The lunch was cooked in the school and the kitchen has a connection with the canteen, so cooking steam expands to the eating area.

All meals consists in a vegetables soup, main dish (Tuesdays and Thursdays fish; in the remains days, meat) and dessert (fruit, except Friday in which they eat gelatin).

In the canteen are several washbasins, paper to dry hands and liquid soap.

Each table share the plastic water jug and paper napkins. Each table allows about ten sittings.

The kids receive a food tray and carrier it to a table of his/her choice.

The first and second grades lunch first and then lunch the third and fourth grades. There is no cleaning procedures during lunch time, unless there is some unexpected situation.

The snack was provided in the classroom, by the teacher, and usually consists in chocolate milk and bread with cheese or cookies. Some kids bring they own snack and that wasn't predictable.

3.2. Risk assessment and measures to reduce it

The unexpected contact through contamination was very likely in both cases but in different places: "Ana" in the classroom, at snack time, and “Sara” in the canteen, at lunch time. Both children had a serious risk at playground, because classmates may not have cleaned properly their hands and mouths.

The epinephrine needs to be kept at a place that all caregivers know and can access quickly but not the kids.

So, that was agreement that “Ana”`s epinephrine stays in classroom, in teacher desk drawer, and “Sara”`s epinephrine in the kitchen, with the insurance that all staff knows that.

“Ana”`s snacks were always provide by her family.

“Sara”`s family had choose take home lunch in the fish meals days.

3.3. Learning sessions

Learning sessions was asked for the families to the doctor, with children agreement and was provide to caregivers (administration, teachers, school assistants (that includes kitchen staff) and classmates in the same day at different times. Only class mate students had formation, to the remain school students there is no chance to perform learning sessions.

The same items were approached, but with different language to adults and to kids. Specially to the 6 years old kids it`s very important to use a simple language and never stigmatize the allergic child but insure that all understand the risks and explain.

I opt here by kid’s language, because it’s the more challenging approach and also less present in literature, so can be a useful resource to teachers and parents. The exceptions are in the therapeutic management, that kids don’t need to know and that can even be dangerous try teach it to young children.

3.3.1. Why is my colleague weird?

Not weird, allergic.

There is several situations that increase the risk we will be allergic: we can inherit of our parents, like our hair color, for example, or be one thing only ours. Sometimes, infections when we are babies (like SRV infection-respiratory syncytial virus) or smoke exposure increase our chance to be allergic.

3.3.2. What is allergy?

Allergy is an extra reaction of the body against thinks that should be accepted. Human body has a defense system against bacteria, virus, parasites, called immune system.

It has soldiers, not specific, that work in all kind of situations, and it has elite troops, specialized in each kind of danger, the immunoglobulins (Ig).

The IgE is specialized in parasitic infections. We all know that we should wash our hands, so we don’t have a lot of this kind of infections and IgE has nothing to do, so IgE is bored… and what do kids when they are bored? They behave badly. Also IgE do the same: IgE starts fight things that don’t hurt us, but IgE thinks it does, and make a mess.

3.3.3. What is an allergen?

An allergen is s small peace of a pollen, a dust mite or a food that our IgE recognize as a danger and react against it. It usually a protein.

3.3.4. What is an allergic reaction?

Some IgE is attached to cells (mastocytes, for example) full of “munitions” like histamine. When the foreign protein is attached to IgE, the cells blow up and munitions are release causing allergy.

3.3.5. How can I recognize an allergic reaction?

The allergic reaction can happen in several organs:

- Skin: atopic dermatitis (severe itching and the skin is injured), urticaria (red lesions similar to insect bite but that disappear faster), angioedema (swelling).
- Lungs: Asthma (difficult to breath, wheezing, cough; episodes can start at school with faster or long running or with cold whether; in that case, should stop the exercise and use the rescue therapy prescribe by the doctor).
- Nose and eyes: Allergic rhinitis or rhinoconjuntivitis: sneezing, itching, snoring most of the time or in presence of allergens.

When several organs are affected at the same time it`s called anaphylaxis: gastrointestinal (vomiting, diarrhea, abdominal pain), respiratory (difficult to breath, wheezing, cough, sneezing, itching nose and eyes), mucocutaneous (urticaria, angioedema) and cardiovascular (with dizziness that can precede loss of conscience).

3.3.6. What is food allergy?

Food allergy happens when IgE recognizes a food protein and can develop any kind of allergic reaction.

Small amounts of food are enough to lead to an allergic reaction. For example, use cooking material not previous cleaned or receive a kiss without proper cleaning after a meal. In some cases, inhalation cooking steam can by enough to cause a reaction.

3.3.7. Can I prevent an allergic reaction?

In case of food allergy, everyone can help to avoid an allergic reaction. Kids should not share food, drinks, gums, makeup or anything else with their collegues. They should wash hands and faces very well after meals and ask their parents to advoid the allergic proteins when bring to school some meal to share with all class, like a birthday cake.

Remember that any contact can be so dangerous like put fingers in the electrical outlet or jump from a building: it`s a life risk situation and kids shouldn't play with it.

3.3.8. What should I do in the presence of an allergic reaction?

To kids:

The most important is recognize and call grownup help immediately. Do not try solve the problem by yourself.

To adults:

There is several publish algorithms about how to deal with anaphylaxis.

In a short way:

Rescue prescription generally consists in anti-histamine pill or drops, corticoid pill or drops, epinephrine autoinjector and inhaled beta 2 agonist.

If there is urticaria: use antihistamine

If there is angioedema (swelling): use antihistamine and corticoid

If there is wheezing: use everything.

If there is any kind of reaction but without wheezing, give everything except inhaled beta 2 agonist.

If everything is needed:

- First: inhaled beta2 agonist and epinephrine auto-injector.
- After: corticoid and antihistamine.

In the presence of any kind of reaction that needs epinephrine, is mandatory, after performed therapeutics, to resort a hospital immediately: the patient can improve a lot immediately after epinephrine, but can have a second reaction and there is no more epinephrine auto-injector to him/her. Don`t wait for parents in the school - warn them and inform to what hospital you are going.

If there was no need of epinephrine, then call the parents to the school to keep surveillance at home.

3.3.9. How to use epinephrine auto injector? To adults only:

There are several epinephrine auto-injector brands, and each one has it`s own way to activate. The kits are provided with instructions that include illustrations. Is very important study them, and review how to use every week at first, and then every months, because in the presence of an anaphylactic reaction there is no time for that.

No mater which brand is, the auto-injector should be use in outer thigh, vertically, and maintain it about 15 seconds. Then, keep the empty auto-injector to show the doctor.

The auto-injector can be use over the clothes- don't waist time dressing up the child; just be careful and avoid coins, cards or other hard objects in the pockets and seams of jeans.

4. Conclusions

In this two schools, the knowledge about this disease and its treatment was very low.

That was expectable for kids but adults that take care of so much children every day should be more informed. That is an overall problem not only throughout Europe [2-3]. In Qatar study, was estimated that more than 80% of the families and the school staff were unable to recognise the symptoms of anaphylaxis [3].

Improve knowledge into families and scholar community about health in general and allergy in particular should be a priority in educational and health policies.

These two experiences was successful: during the four years that the children attend the primary school, there was only one child, "Sara" with one episode of cutaneous reaction related with inhalation exposure, and the approach was appropriated.

Parents, school teachers, other students and their families actively collaborated in all situations and appreciate a lot the knowledge improvement about this kind of situations, also useful for other kids they eventually will need to care.

"Ana" and "Sara" loved have had their doctor with their classmates and teachers and felt more confident with their illness.

5. Acknowledgements

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Analysing the Learning Model of Museum Hands-on Scratch Programming with Activity Theory

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Abstract. With the rapid application of artificial intelligence and internet of things technologies in recent years, there have been active trends of program learning activities in the world. In addition to the traditional classroom-based learning, informal education institutions such as museums which play a bridge of the programming education for the citizens. Base on the analysis unit of Expansive learning theory, this study surveyed two hands-on programming learning open activities in one southern Taiwan museum on 2017/10/22 and 2017/12/10. According to the observation record and the responses of the public, we propose a learning model of informal programming education which include experience felling, project analysis, problem solving thinking, coding design, execution testing, reflection correction, and innovative design. First learners experience the results of programs and elicit their interest in learning programming. With teacher's analysis of programming project, learners try to understand the principles of the programming and think about problems solving. Then proceed to design the programs' components and instruction codes. Based on the execution result of programming test, learners construct patterns of coding at the event and extend it to other programming units. The programming experience activities are different from traditional learning methods, it let the learners feel the programming functions from the effect of programming execution. Those activities inspire the interest of learners to code programs with rethinking programmatic problem solving. The programming related activities can take experiencing at the first, then guide learners explore and think about solutions to programmatic topics through explanations and challenges with questions. Comparing the programming teaching of formal education, museums have open space for programming learning activities. In order to guide people's learning the programming in informal situation, there need an effective learning model. Future research can be conducted on experimental studies on the teaching of different programming languages and informal educational institutions.

Keywords. Activity theory, informal education, programming learning.

1. Introduction

With the development of information technology, the application of technologies such as Artificial Intelligence and the Internet of Things has become increasingly sophisticated in recent years, program education become one of the key development directions for governments of all countries. The programming learning needs learners to experience the pleasant experience of applying in solving the problems with what they learned. The goal of programming education is to enhance the learners' knowledge of the program and, more importantly, to train their computational thinking skills so that learners can understand what they learn. Programming is a core curriculum that uses programming language to solve problems. It is used to develop important skills for learners to integrate related knowledge to solve computer software related problems. However, many learners often lose the willingness to learn programming in the programming process because they cannot obtain guidelines for solving problems. Therefore, there is a need to provide learning models to help learners solve problems and make learners imitate the problem solving process of the experts.

The formal education curriculum will use flow charts to understand the process of program execution. However, for beginners, the flow chart cannot specify the relationship between the program target and the design project. At the same time, the contents of the flow chart need to be converted. This is different from the program teaching of formal education. The program teaching activities of the National Science and Technology Museum of informal education institutions need to attract people's interest in programming in the beginning., Through the experience of program execution results, learners can experience changes in program execution, which in turn trigger interest in program learning, thereby promoting the integration of learners' knowledge. This study attempts to propose a feasible program teaching model for an informal education institution, and to verify the feasibility of teaching through actual program experience activities. The research question in this study is defined as: What are the possible modes of program teaching in informal education?

2. Literature Review

Programming is a problem-solving activity. To become a good programmer, it must be a good problem solver; therefore, one of the teaching goals of programming is to improve the problem-solving ability of students [1]. Some researchers found that program design has two advantages of learning motivation that are different from other courses [2]. One is creative, learners use the program to create artifacts to accomplish certain tasks. Second, programming is an activity that can immediately receive feedback which is also an important factor for active learning. Therefore, teachers should provide opportunities for learners to create their own program projects in program teaching, and adjust self-learning and problem solving through the feedback of program execution results. Experts and novices solve problem solving. Experts can understand most of the meaningful patterns in their knowledge areas and help solve problems quickly. Experts also hold a strong concept of hierarchical cohesion, with stronger post-cognition or self-monitoring capabilities [3]. It is necessary for teachers to assist students in constructing their own meta-cognitions of professional knowledge, so that they can problem solving from novice to expert. In addition, [4] demonstrated that the activities in the classroom include films, discussions, and specific tasks that are considered by learners to be an important key to maintaining their interest in learning. The process of designing a program to solve problems includes the integration of computer-related knowledge, the use of computer operations skills, and the cooperation of problem-solving situations, such as recognition, skills and affection. Therefore, the teaching of programming should be combined with image-based cognitive tools, teachers or teaching assistants. Skills demonstrations and spiritual support from friends and relatives to complete problem solving with confidence.

Some researchers found that Scratch's program platform can improve the user's self-efficacy in addition to improving the user's computer knowledge and skills [5]. One of authors demonstrated that program teaching must train learners to integrate relevant knowledge, and the process of problem solving requires explicit ideas and tools to use programming language to solve important problems in computer software related issues [6]. Another researchers also found that boys think that programming is easier in the teaching of college program introduction courses, and they have higher intentions and better learning performance than girls [7]. Some researchers revealed that the programming curriculum should select the appropriate programming language according to the level of students' learning and the characteristics of the program [8]. How to choose a suitable programming language for teaching will be the key to decide whether or not learners can interest in learning. For novices of programming, consideration should be given to reducing their frustration in the learning process and the ability to instantly display the results of program execution.

The theory of activity theory was first proposed by Engeström [9], and develop a new theory for learning. In activity theory, learners learn some abstract things. Learners construct new objects and concepts for cooperative activities and apply them to practical activities. The theory of activity theory provides a framework for analysing dynamic systems which based on human activities and the activities of groups have five principles. First, there is cooperation between different activity systems, media and individual-oriented network relationships. Second, multiple voices in the event system. Third, historic features. Fourth, the central role of conflict is the source of reform and development. Fifth, expand the possibility of conversion [10].

3. Research methods

This study uses activity theory to analyze the programming teaching in informal education institutions. Its structure was shown in Figure 1. The learner experiences the performance of the program. Then the teacher understands the principles of the program through demonstration teaching, and solves the problems of the program. Using tool design coding and implementation of the results of the test program, reflection correction program design to achieve the goal of the program. Teachers can also use tools such as program experience lesson plans to enhance learners' programming learning. At the same time, learners can also complete the goal of program learning through the division of the family community and teaching assistants under the relevant program rules.

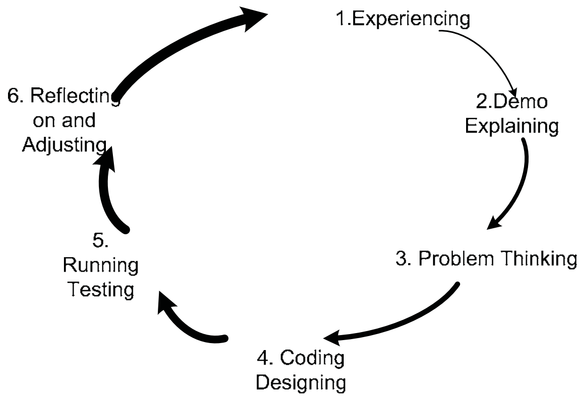

Figure 1 Theory of expansive learning (Adjusted from [11])

The participants of this study were those whose ages range from older grandparents to parents, young adults and teenagers who joined the Scratch program experience activities of the National Science and Technology Museum for 2017/10/22 and 2017/12/10. Since the two-day experience activities are all free for participation, it was difficult to collect participants' personal data. The researchers recorded the learning process of the program experience activities by photography and designed the following course units to provide guidelines for learner learning.

Unit 1: Self introduction
Principle: Sequences are executed sequentially from top to bottom according to building blocks.
Operating: When the green flag was clicked, Avery began to introduce herself.

Unit 2: Avery walks
Principle: Loop repeat execution of the same set of building blocks.
Operating: When the green flag is clicked, Evli begins to walk (move)

Unit 3: Cat walks the maze
Principle: Conditions perform different building blocks according to the set conditions and color detection.
Operating: Press the keyboard up, down, left, right, let the cat go to the maze.

Unit 4: Hide and seek
Principle: Loops repeated execution of the same set of building blocks and show the exterior blocks include hide and display.
Operating: When the green flag was clicked, playing hide-and-seek with everyone

Unit 5: Easy to use brush
Principle: Loops repeated execution of the same set of building blocks and use the brush tool.
Operating: Click on the "green flag" to use a pencil to draw lines; press the "blank button" to stop writing and remove handwriting.

Unit 6: Fish in the water
Principle: Events applications and exterior building blocks to change in size.
Operating:Press the keyboard up, down, left, right, let the fish swim.

4. Research result

The researchers have compiled the concepts and actual content involved in each course units as shown in Table 1 as teaching guidelines for informal educational programming learning.

The purpose of this study is to explore the pattern learning model of informal education, and then to observe the record according to the program experience activities of the National Science and Technology Museum.

1. Experience. The study found that informal education program teaching activities and program-based experience activities will attract public participants' interest in learning the program and trigger interest in parent-child and people learning programs.
2. Monographic analysis. This study found that family counseling and assistant tutoring can help learners continue to try solving the problems of the program. Under the interactive learning of the community, such as friends, family and teaching assistants, the learners can think and solve the problem of the program and support the

community program to solve the learner's problem.

3. Problem solving. The study found that learners will solve problems in the course units and think about it, inspiring their ability of computational thinking.
4. Coding design. The study found that learners will use the Scratch tool to write programs after thinking about course units and design their favorite interface.
5. Perform tests. The study found that the learners performed the Scratch program that they designed to test whether they reached the goal of programming lesson.
6. Reflective correction. The study found that learners review the relevant interface and programming based on the results of Scratch program execution.
7. Creative design. The learners expand thinking and creative design their own solutions with the challenges of the program.

Table 1. The concept and implementation of the theme of the programming teaching unit

Teaching Unit Theme	Concept	Operation
Self introduction	Sequence	Each step or instruction is executed sequentially
Avery walks	Loop	Repeat for the same sequence or action
Cat walks the maze	Conditions	Judging according to the set condition
hide and seek	Loops	Repeat for the same sequence or action
Easy to use brush	Loops	Repeat for the same sequence or action
Fish in the water	Events	One thing triggers one or more coping mechanisms

In the informal education, the learner's program learning also learns critical reading, analytical thinking, problem solving, and event detection skills. In addition to cultivating the creativity of the learner's design program and the ability to solve problems related to computer software, programming education also requires learners to use computer language to write, execute and debug operational skills in the process of computer programming and writing.

5. Conclusions

Effective problem solving requires thinking about multiple strategies and integrating relevant knowledge. Programming involves the concepts of logic and data structure. Programmers must be able to integrate relevant concepts and skills, think and develop strategies for solving problems, and use computers. Operating skills to execute and display program output.

This study modified the activity theory of [11] and explored the learning patterns of the Scratch program experience activities in the National Science and Technology Museum through field observations. Based on the observation records and the public reactions, the study proposed an informal education program: Experience Experience - Topics Analysis - Problem Solving - Coding Design - Execution Testing - Reflection Correction - Learning Mode for Innovative Design.

The program teaching of informal educational institutions recommends experience activities as teaching strategies, emphasizing the cognitive participation of learners in solving procedural issues. Program teaching provides explanations and manipulative instructions for programming as a demonstration of learning. The timely disambiguation through teaching assistants during program teaching helps to reduce learner learning frustration and create a meaningful learning environment. With regard to research restrictions, as the teaching of this research experience experience program takes place at the National Science and Technology Museum of non-standard educational institutions, the stay of the learners is difficult to control, and it is difficult to conduct fixed-point implementation of learning assessment. As a result, the verification of teaching effectiveness is difficult. place。 Future studies can use tools to collect learner learning history and feedback without affecting learners' learning so as to analyze their learning effectiveness.

6. Acknowledgements

This study thanks the Ministry of Science and Technology project (MOST 106-2515-S-232-001) for financial support and the National Science and Technology Museum for providing program experience activities teaching equipment and venues.

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Self-Similarity in Mathematical Modelling

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Abstract. As a student in Biochemistry and Mathematics one usually finds biological systems which are complicated from a qualitative point of view. These systems are difficult to study since their complications arise from difficulty in measuring their behaviour. Mathematical models in biology come out as a powerful tool, making carefully-thought simplifications in order to be able to study this systems and make useful predictions that can be tested for accuracy afterwards. These models can be extremely complicated, both mathematically and biologically. Complicated models involving differential equations are beyond the scope of this exposition. The main purpose of this paper is to review two of the simplest models, the Fibonacci sequence and the fractal, as a means to show the inner mathematical beauty of nature. These models are based on an interesting mathematical property called self-similarity. An object is self-similar if is exactly or approximately similar to a part of itself. The mathematics of self-similarity are deeply understood so it is a good tool to make models.

Keywords. Mathematics, modelling.

1. Fractals in nature

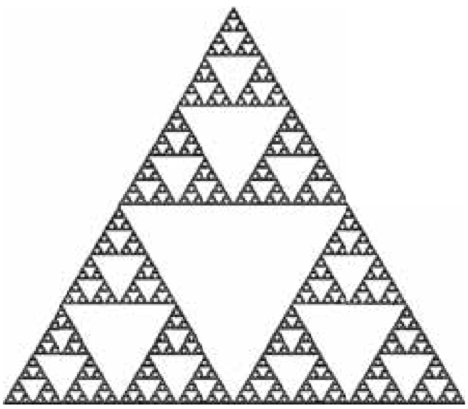

Figure 1. The Sierpinski Triangle is a fractal and as such it exhibits self-similarity

Mathematically, fractals arise from the iteration of affine transformations [1]. This can be seen in nature in the leaves and flowers of many plant species.

Geometric fractals are the limit step in the iteration process. Nature is not infinite and as such fractals, which are mathematical abstractions can only represent the biological system up to a point

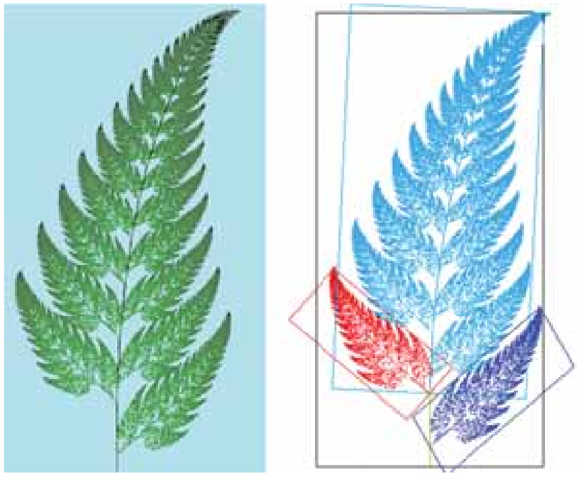

Figure 2. Fern leaf (left) and the Barnsley's Fern is a geometric fractal that consists in the iteration of displacements, scaling and rotations (right) [2]

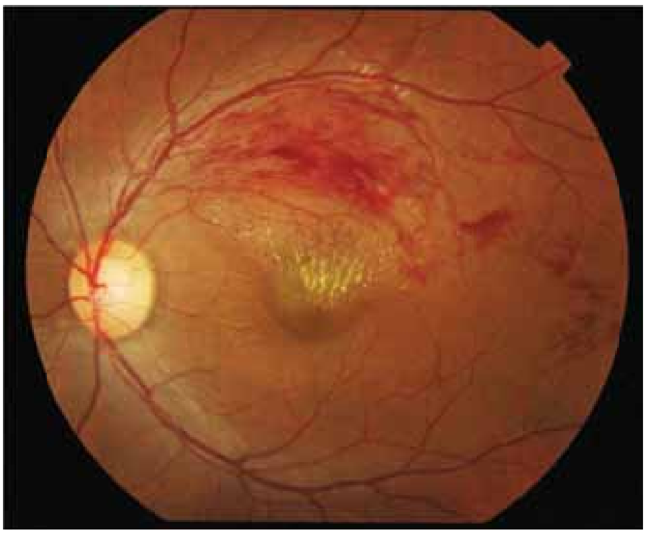

Figure 3 Retina blood vessels show a fractal structure [3]

2. The Fibonacci sequence

A Fibonacci sequence is a recurrence relation such that

$$a_n = ba_{n-1} + ca_{n-1} \quad b, c \in \mathbb{R} \tag{1}$$

The most famous of such sequences is the case when $b = c = 1$. It can be shown that the general term of this particular sequence is

$$a_n = \frac{\phi^n - (-\phi)^{-n}}{\sqrt{5}} \qquad (2)$$

Where $\phi = 1.6180 \ldots$ is the Golden Ratio.

A sequence can't be a self-similar object since it is not continuous. However the ratio of $\frac{a_n}{a_{n-1}}$ approaches ϕ as n increases which establishes a non-rigorous similarity between different sets of values of the sequence.

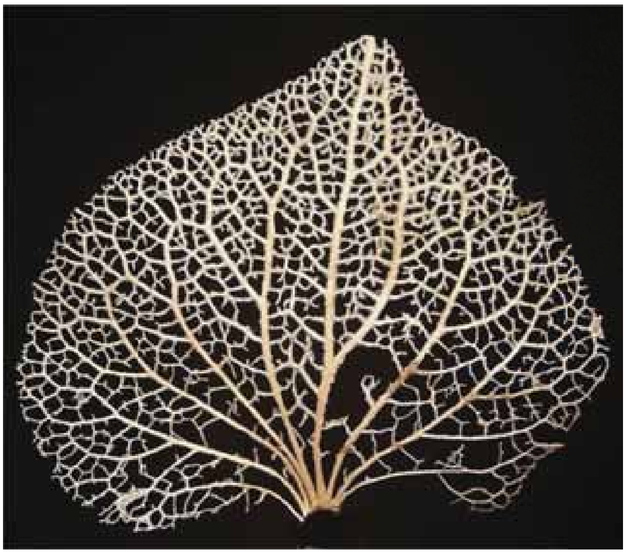

Figure 3 The veins of this leaf follow a Fibonacci sequence. Every time a new vein arises from a main vein, the number of veins in that level follow the Fibonacci sequence [4]

Figure 4. The number of petals in each layer follows a Fibonacci sequence [5]

The Fibonacci sequence can be used to construct logarithmic spirals which appear often in nature. Pinecones, flowers and some shells are famous examples.

Figure 5. Nautilus shells form logarithmic spirals that can be built with a Fibonacci sequence [6]

3. Applications

The examples given in this exposition are simple cases which show the beauty and potential utility of mathematical models using self-similar objects. The applications of such models are ubiquitous. Neural networks, processing of fMRI data, study of population dynamics

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Application of the GBL to the Teaching of Science

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Abstract. The introduction of new methodologies in the educational world is behaving transformations at different levels, from the organizational structure of the schools to the teaching practices. The progress in disciplines such as neuroeducation, school psychology or technology, are causing that at many schools new methodologies and tools are being introduced. Some of them are based in game-based learning (GBL) using mobile or tablet as item of gamification. The combination of both elements aims to teach and increase student motivation for some contents which sometimes don't raise a special interest among the students.

Keywords. Apps, GBL, teaching of science.

1. Introduction

In recent years, advances in some disciplines such as neuroeducation, school psychology or technology, is behaving the introduction into the classroom of new methodologies and work tools. In fact, these new practices are part of a transformation project in the larger educational world that is behaving changes that affect not only the daily teaching practice, but also to structural changes in the schools and the way that teachers prepare their sessions. Some of the objectives of this new educational approach are to offer a more personalized attention to the student in function at their pace of learning, the evaluation by competencies and the increase of their motivation.

Despite the reserves or doubts of some teachers about how to implement some tools or their use in the classroom, the fact is that there is an increase in the number of projects developed in schools that incorporate new elements like for example GBL (Gamed Based Learning).

The GBL is defined as the use of games like vehicles and tools of support to the learning, the assimilation or the evaluation of knowledge [1]. Some of the advantages of the GBL are the increase of motivation of the students, greater control of his learning and to allow an active learning [1].

According to Muñoz and Valenzuela [2] this approach is not new: "To the game with educational purpose has given it to call" serious game. Although the expression is not new (nor its use in classrooms)... ". So, this type of practice was being already carried out in the classroom years ago, especially in the first educational levels. However, what is new is the means with it can be carried out. Thus, for example, augmented reality or the use of mobile applications (Apps) can be used to work some contents that sometimes are unattractive to students.

One of the famous resources is mobile applications, although, they do not always fit what the teacher wants [3]. In this case, the teacher could consider the creation of an application that fits his needs. Below it is described the process of designing and programming a mobile application that allows to work some aspects of the periodic table applying the principles of GBL. In this case, the aim is guess a chemical element of the periodic table by means of questions about its characteristics or applications. It is important to say that although this application focuses on the elements of the periodic table, its methodology (question-answer-elimination) can be used to work contents of other subjects.

2. Description

To get the application, we divided the process into two stages: design and the programming.

2.1. Design process

The first step has been to establish the general and specific characteristics that the application should have. Thus, it was initially considered as general characteristics:

- Application must allow to choose levels of difficulty, in this case according to compulsory secondary education and high school.
- Can be used individually or in pairs.

- At the beginning of application, it should explain briefly which are the operation and rules of the game.
- Can be programmed with the App Inventor program.
- Must have an attractive design for students.

On the other hand, the specific characteristic that we considered was:

- The screen should provide some information to answer some questions so that a player with little knowledge of chemistry can start playing.

Due to spatial limitations of the screen (especially of the mobile) and considering that we must incorporate more information apart from the elements, we decided to show only some elements of periodic table. So, we had to decide of how many and what elements to choose.

Figure 1. The periodic table [4]

After considering several possibilities, it was concluded that the application would show only two rows and seven columns and that the relative order between the elements would not be respecting to get more freedom when choosing the elements.

Two combination options have been considered: using three elements of four groups plus hydrogen and one transition metal or, employing three elements of four groups plus two transition metals. In total fourteen elements.

Lanthanides and actinides have been ruled out, and we have considered elements that we believe may be familiar or closer to the students by their practical applications or because they are usually studied in the classroom. Figure 1 shows the periodic table used as a model.

Table 1 shows elements chosen for compulsory secondary education and high school level (elements in bold only for high school).

G.1	H	Li	Na	K					
G.2	Ca	Mg	Ra						
G.13	B	Al	Ga						
G.14	C	**Si**	Sn	Pb					
G.15	N	P	As						
G.16	O	S	**Se**	Po					
G.17	F	Cl	I						
G.18	He	Ne	Ar						
Metal transition	Au	Ag	Hg	Cu	Fe	**Ni**	**Cr**	**Mn**	**Pt**

Therefore, in each game, fourteen elements of the preceding table are selected so in several games, students work eight groups of the periodic table and some transition metals.

Once the elements have been chosen, we had to formulate the questions that the user can make to the application in order to guess the element and fix the maximum number of questions that can be asked, which in this case are eight. In this way, the game is not a mechanical process of question and elimination and incorporates an extra degree of difficulty because if the student does not choose well the questions, may not be able to guess it and lose the game. The questions selected are as follows:

1) Is it a metal?
2) Is it a non-metal?
3) Is it a transition metal?
4) Is it a metalloid?
5) Is it a post transition metal?
6) Is it belong to group 1?
7) Is it belong to group 2?
8) Is it belong to group 13?
9) Is it belong to group 14?
10) Is it belong to group 15?
11) Is it belong to group 16?
12) Is it belong to group 17?
13) Is it a noble gas?
14) Is it a solid?
15) Is it a liquid?
16) Is it a gas?
17) Does it have several oxidation numbers?
18) Application/s (only available when the user has asked one question)

2.2. Programming process

In this second stage, we focussed the programming in monoplayer case. When this part will be ended, we want to develop the multiplayer case.

To develop the application, we have used App Inventor. It is a software programming environment created by Google Labs for creating applications for Android mobiles. To create applications with this tool, it is not necessary for the user to have advanced knowledge in programming. The user can, in a very visual way, connect a serial of several blocks that will shape the app.

To begin using App Inventor, it is only necessary a web browser and telephone with Android operating system connected to the computer to visualize the application. It is worked in two different parts:

- App Inventor Designer: here is defined the user's interface, that is to say, the screen that will see the user.
- App Inventor Blocks Editor: defines the behaviour of the different components of the App.

So that the user do not has to actualize the application every time that the data are updated, these have been saved in Google Fusion Tables. It is a Google web service for data management to save these in several tables that internet users can see and download. By doing so, if an error is detected or we simply want to modify the elements, we only need to modify the information in the tables with no need of generating a new version of the App and its subsequent publication.

To test the application, App Inventor has the option to make simulation with no need of generating the App.

Once finished the application, App Inventor enables to generate the apk for its distribution in Google Play Store.

3. Conclusions

According to the process carried out and considering that it has not been done yet a test of the application with real students and we want to develop the game to play in pairs and add some extra functionalities, we can conclude that the process of design and programming of this application implies an important investment of time. Therefore, if a teacher would like to carry out the design process and create a mobile application to use with his students, it may be interesting carry out the process in an integrated way to the curricular activity of the centre. Thus, for example, the design and development of the App could be carried out in the classroom with the students of higher courses as a project in class of technology, where in addition to developing the application, they should document design and programming process. With this project, we can increase the motivation of our students because they perceive the usefulness of their application.

4. Acknowledgements

We would like to thank Josep Maria Fernandez Novell of the Col·legi Oficial de Químics de Catalunya for their support and advice throughout the process of conception, design and creation of the application.

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Applied Biochemistry: An Approach to Pokémon Cytology

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Abstract. Pokémon are fictional creatures that have captivated whole generations. As a matter of practice, an approach to how they could function and work in real life has been made. Cytology and chemistry basic criteria have been applied in this reasoning, trying to provide its supernatural abilities with logical mechanisms. Even though there are many branches and aspects to be answered, the focus of this paper has been the cell, its role and structure in the Pokémon biology.

Keywords. Pokémon, cytology, chemistry, cell, applied biochemistry

1. Introduction

The history of the Pokémon franchise [1] spans over two decades from when work began officially on the first game until nowadays, with the latest announcements and the blockbuster "Pokémon GO". Debuting in Japan in 1995, originally produced for the Gameboy line in Nintendo, Pokémon quickly became wildly popular in the United States. In the games, players assume the role of Pokémon trainers, obtaining cartoon monsters and developing them to battle other Pokémon. Thus it became one of the most successful video game franchises in the world.

The original Pokémon is a role-playing game based on building a small team of creatures to battle other monsters in a quest to become the best trainer in the game. Pokémon are divided into types, such as water, fire, grass, fight, ghost or electric, each with different qualities, powers, forms, strengths and weaknesses. With experience, Pokémon grow stronger, gaining new abilities and powers and finally, evolving, that is to say, adapting new and more awe-inspiring forms. By defeating Gym Leaders and obtaining Gym Badges, trainers garner acclaim to prove their success in the Pokémon world.

Over the years, Pokémon has taken over whole generations of both children and adults worldwide by inspiring, besides games, a cartoon series, movies, books, toys, numerous spin-offs, clothing, cards and making its "Pocket Monsters" an icon. This advertising strategy has make such creatures an interesting context for those curious for the different explanations of different happenings in the many various movies, comics and Pokémon-related merchandise explained above.

Knowing this background, what if someone used this powerful phenomenon as a tool to approach science to people, specially kids? What if these fictional monsters could be explained by science?

2. Using science to explain fictional facts

Nowadays, it is very common to find through the internet a load of theories, videos, documentaries and even papers that try to give a real and scientific explanation to science-fiction realities. It might be the result of our effort to explain our world applied to made-up, impossible excogitations, even imagination itself. Therefore, many theories that try to break down the basis of worldwide science-fiction sagas such as Jurassic Park, Star Wars, Star Trek or Marvel [2] emerge with our prevailing knowledge of science.

While making up concepts may be a bit confusing and sometimes lead up to mistaken conclusions in the audience, approaching science to fictional situations is a very powerful tool that helps the people who are doing it to fix contents and deepen in the subject; but the most important is the impact in the divulgation, as combining both science and fiction makes the real science more appealing to people who are not science professionals, teaching them and introducing them to a basic knowledge. The authors of the article not only believe that it is an important way to make outreach, but it allows people with many different interests with a common bond (Pokémon) to share the liking for a topic from the scientific point of view and make science a fun and exciting tool.

Getting here, the authors of this paper have tried to introduce the Pokémon world to biochemistry and will give an answer to a few questions on how Pokémon might work if real, inside the fiction.

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3. First International Pokémon Symposium

Doctors all around the world have gathered together for the first time in order to settle once and for all a unique theory of the amusing creatures that inhabit our world: the Pokémon. With the widely known Professor Oak managing this big event, some questions about Pokémon biology have been answered, mainly about their cytology.

3.1. Biological origin of Pokémon

Nowadays it is well known that all living beings from Earth come from a Last Universal Common Ancestor (LUCA). From this point, organisms have been developing themselves. In the Eukarya domain we can find different kingdoms, such as Fungi, Animalia and Plantae.

Figure 1. Comparison between a Pokémon and a plant. It can be clearly seen that the Pokémon, named as Exeggutor, has a similar shape as the palm of the photo [3-4]

At some point of past, an organism arrived in the Earth from space. This had a completely different origin from plants and animals. This creature has been named Original Pokémon Ancestor (OPA). The OPA, in the beginning, fought for its survival against pre-existing organisms on Earth, but it managed to adapt itself to our living conditions, starting a convergent evolution.

Both descendants, the ones from LUCA and the ones from OPA, had to live together in the Earth. Nowadays it can be clearly seen that Pokémon first ancestors have coevolved with animals and plants, having formed a symbiotic relationship, and finally copying their appearance and their way of living along with all the abilities that the OPA incorporated.

Figure 2. Comparison between a Pokémon and an animal. Again, the Pokémon, named as Aerodactyl, has a similar physiognomy as the Pterodactylus of the photo [5-6]

3.2. Pokémon cell structure

Starting from the OPA, the new type of cells that adapted to our planet and emerged with our living forms to build new ones, called from now on “Pokéryotic Cells” or “Poké-Cells” have some characteristics that must be taken into account.

Poké-Cells are polynucleated cells in which, from the formation of the individual, a single nucleus is active. The other nucleus stay inactive until the evolution to another Pokémon form happens. The nucleus is in charge of DNA replication and its transcription into RNA, that later will be translated to proteins that give each Pokémon its powers and abilities. Each nucleus codifies the abilities and morphology of the stage in which the Pokémon lives and develops. Even though the genetic information contained in each nucleus is different, every cell has the whole genome within.

It is a fact that exist many different types of Pokémon, and this is because of the diversity caused by the adaptation to different environment. Each Pokémon type has its own Poké-Cell subdivision. Those different kinds of Poké-Cells have organelles and proteins that develop their abilities that other types don’t possess. But, what happens with the other nucleus and evolution?

3.3. Pokémon evolution system

We could say that Pokémon are divided in species like animals. Each species can be shown in different shapes with their own specific abilities which is known as evolutions. Pokémons are at first in their basic evolution stage and they need to get enough experience, in order to be able to evolve to the following evolution. When the evolution starts a chain of complex cellular processes are triggered.

So how does an evolution take place? An evolution may be understood as a process in which, at a metabolic level, the genes that the Poké-Cell expresses go to be the ones from a nucleus to others of a previously turned off core. That way, the more nucleus the cells of a Pokémon have, the more evolutions it can suffer. Normally, there are three evolutions, but some species have two or even zero. It might be defined as a metamorphosis but in a differential time.

When the Pokémon evolves and the new core "wakes up" in cells, all the features that its DNA codifies, which will give the Pokémon a new form, abilities or even change completely its nature due to a new metabolism, sum up to the basic living functions and some of the previous aptitudes. The old nucleus does not completely disappear, but in fact, fuses the new activated one. Some of the genetic material found in the new nucleus can act as an inhibitor of genes expressed before, that way explaining how a Pokémon may lose some faculties, acquire new ones and change its morphology.

Evolutions are very energetic procedures in which heat is released as a result, and that can be seen by the shining flash the Pokémon lose. In such manner, that means Pokémon need a huge amount of energy to carry out the transformation. Poké-Cells contain a specific organelle specialized in the storage of chemical energy, in mechanisms and forms yet to determine, which are called PESU (Pokémon Energy Storage Units). When these PESU arrive to a limit amount of energy, the conditions to the activation of an operon zone ("Pokéron") in the first nucleus are given. An operon is a functioning unit of DNA containing a cluster of genes that will express under the same promoter. Once the operon starts transcribing its genes, evolution begins. The proteins codified within the Pokéron are responsible for the metabolic pathway that will switch on the nucleus from the new stage, stimulating the expression of its genes and fulfilling the attachment of the old genetic material. Once this process is accomplished, a complex of inhibitors of the new core inactivate the Pokéron zone until further evolutions.

Even though PESU are the main tools that a Pokémon has to trigger its evolution, proof has given the existence of some stones and materials that can initiate the evolution too. That can possibly be caused by the fact that these materials are radioactive, being radiation an energy that can also activate the Pokéron.

Figure 3. Different types of evolutionary stones. From left to right, a leaf stone, a fire, a water, a thunder and a dawn one. Below there is a sun stone, a shiny, a moon, a dusk and an ice one [7]

But, which factors, besides energy warehousing, determine the evolution? Evolution may have been the method that Pokémon have developed through the history of evolution to adapt to change of environment. That way, if a Pokémon species migrated or changed its habitat, those individuals who could execute a metamorphosis in the correct direction that gave them new abilities to survive, passed their genes to new generations, concluding that Pokémon are too held to natural selection. Furthermore, it may be declared that Pokémon evolution is displayed to epigenetics, that is to say, the influence of environmental factors in the expression of genetic material, such as the change of habitat due to a migration, explaining why Pokémon evolve at a determined point of its life.

3.4. Different Poké-Cells types

As aforesaid explained, different types of Pokémon species coexist, with different abilities and powers. Each type, of course, is built and composed by different Poké-Cell types. Pokémon types (fire, water, plant, rock, normal, dragon, etc.) are the product to adaptations and coevolution of species to different environment through time. Those individuals who took profit of the resources and nature of the territory inhabited were chosen by natural selection. These types allow our community to establish a way of classifying Pokémon species, a taxonomy.

There are normal type Pokémon, with no speciality nor natural power. Those could be seen as the least adapted species of Pokémon, but what if they were the most versatile among

Pokémon beings? Take for instance Eevee, a normal Pokémon whose evolutions can be of any type.

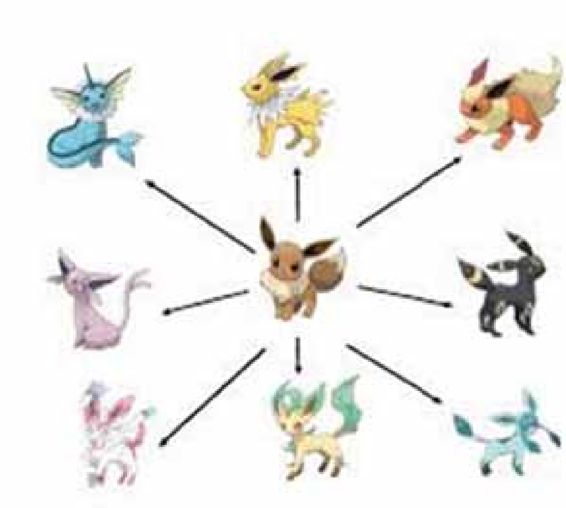

Figure 4. Different evolutions of Eevee. This Pokémon can evolve to many different ones, depending on the conditions: Jolteon, Flareon, Vaporeon, Espeon, Umbreon, Leafeon, Glaceon and Sylveon [8]

Proof has shown that legendary Pokémon do exist. Legendary Pokémon are extremely powerful and valuable species of Pokémon because of the hardness to spot them. Legendary Pokémon would be endemic species, that is to say, species only found in a very concrete region or territory. Its reduced population could be explained by a human factor. Stories and legends about those Pokémon take place in remote times. Perhaps human transformation of the environment has caused a shrinkage of their habitat, taking the species close to extinction. Here lies the fact of their value and extreme difference with other Pokémon, having suffered an isolation of other Pokémon species and having evolved completely apart.

3.4.1. Electric Poké-Cells

As an example of Pokémon cell, electric type will be briefly explained. In order to get electric powers, electric Poké-Cells contain metabolic pathways of synthesis of highly oxidant and reductant compounds. Oxidant substances are stored in specialised organelles, “catochondria”, and reductor in “aniochondria”. Those Pokémon have specific tissues alongside their bodies with huge accumulations of those organelles, that are separated. These creatures have systems that act as saline bridges and also protein tubules that conduct electricity, Pokétubules, that connect both zones and enable the organism to create a very powerful both intern and extern electric current.

3.5. Other considerations

It is widely known that Pokémon trainers make use of MT’s and MMO’s that grant its companions new attacks, abilities, movements and powers. This technology is based on CRISPR-Cas9 capsules that contain the gene for the expression of the new power. Once the Pokémon gets this capsule, the gene is built-in its own genetic material.

4. Conclusion

Thus far, the first International Pokémon Symposium comes to an end. There are yet many secrets to explain, many processes, types and powers to give a biological answer to, which may be discussed and exposed in the future.

This project hopes to approach science to a really beloved fiction with the objective of putting forward biology concepts to draw the attention of those who love both science and want to learn in a ludic way. In this way, there are many steps to follow and different kind of methods that every scientist with the willing to divulge should explore.

5. Acknowledgements

The authors of this paper would like to thank Dr. Josep María Fernàndez Novell for encouraging us to start and carry out this initial project.

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Bioinformatics Tools in the Understanding of Drugs' Function

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Abstract. The use of computers in research has facilitated the management of big amounts of information, minimizing the time used. Moreover, through computer software, the design of the appropriate molecules used for medicines can be chosen more precisely. However, bioinformatics is not used only in the field of pharmacological research; its versatility makes it useful in other areas of science.

This article will analyse two computer softwares used to recreate molecules: Jmol and ChemSketch.

These computer programs represent molecules and give information about them. In order to recreate the molecules we want in these computer programs we have to use a special language called SMILES™. This article will expose the usefulness of these tools in the understanding of the effectiveness and function of different types of drugs.

It is important to emphasise that the programs used in this paper are freely available on the Internet and can be used for educational purposes.

Keywords. Amoxicillin, aspirin, ibuprofen, SMILES™.

1. Introduction

The development of Bioinformatics began in the 1960's. Margaret Dayhoff innovates publishing the Atlas of Protein Sequences, which sets the basis for the development of the field of statistics applied to bioinformatics. 1980's saw the creation of two important databases, GenBank and Swiss-prot.

The research carried in the biochemistry field began to be compiled in those databases as a way of connecting the scientific community, and therefore helping further all investigations in the field.

One of the biggest challenges that bioinformatics helped to solve, due to the massive amount of information contained, was that of the Human Genome Project, whose aim was to analyse the whole sequence of the human genome. This project was launched in 1990 and was finally finished in 2003.

Nowadays the creation of new medicines requires a huge investment of both time and monetary funds, which often stops pharmaceutical companies conducting the necessary research.

The different phases of development are often lengthy, especially due to undesired effects that the active component can produce. One of the main tools that are being used to resolve this issue can be found on the progress made in the Bioinformatics field.

2. SMILES™

In order to create the correct molecule an efficient communication between the scientist and the program is needed. This need for communication was satisfied by the Weininger brothers in the 1980's, through the creation of a simplified chemical code.

Although, as mentioned, this code was heavily simplified, certain rules apply for its use, as explained below.

This code is always written without spaces. Hydrogens can also be omitted, as the program will add them to fill their valence. There are four different types of categories which can be represented in this code: atoms, free radicals, cyclic structures and ionic compounds.

Atoms are represented through their letter in the periodic table. We have to pay attention to the valence of the atom used; as the program will fill with hydrogens all the bonds left. Ions are written between square brackets, and the charge has to be specified, too. The code admits three types of bondings between atoms as follows: single bonds, double and triple bonds represented with the symbols -, = and # respectively. When writing two atoms together the single bond symbol can be omitted.

Radicals are external ramifications of what we can consider the main chain. Everything written between brackets will be understood as one ramification.

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SMILES™	Name	Symbol
C	Methane	CH_4
N	Ammonia	NH_3
[H+]	Hydrogen ion	H^+
C=C	Ethylene	$CH_2=CH_2$
C#N	Hydrogen cyanide	HCN
C1CCCCC1	Cyclohexane	C_6H_{12}
c1ccccc1	Benzene	C_6H_{12}

Table 1. Examples of SMILES™ language

Cyclic structures are represented by an atom followed by a number 1, writing as many atoms as the structure will have, ending it with a number 1. In case of aromatic structures the alternation between single and double bonds are represented in lowercase letters.

One of the greatest assets of this simplified chemical code created by the Weininger brothers is based on its freedom to create and start the molecule from any part of the chemical chain. For that same reason, it is possible to create a molecule with more than one code.

Some examples of the structures mentioned will appear in the Table 1.

3. ChemSketch

The program ChemSketch allows us to recreate in 2D or 3D the chemical structure of a molecule, while gaining information about its chemical properties. It uses the before mentioned language SMILES™. It can be downloaded for free on the Internet, although only an English version is available. It has been developed by ACD Labs.

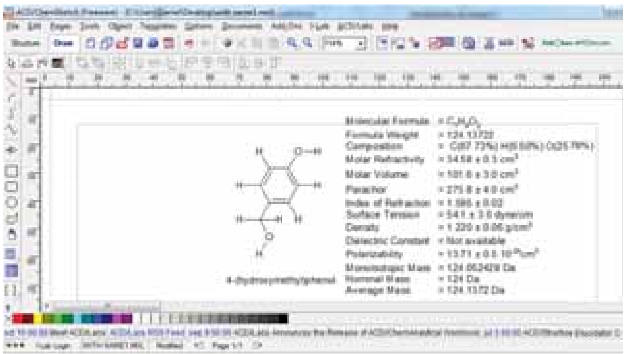

Figure 1. Screenshot of the representation in 2D of 4-(hydroxymeethyl)phenol using ChemSketch

ChemSketch consist of three connected softwares, each one with a different function. One of them allows us to represent the molecule in 2D giving us its properties. The second one shows the molecule on a 3D viewer, allowing us to turn the molecule in all directions. The last thing we can do is to visualize the spectrum of our molecule.

In order to facilitate the reader the use of ChemSketch the download link will be given in the section of references [1].

4. Jmol

Jmol is a program which represents the chemical structures in 3D. It is oriented to educational and research purposes. This software is written in the programming language Java and it is also available for free on the Internet. Other functions are available to download to reproduce more complex experiments.

The link to download Jmol will be given in the section of references [2]. User instructions are also downloaded into the same folder.

5. Use of Jmol and Chemsketch in the understanding of the mechanism of three different drugs

The use of Jmol and ChemSketch can give us a lot of information about current drugs. Using three examples of drugs we will demonstrate the potential of these tools.

Ibuprofen (2-(4-Isobutylphenyl) propionic acid) is a nonsteroidal anti-inflammatory drug commonly used in cases of pain, fever and inflammatory reactions. ChemSketch can show us that our molecule is a-polar, and therefore insoluble in water carried by plasmatic proteins. Its absorption into the system is fast and almost complete. The representation below also is capable of showing that the molecule is so small that it enables the processes of diffusion, facilitating the arrival to the target.

The mechanism of action of ibuprofen is based on an inhibition to the cyclooxygenase enzymes, which convert arachidonic acid to prostaglandin H_2. The absence of prostaglandins diminishes the vascularisation and the flow of fluids to the extracellular medium. That would avoid the inflammatory response.

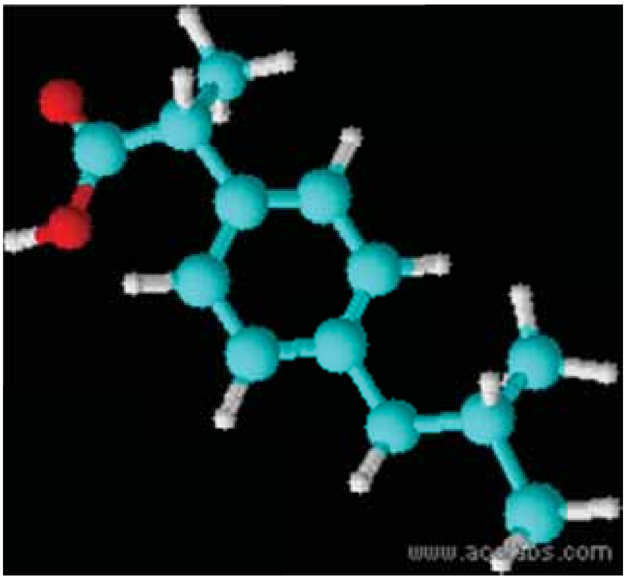

Figure 2. 3D representation of a molecule of ibuprofen using ChemSketch

Another common drug is aspirin, also known as acetylsalicylic acid. It is used as an analgesic. Aspirin acts on two types of cyclooxygenase enzymes, COX-1 and COX-2. COX-1 is irreversibly inhibited by aspirin, and the enzymatic function of COX-2 is modified. That one in normal conditions produce prostanoids which are proinflammatory, but this modification induce the production of lipoxins, which are anti-inflammatory. The chemical modification that produces acetylsalicylic acid is an acetylation in a serine group in the active site of this enzyme and inhibiting it. This acetylation reduces the capability to produce prostaglandins, consequently, the symptoms of pain will disappear.

The representation as seen in Figure 3 below, shows us that the acid group resonates with the cyclic structure, making the molecule a weak acid. Little of it will be ionized, and its absorption will be through the cell membrane of the stomach in acidic conditions. In the left part of the Figure 3 we can see the acetyl group, which interacts with the enzyme inhibiting it.

A different example would be amoxicillin, an antibiotic derived from penicillin. It is a ß-lactam antibiotic. It is easily classified by its ß-lactam ring, which include one atom of nitrogen (represented in blue) and another of sulphur (represented in yellow). At a physiological pH range there are two ionizable groups, the amino group in alpha-position to the amide carbonyl group and the carboxyl group.

Figure 3. 3D representation of a molecule of aspirin using ChemSketch

The target of amoxicillin is the cell wall of bacteria, especially the peptidoglycan layer. Peptidoglycan is a polymer formed of sugars and amino acids. The sugar components consist of alternating residues of ß-(1-4) linked N-acetylglucosamine and N-acetylmuramic. The amino part consists of three to five amino acids attached to N-acetylmuramic acid. Its effectiveness is indeed restricted to Gram-positive bacteria, in which the peptidoglycan layer constitutes an important part of the cell wall contributing to its strength and rigidity.

Amoxicillin inhibits the linkage between the linear chains of peptidoglycan, destabilizing the cell wall and producing the death of the bacteria. In fact, amoxicillin inactivates penicillin-binding proteins (PBP's) located in the inner membrane of the bacterial cell wall. That inactivation interferes in the stability of the cross linkage of peptidoglycan chains. Weakening the bacterial cell wall the bacteria will end in lysis.

As described above, the functions of the drugs explained are tightly linked by its structure. Ibuprofen is designed to be binded to the cyclooxygenase enzymes, leaving no place to arachidonic acid to bind to it. The representation of Aspirin makes possible to see the group acetyl of its molecule, which produces an acetylation and therefore an inhibition of the cyclooxygenase enzymes. Also, it is possible to see clearly the case of amoxicillin's active component, the ß-lactam ring. All this information can be acquired by the programs Jmol and ChemSketch, as they connect their physical structure to their function.

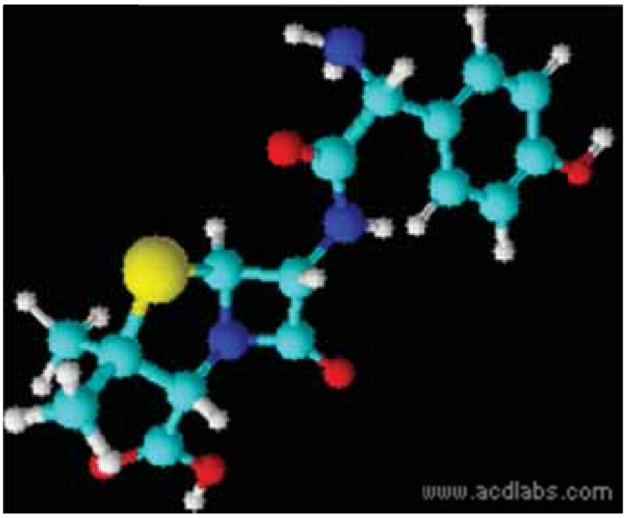

Figure 4. 3D representation of a molecule of amoxicillin using ChemSketch

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Citizen Science in School

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Abstract. One of the main problems facing European society is the decline of students who choose scientific or technological careers after finishing high school. Encouraging interest in science is essential to approach the current problem of shortage of scientific vocations. This paper describes a citizen science experience accomplished in a school located in the center of a city in the North of Spain. 42 Secondary students completed a questionnaire based on a previous study by RecerCaixa. The results show a significant positive change in the student's perception of science and scientists. In addition, students highly appreciated their participation in the activity.

Keywords. Citizen science, scientific vocations, secondary education, student perception.

1. Introduction

In recent years, a lack of experience or skills in young people is being observed. In fact, four out of ten employers in the European Union say they have difficulties in finding skilled workers with the skills required for a vacancy. The lack of skills in the scientific field is often mentioned in the European economic sphere. But, in addition to the lack of technical, practical or specific skills for a job, there is also a shortage of so-called soft skills, such as the ability to plan, organize, solve problems and work as a team. It is pointed out that some of the reasons for this problem are the inflexibility of the educational systems and the tendency to educate tomorrow's young people with the skills required by yesterday's industry [1-2]. Another major problem facing European society is the decline of the number of students who choose scientific or technological careers after finishing high school [3]. But this crisis, as shown in the literature [4-5], is also being perceived in secondary education, where many students do not choose scientific disciplines. Also, as indicated by Ribas [6], girls show less interest in science than their male classmates. The main factor of this cause is school science curriculum, which he connects with the question Who decides what is relevant in school science? In that question he directly points to universities, according to which the teaching of sciences in secondary school must have the purpose of instructing students in scientific concepts that are necessary for higher education. For these reasons, it is necessary a transformation that implies the democratization of sciences, a vital task for students in order to make them understand how and why science is relevant to our lives [7]. As a result, new approaches to teaching have emerged, such as STEM (Science, Technology, Engineering and Mathematics), STS (Science, Technology and Society) and new methodologies, such as PBL (Problem/Projects Based Learning), IBL (Inquiry Based Learning), etc. designed to prepare students in the development of these skills and abilities needed in the 21st century. Within this framework, Citizen Science is born as a form of democratic participation in science, in which citizens are an active part of a scientific project. In this way, Citizen Science acts as a link between scientific education and democratic participation, in addition to originating the acquisition of new knowledge and scientific skills. It also encourages a change of attitude towards science in which we can all participate and contribute to the resolution of a common problem. And, as if that were not enough, Citizen Science projects allow a participation in the training of agents of non-formal education [8], as well as a development of many scientific skills (Figure 1).

Figure 1. Some of the scientific skills developed in non-formal education [8]

1.1. Contributions of Citizen Science

The most direct impact of Citizen Science is the increase in scientific knowledge experienced by participating members. Engaging in these projects gives citizens the opportunity to ask and respond to certain questions that arise from the curiosity of their daily experiences, as well as describe, predict and explain various natural phenomena [9]. In a study [10] an increase in knowledge about ecology was perceived simply through the observations required by the project. For instance, the participants of a bird-breeding observation project improved their knowledge about poultry and local ecology.

However, two factors are presented as the most influential when developing scientific knowledge in a Citizen Science project, which are: the motivation and interest of the participants and the level of interaction between professional researchers and citizens [11]. In the communications between researchers and citizens a sign of interest on the part of the participants was seen in relation to aspects of the scientific method, own observations and conclusions and other questions that arose without being the main objective of the study. Within the interactions, those that were made face to face were the most valued by the participants. Finally, one of the repercussions perceived by the people involved after participating in a Citizen Science project, was a change in their attitude [10-12]. Although, it has been seen that attitude changes do not occur significantly if a certain level of knowledge about the subject is not acquired. The most common reaction among participants is to talk about the object of study with people around them, showing some concern or sharing their experience. These conversations reinforce the participant's learning and expand the impact of the project to the rest of the community.

1.2. Citizen Science in the school: AQUA Project

There are many benefits of Citizen Science, already mentioned above, but there are other positive aspects that directly affect students who are involved in a project of this kind. The repercussions of using Citizen Science in the classroom that are presented in the literature [9,13-15] are mentioned below in the following paragraphs.

The participation of students in real scientific studies fosters interest in science and develops scientific knowledge. In these experiences, students are using the scientific method and working with science as a way of understanding the world around them. In addition, interaction with professional scientists encourages them to consider scientific careers as a possibility for the future, which otherwise would not have been considered.

No less important than generating new scientific knowledge, students are developing new scientific skills. Through collaboration with researchers, they learn how to plan a data collection, how to collect it and how to interpret it in a way that gives us relevant information about the environment and/or our daily life.

Direct contact with scientists and being involved in an investigation results in a transformative experience that helps them to modify false preconceptions. For example, the term biodiversity not only refers to wild animals in faraway places, but also to those which are in the school garden.

On the other hand, direct exposure to the environment around us, especially during childhood, helps us to improve skills such as creativity and problem solving, as well as involving emotional and intellectual development. Adolescents who have been involved in a Citizen Science project present a greater understanding of scientific concepts, improve cooperation, the ability to resolve conflicts, self-esteem and behavior in the classroom.

Citizen Science is a tool that allows students to experience for themselves damages and disturbances in their localities and understand how it affects the environment and biodiversity. In this way, they come to understand global problems and develop a critical thinking based on.

2. Aim and methodology: description of the AQUA project

The aim of this research was to elaborate a study based on the change in student’s opinion after their participation in a Citizen Science project carried out in their educational center.

AQUA is a Citizen Science project of the Ibercivis Foundation, funded by the FECYT (Spanish Foundation for Science and Technology) of the Spanish Ministry of Economy, Industry and Competitiveness [16]. The aim of the project is to study the quality of the water of our homes, for which it has had the collaboration of thousands of students from all over the country. The results of their

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measurements are shown in an online map of free access for the entire population (Figure 2).

Figure 2. Map of Spain where the AQUA project data are geolocated [16]

In particular, the parameters analyzed were the chlorine content, pH, taste and smell of the water. To make the measurements of these parameters, each student has received an experimental kit (Figure 3), and an explanation of the procedure that they should follow to analyze the water in their homes. In addition, the students had to determine the value of the water parameters and upload them to the project website.

Figure 3. The kit provided to students allows to analyze drinking water

So, directly, students apply the scientific method using different biochemical tools (Figure 4); and also record a video and take photographs of the process acquiring the habit of documenting their research experiences.

Figure 4. Students learn science by playing the role of scientists

In addition to the specified purpose, with the participation in this project other concepts are implied such as the main pollutants that deteriorate the water quality and the purification process prior to the water reaching our homes. On the other hand, this project allows the diffusion of the clean drinking water problem. Pollution is the reason why this problem has being experienced year after year and this project emphasized that only a minimum part of the whole amount of water on our planet can be used for that purpose.

3. Evaluation

In order to assess the repercussions derived from the participation of students in a Citizen Science project, a survey has been prepared. It is based on a previous study with the same purpose which was implemented in Catalonia [17].

The aspects analyzed in the survey were: a) the previous ideas of the students about science, b) the perception about science, scientists and a scientific project, c) the competences that the student believes he has acquired after participating in the project, and d) the overall assessment of the experience. 42 students (22 girls and 20 boys) from a school in Burgos aged between 14 and 16 years, who are studying 3rd or 4th of ESO, have been surveyed. A quantitative methodology was used by test questions or specific answer (yes or no), and also a qualitative methodology with open questions that allow students to provide more personal information and ideas.

Analysis of the results reveals that students show a great change in their perception about science and scientists, they believe they have improved their scientific skills, and they all appreciated the experience saying that they would like to participate in more projects of Science. We should note that the beliefs of the student regarding their confidence and precision are the major precursor of learning [18].

4. Conclusions

Citizen Science offers a new approach of collective participation in science with very positive repercussions in different areas [19-20]. In addition, it offers the population the opportunity to learn more about science and thus achieve a better understanding of the world around us. That is, Citizen Science is a kind of non-formal education open to all society.

Citizen Science allows the development of skills and abilities necessary and required in the 21st century, both scientific or technical skills (*hard skills*) and others related to planning, problem solving, teamwork, etc. (*soft skills*). In the literature it is exposed [2] that it is important to work these at an early age, since it is easier to acquire them when you still have a more open mind to new ideas, than when you have already acquired certain patterns and habits. At an educational level, the Citizen Science addresses the proposals indicated by UNESCO on education for the 21st century, which structures four basic learnings: learning to know, learning to do, learning to live together and learning to be [21].

At school, Citizen Science is an innovative science learning tool, presented to students as a social activity. It is necessary that society is involved in science and that science is open to society. Statistics show that, in general, citizens feel little informed about scientific issues. Specifically, Spain ranks 20th out of the 32 European countries analyzed in relation to this issue [22].

The results obtained from the study in the educational center agree with those presented in the literature [9,13-15] implying a knowledge development, improvement of the scientific capacities and a change in the perception on the science of the students. In addition, one of the impacts caused by the fact of participating in a real scientific study in the classroom is the promotion of interest in science [13]. This interest is fundamental to address the current problem of scarcity of scientific vocations [3-4].

5. Acknowledgements

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Diabetes and Metabolic Role of the Adrenaline

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Abstract. Patients with diabetes need an intensive insulin treatment, which usually involves complications and presents a high risk of hypoglycemia, which causes a risk in the patients' lives. From this, a mechanism is initiated that consists in the rapid release of adrenaline and noradrenaline, which is followed by other later processes.

Adrenaline is a hormone with notorious activities in the cardiovascular system and is also known to mediate the response of physical and psychological stress (fight-or-flight response). However, more and more, it is being given the necessary recognition regarding the action that it carries out in the metabolism of glucose due to its action in the greater secretion of glucagon and an inhibition of insulin by pancreatic cells. For this reason, it is believed that adrenaline plays an important role in the regulation of type 1 diabetes mellitus.

Keywords. Adrenaline, insulin, type 1 diabetes mellitus, glucagon, hypoglycemia.

1. Diabetes Mellitus

It has been clearly established in recent years that diabetes mellitus is a genetically and clinically heterogeneous group of metabolic diseases characterized by hyperglycemia resulting from defects in insulin secretion, insulin action, or both. The evidence in favour of this heterogeneity is overwhelming: there are more than 30 distinct, mostly rare, disorders in which glucose intolerance is a feature.

The chronic hyperglycemia of diabetes is associated with long-term damage, dysfunction, and failure of different organs, especially the eyes, kidneys, nerves, heart, and blood vessels. Several pathogenic processes are involved in the development of diabetes.

These range from autoimmune destruction of the b-cells of the pancreas with consequent insulin deficiency to abnormalities that result in resistance to insulin action. The basis of the abnormalities in carbohydrate, fat, and protein metabolism in diabetes is deficient action of insulin on target tissues. Deficient insulin action results from inadequate insulin secretion and/or diminished tissue responses to insulin at one or more points in the complex pathways of hormone action.

Impairment of insulin secretion and defects in insulin action frequently coexist in the same patient, and it is often unclear which abnormality, if either alone, is the primary cause of the hyperglycemia.

1.1. Type 1

The first subclass of diabetes, type I or insulin-dependent diabetes mellitus (IDDM), is usually characterized clinically by abrupt onset of symptoms, insulinopenia and dependence on injected insulin to sustain life, and proneness to ketosis.

This form of diabetes, which accounts for only 5–10% of those with diabetes, results from a cellular-mediated autoimmune destruction of the b-cells of the pancreas. Markers of the immune destruction of the b-cell include islet cell autoantibodies, autoantibodies to insulin, autoantibodies to GAD, and autoantibodies to the tyrosine phosphatases IA-2 and IA-2b. One and usually more of these autoantibodies are present in 85–90% of individuals when fasting hyperglycemia is initially detected.

In this form of diabetes, the rate of b-cell destruction is quite variable, being rapid in some individuals (mainly infants and children) and slow in others (mainly adults). Some patients, particularly children and adolescents, may present with ketoacidosis as the first manifestation of the disease. Others have modest fasting hyperglycemia that can rapidly change to severe hyperglycemia and/or ketoacidosis in the presence of infection or other stress. Still others, particularly adults, may retain residual b-cell function sufficient to prevent ketoacidosis for many years; such individuals eventually become dependent on insulin for survival and are at risk for ketoacidosis. At this latter stage of the disease, there is little or no insulin secretion, as manifested by low or undetectable levels of plasma C-peptide. Immune-mediated diabetes commonly occurs in childhood and adolescence, but it can occur at any age.

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Autoimmune destruction of b-cells has multiple genetic predispositions and is also related to environmental factors that are still poorly defined. Although patients are rarely obese when they present with this type of diabetes, the presence of obesity is not incompatible with the diagnosis. These patients are also prone to other autoimmune disorders.

1.2. Type 2

The second subclass of diabetes, type II or noninsulin-dependent diabetes mellitus (NIDDM), frequently presents with minimal or no symptoms referable to the metabolic aberrations of diabetes. This form of diabetes, which accounts for; 90–95% of those with diabetes, previously referred to as noninsulin-dependent diabetes, type 2 diabetes, or adult-onset diabetes, encompasses individuals who have insulin resistance and usually have relative (rather than absolute) insulin deficiency At least initially, and often throughout their lifetime, these individuals do not need insulin treatment to survive. There are probably many different causes of this form of diabetes. Although the specific etiologies are not known, autoimmune destruction of b-cells does not occur, and patients do not have any of the other causes of diabetes listed above or below.

Most patients with this form of diabetes are obese, and obesity itself causes some degree of insulin resistance. Patients who are not obese by traditional weight criteria may have an increased percentage of body fat distributed predominantly in the abdominal region. Ketoacidosis seldom occurs spontaneously in this type of diabetes; when seen, it usually arises in association with the stress of another illness such as infection. This form of diabetes frequently goes undiagnosed for many years because the hyperglycemia develops gradually and at earlier stages is often not severe enough for the patient to notice any of the classic symptoms of diabetes. Nevertheless, such patients are at increased risk of developing macrovascular and microvascular complications. Whereas patients with this form of diabetes may have insulin levels that appear normal or elevated, the higher blood glucose levels in these diabetic patients would be expected to result in even higher insulin values had their b-cell function been normal. Thus, insulin secretion is defective in these patients and insufficient to compensate for insulin resistance. Insulin resistance may improve with weight reduction and/or pharmacological treatment of hyperglycemia but is seldom restored to normal. The risk of developing this form of diabetes increases with age, obesity, and lack of physical activity. It is often associated with a strong genetic predisposition, more so than is the autoimmune form of type 1 diabetes. However, the genetics of this form of diabetes are complex and not fully defined.

2. Hypoglycemia in diabetes mellitus

Hypoglycemia is the most frequent acute complication of the treatment of diabetes mellitus. More than 35% of patients with type 1 diabetes mellitus experience, during the course of the disease, at least one episode of severe hypoglycemia that requires attention by another person. The results of the Diabetes Control and Complications Trial have shown that intensive treatment with insulin increases 3.3 times the risk of severe hypoglycemia compared to conventional treatment, and that more than 50% of episodes of hypoglycemia occur during the night. Therefore, the risk of hypoglycemia is, nowadays, the limiting factor in the achievement of strict glycemic control. Some causes are related to an absolute or relative excess of insulin that includes the dose, the type of insulin and the time of administration, time of meals and supplements, physical exercise, alcohol intake and renal function. Other risk factors for hypoglycemia they are related to inadequate counter-regulation mechanisms that include previous history of severe hypoglycemia or asymptomatic hypoglycemia, intensive insulin therapy, recent hypoglycemia and established autonomic neuropathy.

The emergency measures to combat hypoglycemia, such as the appearance of a series of warning symptoms that encourage ingestion of food and the secretion of different hormones aimed at increasing blood glucose concentrations through different mechanisms. All these measures are necessary since the brain necessarily needs a continuous supply of glucose as an energy substrate. These defence mechanisms when blood glucose levels drop, may be altered in patients with diabetes mellitus type 1 and, therefore, hypoglycemia can become a serious risk to their lives.

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2.1. Counter-regulatory response to hypoglycemia

In a situation of decreased blood glucose concentration, a series of events tend to normalize blood glucose. After a first fundamental response consisting of intravenous administration of insulin and glucose, a second response is produced, which consists in the secretion of the glucagon by the alpha cells of the pancreatic islet. The mechanism of glucagon secretion in the face of hypoglycemia seems to be multiple. In an overlapping manner to the secretion of glucagon before the drop-in blood glucose there is an increase in the secretion of adrenaline.

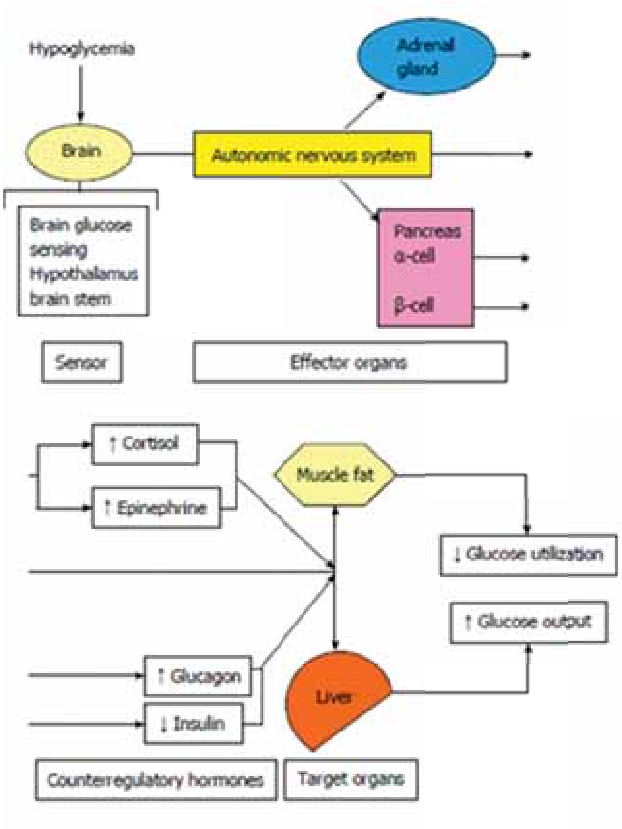

Figure 1. Counter-regulatory response to hypoglycemia

After the stimulation of the sympathetic and parasympathetic autonomic system, symptoms of adrenergic response appear, such as palpitations, nervousness and tremors. All of these hormonal secretion responses happens quickly and get normalize blood glucose levels in 10-20 minutes. The cortical functions of the central nervous system are not affected until the glycemia values reach 50mg/dL, causing neuroglycopenic symptoms and a neuroglucoprivation that results in difficulty in concentration and blurred vision.

3. Adrenaline

Adrenaline, also known as epinephrine, is a hormone and a neurotransmitter, which is classified within the group of catecholamines, which it shares with noradrenaline and dopamine. The molecules that belong to this group are characterized by being neurotransmitters that are poured into the bloodstream, be synthesized from the amino acid tyrosine, and contain the catechol and amino groups. Adrenaline is best known to pharmacologists as a substance that has profound effects on the cardiovascular system. In general, the effects of exogenously administered adrenaline on the cardiovascular system are similar to that of sympathetic nerve stimulation. Intravenous injections of adrenaline rapidly produce a powerful vasopressor effect as a result of profound vasoconstriction, an increase in the rate and force of contraction of the heart, increased myocardial cell automaticity, bronchodilatation, increased respiratory rate and redistribution of blood towards the brain, heart and skeletal muscle and away from skin, kidneys and gut.

3.1. Biosynthesis

Adrenaline is synthesized in the adrenal glands, specifically, in the adrenal marrow of these glands. They are produced thanks to cells called chromaffin or adrenal marrow cells. Adrenaline is synthesized by an enzymatic route that converts the amino acid tyrosine into a series of intermediates and, finally, into adrenaline.

In order for it to form, tyrosine is hydroxylated by a hormone called tyrosine hydroxylase, obtaining L-DOPA. Then DOPA goes through a decarboxylation process through the DOPA decarboxylase enzyme and dopamine is produced. From dopamine beta-hydroxylase, noradrenaline is obtained. Adrenaline arises when the primary distal amine of norepinephrine is fed by the action of the phenyletanolamine N-methyltransferase (PNMT) enzyme, by S-adenosylmethionine, a cofactor to give the methyl group to norepinephrine, adrenaline. and thus, creating adrenaline. When released into the circulation from the adrenal medulla, adrenaline and noradrenaline are O-methylated by catecholamine methyltransferase (COMT) to produce metanephrine and normetanephrine, which are then deaminated by MAO to form 3-methoxy-4-hydroxy-mandelic acid.

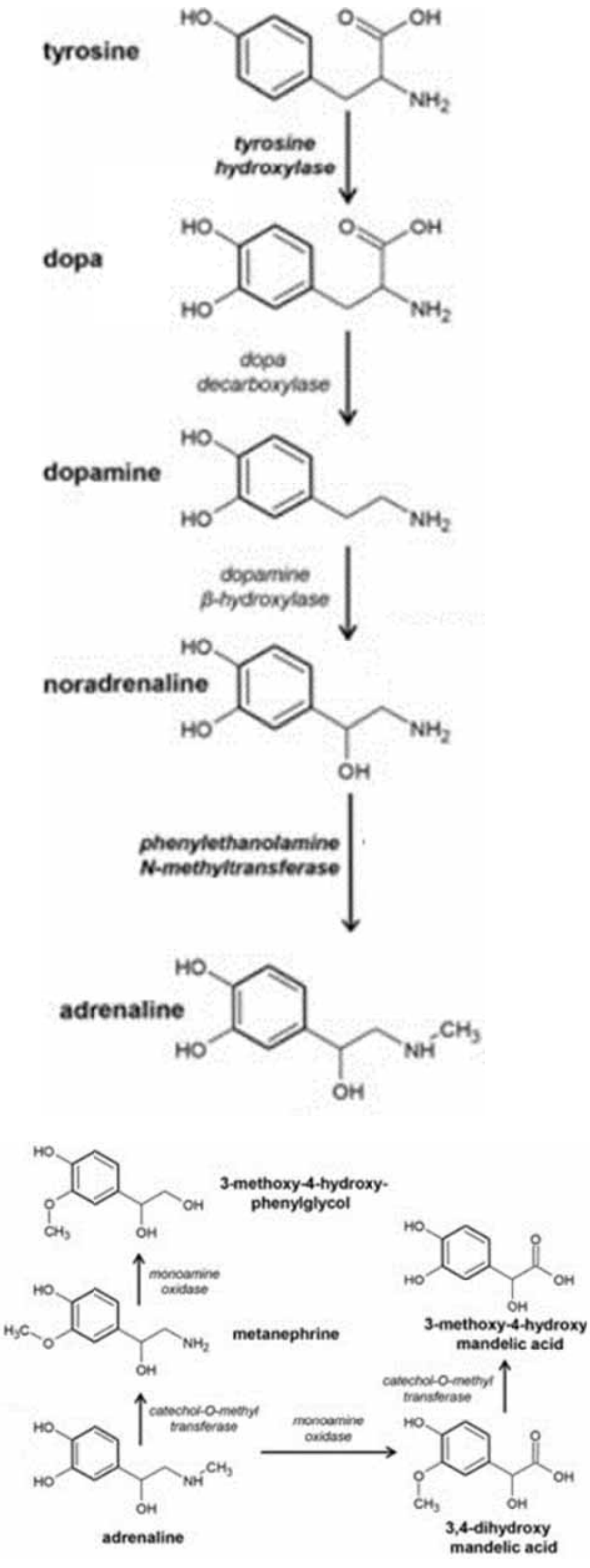

Figure 2. Biosynthesis of adrenaline

3.2. Activity of adrenaline in the metabolism of the glucose

Adrenaline has some very important metabolic actions that have the consequence of the increase in glycemia and free fatty acids. The increase in glycemia is caused by a conjunction of direct and indirect effects that lead to an increase in the production of glucose and a decrease in peripheral use caused by the union with the adrenergic beta receptors that causes the secretion of glucagon in the pancreas.

The indirect effect of catecholamines on the metabolism of carbohydrates through the inhibition of insulin secretion seems to be quantitatively the most important effect. This action is mediated by adrenergic alpha 2 receptors of the b cells of the pancreas.

4. Effects of glucagon and insulin

The alpha and beta cells of the Langerhans islets from the pancreas secretase glucagon and insulin. Insulin is a hormone of protein origin that performs various effects on the transport of metabolites.

At the muscular and adipose level this hormone increases the permeability of the membrane to facilitate the entry of glucose, amino acids, nucleotides and phosphate to the cells, although the liver and nerve tissue are permeable to the ingestion of glucose; and during the physical activity, the presence of insulin is not necessary to allow the entry of the nutrients through the membrane in the tissues. At the carbohydrate level, insulin increases the glucose transport in the cellular interior causing a decrease in blood glucose values, promotes glycogenesis (glucose storage as glycogen).

Glucagon is a complementary hormone in the regulation of blood glucose concentration. At the level of carbohydrates, glucagon promotes glycogenolysis and gluconeogenesis from amino acids to the liver, as these two processes generate an increase in glucose levels available for the body.

When glucose levels increase, there is an inhibition of glucagon secretion and an increase in insulin secretion, while glucose decreases when glucose decreases, and insulin decreases respectively. The mechanism consists in regulating the levels of glucose in the blood, to keep them in balance. A carbohydrate-rich diet will significantly increase blood glucose levels and insulin will have to rise (and decrease glucagon release). On the other hand, low levels of blood glucose (such as those that can be observed if they are long-lasting sports) will force the liver to release glucagon (to increase blood glucose levels).

5. Neuroglucoprivation and adrenaline secretion

The brain has a continuous glucose consumption of more than 50% of body consumption. Circulating glucose crosses the blood-brain barrier through the capillaries by diffusion facilitated by membrane glucotransporters. In diabetic subjects suffering repeated episodes of hypoglycemia, it has been observed that the catecholamine secretory response threshold, such as adrenaline, drops significantly. In studies carried out in this type of patients, it has been proven that during the hypoglycemia episodes the brain maintains a normal blood flow, while the glucose uptake increases. Although this adaptive mechanism of the brain to tolerate hypoglycemia is beneficial to preserve cognitive functions, it is detrimental to the diabetic patient, since it introduces him into a vicious circle of hypoglycemia unawareness, in which symptoms of hypoglycemia are no longer perceived.

In both liver and skeletal muscle, glycogenolysis occurs as a result of β1-adrenoceptor-mediated activation of glycogen phosphorylase. In type 1 diabetes and advanced type 2 diabetes, adrenaline is of primary importance for the response to hypoglycemia because the ability to secrete glucagon is lost or impaired (Cryer, 2012). Indeed, the glucagon response to hypoglycemia is lost within 5 years of diagnosis of type 1 diabetes. Depriving the brain of glucose (neuroglucoprivation) activates the glucose counter-regulatory response to restore normal levels of blood glucose (normoglycemia). In humans, the glucose counter-regulatory response consists of release into the circulation of the rapid-acting hormones: glucagon from the pancreatic α-cells and adrenaline from the adrenal.

Growth hormone and cortisol, referred to as slow-acting hormones, are also released during prolonged hypoglycemia, but their counter-regulatory effects do not become evident for some hours. Glucagon acts exclusively by stimulating glucose production in the liver, whereas adrenaline acts by suppressing endogenous insulin secretion, stimulation of hepatic glucose production, stimulation of lipolysis (β3-adrenoceptor-mediated activation of lipase in adipose tissue) and reduction of glucose utilization.

6. Counter-regulatory response in patients with type 1 diabetes mellitus

At the beginning of the disease, the counter-regulatory responses to hypoglycemia presented by the patient with type 1 diabetes mellitus are superimposable to those of the non-diabetic subject. In the following 5 years a decrease in glucagon secretion was observed in the face of hypoglycemia and, generally, the secretion of this hormone is non-existent after 15 years of illness. Thus, in the patient with type 1 diabetes, an alteration, clearly acquired, develops in the response of glucagon before hypoglycemia. This defect of the alpha cell is specific for hypoglycemia, since the secretion of this hormone in response to arginine it remains normal, and glucagon secretion is elevated in situations of hyperglycemia in these patients. The mechanism of alteration in secretion of glucagon in the face of hypoglycemia in the diabetic patient remains poorly understood. It is considered that the loss of beta cells should play an important role in the disappearance of the local inhibitory tonic effect of insulin. It is also possible that it is due to a dysfunction of the autonomic system, perhaps due to hyperglycemia or, as in some studies has been documented, due to repeated hypoglycemia.

As indicated previously, glucagon secretion is essential to defend against hypoglycemia, so patients with type 1 diabetes mellitus depend on an adequate catecholamine response to this situation. The response of the autonomic nervous system fails in many patients with diabetes mellitus type 1, not only in those who develop the complication of autonomic neuropathy but also in patients who do not perceive the autonomic symptoms of hypoglycemia, mainly after repeated episodes of hypoglycemia. In these patients the glycemia lintel to present symptoms is much lower and, sometimes, they enter directly into a situation of

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neuroglycopenia. The mechanism that produces dysfunction of the autonomic nervous system in the patient with type 1 diabetes mellitus is not yet clear.

Another aspect that must be taken into account is the greater predisposition to hypoglycemia after physical exercise. It is known that physical exercise increases sensitivity to insulin, so patients with diabetes mellitus type 1 should always adjust the insulin dose or increase the carbohydrate intake, not only before and during the exercise, but also when this one has finished. In addition, a history of hypoglycemia may decrease the counterregulatory hormone response that occurs during exercise, as documented in normal subjects. This mechanism could occur in the diabetic patient with a history of hypoglycemia, and physical exercise may increase the risk of subsequent hypoglycemia.

7. Education in diabetes

The results of some meta-analysis support that patient education improves glycemic control in patients with diabetes. There have been large and descriptive analysis with results that have face validity to the statement. Many diabetes educators would agree that interventions that rely on face-to-face interaction enhance communication and are therefore more likely to be successful. Educational models that employ cognitive reframing as a method of teaching are likely to be interventions that include a larger amount of psychosocial interaction and require the patient to become more engaged in the process. Similarly, the inclusion of exercise in the content of an intervention may be important not just because exercise is beneficial but potentially this is a marker for more sophisticated interventions

In these studies, the time to the post-intervention value (from 3 to 15 months) and the type of diabetes were included as covariates in the regression model and the results, reported above, remained the same. The correlation between the post-intervention glycated hemoglobin (HbA1c) change from baseline in the intervention group and the post-intervention HbA1c change from baseline in the associated control group was 0.77. This high positive correlation may indicate that factors within the milieu of the study may have favourably affected both intervention and control groups. The meta-regression was repeated with the post-intervention HbA1c change from baseline in the associated control group as a covariate. Interventions that were performed face-to-face or which included exercise as a part of the content remained associated with a larger decrease in the post-intervention HbA1c whereas cognitive reframing teaching method was no longer statistically significant.

This analysis supports the benefit of educational interventions in diabetes and suggests specific domains that may predict increased likelihood of success. Moreover, these studies highlight opportunities to investigate specific attributes of educational interventions that may better impact glycemic control in patients with diabetes. Coordinated efforts of interventions, using specific delivery techniques, teaching methods, and content, given at a specific dose will better quantify the impact of educational interventions in a chronic disease where self-management is critical.

8. Conclusion

Although the use of adrenaline has been focussed on the substantial circulatory effects and on the role of adrenaline in the fight-or-flight response, recent evidence summarized here suggests that endogenous adrenaline is, in fact, primarily a metabolic hormone, which is of critical importance in the glucose counter-regulatory response evoked by hypoglycaemia. In fact, adrenaline is now acknowledged as the primary counter-regulatory hormone in people with type 1 diabetes.

Apparently, if adrenaline has a role in the metabolism of carbohydrates increasing the synthesis of glucagon and inhibiting the synthesis of insulin, causing an increase in blood glucose, and type 1 diabetes mellitus has a deficit of the hormone insulin that causes high levels of glucose to the blood vessels that have to be regulated; it is deduced that adrenaline has a negative effect on diabetic people and that they may be more sensitive to situations of physical and psychological stress, or in situations of an aggressor stimulus, which are situations where this hormone has a greater secretion.

However, due to the frequent and repetitive cases in which people with diabetes suffer from hypoglycemia, their adrenaline responses in the first years of insulin treatment are normal, however repeated bouts of hypoglycaemia can lead to hypoglycaemia unawareness. Hypoglycaemia unawareness is characterized by marked loss of the sympathetic responses mediating adrenaline secretion and, if left unchecked, can lead to coma or even death. Understanding how hypoglycaemia activates central neurons to cause adrenaline release from chromaffin cells will be important for identifying new therapeutic targets to combat this potentially life-threatening condition.

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Generating 3D Printable Models of Organic Compounds Using SMILES™

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Abstract. Although the three-dimensional structure is a key determining factor for most of organic compounds properties, nothing but flat representations of those compounds on a blackboard are available for high school students.

Today, technology enables an epic change in that situation. We can now easily generate 3D models of any organic compound to be seen, manipulated on a screen and even printed with a 3D-printer.

First, we must be able to properly communicate with the computer in order to "tell" the machine which is the molecule that we want to model. This communication is easily achieved using a de facto standard language for chemical structures named SMILES™ (Simplified Molecular Input Line Entry System).

SMILES™ is a simplified chemical language which provides easy communication between people and computers.

Once we have coded the molecule using SMILES™ language, we can use dozens of online services for extended functionality, such as getting chemical information, rendering 3D dynamic model on any screen and obtaining a file written in one of the 3D-printing standard formats.

In this talk, we are going to fully reproduce the sequence of actions required to get an on-screen 3D dynamic model and a 3D printable model of any given organic compound.

With this idea on mind, you can easily scale the sequence to your own needs; thus you can teach students to write SMILES™ code, or you can use easily available SMILES™ code of many organic compounds; you may 3D print your models, you can also create collections of compounds models, and so on.

This sequence has been successfully tested with high school students at Sant Gabriel School in Viladecans, near Barcelona, Spain.

Keywords. 3D model, 3D printing, classroom experience, organic compounds, scalability, SMILES.

1. Why 3D modelling?

First of all, we must consider that modelling the reality forces us to do some simplifications, so the question is: how close to the original must be a model to become a good representation of this reality?

Of course, it's impossible to generate a "perfect" model. The only one model that fits exactly the reality is the reality itself.

Then, when we model an organic compound we must try to build a model as similar to the reality as possible. Molecules are 3D objects, so flat representations do not provide good models of them. However, there is a reason for not using 3D models of organic compounds in our classrooms: the technical difficulty related with building these models.

Although there are certain properties of organic compounds that depend on their 3D structure, the complexity required to build such models has prevented Chemistry and Biology teachers from using them in the classroom.

In this talk we are going to provide the technological tools that will allow everyone (students and teachers) to easily generate 3D models of any organic compound, to view and manipulate on the screen and also to build printable ones.

In the following section we'll review some examples supporting the benefits of working with 3D models in addition to classical flat representations of some interesting compounds.

1.1. Benzene vs. cyclohexane

By only using flat representations of these two compounds (Figure 1), probably our students would be tricked into thinking that these two compounds are really similar one to another.

In most cases, after viewing the following figures they are going to describe both molecules simply as "hexagons".

Then, if we want to go deeper, we need to use 3D models (Figure 2) to properly highlight the structural difference between benzene (a real flat molecule) and cyclohexane (a non-flat molecule).

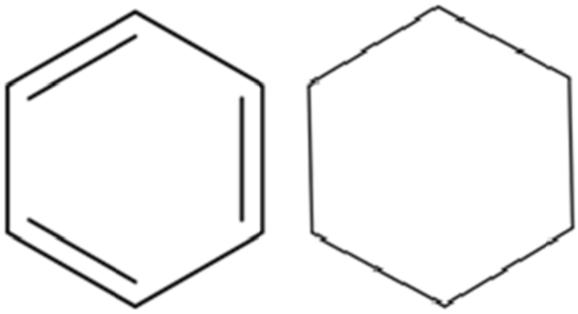

Figure 1. Flat models of benzene (left) and cyclohexane (right) generated from SMILES™ code at molview.org

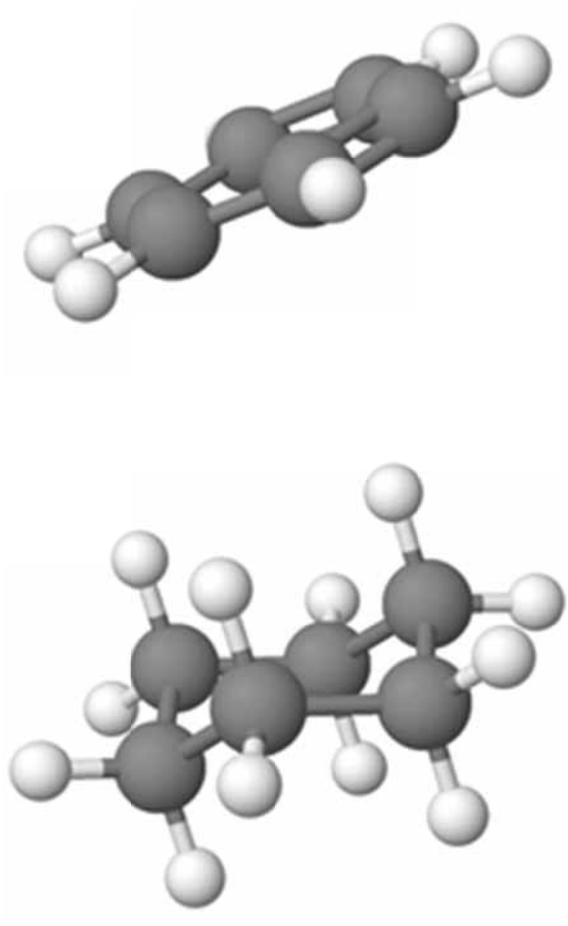

Figure 2. 3D models of benzene (top) and cyclohexane (bottom) generated from SMILES™ code at molview.org

1.2. *Trans* vs. *Cis* fatty acids

While monounsaturated fatty acids in their cis- configuration are widely considered as healthy diet components (cis-oleic acid is the canonical example), many evidences prove the relationship between trans- fatty acids and a large set of cardiovascular diseases.

It seems much easier to understand such different behaviour by using 3D models of both kind of fatty acids (Figure 4) instead of simply using flat models (Figure 3).

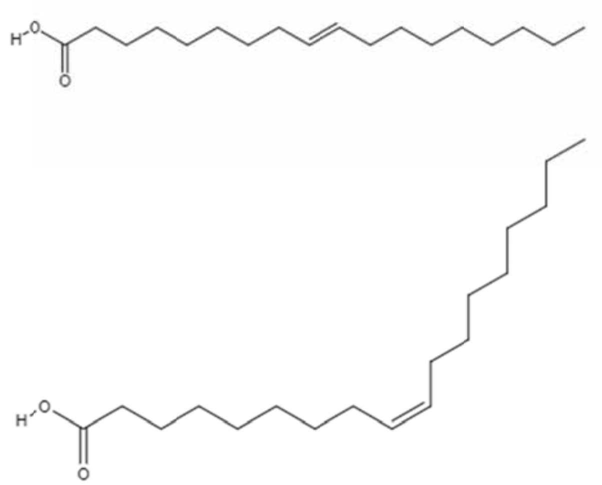

Figure 3. Flat models of trans-elaidic acid (top) and cis-oleic acid (bottom) generated from SMILES™ code at molview.org

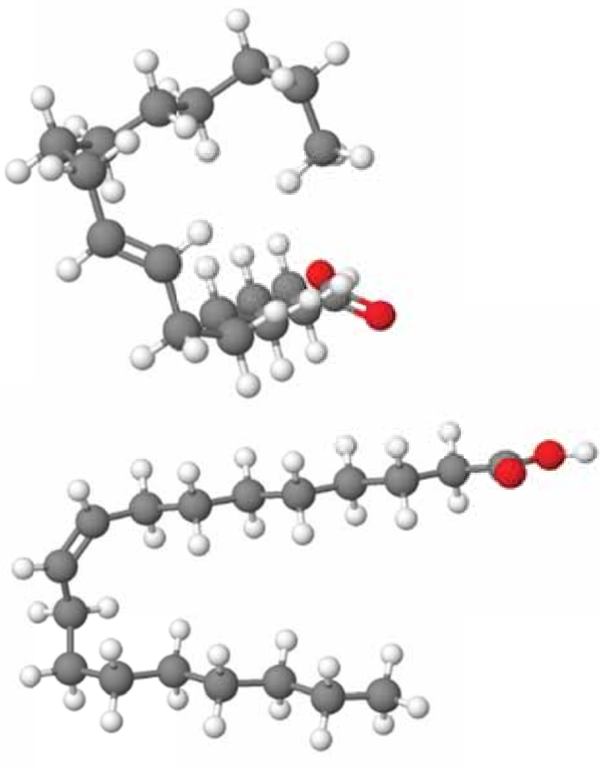

Figure 4. 3D models of trans-elaidic acid (top) and cis-oleic acid (bottom) generated from SMILES™ code at molview.org

2. How difficult is to code an organic molecule with SMILES™ language?

Easy, in fact coding an organic compound with SMILES™ is very easy. Let's see the main rules of SMILES™ coding [1]:

1) Atoms are represented by their atomic symbols.
2) We do not need to write hydrogens if the number of them attached to any atom conforms to the lowest normal valence consistent to explicit bonds.
3) Lower case letters specify atoms in aromatic rings.
4) Single, double, triple, and aromatic bonds are represented by the symbols -, =, #, and :, respectively. Adjacent atoms are assumed to be connected to each other by a single or aromatic bond (single and aromatic bonds may always be omitted).
5) Branches are specified by enclosing them in parentheses.
6) Cyclic structures are represented by breaking one bond in each ring. The bonds are numbered in no particular order, designating ring opening (or ring closure) bonds by a digit immediately following the atomic symbol at each ring closure.

With this simple set of rules, you can code most of the organic compounds; almost all the examples in this paper (Table 1). For more complex use cases, you can check the complete tutorial at the website of SMILES™ language developers.

Table 1. SMILES™ codes of the example compounds used in this paper

Compound	SMILES™ Code
benzene	c1ccccc1
cyclohexane	C1CCCCC1
transelaidic acid	CCCCCCCC/C=C/CCCCCCCC(=O)O
cisoleic acid	CCCCCCCC/C=C\CCCCCCCC(=O)O

3. Getting an 3D on screen model

Once you have coded your molecule using SMILES™, you need a computing engine capable of parsing this code and generate your 3D model. As of today, there are dozens of free online services that can do this work for you. All the 2D and 3D models that you can see in this paper have been generated using molview.org [2].

Then, you can create, for example, collections of models [3], and access to specific information of any compound using the SMILES™ code for querying databases, and so on.

4. Next step: getting a 3D printable model

Today we are witnessing the raising of a new technology: 3D printers are reducing dramatically their prize and overcoming their initial limitations, such as the long time needed to produce a single piece. It seems easy to predict that in a few years most of high schools will have a 3D printer. In this context, Chemistry and Biology teachers will welcome ideas taking advantage of this new resource. Physically putting the models into the hands of our students increases their understanding of the structures they can manipulate.

The sequence of actions you must do to get your model on your hands is very easy [4]:

1) Choose an organic compound
2) Code your compound using SMILES™
3) Transform your SMILES™ code into a specific chemistry language (.mol) file using an online service [5].
4) Get a 3D printable file (.stl) using another online service [6]
5) Print your model with your 3D printer.

5. Acknowledgements

I want to acknowledge first Dr. Ángel Herráez, at the Universidad de Alcalá de Henares, who first introduced me into the world of SMILES™ language.

Second, my colleague Angel Lucas, at Col·legi Sant Gabriel de Viladecans who shared with me our first steps using SMILES™.

Finally, Dr. Josep Maria Fernández Novell, at the Universitat de Barcelona, who encouraged me to develop these materials in the context of the “Crazy about biochemistry” [4], an excellence program addressed to high school students and funded by the Catalunya la Pedrera Foundation.

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How Are GMOs Made?

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Abstract. GMOs initials stand for the words Genetically Modified Organisms. The scientific community and the U.S. Food and Drug Administration (FDA) define GMOs as animals or plants that have been created through genetic engineering, which is a term used to describe biotechnological methods used by scientists to directly manipulate an organism's genome. Under this definition, GMOs do not include plants or animals made by selective breeding, or animals modified by being given hormone supplements or antibiotics.

This genome alteration does not occur naturally by mating and/or natural recombination, but it is done in order to favour the expression of desired physiological traits or the production of desired biological products. To do this, scientists use the gene transfer technology, which is a sophisticated version of a "cut-and-paste" operation.

Once the desired gene is identified in the native organism's genome it can be cut out, transferred to the target organism, and pasted into its genome. Then, it will grow expressing the introduced feature.

GMOs are usually created in order to enhance species by adding features that create advantage to their producer or their consumer. For example, in GM foods, this means that the product will be able to have a lower price or a greater benefit in terms of durability or nutritional value. It also would improve crop protection, as they would achieve resistance against insects by incorporating the gene for production of a toxin that is safe for human consumption, or they would achieve herbicide tolerance through the incorporation of a gene from a bacteria resistant to some herbicides [1].

1. Making a GMO

To obtain this kind of organisms, there is a procedure that has to be followed. The main steps for it are the following [2]

Keywords. Genetically Modified Organism (GMO), DNA, genetic trait, vector.

2. First step: Identify a desirable new trait

For this, scientists most often look to nature. For example, if a researcher is interested in a trait that would allow a crop to survive in a specific environment, they would look for organisms that are naturally able to survive in that specific environment. An actual example of a trait currently in GMOs that was identified through this kind of example is tolerance to the herbicide Roundup, created by Monsanto, or the Golden Rice, created by Syngenta. This rice is designed with an increased amount of pro-vitamin A, which the human body may turn into vitamin A. With this, the company intended to reduce the nutritional needs of vitamin A in deficient communities.

3. Second step: Isolate the genetic trait of interest

Using comparative analysis, researchers decode the part of an organism's genome that contains this trait of interest. For example, the genomes of plants with the trait are compared to genomes in the same species without the trait, with the goal of identifying genes present only in the former. The genomes of different species with the same trait may also be compared in order to identify a common gene. However, if there's no database of genetic information for comparison, scientists will knock out (purposely delete) parts of the genome of interest until the desired trait is lost, thereby identifying the genes that lead to the trait.

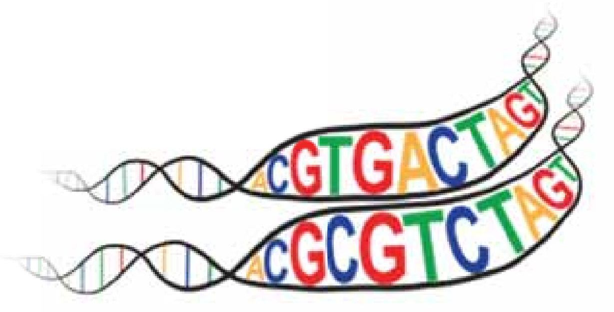

Figure 1. Obtained from [2]

The DNA of interest is cut by restriction enzymes, which always cut specific nucleotide sequences. These restriction enzymes are found in bacteria, which use them to kill viruses, as they attack the viral DNA and break it into useless fragments. Restriction enzymes work by shape-to-shape matching. When it

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comes into contact with a DNA sequence with a shape that matches a part of the enzyme (recognition site), it wraps around the DNA and causes a break in both strands of the DNA molecule. Each restriction enzyme recognizes a different and specific recognition site, or DNA sequence.

If the amount of initial DNA is reduced, the Polymerase Chain Reaction (PCR) is used. This technique causes an exponential growth in the quantity of DNA chains, which contain all the same information, as they are copies.

4. Third step: Insert the desired genetic trait into a new genome

There are different methods for doing this, such as the insertion by non-biological methods or the insertion by a vector.

Regarding non-biological methods, there exist electroporation, microinjection and the gene gun.

Electroporation consists of subjecting cells to a high voltage for a very short period of time. This method occasions temporal holes in these cells membranes, so that the external DNA can enter them.

Microinjection is a technique which consists of the direct injection of DNA into the cell by means of a very small needle (approximately 1'5µ).

The gene gun works by shooting DNA into the plant cells. Hundreds of copies of the gene to be introduced are coated with microscopic gold or tungsten particles. In earlier versions of the gene gun, the DNA coated metal was loaded into a cartridge and then shot into cells, but current versions place this DNA in a vacuum chamber and propel the metal particles with a high pressure gas that is released in a sudden burst.

Vectors are circular DNA molecules that look very similar to pieces of bacterial DNA. Most vectors are based on plasmids, which are small circular sequences of DNA that occur naturally within bacteria. Plasmid vectors can accept a few genes worth of DNA. They consist of several parts:

- Origin of replication (ORI), which is a DNA sequence that allows initiation of replication within a plasmid by recruiting transcriptional machinery proteins, and ensures it gets replicated by the host bacteria.
- Promoter region, which drives the transcription of the target gene. It's a vital component for expression vectors, because ensures that the introduced gene can be expressed (and a protein produced).
- Selectable marker, which is a gene that indicates the success of the introduction of DNA in the cell. They are usually genes encoding resistance to antibiotics such as amicillin, or chromophores [3].
- Multiple cloning site (MCS), also called polylinker, which is a short segment of DNA that contains several restriction sites allowing its insertion.
- Gene you want to introduce.

However, as plasmids don't work for all types of cells, scientists use the *Agrobacterium tumefaciens* for plant cells, as it provokes tumours; and yeasts for animal cells, as they present plasmids that can get into chromosomes.

To introduce foreign DNA into a circular vector, scientists cut the circular DNA sequence of the vector. They use the same restriction enzymes as they used to cut out the gene in the second step to enable the cohesion between segments. This turns the vector into a linear molecule and makes it ready to accept the new piece of DNA.

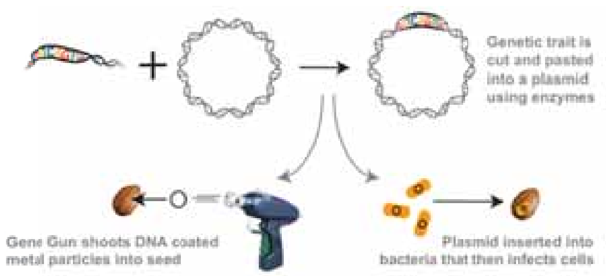

Figure 2. Obtained from [2]

However, as in prokaryotic cells there isn't mRNA maturation, if an eukaryotic gene is wanted to be inserted into a bacteria the DNA segment cannot be inserted with its introns and exons, so there is needed to use an enzyme with a viral origin. This enzyme is called reverse transcriptase because it produces DNA from mature mRNA (molecule in which there aren't introns). Then, DNA must be duplicated so that double-helix DNA is formed, and then introduce it into the vector.

Finally, they stick the vector and the gene together by using a bacterial enzyme named DNA-ligase. It sticks DNA ends together to form a single circular molecule that includes both the vector and the gene.

5. Fourth step: Growing the GMO

After the genetic trait has been successfully inserted into an organism's genome, this must be able to grow and replicate with its new feature, as the vector had an origin of replication and it is copied and passed to daughter cells in the same way as the bacteria's own DNA. First, the genotype of the organisms must be checked so that researchers are only propagating organisms in which the genome was modified correctly. Chromophores [3] and antibiotic resistance genes are used for this purpose.

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Ketone Bodies and Diabetes?

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Abstract. Ketone bodies are three biomolecules: acetoacetate, ß-hydroxy-butyrate and acetone. Which were firstly found in the plasma of diabetic patients in the half of XVIII century.

They are quite small molecules with a molecular weight less than 104. The fact that ketone bodies are water-soluble allow them to freely diffuse across cell membranes being able to cross the Blood-Brain barrier serving as a source of energy.

In Type I diabetes, the hormonal regulation of ketone bodies production by the glucagon/insulin ratio becomes perverted and an overproduction of this metabolites is produced.

Keywords. Ketone bodies, ß-hydroxy-butyrate, acetone, ketolysis, blood-brain barrier, ketogenesis, insulin, glucagon.

1. Introduction

Almost all the human body cells have the ability to catabolize free fatty acids. However, some cells such as: erythrocytes, skeletal muscle fibres type II, renal medulla cells or bone marrow cells cannot use them and while a glucose fasting period ketone bodies are needed as a source of energy.

In Figure 1 Ketone bodies are shown. There are three biomolecules: acetoacetate, ß-hydroxybutyrate and acetone. Which were firstly found in the plasma of diabetic patients in the half of XVIII century. They are quite small molecules with a molecular weight less than 104.

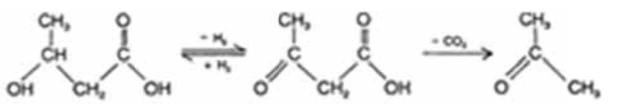

Figure 1. Ketone bodies and their inter-relations [2]

The fact that ketone bodies are water-soluble allow them to freely diffuse across cell membranes being able to cross the Blood-Brain barrier serving as a source of energy [1].

Acetone is usually omitted when talking about the metabolism. Under normal healthy conditions, the ß-hydroxybutyrate: acetoacetate ratio uses to be 1:1 but this ratio can raise to 10:1 when a diabetic person does not have a correct control of its glucose plasma levels.

The ability of ketone bodies to be used as an energy source can be showed measuring its plasma concentrations (Figure 2) under different situations. Concentrations vary from 0.1 mmol/dl to 25 mmol/dl during diabetic ketoacidosis [3-4].

Metabolic state	Ketone body concentration (mmol/dl)
Mixed diet	0.1
Ketosis	0.2
Fasting 2-3 days	1
Post-exercise	Up to 2
Fasting 1 week	5
Ketogenic diet	5-6
Fasting 3-4 weeks	6-8
Ketoacidosis	8+
Diabetic ketoacidosis	Up to 25

Figure 2. Ketone bodies concentration in different metabolic situations [5]

The fact that ketone bodies are generally found in diabetic people has associated them as signals of metabolic problem, but it is not necessarily true.

That early 1900's Ketogenic Diet become popular due to the ability to treat a lot of healthy problems, especially childhood epilepsy. An easy way to produce high quantity of ketone bodies without the presence of a diseases is having a high fat diet (around 75-80% of total calories), medium in protein consumption and very low in carbohydrate intake [6].

Ketogenesis is the biosynthetic pathway by which ketogenic amino acids and free fatty acids are transformed to ketone bodies. The main intermediate is Acyl-CoA obtained from the ß-oxidation when free fatty acids are used as precursor. Only liver cells, hepatocytes, are able to create these metabolites.

Ketolysis is the process by which ketone bodies are catabolised to obtain Acetyl-CoA offering around 4.2kcal/g. This process occurs in many extra-hepatic organs being particularly important to central nervous system. The two main steps in this pathway are thinly regulated by the enzyme succinyl CoA-oxoacid transferase and methyl-acetoacetyl CoA thiolase.

Ketone bodies production is enzymatically regulated by three enzymes: hormone sensitive lipase, acetyl-CoA carboxylase and HMG-CoA synthetase being hormonally regulated by the glucagon/insulin ratio. Highest the ration, highest the production of these metabolites.

2. Ketone bodies and Diabetes Mellitus, ketoacidosis

Type II diabetes or non-insulin dependent diabetes is a disease in which a raise in ketone bodies concentration is not produced [7] so it will be omitted.

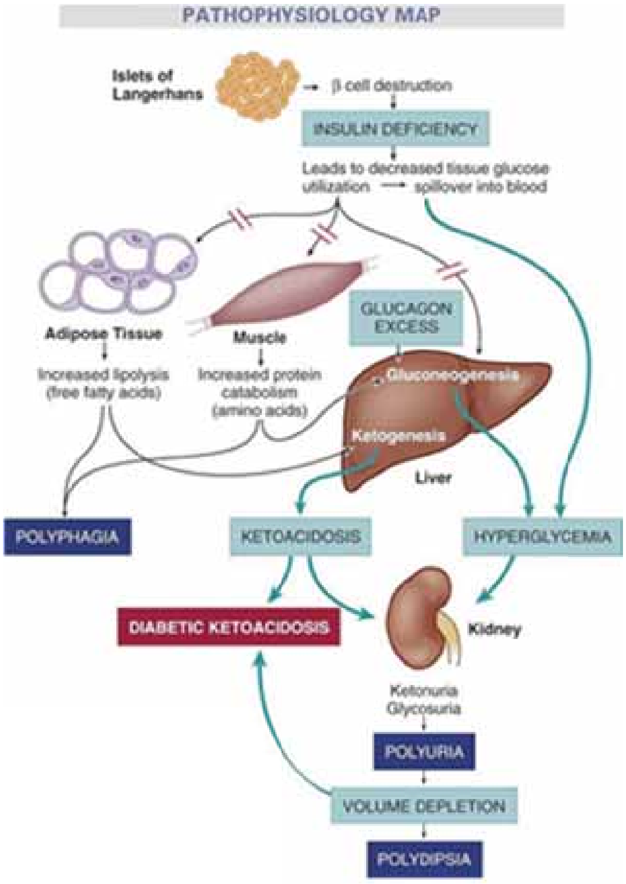

Figure 3. Metabolic events leading to diabetic ketoacidosis [10]

Diabetes mellitus or type I diabetes, is a medical condition in which insulin is not produced by the ß-cells presented in the Islets of Langerhans or Pancreatic Islets.

Type I diabetes is suffered by a 15% of diabetic patients, diet treatment is incomplete to treat this disease and insulin injection is essential. This metabolic problem is normally discovered in young people and its typical symptoms are [8]: polyuria (abnormally large production of urine), polydipsia (excessive thirst) and polyphagia (excessive hungry).

The hormonal regulation of ketone bodies production by the glucagon/insulin ratio becomes perverted and an overproduction of this metabolites is produced.

A high plasma concentration of ketone bodies produces ketoacidosis. ß-hydroxy-butyrate and acetoacetate dissociates triggering a reduction in pH which could be fatal [9]. Ketogenic Diet does not induce ketoacidosis. The principal difference between ketoacidosis and Ketogenic Diet, is the correct function of insulin and a lower concentration of ketone bodies in plasma. You show in Figure 3 the pathophysiologic map.

3. Ketogenesis

The biosynthesis of ketone bodies is named Ketogenesis and is the process whereby ketogenic amino acids and free fatty acids are transformed to acetoacetate firstly and ß-hydroxybutyrate and acetone later. This process is only achieved by hepatocyte mitochondria.

Acetyl-CoA is the key molecule in this process. This metabolite can be produced from free fatty acids through the ß-oxidation pathway and afterwards enter to the mitochondria.

There are three main steps in ketone bodies production (Figure 4):

1) Acetoacetyl synthesis through the enzyme 3-ketothiolase
2) Conversion of Acetoacetyl-CoA to HMG-CoA catalysed by mitochondrial HMG-CoA synthase. HMG-CoA can also me produced by ketogenic amino acids: Leucine, lysine, isoleucine, phenylalanine, threonine, tryptophan and tyrosine.
3) The last reaction is controlled by HMG-CoA lyase producing acetoacetate.

After acetoacetate is produced it can be transformed to ß-hydroxybutyrate. This reduction is catalysed by the enzyme 3-hydroxybutyrate dehydrogenase and is NADH2 dependent. The acetone synthesis is generally a spontaneous decarboxylation.

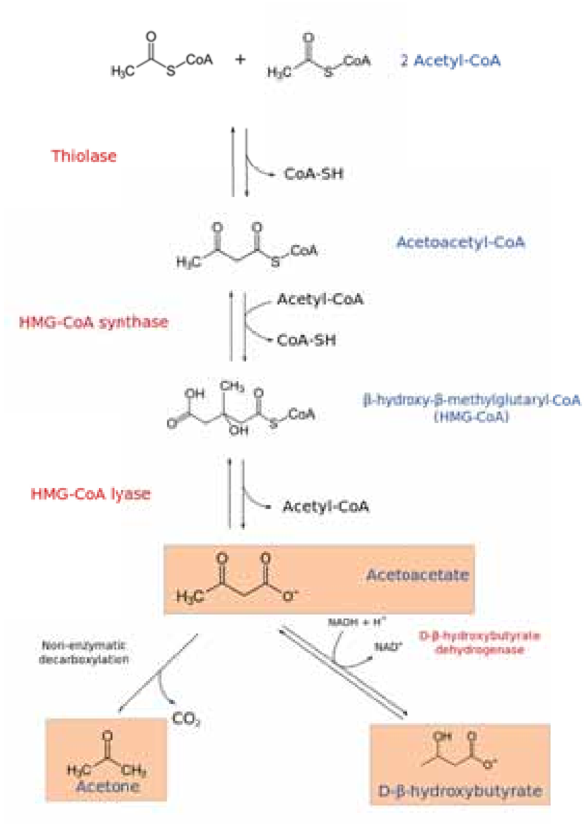

Figure 4. Ketone bodies synthesis pathway [11]

4. Ketolysis

The breakdown of ketone bodies to produce acetyl-CoA occurs in the mitochondria of many extra-hepatic tissues.

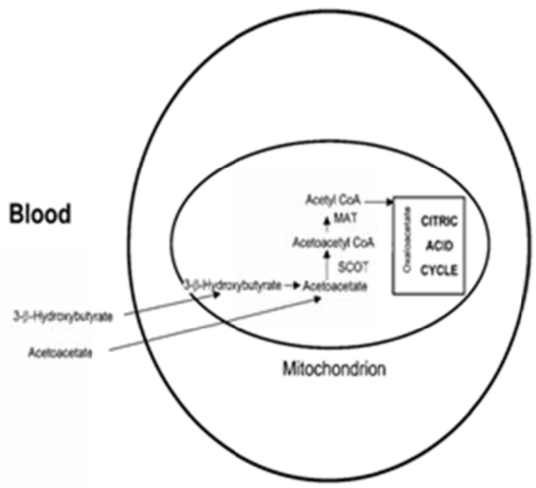

Figure 5. Ketone bodies degradation pathway [12]

Succinyl-CoA oxoacid transferase is the determinant enzyme in Ketolysis, as you can see in Figure 5 [12] and the last step is catalysed by methylacetoacetyl-CoA thiolase ending the synthesis of acetyl-CoA which can enter to the citric acid cycle.

5. Acknowledgements

Author wants to thank Anna Clua, Coral Salgado and Jordi González for their assistance and language revision.

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Multimedia and ICT Applied to the Study of Visual Acuity in High School Education

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Abstract. Multimedia and ICT have become a fundamental part of people's everyday lives, especially for young people. They can be used for research or even just for leisure, and that makes technologies an ever-present element in a teenager's daily life. Because of this, we think that it's very important to include all of these multimedia and ICT in their learning methods [1].

Our sight plays a vital role in the use of multimedia and ICT. For this reason, we suggest an activity for high school students that involves both subjects and acts as an introduction to the world of Optometry and Visual Health. The workshop consists of measuring the visual acuity of all the students in the class. The only tool needed is a computer with the standard Office Suite installed. After a brief theoretical introduction concerning visual acuity led by the teacher, the students will have to design the standard optotype (the Landolt ring) or the Tumbling E optotype, using slide presentation software in order to make their own visual acuity chart, following [2].

Once all the members of the group have determined their visual acuity with and without corrective lenses and also with a pinhole, the population analysis of visual health taking into account [3] will start. Is there any student visually impaired without corrective lenses, and with?

Another aspect worth analysing are the minimum levels of visual acuity required, corrected and uncorrected, in order to access different jobs, professional activities or getting different licenses. Which students would or wouldn't be able to apply for such jobs/licenses?

The suggested workshop leads the student through several subjects, from Maths and Graphic Design to Visual Psychophysics and Public Health, making it a very complete and interesting activity.

Keywords. High school education, multimedia and ICT, optotypes, visual acuity, visual health, visual psychophysics.

1. Introduction

1.1. Visual acuity

Visual acuity (VA) is a very important parameter in Optometry and Visual Health because, in most cases, it is the reference used in the determination of the far vision subjective refraction [4]. Moreover, VA is also a reference to establish the different degrees of visual impairment according to the WHO [3]. However, low and not so low VA values rule out people for some professions or activities [5].

VA is somehow related to the resolution of the visual system, not being strictly its resolving power. Whilst this consists of the ability to separately perceive two independent elements, VA is the ability to recognize the shape and details of a test, called optotype. Figure 1 shows the Landolt ring, the only standardized optotype [2], reaching up to eight different orientations.

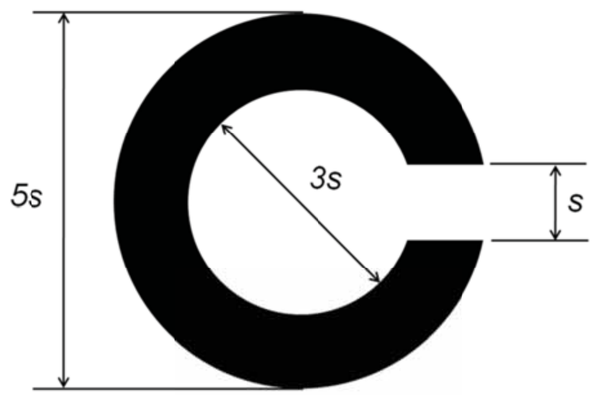

Figure 1. The standard optotype, the Landolt ring

Even though the Landolt ring is the only standardized optotype, it is useful to use other kinds of optotypes such as letters or the tumbling E (Figure 2), this last one reaching up to four different orientations. All of them fulfil the same design requirements: they are contained in a $5s$ x $5s$ sized box and the stroke thickness is s.

The level of VA is computed as the inverse of the angle subtended by the minimum detail

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of the smallest optotype perceived, in arcmin, such as in Equation (1) (Figure 3):

$$VA = \frac{1}{u\ (arcmin)} = \frac{\pi}{10800} \cdot \frac{d}{s}\ , \qquad (1)$$

s being the stroke width, that is the size of the minimum detail to be distinguished and *d* the observation distance.

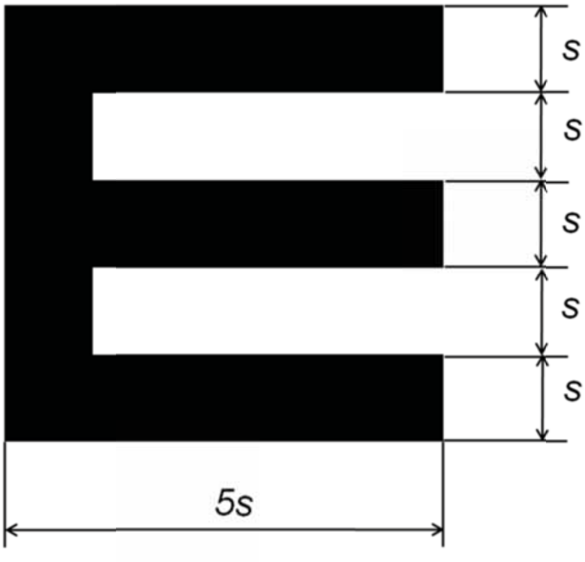

Figure 2. The tumbling E optotype

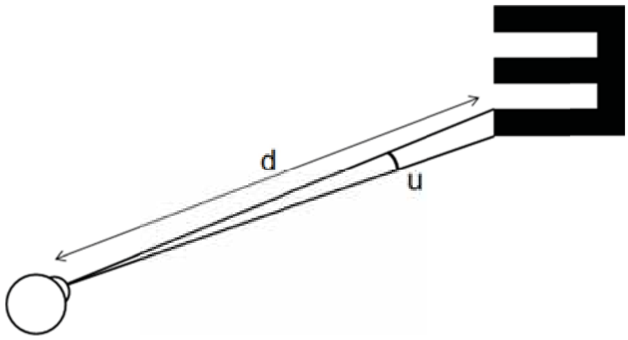

Figure 3. Visual acuity calculation

1.2. Visual acuity notation and charts

The VA value obtained from Equation (1) is expressed in decimal notation. However, there are many other ways to express visual acuity but the most common are the Snellen notation and the logMAR notation. In the Snellen notation, Equation (2), the VA value is expressed as a fraction of distances (either in meters or feet), *d* being the observation distance and $d_{1'}$ the distance to which the critical detail of the optotype subtends 1 arcmin or, similarly, the optotype has a decimal VA value equal to 1:

$$VA = \frac{d}{d_{1'}}. \qquad (2)$$

In the logMAR notation, Equation (3), the VA value is expressed as the decimal logarithm of the angle subtended by the critical detail in arcmin, u, or MAR (Minimum Angle of Resolution):

$$logMAR = \log(u) = -\log(AV). \qquad (3)$$

Another issue to be analysed is the way that the optotypes are presented. The ensemble of optotypes is called the VA chart. In its design, modern charts are built following [2] which is the Bailey-Lovie model. It consists of a sequence of lines of five optotypes per line where each VA value is expressed in logMAR notation, having an increment equal to –0.1 between two consecutive lines. The separation between optotypes is not less than a 5*s x* 5*s* box and the separation between two consecutive lines is not less than the height of the smaller one (Figure 4). An observer is considered to have passed a line in the chart if, at least, three optotypes are correctly identified. If not, the observer has failed this line. So, the visual acuity of the observer is that of the smallest sized passed line.

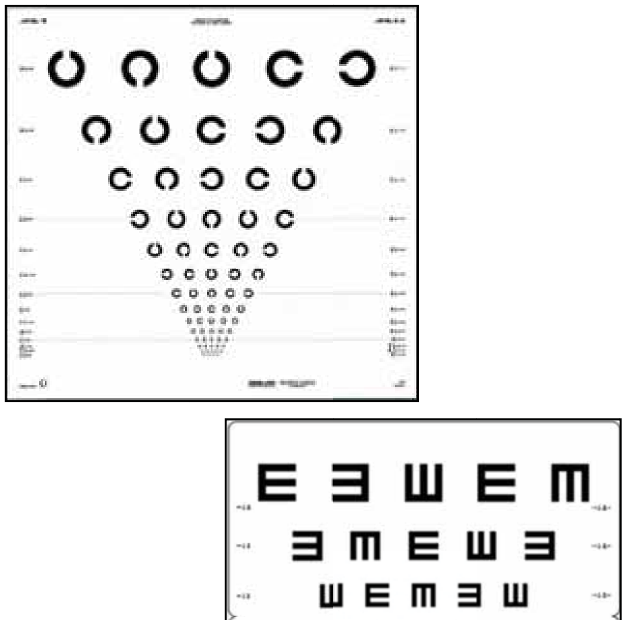

Figure 4. The Bailey-Lovie chart: Landolt ring (top); Tumbling E (bottom)

A 5 m distance Bailey-Lovie chart typically includes the lines and sizes listed in Table 1.

Line #	LogMAR	VA	Snellen	s (mm)	5s (mm)
1	1	0,10	5/50	14,50	72,50
2	0,9	0,13	5/39,7	11,52	57,59
3	0,8	0,16	5/31,5	9,15	45,74
4	0,7	0,20	5/25,1	7,27	36,34
5	0,6	0,25	5/19,9	5,77	28,86
6	0,5	0,32	5/15,8	4,59	22,93
7	0,4	0,40	5/12,6	3,64	18,21
8	0,3	0,50	5/10	2,89	14,47
9	0,2	0,63	5/7,9	2,30	11,49
10	0,1	0,79	5/6,3	1,83	9,13
11	0	1,00	5/5	1,45	7,25
12	-0,1	1,26	5/4	1,15	5,76
13	-0,2	1,58	5/3,2	0,91	4,57
14	-0,3	2,00	5/2,5	0,73	3,63

Table 1. Typical Bailey-Lovie chart values

2. Procedure

2.1. Designing the optotype and the chart

The design and the presentation of the optotypes will be carried out with any slide presentation software with a drawing tool. The optotypes will be visualized on the monitor screen in the presentation mode. In order to properly draw the optotypes, the size in the edition mode has to be the final size 5*s* of Table 1 (in presentation mode) divided by the magnification $size_{presentation}/size_{edition}$ (1.5 in Power Point). Thus, all the optotypes can be derived from an initially large one designed, suitably resized and rotated.

Considering the small extension of the computer screen, each line of the formal Bailey-Lovie chart will be placed in an independent slide of the file. At the bottom of each slide we recommend placing a small label with the VA values (like in VA charts). The optotype presentation will start with the biggest optotypes, followed by the rest of the sizes (lines of the chart), until the observer cannot correctly name at least three optotypes of a line. Then, the VA value will be the one of the previous line.

2.2. The pinhole disc

The pinhole disc "is an opaque disc with a central circular aperture of about 1 mm in diameter" [4]. If it's placed in front of an uncorrected ametropic eye and it provides a better VA it's because the blurred image is due to an uncorrected refractive error. If the pinhole doesn't improve the VA, the observer is likely to suffer from a pathology. Thus, it will be very interesting to test uncorrected and corrected observers with the pinhole on, in order to analyze the nature of their ametropies/impairment and the updating of their correction [6].

The creation of a pinhole disc is very easy: just a piece of black card laid on the hard side of an old mouse pad and a thick needle are needed.

2.3. Visual acuity measurements

In this paragraph, only the VA measurement of one eye will be considered. The procedure can be used for both eyes and binocularly, using different VA charts every time. A standard and ideal VA value is 1 or higher. This is the VA value that optometrists try to reach with their patients when they measure the subjective refraction.

A first measurement of the VA will be done in normal conditions (with correction in case of needing it or without). Then, repeat the same measurement using the pinhole. The second measurement is more than likely better than the first one. If it is, it's because of a bad correction updating. If the second measurement is not better than the first one, it may be due to other reasons instead of a refractive error.

Next, the previous procedure is repeated without the correction.

3. Data processing and interpretation

a) Measure you're a classmate's distant VA under the patient's normal conditions (even if they wear glasses or contact lenses). Do it with one eye first, covering the eye not tested and vice versa. Then, perform the test with both eyes. Measure each patient's VA looking through the pinhole as well.

- Represent the distribution for the VA values of each eye with percentages in a bar graph for each sex and globally.

- Make the same graphs but for the tests performed with the pinhole disc.
- What's the percentage of observers that improve their VA with the pinhole?

b) Measure you're a classmate's distant VA (monocularly and binocularly) but this time without corrective lenses. Perform the test looking through the pinhole as well.

- Based on the uncorrected binocular VA obtained without correction, represent in a bar graph the percentage of patients with severe visual impairment (VA ≤ 0.3), moderate visual impairment (0.3 < VA ≤ 0.5) and normal vision (VA > 0.5) according to the WHO classification.
- Make the same graph but for the tests performed with the pinhole disc.
- What's the percentage of observers that improve their VA with the pinhole?
- Identify the people whose refractive errors are uncorrected, inadequately corrected or properly corrected and represent them using percentages in a bar graph for each sex and globally.

c) Do some research on what the eyesight requirements are for jobs/activities that require excellent vision, such as being a pilot or a firefighter. What percentage of your classmates wouldn't be able to apply for these jobs?

To sum up, how would you rate your classmates' vision?

4. Acknowledgements

We thank Miquel Ralló Capdevila for his advice and Lola Garcia Tàpias and Mike Twort for the English revision.

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Playing with Spectrophotometry

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Abstract. It is essential in biochemical research the use of techniques to know the concentration of biomolecules in a sample. One of the most used method to find out the concentration of a sample is using a spectrophotometer. This tool emits a beam of light at the selected wavelength on the sample; according to the properties of the sample, it will absorb a certain amount of light and this will be quantified by the spectrophotometer, which will give us an absorbance number. In certain values, the concentration of a molecule is proportional to the measure of absorbance. It will be discussed the quantification of protein with dye Coomassie Brilliant Blue G-250 by the Bradford method.

Keywords. Biochemistry, spectrophotometry, biomolecules quantification, protein.

1. Introduction

In order to know what is in a biological sample we need to use biochemistry techniques for the detection and quantification of biomolecules. These techniques could be qualitative or quantitative.

The qualitative methods answer a question with yes or no. These tests inform of the presence or absence of a biomolecule in a sample like Fehling's solution or Lugol's iodine to detect sugars with reducing power or starch respectively.

The quantitative experiments inform of the concentration of molecule that we already know its presence in a sample like an acid/base rating or spectrophotometry.

2. The physics of spectrophotometry

The spectrophotometer works with light from the electromagnetic spectrum, so it has associated a wavelength, a frequency and an energy all related by the Planck constant.

The spectrophotometer emits light with a determined wavelength that crosses our sample. The sample will take up part of the light (absorbance) and will let pass the rest of the light (transmittance). The spectrophotometer will detect the transmittance in its detector after the sample.

If you want to quantify a biomolecule you need to know in which wavelength your molecule shows a maximum absorbance or a minimum transmittance doing an absorption spectrum (measuring the absorbance in different wavelength).

Once you have the light wavelength of maximum molecular absorption of your molecule you are able to apply the Beer-Lambert law which relates the attenuation of light to the properties of the material through which the light is travelling [1-2].

$$I_{abs} = I_0 - I_{trans} \quad (1)$$

I_0 is the emitted intensity of the light, I_{abs} is the light absorbed intensity and I_{trans} is the light transmitted intensity.

$$\log\left(\frac{I_0}{I_{trans}}\right) = \varepsilon \cdot c \cdot l \quad (2)$$

c is the concentration of the sample, l the length of the bucket and ε is the proportional constant.

$$T = \left(\frac{I_{trans}}{I_0}\right) \cdot 100 \quad (3)$$

T is the transmittance,

$$A = \log\left(\frac{100}{T}\right) \quad (4)$$

A is the absorbance,

$$A = \log\left(\frac{I_0}{I_{trans}}\right) = \varepsilon \cdot c \cdot l \quad (2)+(3)+(4)$$

$$A = \varepsilon \cdot c \cdot l \quad (5)$$

All these means that exists a direct proportionality between absorbance and concentration.

Imagine that you are in a room with invisible people that you can not see or hear them, but you can interact with them. How could you count them? You can throw for example ten tennis balls to the floor and ask that each person has to take one ball. If you observe two remaining balls in the floor it means that there are eight invisible people in the room.

In this example, the invisible people are the molecule that we want to quantify, the balls are the light, the balls that the people has taken is the absorbance and the balls that we observed in the floor are the transmittance.

3. How to link absorbance and concentration?

If you measure the absorbance of a molecule at his maximum absorbance wavelength and the spectrophotometer returns you the absorbance, how can you link that absorbance with the concentration?

If you want to apply the equation number five in order to find out the concentration of the molecule you need to know the constant of proportionality "ε".

The equation number five describes a straight line. So, if you measure the absorbance of different samples with a known concentration of your molecule you will be able to build graphically a straight pattern. With your obtained data can sketch a straight pattern and also you can do a linear regression to obtain the equation of the straight patter.

Table 1. Absorbance at 700 nm of different samples with different concentrations of albumin treated with Folin-Lowry reactive

		Absorbance	
Albumin (µg/mL)	0	0.046	0.047
	25	0.090	0.107
	50	0.136	0.149
	100	0.266	0.254
	150	0.337	0.358
	250	0.537	0.544

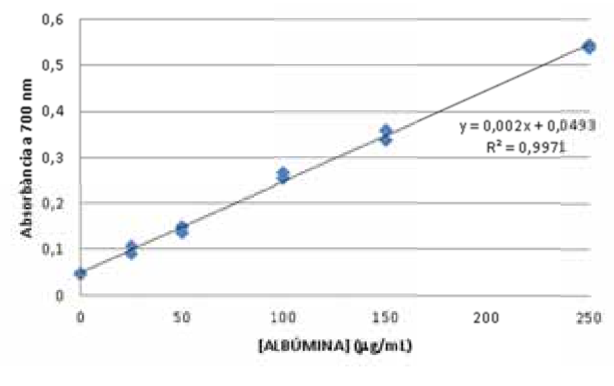

Figure 1. Graphic representation of the data from table 1 and its linear regression

Once you know the constant of proportionality "ε" you can isolate "x" from the equation of the linear regression from the absorbance of your sample. "x" is equal to "c" doing an interpolation. You only can isolate "c" if your absorbance is inside your straight pattern because if you extrapolate you can do a mistake because the linear relation between absorbance and concentration is not into the infinity.

4. Protein quantification with dye Coomassie Brilliant Blue G-250

Proteins only present absorbance between 200 and 300 nanometers and changes depending on the proportion of aromatic amino acids of the protein. So, if you want to quantify a biological sample with different types of proteins with different proportions of aromatic amino acids you need to use an indirect method like a dye reagent.

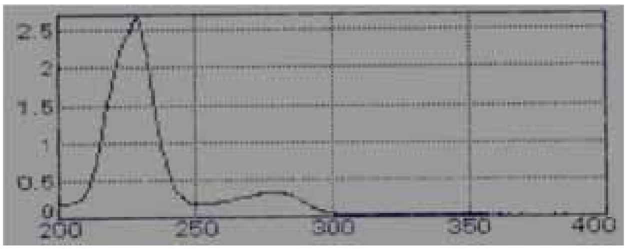

Figure 2. Absorption spectrum of albumin

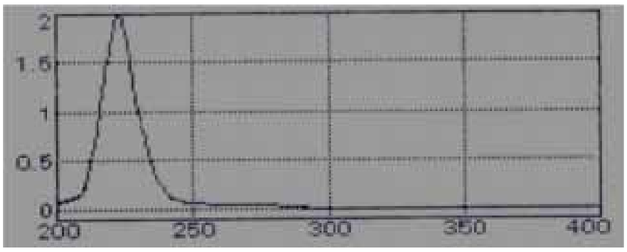

Figure 3. Absorption spectrum of collagen

To quantify protein with the Bradford method [3] you have to use the dye Coomassie Brilliant Blue G-250. This reagent has two possible colors: red when it is not in presence of proteins and blue when it is in presence of proteins. This change of color could be followed by a spectrophotometer at 595 nm and allows you to build a straight pattern and calculate a linear regression in order to know the concentration of proteins of different biological samples.

As you can see in Figure 4 the dye Coomassie blue presents a maximum

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absorbance at 595 nm so it's the better wavelength to study its concentration. Measuring the concentration of Coomassie Blue means measuring the concentration of protein.

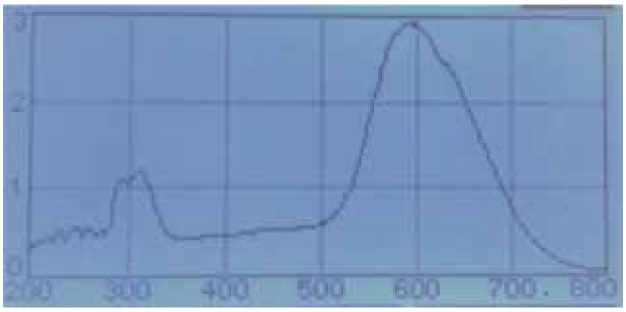

Figure 4. Absorption spectrum of dye Coomassie Blue in presence of protein

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Science, Medicines and Biotechnology in a Summer Camp

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Abstract. Science is everywhere, so we can use it in different ways of our daily life, even though we are not always thinking about all the moments we are applicating it. Here, you can find how the young people can get some scientific knowledges while they are doing different tasks and without the necessity of doing specific activities. The explanation is based on the experience with a group of teens. It was developed in a summer camp in the middle of nature in Pont de Suert.

Keywords. Health, injuries, diseases, nature, nutrition, science.

1. Introduction

Being all day in contact with nature is a good opportunity to teach teens about different ways in science. The main purpose of this summer camp was restoring historical fields in Pont de Suert Mountains. Teens could learn and applicate concepts about geometry, geology, physics, zoology, botany, ecology and health.

Furthermore, teens were distributed in different groups, in which tasks were divided. They had to cook the meals and maintaining clean all the spaces, under the monitor's team supervision. The foundation Escolta Josep Carol [1] organized this summer camp.

2. Methodology

In this point, geology, physics, botany, zoology and ecology are studied.

2.1. Playing with Geology

With the pass of time, some stones are falling from the top of mountains to the base, where are the fields. To avoid stones accumulations on fields there were used walls. With this practice, teens could learn about geology [2] because is important to know the characteristics of the stones are used to construct the walls, so the wall does not break and fall throughout years. They also applied geometry studying how to fit the stones together. There also were constructed channels to delimit the pass of the river. Here they could know about physics [3], because it is necessary to make a good fissure on the field, with a good inclination to make the water pass only for there. It was also important the geometry and geology knowledges acquired with walls construction.

2.2. Playing with Botany and Zoology

There, while we were walking and making activities with plants, I was telling them the scientific and common names of plants species are there [4]. An example is *Quercus pubescens* (Figure 1). They had also taught about the own and distinctive properties of each one. Furthermore, they learned the general characteristics that allow all of them being adapted to the climate. The explanation of animals founded in the area, including their classification, names and their role in interactions between them and with plants is a good way to make them know some concepts about zoology [5] and ecology [6].

Figure 1. *Quercus pubescens*. Image obtained from the webpage [7]

Is relevant to concern teens about the significance has taking care of nature and not destroying it to have a good environment. To support this idea, they had been explained why is important taking this caring action to our planet and for us. Some of the reasons were that Earth gives us the correct conditions so we can live well, which affects so much on health of all the living organisms and our planet also gives us food.

3. Health and nutrition
3.1. Injuries and diseases

In consequence of the work on mountain it was frequent making injuries, especially on the skin. The main causes were touching the plants prickles, or using the tools needed to make the work correctly without gloves. Here they learned the big significance of getting rightly protected when are working. This is also applied to science; it is not just important to know lot of scientific concepts and how to make discovering, but it is very relevant to be always protected during the realization of the work to be healthy.

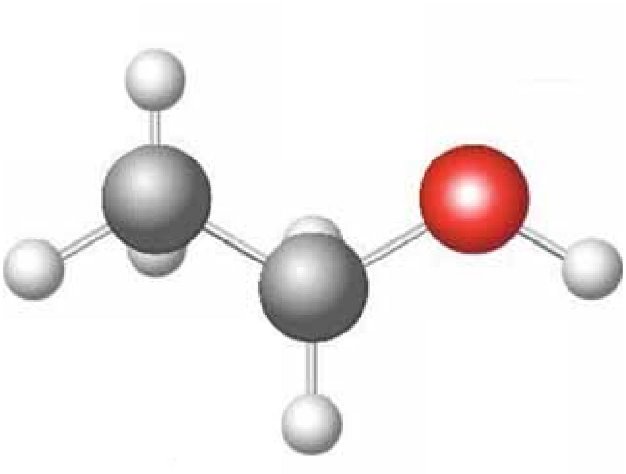

Figure 1. Ethanol molecular structure. Image obtained from the webpage [8]

To treat the wounds, after cleaning my hands and using gloves, it had used properly disinfected needles and forceps, if were required, and disinfectant. As a disinfectant it was used ethanol 96º (Figure 1) and to cover the injuries plastics and an impregnated gauze with propionic acid (Figure 2).

It is important to concern teens about self-medicate. For this reason, it was necessary a parent's or guardian's consent to give them medication if they felt bad. It is necessary a strict control of the quantity they take and possible allergies to some medication. They have to be aware of the consequences can imply in themselves self-medication and in global society, especially if they take antibiotic without control and medical's prescription.

Health is not only maintained by curing well an illness or injuries. It is also necessary cleaning very well spaces where we live, standing out bathrooms, rooms and the kitchen (including cooking accessories). Smarting ourselves up and cleaning well hands before cooking and eating is essential too. Does not mind what times teens have to be warned about this until they integrate the concepts and put them into practice.

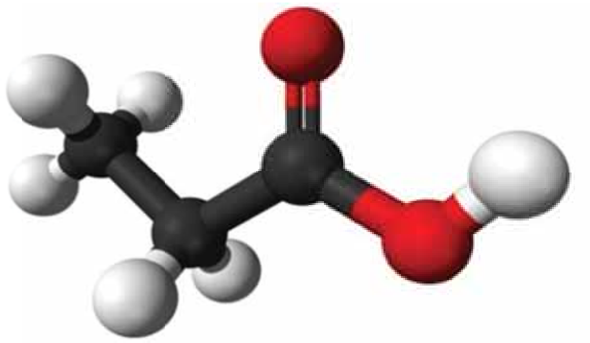

Figure 2. Propionic acid structure. Image obtained from the webpage [9]

3.2. Nutrition

The importance of a balanced diet, combined with physical activity was fundamental in the summer camp. It was also imperative concerning them about the importance of diet and why. For this reason, the daily menu were previously established for guarantee that everybody had covered food requirements.

Before starting cooking, teens were exhaustive explained how to clean the kitchen and hygiene rules while cooking to avoid food contamination. They had known about the contamination and crossed-contamination in aliments and the danger it can imply in our health. An example of an exhaustive cleanliness needed during cooking is cleaning tongs after taking raw meat and before taking another food with them. They also learned what type of kitchen utensils are used depending on the food were cooked.

Another precaution to avoid possible illnesses product from an incorrect food handling was cooking very well, keeping away from undercooked or burned food. Taking in account the importance of cleaning and why and the way how to cook the food, they learned about microbiology [10]. They were explained about some microorganisms who live in food and dye at high temperatures and in another certains conditions.

3.3. Problems with food

There were some teens, which had allergies and / or intolerances to some foods. The most common intolerance was to lactose (Figure 3), so it was essential to cook the food of intolerance people apart from the rest of food. However, the mean allergy was to gluten (Figure 4).

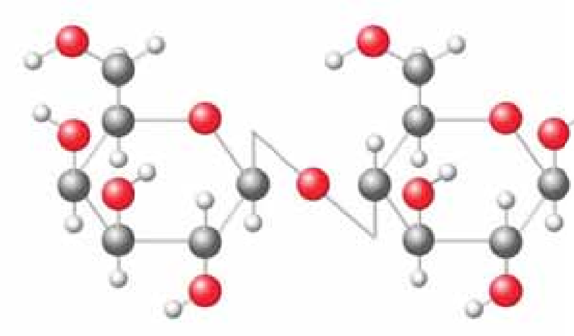

Figure 3. Lactose structure. Image obtained from the webpage [11]

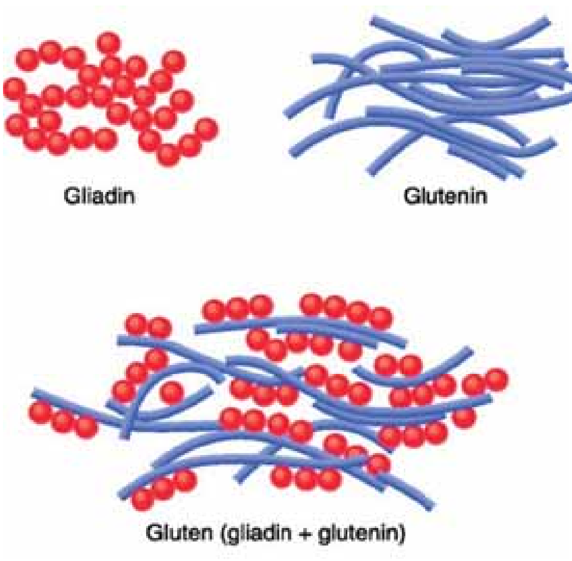

Figure 4. Gluten composition and structure. Image obtained from the webpage [12]

To make teens understand the importance to have a strict control about the food every person ate, they were explained about the differences between allergies and intolerances. They also learned some of the effects affected people have if they eat the particular food for which are allergic or intolerant. Explaining to them that allergies are an exaggerated response of immune system, I had the opportunity to teach them about immunology [13] in human organism.

Figure 5. "Herpatiform dermatitis" from a celiac person who eat gluten food. Picture was obtained from the webpage [14]

In addition, food intolerances were characterized as difficulties to digest some food. Teenagers learned molecular biology [15] ideas about the reason of this problem. Food intolerance people have problems with specific enzymes involved on the digestion of particular food. It was explained to them what enzymes are related to food intolerances and their characteristics. Furthermore, it was also explained the enzymes importance for us.

To avoid this, teens were very careful when they were cooking. They took in account that cooking instruments could not be in contact with normal food and then in contact with intolerant or allergic people's food.

4. Conclusions

At the end of the summer camp, teens recognized that they had learned lot of concepts about science which they had never listened before. They ensured that they were not concerned, until these two weeks, about the importance of how maintaining the hygiene in all ways and nutrition. Some of them returned at home motivated by science and thinking about dedicating their future career to science.

Living with daily injuries and people with health problems related to nutrition, concerned me about products we have nowadays and the modifications we can do to them. Biotechnology can help us modifying food components, making them accessible to everybody. As well as it can contribute on this, it can improve pharmacological products to cure diseases and injuries even more effectively than nowadays.

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The Mysterious Element

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Abstract. The introduction of technology and new methodologies in the educational world is generating new teaching practices.

One of the objectives that can be achieved with this new type of activities is to motivate the students and increase their interest in some contents that there are not particularly striking for them.

An example is the study of the elements of periodic table. As their learning could be unattractive, it is proposed its study using a mobile application (App) and the game-based learning (GBL) which offers several advantages such as allowing an active learning and giving the student control over their learning.

Keywords. Apps, GBL, Periodic Table.

1. Introduction

The introduction of new technological tools and methodologies in the classroom is leading to the implementation of teaching-learning processes that are different from classical master classes. The advancement in disciplines such as neuroeducation, school psychology or technology, allow us to incorporate new ways of working content, not only curricular, but also procedural or attitudinal. The use of mobile in the classroom, augmented reality, 3D printing, are just some of the examples.

To offer a personalized attention according to the needs and aptitudes of the student, to increase his motivation or interest for certain contents or the training and evaluation of competencies, are some of the objectives of this new educational approach.

Beyond the difficulties that may arise in its practical application or the reserves of some teachers in its implementation, the fact is that there are many projects and initiatives that show new ways of working in the classroom.

Some of them are based on game-based Learning (GBL) which is defined as the use of games like vehicles and tools of support to the learning, the assimilation or the evaluation of knowledge [1]. Some of the advantages of the GBL are the increase of motivation of the student, greater control of his learning and to allow an active learning [1].

This kind of activities can be used to work certain contents that sometimes fail to arouse a special interest among the students.

It is common to confuse GBL with gamification. However, there are several differences. For example, while the GBL consists in the use of games and videogames for didactic purposes in educational contexts, the gamification consists of the use of game mechanics in traditionally non-recreativity environments; other difference is that while in the GBL the games have defined the rules and objectives in the gamification can be a collection of tasks with points or a form of reward [2].

Some GBL projects applied to the classroom use the mobile or tablet as an element through which the activity is carried out. The mobile is especially popular and attractive for students of all ages, from the youngest who surprised by their ability to use, to teenagers who know and popularize many applications (commonly called Apps). However, we should take in account that Apps do not always fit what the teacher wants [3].

The game is the second of the elements introduced. In fact, this is not new because since our childhood, game is associated with fun, entertainment and learning. According to Muñoz and Valenzuela [4] this approach is not new: "To the game with educational purpose has given it to call" serious game. Although the expression is not new (nor its use in classrooms) ... ". So, this type of practice was being already carried out in the classroom years ago, especially in the first educational levels. However, what is new is the means with it can be carried out.

2. Description

The mysterious element is an application designed for mobile or tablet for students of compulsory secondary education and high school students to make the learning of certain aspects of the periodic table more attractive.

The objective of the game is guessing a chemical element of the periodic table through the formulation of questions about its characteristics and/or applications. With the answers provided by the application and the elimination of the elements that do not fit with the answers, the student can discover the hidden element.

To use this application, we must have internet connection. The first thing to do is download the application on a device (mobile or tablet) with Android operating system.

Once downloaded, the application starts and we find the first screen where we can choose the desired level (compulsory secondary education and high school level) and know the instructions for use of the application as well as additional information. Thus for example:

- The maximum number of questions that can be asked is eight
- The question application is only activated from the first question

From here, fourteen elements are showed being each of them candidate to be the hidden element.

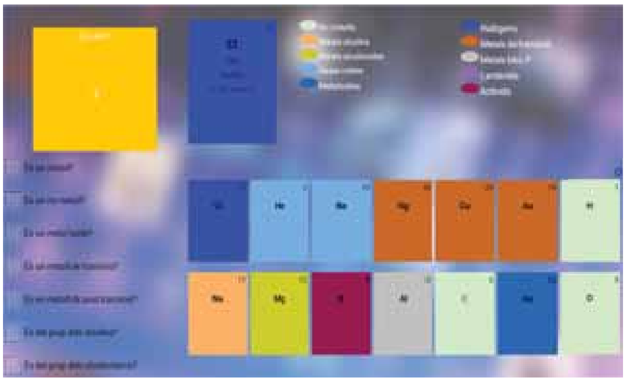

Figure 1. Main screen of application

As we can see in the Figure 1, in the upper left appears the mysterious element and below we can see the questions available. In the upper central part of the screen, we can see in a coloured way the name of the different groups of the periodic table and in the central area we can see fourteen elements arranged in two rows of seven columns. Each rectangle displays the chemical symbol and the atomic number so that if we click on the element, it will appear expanded in the upper rectangle. Moreover, in this rectangle we can see atomic weight, oxidation’s number and the name of the element.

Also we can see that the background of each rectangle is different according to the group of the table it belongs and according to the colour code shown at the top of the screen.

The application does not use all elements of the periodic table, but we have selected some elements that could be closer or familiar to the students by their study in the classroom or according their common applications.

Table 1 shows elements chosen for compulsory secondary education and high school level (elements in bold only for high school).

Table 1. Elements chosen for application

G.1	H	Li	Na	K						
G.2	Ca	Mg	Ra							
G.13	B	Al	Ga							
G.14	C	**Si**	Sn	Pb						
G.15	N	P	As							
G.16	O	S	**Se**	Po						
G.17	F	Cl	I							
G.18	He	Ne	Ar							
Metal transition	Au	Ag	Hg	Cu	Fe	**Ni**	**Cr**	**Mn**	**Pt**	

From this moment, the student asks questions and deletes elements. To do this, simply press the rectangle of the element for a few seconds. When done, the element will be in gray indicating that it is removed.

Student can select any question, except application question, that is only available from the first question. Figure 2 is an example of sequence of deletion.

Once the questions have been made and the candidate element is available, the student can press on the mysterious element rectangle and choose the chemical symbol of the element that he has obtained after making the deletes. At that time a message will appear on the screen indicating whether the chosen item corresponds to the mysterious element.

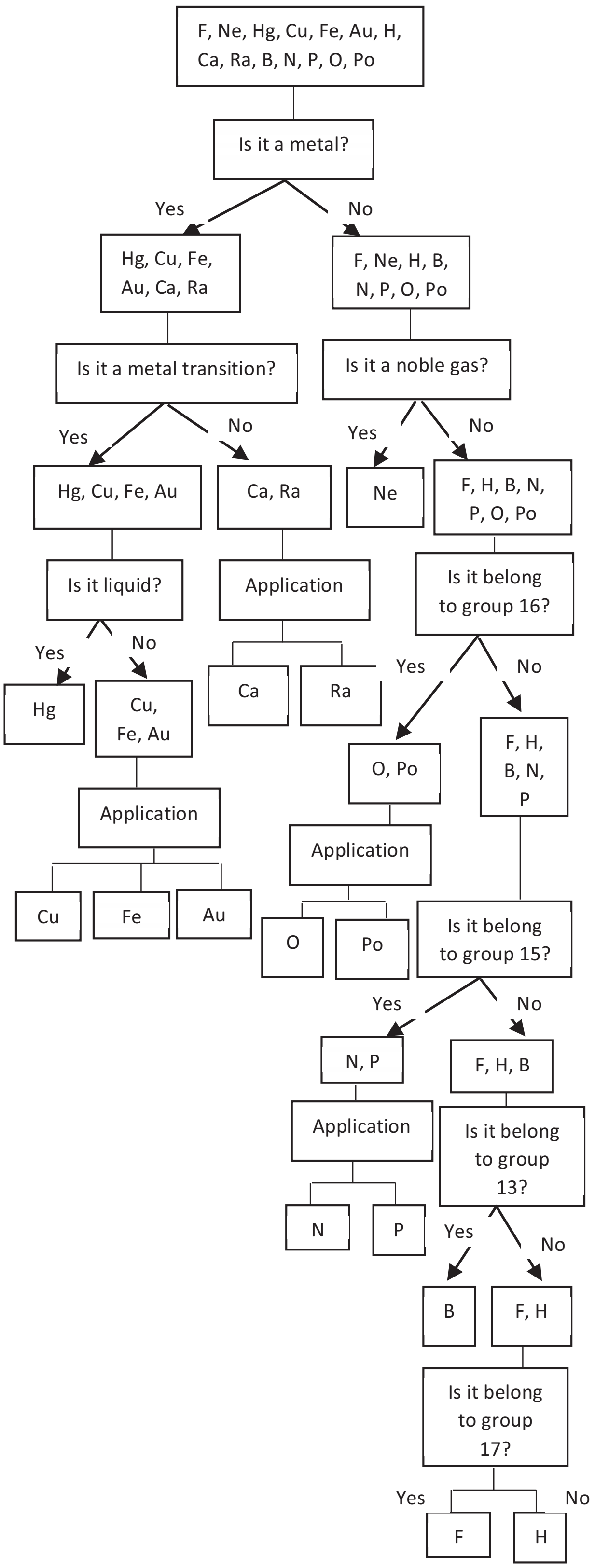

Figure 2. Sequence of deletion

3. Conclusions

Although test of the application has not yet been carried out in a real environment, and we want to add some extra functionalities, the development of the application carried out so far shows that it is possible to do the design and programming of an App with a programming tool relatively simple as App Inventor. So, without entering code directly, and using blocks, we can get a useful application for teaching and learning the periodic table.

4. Acknowledgements

We would like to thank Josep Maria Fernandez Novell of the Col·legi Oficial de Químics de Catalunya for their support and advice throughout the process of conception, design and creation of the application.

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Magnetic Collision Experiment

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Abstract. Collision is a very common phenomenon in our daily life. In Physics, collisions are clearly defined as two or more objects that interact with each other within a relatively short period of time. In this relatively short period of time, "external forces" can be ignored or do not exist at all. In this way, so-called collisions occur with these interacting objects. It is worth noting that there is no restriction on the forces acting between the colliding objects.

This is a well-known elastic collision experiment. It was originally demonstrated with a basketball and a tennis ball. The tennis ball was placed on top of the basketball and then both of them fell to the ground. After the collisions, the tennis ball could bounce to a higher height than that where it fells down.

If the force between colliding objects is a conservative force, the collision is an elastic collision. Therefore, gravity, elastic force, and even magnetic force can all be used as elastic colliding forces.

Applying this conclusion flexibly, the author redesigns the above illustrated elastic collision experiment with springs and magnets. The use of magnetic force to conduct this elastic collision experiment is a pioneering work. On the one hand, it can easily demonstrate this seemingly unbelievable experiment. On the other hand, it breaks the narrow understanding of collisions by people. Furthermore, the magnetic elastic collisions experiment causes students' curiosity and inspires them to truly understand the nature of the collision.

Keywords. Conservative force, elastic collision, magnetic force.

1. Introduction

Collision is a very common phenomenon in our daily life. Thinking of collisions, many people think of playing billiards or playing marbles. However, the so called collision phenomenon is clearly defined in Physics. According to the clear definition, the content of collisions is more varied and useful.

The clear definition of collisions in physics is that two or more objects interact with each other within a relatively short period of time. In this relatively short period of time, "external forces" can be ignored or do not exist at all. In this manner, so-called collisions occur with these interacting objects.

It is worthy to note that there is no restriction on the forces acting between the colliding objects. In other words, when object collisions, they do not necessarily collide like two marbles, and they do not have to contact with each other like two marbles.

2. Collision Theory

The theoretical analysis of the collision phenomenon can be based on the theoretical calculation of a many particles system. The important conclusions of the theoretical calculation of the many-particles system are as follows:

1) The total kinetic energy of the entire many-particles system is equal to the mass center kinetic energy of the entire system plus the kinetic energy of each particle relative to the mass center motion. It can be expressed as a formula as follows:

$$KE_t = \frac{1}{2} M v_{cm}^2 + \sum_i \frac{1}{2} m_i v_{ir}^2 \qquad (1)$$

Here, as we know, the total kinetic energy of the entire system is the sum of the kinetic energies of all the particles, M is the total mass of the entire system, v_{cm} is the velocity of the center of mass of the system, m_i is the mass of each particle and v_{ir} is the velocity of each particle relative to the center of mass of the system.

2) If the vector sum of external forces applied to the system is F_{ext}, Newton's second law can be written as:

$$\vec{F}_{ext} = M\,\vec{a}_{cm} = \frac{d}{dt}\sum_i \vec{P}_i = \frac{d}{dt}\sum_i m_i \vec{v}_i \qquad (2)$$

Here $\vec{a}_{cm}$ is the center of mass acceleration, $\vec{v_i}$ is the speed of each mass point, and $\overrightarrow{P_i}$ is the momentum of each particle.

3) The external torque, defined by the external force of the system to the center of mass, will change the angular momentum defined by the system to its center of mass, ie

$$\vec{\tau}_{cm} = \frac{d}{dt}\vec{L} \tag{3}$$

Here, $\vec{\tau}_{cm}$ is the external torque defined by the center of mass as the reference point, $\vec{L}$ is the total angular momentum defined by the whole system to the center of mass.

According to the definition of the collision, the system formed by the colliding objects is not subjected to external forces, therefore:

1) Since the system is not subject to external forces, regardless of the forces acting between the objects, $\vec{a}_{cm}$ the center of mass acceleration of the system is zero. So the total momentum of the system is conserved.

$$\vec{P}_{total} = \sum_i \vec{P}_i = \sum_i m_i \vec{v}_i = constant \tag{4}$$

2) Since the external torque defined for the center of mass is also zero, the total angular momentum defined by the entire system for its center of mass is also conserved.

$$\vec{\tau}_{cm} = \frac{d}{dt}\vec{L} = 0 \rightarrow \vec{L} = constant \tag{5}$$

3) Because there is no external force, the center of mass acceleration of the system is zero, the speed of the center of mass of the system remains the same, and the center of mass kinetic energy of the system remains unchanged. However, the kinetic energy of the relative center of mass changes in the collision process.

If the force between colliding objects is a conservative force, it is an elastic collision; if the interaction force between colliding objects is a non-conservative force, it is an inelastic collision. The usual conclusion in general textbooks is that the total kinetic energy of the system is conserved before and after collision in the case of elastic collisions. If it is not an elastic collision, the total kinetic energy of the system is not conserved before and after the collision. This conclusion is not delicate enough and it is not powerful to use.

A better conclusion is that the kinetic energy of the center of mass of the system remains the same regardless of elastic collision or inelastic collision.

$$\frac{1}{2}Mv_{cm}^2 = constant \tag{6}$$

However, when the elastic collision occurs, the sum of all kinetic energy of the relative center of mass does not change before and after the collision.

$$\sum_i \frac{1}{2}Mv_{ir}^2 = constant \tag{7}$$

In the case of inelastic collision, the sum of kinetic energy relative center of mass will decrease or even disappear completely.

3. An interesting collision experiment

This experiment is a well-known elastic collision experiment. It was originally demonstrated with basketball and tennis. Under the basketball, the tennis ball was placed on it and it fell to the ground and the tennis ball could bounce to a higher height. In the same collision experiment, manufacturers also produced experimental equipment consisting of two rubber elastic balls of different sizes and weights, but the problems were inconvenient to use.

4. Author's design of the Collision experiment

If the force between colliding objects is a conservative force, the collision is an elastic collision. Therefore, gravity, elastic force, and even magnetic force can be utilized as elastic colliding forces. Take the advantage of the flexibly of forces occurring in a collision, the author could not use the plastic bouncy ball in the early elastic collision experiment. Author used springs and magnets to perform the elastic collision experiment [1] described in this article (see Figure 2).

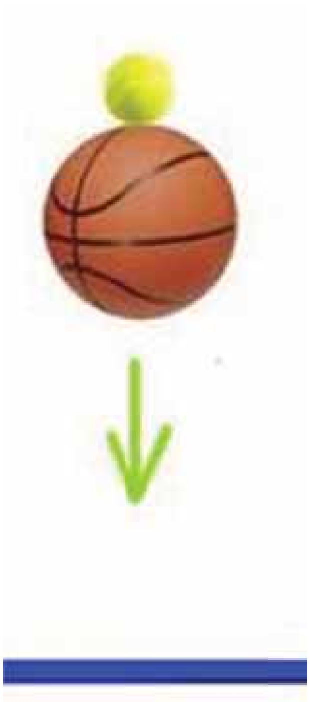

Figure 1. Interesting collisions

If this experiment is carried out with several magnets, all of them must be strongly magnetized. Therefore, the neodymium-iron-boron magnets are used in the collision experiment. The price of rare earth magnetism is not cheap (the weight of the collision body, which is lower in the experiment, shall be at least 5 times greater than that of the upper collision body. Furthermore the force between lower colliding objects is more than 5 times larger, compare with that between higher colliding objects. Consequently the total weight of the entire instrument could be quite big. It becomes inconvenient and expensive to carry out this interesting collision experiment. Due to the magnetic characteristics, the whole instrument must be larger, more expensive, and inconvenient to be carried.

The author then used several small magnets with central perforation and axial magnetization as the collision objects. But in this experiment the middle pillar must be thin and hard, and it therefore is very dangerous. The upper small magnets that spring out are easily lost. However, it is instructive to use magnets for collision experiments and be creative.

In this article, the author proposes a better to conduct this experiment. Firstly a wooden frame with a height of about 80 cm is made. With a proper and simple method, tighten a fishing string with a diameter of about 0.6 mm on the wooden frame (Figure 3). The diameter of the magnets is 6 mm, and the diameter of the middle hole of the magnets is about 1 mm. The magnets are stringed in this tightened fishing string. Six small magnets are combined into one and acts as the lower collision object. A single small magnet acts as an upper collision object. Two small magnets are placed at the bottom (Figure 4). The magnets are mutually repulsed by each other. And the magnetic repulsion forces act as a force for elastic collision. The six small magnets are lifted up and rested (Figure 4 right). The top small magnet can jump very high.

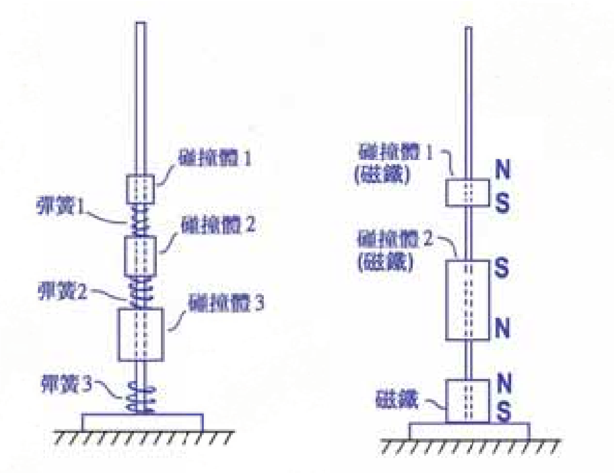

Figure 2. Author's innovative designs

The author has tested the instrument successfully. However, there are some possibilities of improvement

The magnetic force, acting as an elastic collision force, obviously differs from the force between the rubber bouncy ballst. The rubber bouncing balls must contact each other at least, and the force occurs. But the magnets do not have to contact each other, the magnetic happens. Therefore, in the elastic experiment, the distance between the magnets must be long enough before the magnets collide.

Actually here are some obvious improvements. For example, as long as making sure that the lower the collision magnets are heavier, and the greater the force shall be between the lower magnets, people can perform more than three collision magnets experiment using the method described in this article. Experiments are more interesting and unprecedented. However, this article just shows two collision magnets experiments.

Figure 3. The wooden frame

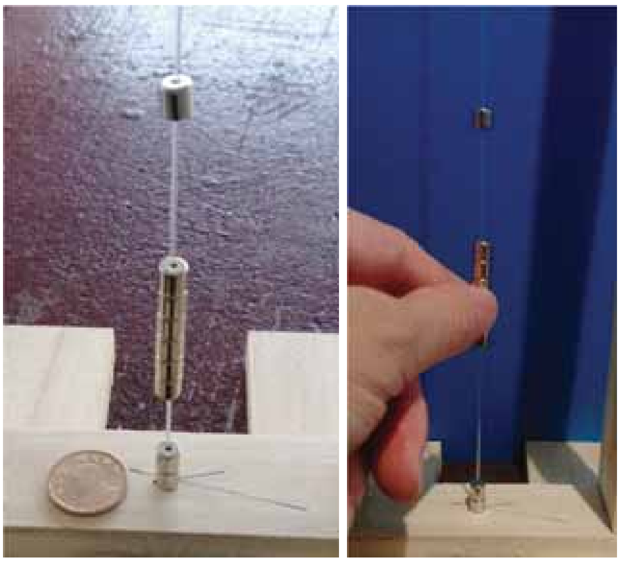

Figure 4. The magnets(left) and operation of the experiment(right)

The middle perforated magnet even can further be made smaller. With a finer fishing string (diameter of the middle fishing strubg is smaller than that of the middle hole of the magnets), a more mini instrument can be made, which is cost-saving and much more portable.

5. Application and Conclusion

The usage of magnetic force to conduct this elastic collision experiment is a pioneering work. On the one hand, it easily demonstrates the very interesting experiment which is seemingly ridiculous and unbelievable. On the other hand, utilizing magnetic force to conduct elastic collisions breaks the narrow understanding of collisions by ordinary people. It also makes people curious and confused and causes students to truly understand the nature of the collision. It is instructive and inspiring in elastic collision teaching.

In the science and education activities, this experiment is usually carried out with magnets of relatively small size to facilitate the promotion. To reduce the size and therefore to reduce the costs make it more convenient to carry the instrument around, However, in the early design shown in Figure 1, the upright thin rod must be hard and thin. It is quite easy to hurt people. In addition, the small magnet at the top of the experiment pops up and is easily lost. The smarter design in this article serves solves these problems simultaneously.

6. Acknowledgements

Thanks to the Ministry of Science and Technology for the implementation of the project (ID: MOST 106-2511-S-238-001-MY2).

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Advancing Science. Improving Education

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Abstract. The inspirational nature of the slogan for the conference is commended and it is suggested that in order to implement it, educational trainers should start by looking at the aims of school education and in particular the aims of teaching science. It is suggested that the most effective time to introduce science is in early years; to harness young children's curiosity and build on this enthusiasm in primary school. It is known that a good early science experience is important as a background to further interest and enjoyment of the subject. The author goes on to encourage the teaching of Earth Science as a relevant science subject for children since it extends and expands on their own experiences in their local environment. Earth Science identifies the important challenges facing our planet and everyone should have an informed understanding of these issues in order to be able to contribute confidently to decisions being made by world governments.

Keywords. Aims of science education, improving science education, early intervention, earth science.

1. Introduction

The title for this year's conference is an inspirational slogan, Advancing Science. Improving Education; but, where do we start? Often intervention schemes designed to enhance science participation are aimed at secondary age children, but I suggest from my experience, that this is far too late. A recent session at NARST [1] showed that teaching science in early years is more likely to lead to students taking up STEM careers. We all know that young children are curious and like to investigate; and most of us, as adults, parents, or teachers endeavour to develop this curiosity by pointing out items of interest-plants, birds, rocks, clouds. We try to encourage children to explore their local environments, be they urban or rural. In most developed countries, at nursery and pre-school, children are encouraged to explore and investigate. Thus they may develop their own concepts of how things in the world work [2]. However, these ideas are deemed children's science [3] and need to examined and discussed, and put into a scientific context so that children can understand how phenomena work and link together.

I believe that the place to start improving science is to identify what we really want our education systems to achieve. Do we want our children to become academics, or career moguls or knowledgeable citizens? Perhaps if we could recognise our main AIM for education then we would have a good starting point for science programmes; and following on from this, we could identify what it is we want our school science education to achieve. However, our starting point must be the children's interpretations, on which we can scaffold their journey to accepted scientific understanding, at an appropriate level.

2. The aim of education

A quick trawl through Google asking the question 'what is the aim of education' produces a wide range of suggestions. The most relevant to my mind is:

'to grow children into productive citizens who will use their knowledge, talents, and learned skills to sustain themselves and help others while pushing the human race forward in areas of equality, equity, and harmony'

Many academics [4-6], have made suggestions about the AIMS of a good education: Reiss [7] proposed that these aims should be dynamic, - moving with the times, perhaps? And that the main aim should be 'to develop individuals to the best of their ability so they can contribute to making the world a better place for themselves and society'. Subsequently, Reiss and White [6] concluded that the fundamental aim of a school education was to enable learners to lead a life that was satisfying in all ways, and enabled the learner to help others to do the same. They go on to state that this should include the 'acquisition of a broad background understanding, moral education, a life of imagination and reflection, and preparation for work.' Another revered academic, Joan Solomon [8] also talked about the need for education to prepare 'demotic citizens', in other words people who would be

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able to discuss and make decisions from an informed viewpoint. Many of these decisions concern the major challenges facing the planet today and are essentially scientific arguments.

In Britain, the House of Commons Education Committee recently completed a report [9] on The Purpose and Quality of Education in England where it asked many respected organisations for their views. Most of the received suggestions stated that it is important for young people to be able to be productive members of society – as well as achieving their full potential. Again, these views stress the need for education to deliver scientifically thinking citizens.

So having decided our Aims for Education, we need to identify what should be taught and why. It seems that 'science' features on everyone's list as a 'must do'. And, if it is so important, what should be included in our science curricula? We want our children to be prepared for life as thinking citizens, with skills, knowledge and confidence to contribute to making the world a better place for all [10]. We want a programme that develops our children into healthy, happy, caring and thinking adults who have a good grasp of the challenges and issues that face their lives, locally, nationally and worldwide. In other words we want our children to understand the Nature of Science and have the opportunity to become Scientifically Literate [11]. Too frequently our curricula are influenced by policy makers who have their own political agendas to follow and are not therefore in the best interests of the education system [12].

3. The aims of science education

We need our science curricula, but most especially our primary science curricula, to ensure the inclusion of an allround basic perspective on life. It is suggested that the science learnt at an early age is the science that stays with one for life [13], so it is essential to get this right. Early Years and KS1 science (ages 5-6) in England concentrates mainly on 'Understanding the World'. The English Early Years National Curriculum [14] suggests guiding children to make sense of their physical world and their community through opportunities to explore, observe and find out about people, places, technology and the environment. This, to me, offers the opportunity to use Earth Science as a starting point as it is the precursor to understanding the environment: rocks and soils, habitats, biodiversity and weather as well as the physical landscape. Teaching Earth Science also offers plenty of opportunities for critical thinking analysis as I discovered at a recent conference in Ukraine, when a delegate colleague decided to watch, then analyse my fossil workshop participated in by about 60 teacher delegates.

4. The importance of Earth Science

Figure 1. Earth Science

Earth science is an all embracing science which includes the physical sciences and physical geography (Figure 1). Earth science can provide young children with an early insight into biology, chemistry and physics through its application to their local environment and the relevant every day changes that can be experienced all around us. The diagram shows that earth science sits at the centre of science learning, and is the starting point for our understanding of science.

I would suggest that Earth Science should therefore feature heavily in our curricula as there are numerous challenges facing us which are scientifically biased – climatic change issues, the use of non- renewable resources, energy to name but a few.

5. Effective time to introduce science

Some researchers have suggested that science should be the essential component at the heart of the primary curriculum. Tawby [15] suggests that primary science should make a significant overall contribution to children's general education, providing authenticity to mathematics and literacy; a very different approach form the earlier didactic forms of teaching science. Pupils also need to develop competency in the range of skills that can be developed through science investigations, and these skills are important life skills which will be used later in everyday work. But what is essential is that any primary science curriculum keeps children's innate curiosity alive so they develop a real interest in the subject matter which they take on to their secondary schooling [11].

Figure 2. Children participating in a Time-Line exercise

I am particularly interested in primary education, having taught at post -16 level for most of my teaching career, then by running CPD sessions for trainee teachers and teachers, and devising workshops for undergraduates and young children. I later spent 20 years designing science weeks and days for primary schools, working with class teachers, identifying the areas of science where the teacher asked for support. I then translated these requirements into lessons with an investigative aspect and brought expert scientists and engineers into the classroom to help the teacher put over the topic. This method produced memorable lessons which when evaluated showed that the children had understood the concepts as well as acquiring new knowledge. But recently in my work with trainee teachers I have been horrified at the lack of what I would assume to be basic science knowledge (in my day called 'general knowledge') in the attendees at my CPD and graduate workshops. So this is my reason for wanting to start at the very beginning if we want to advance science

Figure 3. Children investigating different soils by feeling them

The 2006-2009 Cambridge Primary Review specifically collected evidence from interviews, focus groups, official data and research focussing on a vision for primary schools in England. The review suggested that quick political–fixes and snap reforms should be replaced with a long term sustainable vision, grounded in secure evidence. The project evoked interest in over 150 countries as well as across the UK at that time.

The Review goes on to argue for a curriculum that includes a core of essential

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knowledge, skills and experience drawn from all subjects. Obviously there is need for literacy but the core should include essential knowledge, skills and experience drawn from all subjects. The Trust suggests that because of the diversity of economic, cultural and linguistic differences across the country there are a great number of educational circumstances and needs. If the curriculum was more responsive to local issues and opportunities, children would feel their education was relevant

Figure 4. Trainee teachers investigating erosion

At present, this does happen in the best of our schools, which don't just work closely with their local communities but live the very idea of community in their everyday work and relationships [16]. By looking at issues within their own environment, primary children can and do become cognisant with their local communities, and perhaps more involved in local projects, interesting their families as well. Local flooding, pollution issues, energy saving, recycling are some of the many ideas in which children can put their developing scientific skills to work to find answers to small investigative problems. This gives them a sense of purpose, which helps develop good scientific attitude, something we should be aiming at in our early science teaching. Primary children recently developed ideas for investigations [17] for Commander Tim Peake to carry out in space and these showed how diverse and innovative their thinking can be –'do spiders spin webs in space?' was just one example. Children also developed menus for the space crews, and were involved in a nationwide investigation to see if being in space had any effect on seed growth.

6. Why use Earth Science in the curriculum?

I would suggest therefore that our curriculum would do well to look at Earth Science as an all embracing topic which incorporates all needs at junior level – from age 7-11. Earth Science as an inclusive subject can be used as a cross curricular base, linking all the usual academic subjects but grounding them in the local environment, making science relevant. Our Early Years and Infant curricula currently enable children to explore what goes on around them. Obviously this work is at a very basic level, but it gets children thinking about their sense of place and position in it: how things that they do can impact on their environment, like dropping litter, turning off lights to save energy and not wasting water. They examine everyday materials and soil; investigate where specific plants grow and animals live, and observe the weather.

At the junior stage this can be taken much further and the links Earth Science and the local environment make to other subjects can be exploited locally, nationally and internationally.

There are a number of places where I would include Earth Science as a starting point in our present English science curriculum. We have a section headed 'rocks', which includes comparing and grouping rocks on the basis of their appearance and simple physical properties. Whilst looking at rocks I would identify the minerals in them, and make this lead into a section on materials. This would look at metals and their properties and link them to everyday usage and availability.

Another section requires soils to be taught, and again this section can lead back to rocks and weathering processes. Soils are linked to plant growth and thence to habitats, and at an extreme to food. Fossils and evolution are examples of how animals relate to habitats, which most children find engaging and motivating. Discussion of weather and climate would follow naturally here.

Water is a good resource to show solids, liquids and gas reversible changes, puddles and clouds being visible relevant examples. Irreversible changes can be seen when glass is compared to sand and produced through heating at high temperatures.

Most of these examples can be used as investigations. Weather in particular is a good example of a cross curricula activity used as an enquiry with opportunities for written follow up work (literacy) and the data representation in mathematics.

So Earth Science can be used to introduce the other physical sciences – biology, physics and chemistry – using experiences that children can relate to. Thus the more abstract concepts are learnt through initially investigating familiar materials; for example changes of state of water through liquids to either gas or solid.

Figure 5. Children investigating rocks in a workshop

The latest curriculum developments in the United States [18] suggest that Earth Science should be taught as a major theme throughout their schools, in an effort to encourage more informed thought and decision making about challenges and issues facing the nation. Links are made between earth science, the physical sciences, life sciences and engineering so the social dimensions of national proposals could in effect be discussed with understanding.

Unfortunately this curriculum is not statutory but a number of states have taken it on board with pleasing results [19].

7. Importance of Earth Science, nationally and internationally

The Geological Society of London recently published a report through the European Parliament [20] 'Geology for Society' which identified Earth Science issues and the challenges Europe and the world are facing. The report notes that earth science is rarely taught in schools and feels that it is important the public understands issues relating to energy, mineral resources (especially rare earth elements needed for modern technological appliances), water ,hazards, and environmental issues to name but a few. It states that earth scientists must communicate these issues more effectively, so that the population can be better aware and able to debate from an informed standpoint.

8. Conclusion

At the end of the day if we want to advance science and improve education we need a society that has had a good experience of both in their formative years. I want to see everyone enjoying their primary education because it is relevant to them. This will provoke further interest at secondary and tertiary levels and eventually produce a new crop of citizens who are not only advancing science but are overall scientifically literate citizens who are thoughtful and able to participate in taking decisions to alleviate the challenges facing our planet. This I know is Utopia, but we must start somewhere, and the beginning is a good place.

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An Example from the Basic Engineering Project Subject at the UPC Telecom-BCN School: Learning Radiofrequency Links, Antennas and Amplifiers with the Help of Recycled Materials

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Abstract. The Basic Engineering Project is a third-year subject and the second of four stages tackling design-implemented subjects in the 4-year Telecom BCN curricula. The Introduction to Engineering subject is the first stage and the degree Thesis is the last one. The Basic Engineering Project focuses on technical design, construction, measurement and validation of guided system blocks, which are part of a complex ICT system. The current implementation of the subject enables the students to choose among four different complex system orientations according to the chosen major, namely: (i) sound amplification (electrical engineering specialization), (ii) sound characterisation and enhancement (audiovisual systems), (iii) network protocols and mobile apps (networks engineering), and (iv) WiFi radiolink (telecom systems).

This work addresses the latter specialization, which includes the design of antennas with low-cost/recycled materials and matching a microwave amplifier with adhesive stubs.

Keywords. Design-build subject, hands-on-lab, project-based learning, telecom engineering.

1. Introduction

The Basic Engineering Project is 6-ECTS subject, part of the 4-year-long bachelor degrees at the Telecom Barcelona (BCN) - Electrical and Telecom Engineering School of the Technical University of Catalonia (UPC), started 2010-2011 and implemented according to Conceive-Design-Implement-Operate (CDIO) standards. A detailed description of the four design-implemented subjects, Introduction to Engineering (6 ECTS), Basic Engineering Project, Advanced Engineering Project (6 ECTS), and thesis project (24 ECTS), in the degrees' pathway can be found in [1-3].

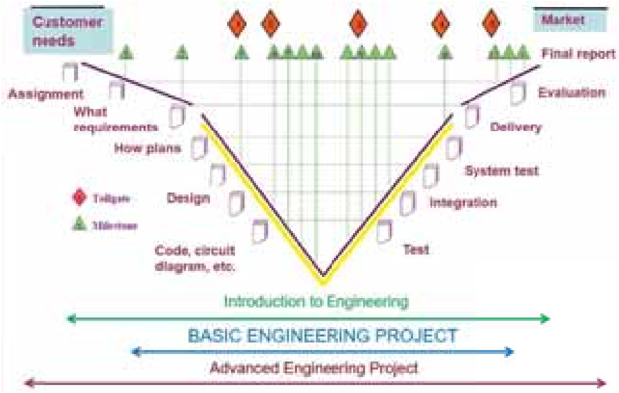

Figure 1. The V-shaped diagram in the LIPS project cycle (adapted from [6])

Central to the CDIO strategy is the break-down of a complex system into smaller parts or subsystems, which enable the students to work in teams and to be exposed to different implementation possibilities [4-5]. In the case of the Basic Engineering Project the project is narrower in scope (i.e., implementation possibilities are lesser and the system breakdown is defined by the faculties) but conveys higher technical difficulty. Figure 1 illustrates the project formulation in comparison to the other two design-implemented subjects, Introduction to Engineering (wide scope - low technical difficulty) and Advanced Engineering Project (wide – high).

Table 1. Targeted skills in the Basic Engineering Project [2]

#	Generic Skill	Exposed	Stressed	Assessed
1	Innovation and entrepreneurship	X	X	X
2	Societal and environmental context	X	X	X
3	Communication in a foreign language (English)	X	X	
4	Oral and written communication	X	X	X
5	Teamwork	X	X	
6	Survey of information resources	X	X	
7	Autonomous learning	X		
8	Ability to identify, formulate and solve engineering problems	X		
9	Ability to Conceive, Design, Implement and Operate complex systems in the ICT context	X	X	X
10	Experimental behaviour and ability to manage instruments	X	X	

Targeted generic skills in the Basic Engineering Project are summarised in Table 1. Assessed skills are highly variable among the different project teams (4 students per team) since the faculties act as both "clients" (project specification) and "technical consultants" (coaching students).

In addition to these skills, *learning outcomes* include: a) on the technical side: (i) multi-disciplinary knowledge about the project topic (students revisit and intensify concepts learnt in specific subjects along the curriculum or being taught during the same academic year), (ii) design and simulation tools, system characterisation, instrumentation and measurement techniques, and (iii) fabrication skills; b) on the transversal side, focus is on project documentation and technical writing.

2. Course implementation

The Basic Engineering Project subject comprises two *tracks:* A 2-ECTS track on the regulatory aspects of ICT projects (which is an important part for ICT practitioners in Spain) and a 4-ECTS track (3 h/week of the lab activity plus 4 h/week of autonomous work) focusing on the complex-system project chosen according to the degree's specialization. For the *major on telecom systems* the proposed project deals with the *design of a short-range radiocommunications link in the 2.45-GHz WiFi band (the "WiFi radiolink" in what follows) by using recycled materials to build the antennas* [7]. The lab. group assembles a maximum of 20 students organised in 5 teams of 4 students each.

The *course schedule* is shown in Table 2 and it is explanatory of the break-down of the complex system under study.

The first block (weeks, w1-3) addresses basic concepts in radiocommunications (free-space, Line-of-Sight and Non-Line-of-Sight propagation, Figure 2, and key related subsystems) around short expository instruction time from the lecturers' side (30 min/session), Moodle-based course materials, and guided reading [8]. Hands-on instruction and *learning outcomes* aim at:

- engaging the students to program their own radio-propagation link-budget simulator in Excel™ (milestone M1), and
- familiarising with transmitters (TX) and receivers (RX, Figure 3a,b), digital modulations and performance (Binary Error Rate (BER) measurement, M2).

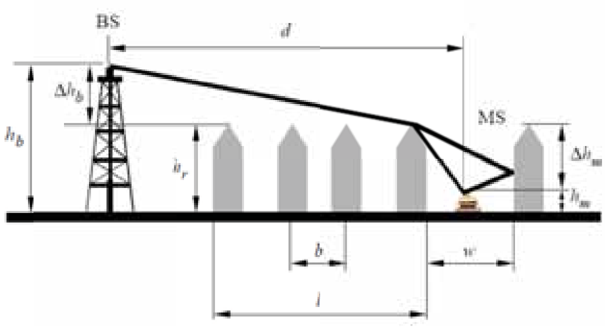

Figure 2. ITU-R 1411-1 model: Example of definition of parameters for the Non-Line-of-Sight transmission case in a short-range outdoor radiocommunication system [8]

The second block (w3-8) is aimed at the construction of five different types of antennas (horn, corner reflector, patch, Yagi, and helix; one for each lab team) by using low-cost / recycled materials. Although a key output of this block is the antenna prototype by itself (M3) hands-on learning involve:

- getting acquainted with antenna simulation software either academic- [9] or professional-oriented (NEC) [10].
- one-port measurements with the microwave Vector Network Analyser (VNA) with a view to antenna impedance matching (M4),
- antenna pattern measurements (M5).

Block two is the most demanding one and hence, the lab teaching strategy essentially combines individual coaching and supervision of each lab team combined with short expository-time guidelines from the lecturers' side.

The third block (w8-11) tackles impedance matching of a microwave amplifier (Figure 3c, to be integrated as an optional block of the WiFi link in reception) using adhesive stubs. Learning goals target:

- to know how and to simulate maximum-gain and minimum-noise amplifier matching techniques with simple CAD microwave software (M6) [11].
- to perform two-port S-parameters measurements with the VNA with a view to amplifier matching (M7).

The last block (w12) wraps up the whole WiFi-link project by carrying out range- and received-power tests outdoor in the Campus with low- and high-speed beacons. By this means, each lab team has the opportunity to revisit and validate their own power link-budget assessment (first presented in the Preliminary Design Review (PDR), w3) by assimilating their antenna and amplifier parameters measured so far.

Project documentation encompass PDR, Critical Design Review (CDR, w8) around the antenna design, and Final Design Review (FDR, w13). A guided outline for each of these deliverables is provided along with indication of the maximum no. of written pages in order to foster succinct scientific writing. Documentation format is a simplified mix of adapted European Space Agency (ESA) templates and the LIPS standard [6].

Table 2. Course schedule (telecom systems track, WiFi radiolink; "M" indicates milestone)

w	ACTIVITY
1	Course introduction (tasks and deliverables). Link-budget (I): Foundations
2	Link-budget (II): Simulation (M1). Wireless transceiver (CC2500): BER assessment (M2).
3	**(PDR)** Link-budget deliverable and oral presentation. Antenna design principles
4, 5	Antenna design and manufacturing. Antenna lab tests: Impedance matching (M3-4).
6, 7	Antenna outdoor measurements: Far-field radiation pattern and gain (M5)
8	**(CDR)** Antenna results, prototype & presentation. Impedance matching: Simulation with PUFF
9	Impedance matching with PUFF: Revision. RF amplifier (I): Matching networks for max-gain design
10	Foundations of the Vector Network Analyser (VNA). RF amplifier: Matching networks (w. stubs) (M6)
11	RF amplifier: Matching networks (w. stubs) & VNA test (M7). RF amplif. (II): Minimum-noise design (simulation)
12	WiFi link: Outdoor measurements & validation (M8)
13	**(FDR)** Final design results and oral presentation

Students are assessed on a progressive basis: PDR (10%), CDR (25%), FDR (50%). The remaining 15% of the mark accounts for the achieved team work in the lab.

The course runs in the radiofrequency (RF) teaching lab of CommSensLab (UPC), which includes basic RF/microwave instrumentation (two VNAs over 3 GHz, one noise figure meter, spectrum analysers, RF synthesizers) and a small anechoic antenna test chamber though only the VNAs are of concern for the present project. The lab is also equipped with a workbench and tools, 10 computers, and RF simulation software already mentioned. Key start-up items delivered to each lab team are summarised in Figure 3 in addition to connectors and cables to build the antenna. The UPC shield CC2500 enables direct interface with Arduino UNOTM and hence, a wide range of configuring possibilities of the RF transceiver (Sect. 3). A limited stock of PVC tubes (e.g., to build the Yagi antenna boom), RF connector pigtails, aluminium ground planes and aluminium foil tape, and copper rods (e.g., to build the dipoles) are also available.

Figure 3. Start-up items. (a) UPC-designed TX/RX system based on the low-cost low power CC2500 radiofrequency transceiver. (b) Similar TX/RX operating as power meter. (c) 2.4-GHz amplifier (position/size of adhesive stubs 1-2 to be found by the students)

3. Example results from the WiFi-link project

Next, example results are shown for selected milestones in Table 2. Results have been compiled and adapted from selected students' FDRs and do not intend to be exhaustive of the whole course syllabus.

3.1 Preliminary WiFi-link performance

The first example (M2, Table 2) aims to study the performance of the WiFi link over a 35-m path between bldgs. C3 and A3 over "Plaça Telecos" square (North Campus, Telecom-BCN School), which is to be set up by the students during w6-7. At this preliminary step (w2), which is carried out in the lab (outdoor test is postponed until w6-7), the link performance is studied in terms of the byte error probability (as a proxy of the BER) between two CC2500 transceivers (Figure 3a). One transceiver is configured as TX and the other one as RX, both interconnected by means of a 70-dB attenuator chain. The TX transmits a pre-defined known 10-byte digital sequence (0123456789) in endless loop fashion, which is later used to statistically estimate the error rate. The 70 dB figure is representative of the expected TX-RX losses (incl. free-space propagation losses). Figure 4 results show that FSK-2 modulation outperforms OOK and that performance is poorer for high-speed beacons, which is in agreement with theory.

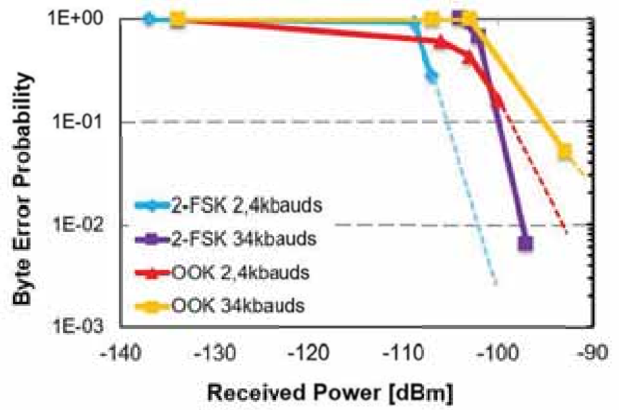

Figure 4. Byte error rate for the lab. Transmission. (Adapted from A. Gonga, A. Pérez, A. Roig and V. Wasmer, FDR, spring 2018)

3.2. Antenna block

A detailed technical procedure on the implementation of the different types of antennas can be found in [7]. The students recycle or buy for themselves the rest of low-cost materials (Sect. 2) needed to fabricate their antennas (M3, Table 2 and Figure 5), which is a good exercise of planning and creativity.

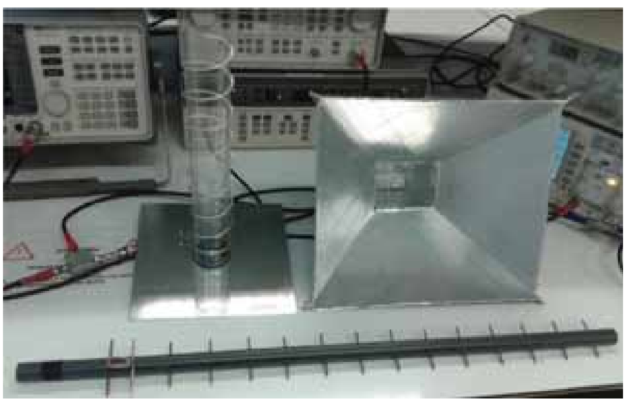

Figure 5. General view of the helix (left, second plane), horn (right) and Yagi antenna (first plane)

For the horn antenna, examples or such recycled materials include a milk tetra brick, which is used as waveguide, foamcore (i.e., a board of polystyrene foam clad with an outer facing of paper on either side) and aluminium tape to make all the walls conductive.

Another example is the helix antenna consisting of a conducting wire (e.g., coil-recycled copper cable) wound in the form of a helix mounted on a reflector. A methacrylate cylinder or a plastic dowel is of help to wrap the wire around. Concerning the Yagi antenna copper rods for the reflector and passive dipoles and a recycled PVC boom are used. To help the students in the balun (balanced-unbalanced) fabrication and soldering process a 2x1-cm through-hole printed circuit board (PCB) is used.

Outdoor antenna pattern and gain measurements (M5, Table 2) are carried out by means of the set-up shown in Figure 6.

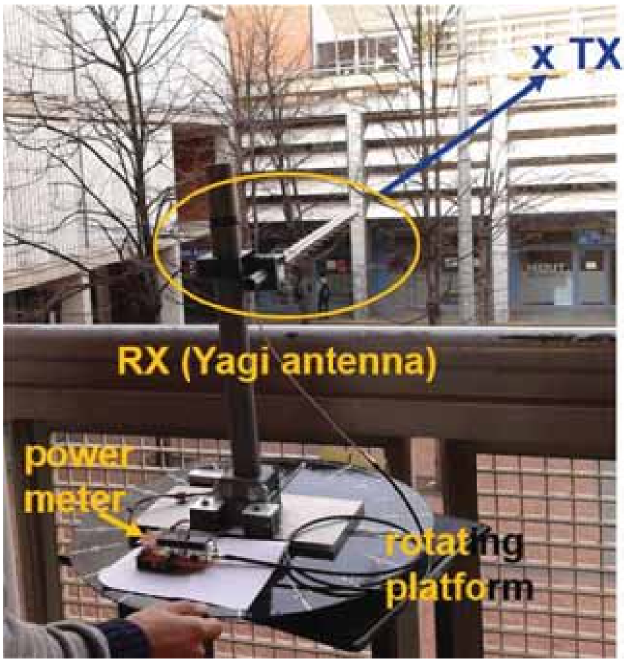

Figure 6. Outdoor antenna measurement set-up (“Plaça Telecos” square, North Campus, Telecom-BCN School)

In transmission (TX) the base station is composed of one CC2500 transceiver (Figure 3a, b) and a four-patch antenna array of known gain, which is given by the faculties. In reception (RX) the antenna under test is positioned on a supporting bar on a rotating platform made of plastic-coated rigid cardboard. In RX, another of such transceivers is configured in Received Signal Strength Indicator (RSSI) mode to measure the received power. The platform has an angular resolution of approximately 9 deg, which is enough for the antenna types considered. E- and H-plane pattern measurements (Figure 7) require to turn both TX and RX antennas 90 deg.

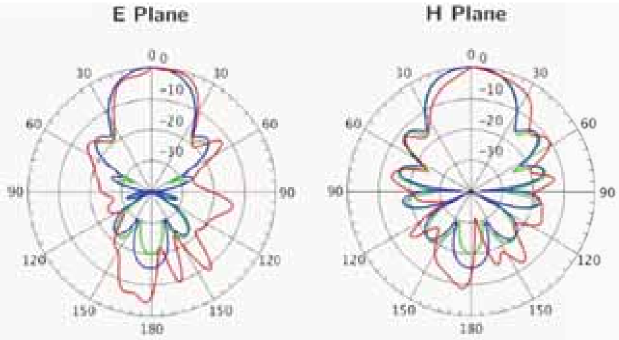

Figure 7. Yagi antenna E- and H-plane radiation patterns (refer to Figure 6). (Blue/green) Theoretical pattern (NEC/Matlab™) [10]. (Red) Measured pattern. (Source: M. Oller, J.A. Ballester and C. Segarra, FDR, spring 2016)

3.3 Amplifier block

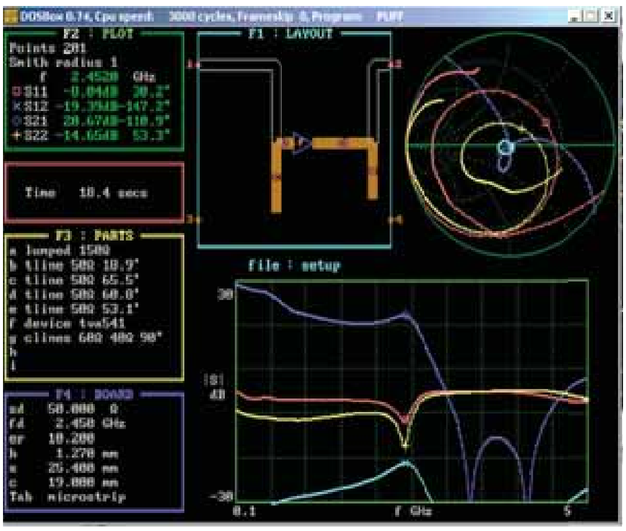

Figure 8. Amplifier matching simulation with PUFF software [11]

Figure 8 shows PUFF2.1 simulation results (M6, Table 2) under the criterion of maximum-gain design. As a previous step to the simulation process the students measure the operating point of the BFG424F transistor (typ. 3V, 10 mA) so as to incorporate the appropriate common-emitter S-parameters into PUFF. Adhesive stubs (to be fabricated by the students, Figure 3c) can be modelled as 6 pF series capacitors because the glue acts as an insulator between the PCB microstrip line and the metallic part of the adhesive stub.

3.4. Outdoor measurement campaign and link-budget validation

This section essentially addresses M8 in Table 2.

In order to carry out outdoor measurements with the WiFi link designed so far, a base station (BS) composed of a CC2500 transceiver and a monopole antenna in transmission is installed on the roof of D3 bldg. The mobile stations (MS) are each one of the students' lab team antennas connected to pertinent CC2500 transceivers configured in power –meter mode. Figure 9 depicts received power levels by one of the MS and related error rate as the MS moves along a row of buildings in the Campus. As expected, received signal levels become lower and lower as the MS moves apart from the BS. Reception cuts out in Non-Line-of-Sight (NLoS) situations arising when the MS is between building alleys or very far. Thus, red font labels represent the average number of wrong bytes per transmitted message (10-byte message).

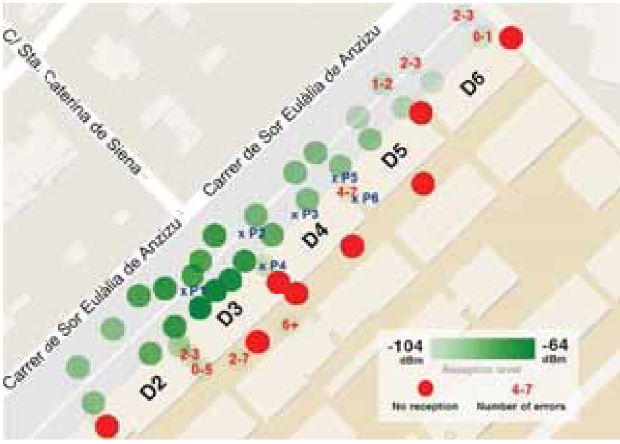

Figure 9. WiFi link performance map. (Green dots) Received signal strength [dBm] (Yagi antenna lab team). (Red dots) Points without reception (Yagi). (Blue points P1-P6) "Patch antenna" team measurement points. (Adapted from M. Oller, J.A. Ballester and C. Segarra, FDR, spring 2016)

Finally, Figure 10 shows categorization of measurement points P1-P6 (Figure 9) into the different propagation situations under study (free space (FS), LoS, NLoS, refer to Sect. 2).

This categorization is achieved by using the propagation-model simulator previously developed by the students (M1 in Table 2) and which is refined now upon validation milestone M8.

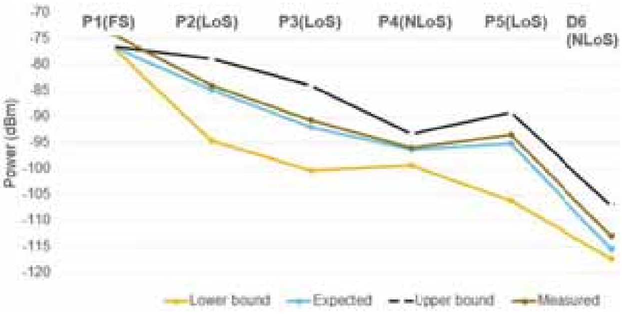

Figure 10. WiFi link: Validation of the categorization of the different reception situations at points P1-P6 (refer to Figure 9) according to ITU1411-1/7 model. (Back line) Theoretical received-power upper bound. (Yellow) Theoretical lower bound. (Blue) Theoretical expected level. (Brown) Measured level (patch-antenna lab team). (Adapted from J. Calderón, F. Guinot, D. Palacios, N. Solà, FDR, spring 2018)

4. Conclusions

All in all, the basic engineering project is to instil on BSc telecom students at the UPC Telecom-BCN School the critical thinking spirit while having hands-on lab.

After eight successive editions (2011-today) CDIO design-implement subjects are demonstrating to be an effective way to foster this challenge on a rampant technological environment as well as a suitable way to explain simple complex reality.

5. Acknowledgements

CommSensLab (merging into a single body Remote Sensing, Antennas, Microwaves and Superconductivity) is a “María de Maeztu” Unit of Excellence funded by the Agencia Estatal de Investigación, Spain. This work has been funded by María de Maeztu MDM-2016-0600, and the Spanish Ministry of Economy and Competitiveness - European Regional Development Funds under TEC2015-63832-P project. Generalitat de Catalunya (Grup de Recerca Consolidat 2017-SGR-272) is also acknowledged.

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BioPREVENT AI^{TM}: A Spanish Health-Care Startup Borned from the Influence of Bioinformatics in Education and Society

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Abstract. Since the last decade, bioinformatics have suffered an exponential grow due to the appearing of big data and artificial intelligence (AI). Those advances definitely help scientists to increase the accuracy when modelling systems, predicting structures or building phylogenetic trees, among other functions. Unlike in the research context, bioinformatics seem to be unappealing for students and this is a deciding factor when forming health-care experts with no knowledge in bioinformatics on any related field. In this article the importance of some basic tools in molecular modelling are highlighted and some insights into current applications and projects carried on by the author are reported during the period of 15 – 18 years old. The tools used are also listed so that the community can design their own projects in their courses.

I want to encourage educators and teenagers to get interested in bioinformatics and discover a new way of making science, as not all high schools have access to a laboratory, but mostly all have access to computers and a network. Furthermore, there is a discussion about BioPrevent AI^{TM}, a Spanish health-care startup founded by the author of this article, which is interested in developing tools using AI to predict and prevent diseases, all by making use of bioinformatics.

Keywords. Bioinformatics, entrepreneurship, education, resources.

1. Introduction

Since the last decade, with the first sequencing of the human genome, bioinformatics have caused a big revolution in society, providing new insights into diseases and the capability to prevent or detect them at early stages. There is no doubt that bioinformatics and molecular modelling are shaping the future of science, the designing of more complex models that resemble the reality is becoming a reality. As an example, United States has launched the Brain Research through an initiative called BRAIN to map the neural connections and advance in the development of new neuro-technologies [1]. Researchers from the University of China have also provided new insights into the metabolome and the proteome using advanced and complex bioinformatics with the help of artificial intelligence algorithms [2].

Bioinformatics can be defined as the application of computational tools to organise biological data and use it to generate new one [3]. Right now, bioinformatics have an increased success in combination with artificial intelligence. Novel algorithms provide new insights into the structures of proteins, prediction of binding sites or new ways to detect cancer using image recognition [3-4]. The goal of bioinformatics is to organise data into clusters of information so that researchers can access the information, develop tools that help society and contribute to new findings by generating tools to interpret the results from biological experiments and predict the outcome [4].

From the educational point of view, mainly focused in high schools, bioinformatics is a term sometimes misassociated only with comparative genomic tools, sequence alignments,…, without taking into account that bioinformatics and computational modelling do also include protein modelling, systems simulation or evolutionary analysis. It is also true that bioinformatics is unknown for students until they reach university, being one of the main reasons of creating highly competitive profiles without basic knowledge in informatics or any programming language [2-3]. The author suggest this might change in a close future due to the importance that informatics is gaining in society.

2. Bioinformatic tools in education and society

In the current section, the author is going to describe some of the most used tools in bioinformatics as well as their application in scientific research. Some current applications that were gave to this tools are going to be reported so that teachers and students can reproduce them in their courses.

2.1. Sequence alignment and phylogenetic analysis

Sequence alignment has been used since the first sequenced genomes in order to determine the species to which the genome belonged to as well as to build phylogenetic trees. Alignment has been processed by the increase in availability of data generated by NGS (Next-generation sequencing) technologies. This process simply consists in comparing nucleotide or protein sequences to a database seeking for significant differences and sequences with a high level of identity (high p-value or low probability of being taken randomly). These tools also allow researchers to identify variations in sequences (single nucleotide polymorphisms or SNP's) and associate differences in genotypes and phenotypes [5-6].

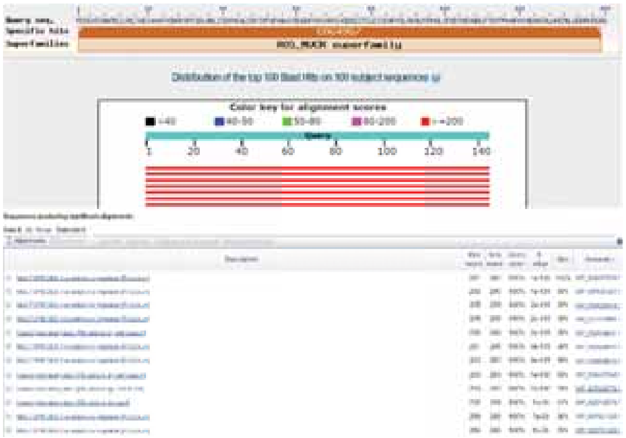

Figure 1. Protein BLAST using NCBI online tool used to stablish the species belonging of a specific aminoacid sequence

The author used a tool called ClustalW for progressive multiple sequence alignment of different species in order to determine their differences. BLAST (Basic Local Alignment Search Tool) was also used in order to identify the belonging of some sequenced genomes from whose species were not identified [7]. This was done specially for a contest called Stick out your Tongue, where users had to identify the species from a given sequence, and allowed me to win a two-week internship at the Centre for Genomic Regulation (CRG), in Spain (Figure 1). Phylogenetic trees were performed using the Simple Phylogeny web server provided by the EMBL (European Molecular Biology Laboratory), which lets users build a full phylogenetic tree from a single sequence as input. All tools listed are free to use and available for institutions and no commercial profits.

2.2. Molecular Docking

The molecular docking approach is used to model the interaction between a ligand and a macromolecule at the atomic level, which allows us to simulate the affinity of certain molecules when bound to the active site of the protein. The docking procedure involves two basic steps: prediction of the best ligand conformation to be bound to the protein binding site and assessment of the binding affinity. The affinity of a ligand in front of a protein is measured by the Gibbs Energy, which provides a close insight into how effective the reaction is when the ligand adopts a certain conformation. Ligands can range from a small molecule, to a DNA fragment, a long or short non-coding RNA, a peptide or even an ion. Researchers make usage of this tools in order to screen millions of molecules with the aim to find the best hits that could potentially act by inhibiting a certain protein related with a specific disease [8-9].

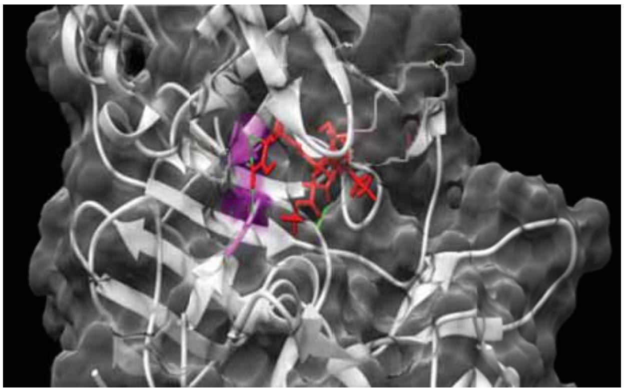

Figure 2. Docking results of the best ligand interaction with BACE-1's active site. Visualisation performed with Chimera

SwissDock (web server) was used along with AutoDock and PyrX in a project presented to the Google Science Fair which was related with the discovery of novel applications of the current drugs approved by FDA (Federation of Drugs and Aliments) against Alzheimer. I was using PyrX to screen millions of FDA commercial drugs and obtain a result of the best hits to find a candidate to inhibit BACE-1, an enzyme which forms beta-amyloid aggregates during the stages of the Alzheimer disease (Figure 2).

Furthermore, MIB (Metal-Ion Binding Site Prediction and Docking Server) was also used to develop a project in which magnesium was proposed as a possible ligand to bind with calmodulin (a calcium regulatory protein) in conditions of hypocalcemia. MIB allowed me to generate a binding affinity graphic between calcium and magnesium against calmodulin binding residues by making usage of molecular homology and docking. Results determined that magnesium could only bind one out of the four binding sites of calmodulin and therefore it was discarded as a possible ligand to substitute calcium in hypocalcemic conditions [9].

Both AutoDock, PyrX and MIB are free to use and available for institutional usage.

2.3. Molecular Dynamics

Those are more advanced techniques used to simulate real biological simulations. Molecular dynamics are very powerful for modelling a protein in a specific environment during a certain timeframe [10]. A specific environment means specific conditions of temperature, the presence of ionic substances and a certain solvent. This allows researchers to simulate complex structures, for example, a specific protein in water (major solvent in the cytoplasm) under a specific thermodynamic environment [11].

Molecular Dynamics were used to simulate DNA structures with different epigenetic conditions (methylation, hydroxymethylation and formylmethylation in the cytosine nucleotide located in CpG islands) and water as a solvent in order to see whether those epigenetic conditions had a certain effect in DNA physical properties and therefore could have a potential impact as cutting-edge research in the development of novel epigenetic drugs based on modifying the epigenome. Those results were lately compared with results obtained from circularization assays, as the formation of circles of DNA can be used as a measure to determine whether a molecule is more or less flexible. Results from both experiments lead to the same conclusion. This study provided me with the 1st Prize of the National Contest in Catalonia. The work was valuable not only because of the results achieved, but for showing the importance of bioinformatics in order to predict and simulate biological systems.

Simulations of transmembrane proteins in certain thermodynamic conditions in the cell were also performed in order to analyse the fluidity of the bilipid layer (Figure 3).

This was performed using Maestro, which is available for a reduced fee for academic institutions and has a great graphical user interface (GUI) in order to set up the simulations.

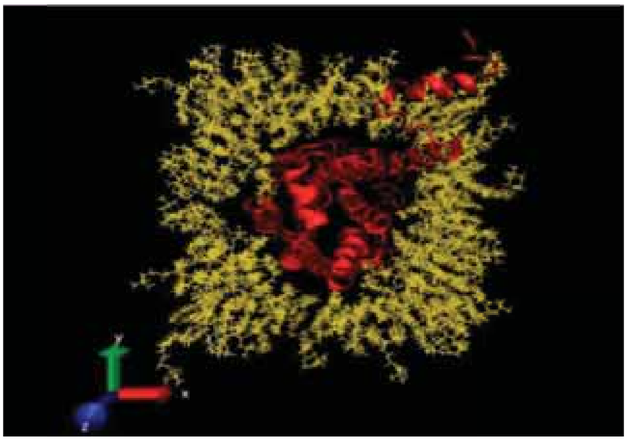

Figure 3. Representation of a timeframe of the transmembrane simulation in a solvent using Maestro

2.4. Monte-Carlo Simulations and Brownian Dynamics

The Monte-Carlo algorithm has a lot of implications when building systems from scratch. The algorithm allows you randomly change a random number of parameters with a certain criteria of acceptance or rejection [12]. This allows researchers to design biological systems within a few initial parameters and then use the metropolis of Monte-Carlo in order to create random structures [13]. Later on, due to statistics, the average of all structures will allow them to obtain a final configuration which resembles to the real behaviour of the real system [13-14].

Monte-Carlo was used in the analysis of the impact of methylation and demethylation pathways in order to generate a tridimensional model of a DNA strand with only the initial parameters and the stiffness constants obtained from molecular dynamics. With those parameters we generated individual random structures with fewer energy configurations (as most of the biological systems tend to reach minimal energetic values, corresponding to their bioactive conformation), except for a certain condition involving the Boltzmann constant (included in the metropolis of Monte-Carlo), in which higher levels of energy where also accepted. This condition was set up to avoid being in the minimal configuration with only a few iterations of Monte-Carlo [14]. Later on the mean of all configurations was performed in order to obtain a final configuration which resembled quite well the properties of the DNA sample of study. Analysis where correlated with the results obtained from both molecular dynamics and circularization assays, achieving the same conclusions. This bioinformatics project allowed me to obtain the 1st Prize in the National Scientific Contest for Young Researchers (Figure 4).

Figure 4. Random DNA structure generated with the Monte-Carlo algorithm to study its flexibility under certain epigenetic modifications

Monte-Carlo simulations were performed by ourselves in C++ and there is no software available to perform them with a graphical interface.

On the other hand, Brownian dynamics are also very useful in particle physics for studying the behaviour of particles in the accelerators or for seeing their effect under certain circumstances of high energetic levels or specific heat flow conditions. In biophysics those type of simulations allow scientists to study the behaviour of proteins with different conformations or study the aggregates of proteins and the interactions between them in a specific solvated environment [15-16].

I have used Brownian Dynamics in order to simulate the folding and the unfolding state of the A2 domains located in the Von Willebrand Factor (VWF), a protein linked with the formation of arterial thrombosis. This protein is reported to unfold under stenosis (reduction of blood vessels, increasing at the time the pressure of blood), and the unfolding state creates clots of platelets that aggregate to vWF. Our study simulated all of the protein domains as spheres and the A2 domains were represented as spring. Thanks to that, energetic levels of the A2 domain could be calculated using the Hooke's Law.

The system was set up in a specific initial environment (temperature, blood fluidity, heat flow) and we studied the frequency of unfolding of vWF in stenosis (Figure 5).

LAMMPS and GROMACS are free and useful software to perform both Brownian dynamics and molecular dynamics simulation. In our case we designed the system using python and later on visualized the results using a software called 3DSphere, in which we could specify the timeframe as well as the speed of the animation.

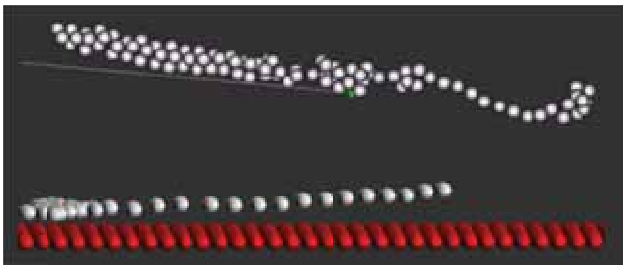

Figure 5. Simulation of the vWF using Brownian Dynamics. First one represents stenosis conditions and the second one represents unfolding in cell's membrane

3. Case report: BioPREVENT AI™, a successful health-care startup in bioinformatics set up by an 18 years old student

Talked about the importance of bioinformatics in both society and education, now we will discuss about the role of bioinformatics in project development and specific we will talk about BioPREVENT AI™, a recently setup Spanish health-care startup with Eric Matamoros (also the author of this article) as founder and CEO.

Until getting to University, high school students lack of the capabilities and institutions lack of the tools to develop projects that empower the scientist in all of us. As explained before, bioinformatics resources and tools are easy to use and available for everybody with access to a computer. Although at the beginning I was not a big fan of computers, they were the only tool I could use to get inside the scientific world and develop projects that could have a potential impact in society. That's how I started to get interested in the world of computing and later on I got immerse in artificial intelligence, until founding a health-care startup called BioPREVENT AI™ under the motto *'Prevention is the best cure for all diseases'* (Figure 6).

Figure 6. BioPREVENT AI™ logo under the motto Prevention is the cure for all diseases. Because we firmly believe that a proper diagnose on time is the most successful treatment

Initially the startup was called TBM Tumor Classifier, coming from Trained Benign Malignant Tumor Classifier, as we developed a single tool which was able to classify tumor images with an 83% of accuracy based on their morphological features. This allowed me, a former biochemist student, to win the Connceted Campus Idea Competition, held by the famous mobile company Huawei, in which the best ideas related with the advances of technology in society were presented by youngsters. At the time Huawei gave us advice and helped in order to take up a business and make our product available for everyone, as we only had a very basic prototype. Lately, a part from designing a solid application for mobiles that was useful and very promising, the company name changed to BioAI, which offered a wide range of services, including cutting-edge software for health-care experts to help them with the detection and the classification of polyps in colorectal cancer explorations or mammographies. It did not success because the product was not well presented and the name of the company was already registered.

Right now, the startup is called BioPREVENT AI™. We are developing cutting-edge tools using bioinformatics and artificial intelligence in order to help, not only health-care experts, but all users, to prevent their potential cancer and further diseases in a near future. We are not only intended to offer software for mobile devices and health-care professionals, we are also planning to host a cloud service in order to offer doctors a server to upload their own models and their patients pictures so that they can follow the progression of the disease in real time with the help of artificial intelligence. Furthermore, we are not only interested to make this product available to developed countries, but to have an impact around the globe, for that reason, campaigns to collect broken functional devices will be used so that we will install our services and them and those will be sent through ONG's to third-party countries, because they do also deserve to be safe. Everything has been performed by an 18 years old student, with no previous knowledge in computational modelling or programming languages, but with a heavy interest in learning and developing new ideas (Figure 7).

Figure 7. Usage of TBM Tumor Classifier, one of the tools to provide a quick prognosis of the nature of skin cancer conditions provided by BioPREVENT AI ™

4. Conclusions

Bioinformatics are very useful for researchers in order to study complex systems and predict their behaviour using biological data from the experimental assays. We are able to take that data and generate new one with using complex algorithms and artificial intelligence.

With this article we want not only to describe the most used tools in bioinformatics and their current implication in research lines, but to empower educators, teachers and students, specifically from high school and university institutions to start teaching students about bioinformatics and developing projects using the resources we have listed in this article. Bioinformatics help at those educational levels to stimulate students to develop projects on their own, to get interested for science and to live a real scientific experience that could lead to some discoveries. Bioinformatics gain more flexibility at the time of the topics you can explore when compared with performing biological experiments, as they reuiere less time and are less expensive, giving you the chance to get results quicker with less failure index.

For us, bioinformatics were the only way to have an impact on scientific society, because the lack of advanced equipment to develop research projects in the current lab of the high school limited our actions. As seen, they allowed us to develop interesting projects involving the study of DNA methylation, the unfolding state of vWF under stenosis conditions, to design inhibitors for oncogenes and even to set up a successful health-care startup with 18 years old and no previous experience in bioinformatics. We are really interested in promoting bioinformatics to students and explain them that it is possible to make scientific research since a very young age. Everything is possible with creativity, passion, interest and some knowledge in bioinformatics. It would be also interesting to impart lessons in academic institutions for teachers relating molecular computation and bioinformatics so that teachers can also get involved and play an active role by showing those methods and procedures in their courses.

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Breathalyser Mechanism: The Oxidation of Alcohol

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Abstract. In the field of applied chemistry, breathalysers are a wide range of devices used to evaluate blood alcohol content (BAC). It is mainly based on a chemical reaction: the oxidation of an alcohol (ethanol) with a carboxylic acid (acetic acid) in the presence of ammonium dichromate, which is reduced to chromium (III) sulphate in the presence of sulfuric acid. Qualitatively, this redox trigger a change from yellow-orange dichromate solution to a greenish-brown when the alcohol is oxidized. As these devices work within a small range of concentrations, the colour change cannot be completely distinguished.

To determine a relation between the amount of alcohol that has reacted and its concentration, it has been used a quantitative method: the spectrophotometry. Through the experiment procedure, 1mM and 2.5mM dichromate solutions have reacted with an ethanol dilution bank, and the reaction was proved in the spectrophotometer.

Keywords. Breathalyser, oxidation, redox, spectrophotometry.

1. Introduction

Breathalysers [1] are a deep spectrum of devices used to evaluate blood alcohol content (BAC). Its beginnings date back to 1931, when Rolla Neil Harger invented the drunkometer, a very rudimentary prototype similar to what Robert Frank Borkenstein would later invent in 1954, based on the reactions of oxidation and photometry to accurately determine concentrations of alcohol in a sample. Later these prototypes would be improved with infrared spectroscopy techniques. Thanks to the invention of this device, the security forces can accurately determine the alcohol concentration of drivers and assess compliance or not of the law.

2. Redox reaction of a breathalyser

The operation of the breathalyser is quite simple [2]. It is mainly based on a chemical reaction: the oxidation of an alcohol (ethanol) to a carboxylic acid (acetic acid) in the presence of potassium dichromate, which is reduced to chromium (III) sulphate in the presence of sulfuric acid.

Oxidation semi-reaction
$CH_3CH_2OH + H_2O \rightarrow CH_3COOH + 4\ H^+ + 4\ e^-$
Reduction semi-reaction
$6\ e^- + 14\ H^+ + Cr_2O_7^{2-} \rightarrow 2\ Cr^{3+} + 7\ H_2O$
Global reaction
$2\ K_2Cr_2O_7 + 3\ CH_3CH_2OH + 8\ H_2SO_4 \rightarrow 2\ Cr_2(SO_4)_3 + 2\ K_2SO_4 + 3\ CH_3COOH + 11\ H_2O$

Table 1. Reactions of a breathalyser. It can be clearly seen that ethanol is oxidised into acetic acid, while potassium dichromate is reduced into chromium (III)

Experimentally the progress of the reaction and the concentration of alcohol in the sample can be observed by means of the change of coloration that occurs in the reaction. This is because the dichromate anion is reddish-orange, while the chromium cation (III) has very dark green tones. This way you can see it qualitatively if the reaction has been carried out or not and, moreover, if it has occurred to a greater or lesser extent.

2.1. Reaction mechanism

The reaction that takes place, the oxidation of an alcohol, is catalysed by an acid. [3] It is commonly used chromic acid (H_2CrO_4), but chromate and dichromate ions in presence of an acid are efficient too. Primary alcohols like ethanol are oxidised, first, to an aldehid. [4] The reaction goes on until the aldehyde is oxidised and turned into a carboxylic acid, giving us the reaction product (acetic acid).

The mechanism is the following:

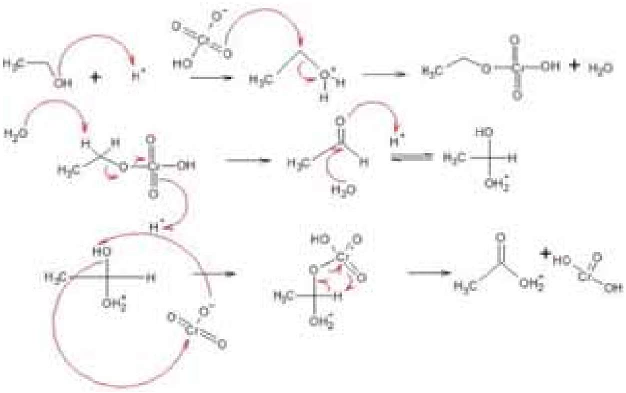


Figure 1. Mechanism of the reaction. The chromic acid attacks the alcohol displacing a water molecule. The water, acting as a base, deprotonates the intermediate and an E2 takes place forming a carbonyl group

3. Development of a breathalyser

Knowing the basics of the reaction which takes place in a breathalyser, some aspects ought to be taken into account. We have to analyse which concentrations to use so as to obtain a successful result. This will basically depend on two main points: the kinetics and the colour.

Figure 2. Ammonium dichromate solutions. From left to right, 10mM 1mM 0.1mM 0.01mM. The more concentrated the dichromate solution is, the more colourful it is

First of all, the reaction has to be fast enough to get the results in a reasonable time. Let us take a hypothetical case: this breathalyser is tested with a real driver in a motorway. Under no circumstances should it take a long time, otherwise it would create traffic problems and queues.

Moreover, there must be a significant change between the colour of the reagents and the one of the products. However, it is well known that the more a solution is diluted, the less colour it will have. 10 mM, 1 mM, 0,1 mM and 0,01 mM solutions were prepared, and in order to obtain both qualitative and quantitative results, the two last were eliminated because of the lack of colour that the dissolution and reaction showed.

3.1. Concentration analysis

First of all, the appropriate wavelength of a dichromate solution had to be found in the experiment, which resulted in a sweep of different wavelengths with the 1mM dichromate solution. Eventually, a 420 nm wavelength was used to measure the absorption of the solutions [5-6].

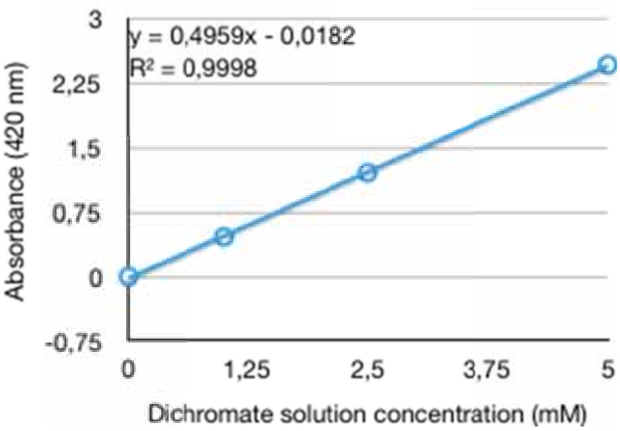


Figure 3. Absorption of different dilutions of dichromate. According to the Beer-Lambert law, there is a linear correlation between the concentration of a solution and the absorbance values

3.2. Reaction analysis

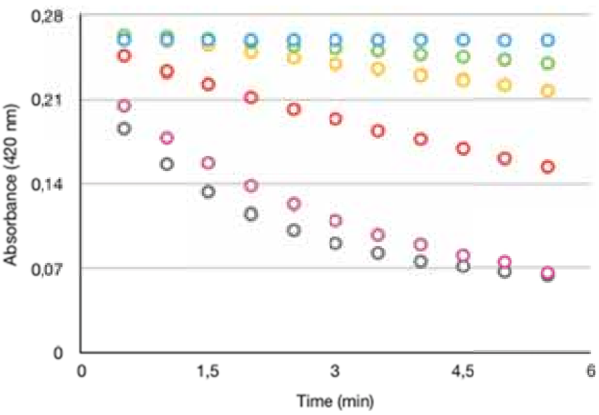


Figure 4. Reaction with 1mM solution of dichromate. It can be seen that the absorbance of the solution decreases as the time goes by, and so does the dichromate concentration. The colours in the chart represent the following quantities:

Twelve different samples were measured within the same wavelength (420 nm) every 30 seconds for 5 minutes.

Each sample was prepared in a test tube where 5 mL of the dichromate reactant were added along with a sufficient volume of sulfuric acid as the catalyser and different alcohol samples.

Figure 4 shows the results of the reaction with a 1mM solution of dichromate. Figure 5 shows the results of the reaction with a 2,5mM solution of dichromate.

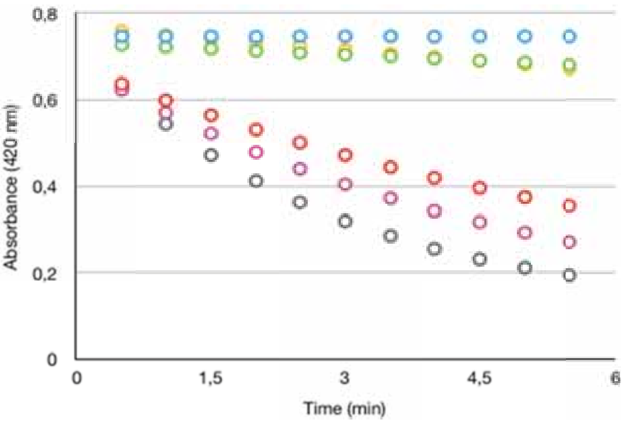
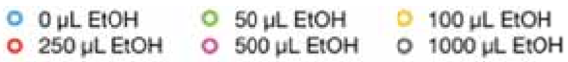


Figure 5. Reaction with 2,5mM solution of dichromate. As in the previous case, the concentration decreases. In fact, in both cases the reaction is faster when we use more alcohol. Again, the colours in the chart represent the following quantities:



4. Analysis of the reaction and results

So as to determine the concentration of alcohol that is reacting, a relation between the slope of the kinetics function and the concentration of ethanol reacting was made, resulting a more effective way to analyse the concentration of an unknown sample. First of all, a new relation was established between the alcohol concentration and the slope of the functions. The results can be found in Figure 6.

5. Conclusion

Taking all matters into considerations, the redox reaction has been analysed so that an alcohol concentration reacting may be determined. If a low ethanol concentration sample is analysed, the reaction is too slow to give a result qualitatively because of the late change of colour and spectrophotometry must be used: that would be the case of a real breathalyzer, taking into account that ethanol concentration in a person's breath is extremely low. If a higher concentration sample reacts, the change of colour is more easily seen, but cannot be compared to an actual breathalyser.

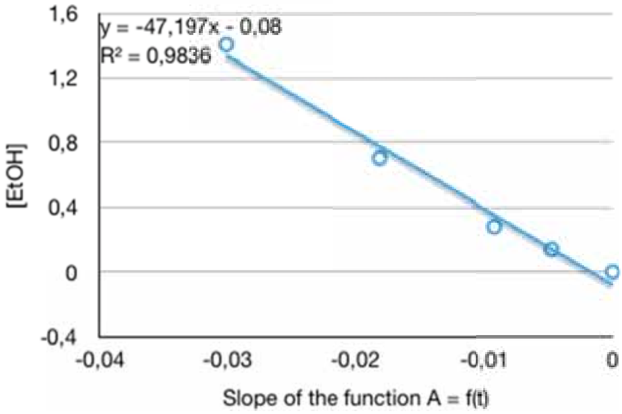


Figure 6. Relation of the slopes and the alcohol concentration. This function can be furtherly used to estimate the concentration of the alcohol in a sample. As a consequence, this would be the key point in a breathalyser

Thus, a direct relation between the concentration and absorbance of the sample has been established. However, proof has given that the reaction takes a long time to arrive to a final point in which the whole lot of alcohol has reacted, giving only the concentration in the point of the reaction that is being measured.

Given this fact, a path to analyse efficiently the sample passes through the kinetics breakdown. Each sample, given a dichromate concentration, will react in a different time. Thereby the relation between the time of reaction and the concentration is a good way to determine the concentration of an unknown alcohol sample.

6. Acknowledgements

The authors of this paper would like to strongly thank and recognise the supervision and tutorship of Dr. Josep Maria Fernàndez Novell through all the project.

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Colour, Chlorophyll and Chromatography

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Abstract. Being in front of a lush green valley, it is fascinating to observe the intensity of the colours. The colours of the plant reign that come mainly from the photosynthetic pigments, which in turn are responsible for one of the most interesting metabolic reactions. Pigments are organic molecules located in the chloroplasts of the leafs and capture energy from the visible light spectrum, that is needed to synthesize carbohydrates from inorganic matter. In other words, the photosynthesis starts with the pigments absorbing the visible light from the sun. There are many types of pigments and they have different colours and properties. Chlorophylls, carotenes, xanthophylls and anthocyans are the most common. In the present article, the proposed hands-on experience consists on the observation of those pigments. From different leafs samples and after a pigment extraction, separation of the pigments is performed by thin-layer chromatography (TLC). In order to characterize the different pigments, the retardation factor (Rf) values are calculated (the quotient between the distance travelled by the compound and the distance travelled by the solvent front). Finally, the pigments from the different leafs can be compared in order to determine if they have pigments in common or else and other pigments that only appear in one of the leafs.

Keywords. Chlorophyll, photosynthesis, pigments, extraction, chromatography.

1. Introduction

In 1943 Archer John Porter Martin, an English chemist and Richard Laurence Millington Synge, a British biochemist, made available for the first time the means of analysis components of plants and for their separation, purification and identification. Both scientists shared the 1952 Nobel Prize in Chemistry [1] for "their invention of partition chromatography". They discovered the paper chromatography.

1.1. Chromatography

Chromatography is a laboratory technique for the separation of a mixture. In our case, the mixture is an extract of plants [2]. This is dissolved in the mobile phase (water or ethanol or hexane or a mixture of solvents) which carries it through a structure holding another material called the stationary phase (paper chromatography). The various constituents of the mixture travel at different speeds, causing them to separate. Mobile phase and stationary phase usually are solvents. One of the solvents is water while the second is more or less hydrophobic such as hexane, chloroform, acetone, ethanol among others. Hence, the partition coefficient measures the hydrophilic or hydrophobic capacity of a substance. This ratio is therefore a measure of the difference in solubility of the compound in these two solvents.

1.2. Leaf pigments

Pigments are organic molecules with a characteristic colour. Plant pigments have different functions but the most popular one is to capture the visible light necessary for photosynthesis. This is the function of chlorophylls and also carotenoids and xanthophyls [3]. Other pigments such as anthocyanines or other flavonoids, determine the colour of flowers that is useful to attract insects or other animals so that plants are pollinized.

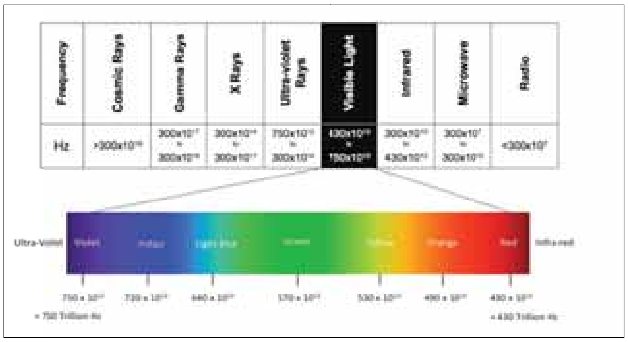

Figure 1. Electromagnetic and visible light spectrum

Photosynthetic pigments are located in the chloroplasts and have rings in their molecular structure that suffer electron rearrangements when excited by the light and they pass this energy to the photosystems, the complexes that are responsible for the reaction of photosynthesis.

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The different photosynthetic pigments (chlorophyll *a* and *b*, β-carotene, etc.) absorb different wavelenghts from the visible spectrum (Figure 1) so that they capture more light.

In fact, carotenoids are accessory pigments that transfer the energy to chlorophylls, that are directly connected to photosynthesis. Therefore, carotenoids (Figure 2) absorb violet, blue and green light and reflect yellow, orange and red (the colour of leaves at autumn, when they start to loose chloroplasts).

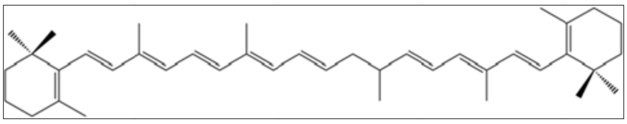

Figure 2. Structure of β-carotene

Then, chlorophylls absorb red and blue and, of course, reflect green, which is the colour of most leaves (Figure 3).

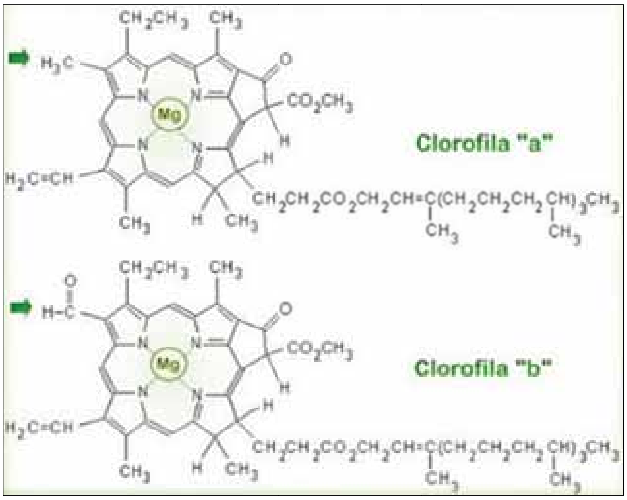

Figure 3. Structure of chlorophyll *a* and *b*

The other type of photosynthetic pigments are xanthophylls (Figure 4), which absorb violet, blue and green light and reflect yellow, orange and red. Its function is to capture spare light that chlorophylls can not take when there is high light.

They can not pass the energy to the photosynthesis and they simple convert its energy to heat.

Finally, anthocyanins have variable absorption and reflected colours that correspond, as we can observe from nature, to the different colours of flowers [4].

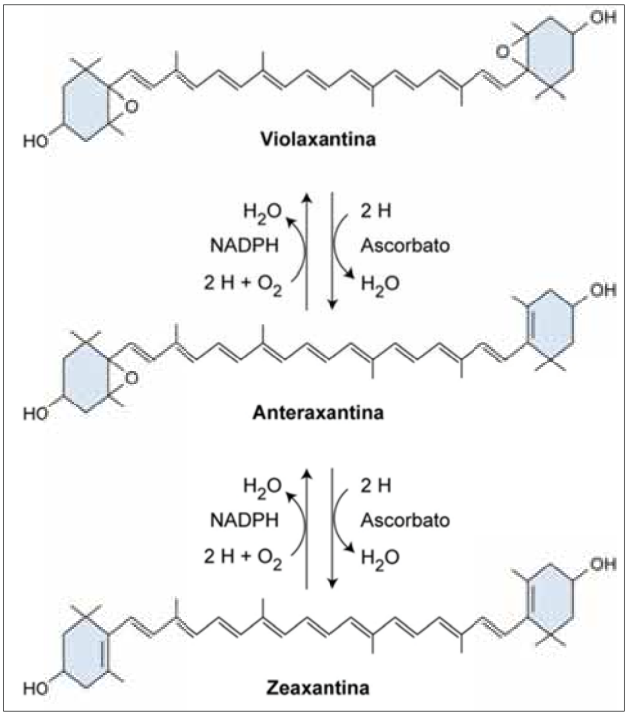

Figure 4. Structure of xanthophylls

1.3. Separation of pigments by TLC

Thin-layer chromatography (TLC) is a convenient technique for separating and analysing the different pigments present in a leaf. A leaf extract containing a mixture of many compounds is spotted onto a TLC plate and an organic solvent is allowed to move up the plate, potentially carrying with it the various compounds in the leaf extract. The different components of a leaf extract are separated based on their affinities for the stationary phase (the silica on the TLC plate) and for the mobile phase (the solvent that is moving up the plate). Compounds with more affinity for the silica (i.e. hydrophilic compounds) will not move very far, while compounds with a high affinity for the organic solvent (i.e. hydrophobic compounds) will move much farther.

2. Laboratory experience: Chromato-graphic separation of leaf pigments

2.1. Material

- Leaf samples (In this examples, from *Epipremnum aurem* and *Ficus benjamina*).
- Chromatography paper.
- Organic solvents: acetone, hexane, chloroform and ethanol.
- Mortar and pestle for laboratory.
- Chromatography chamber.

- Micropipette.

2.2. Procedure

- With the help of the mortar and pestle, crush the leaf sample with 1 mL of acetone.
- Draw a faint pencil line 1.5 cm from the bottom edge of a chromato-graphy paper.
- Using the pipette tip, apply a small amount of each extract to the line in the appropriate chromatography paper. Allow the paper/plate to dry completely before proceeding to the next step.
- Place the paper/plate into a chromatography chamber, a beaker covered with a watch glass, containing hexane-acetone-chloro-form (3:1:1), as the mobile phase. Since these organic solvents are quite volatile, smell bad, and are not good for your health if you breathe them, do this step completely inside a fume hood.
- If desired, use other mobile phases to see the differences between them, for example: water, ethanol (Figure 5), hexane and the mixture hexane-acetone-chloroform (Figure 6).
- Observe as the solvent front moves up the paper/plate. You should also be able to see the pigments separating. Allow the solvent front to travel about 6 cm past the origin. Once the development is complete (about 15-30 minutes) remove the paper/plate from the chromatography chamber and quickly mark the location of the solvent front with a pencil. Allow the paper/plate to dry completely before removing it from the fume hood.
- Photograph the paper chromato-grams/TCL chromatograms with a digital camera as soon as it dries (the colors will fade within a few hours) and then print out a copy (on a colour printer) for your notebook.

Record how many pigments were present in each leaf samples. Identify the plant pigments and calculate the Rf values for each of the pigments observed (Equation 1)

$$Rf = \frac{distance\ traveled\ by\ the\ compound}{distance\ traveled\ by\ the\ solvent\ front} \quad (1)$$

3. Results

In this example (Figures 5 and 6) a leaf extract containing three pigments was spotted onto a chromatography paper at the "origin", then it was placed into a container of solvent.

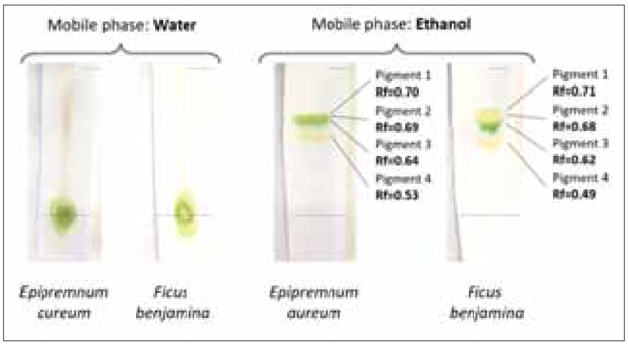

Figure 5. Thin-layer chromatography of leaf samples with water and ethanol as mobile phases

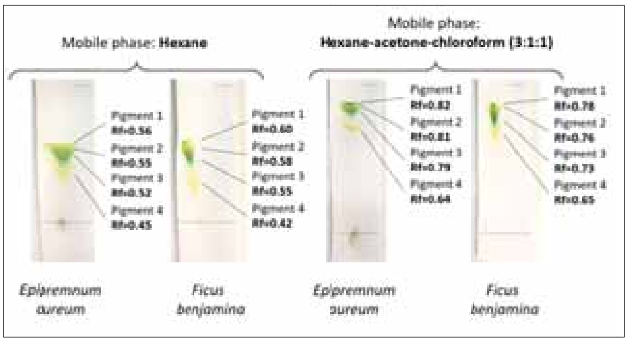

Figure 6. Thin-layer chromatography of leaf samples with hexane and hexane-acetone-chloroform as mobile phases

As the solvent front moved up the paper, the three pigments moved at different rates. Pigment 4 is apparently quite hydrophilic and therefore moved much more slowly that the solvent front while pigment 1 is apparently more hydrophobic since it moved almost as fast as the solvent front. The mobility of a compound in a particular TLC system is the Rf value.

Probably pigment 1 and 2 correspond to carotenes, which are the most hydrophobic pigments as we can see from Figures 2, 3 and 4. Pigment 3 is probably chlorophyll for the green colour that we observe and also because it is less hydrophobic than carotenes. Finally, xanthophylls, that are the more hydrophilic, may correspond to pigment 4.

There are other substances in the leaf

extract of the *Epipremnum aureum* (not in the extract of *Ficus benjamina*) that are totally hydrophilic, as they only move when water is the mobile phase and they stay at the starting point with the organic solvents

4. Discussion

After the experiment, some questions can be made to the students in order to see if they understood the laboratory experience:

- Why is it important not to let your fingers touch the TLC plate (e.g. in Step 1)?
- Why will you probably get a better extract if you work fast (Steps 2 and 3)?
- Why is it important to get rid of all the water in Step 3?
- Study the absorption spectra for various plant pigments (in most biology texts). Which pigments absorb most light from the red end of the spectrum? What colour are they?
- If chlorophyll is the most important photosynthetic pigment, make a hypothesis to suggest which colours of light are most useful to a plant for photosynthesis?
- Light at the blue end of the spectrum penetrates most easily underwater. Why are seaweeds often yellow-brown?

Name some plants whose leaves are not green. How could you find out what pigments they contained?

5. Conclusions

In this article, a simple laboratory experience about leaf pigments is presented. This experiment can be done in any basic laboratory but it is quite attractive, as students can see that from a leaf extract we can separate pigments of different colours, identify them and also observe the difference between plant species. They also realize how important leaf pigments are for photosynthesis as the colour of leafs is due to those pigments.

6. Acknowledgements

We thank to the University of Barcelona and the organization of Hands-On Science Conference 2018.

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El Lab de Papel: DNA Profiling Made by (Forensic) Secondary School Students

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Abstract. The aim of this work was to approach laboratory techniques used in forensic biology among secondary school students. Thus, this activity was thought respecting the following points: use of a familiar case of the students; adaptation of laboratory techniques to the school context by simplifying the techniques and materials used; inclusion of various themes of biology curriculum of Portuguese secondary education.

The new orientations of the science teaching encourage the development of investigative attitudes in the students. Thus, the implementation of a laboratory class must allow the development of cognitive and attitudinal skills of students, in particular the investigative ones. Furthermore, in this kind of hands-on experiences, the students play an active role in promoting and building their own knowledge. The laboratory work also allows students to increase their motivation, learn scientific methodology and develop scientific qualities such as rigour, persistence, critical thinking and creativity.

To achieve these goals, a laboratory activity was developed simulating the work of a forensic scientist. One of the main forensic techniques used in human identification is the DNA fingerprinting. In order to simulate this technique different DNA profiles were obtained using lambda bacteriophage DNAs digested with EcoRI and HindIII endonucleases that were subjected to agarose gel electrophoresis. This provides distinct band patterns allowing to introduce restriction fragment length polymorphisms (RFLPs).

The scenario used to provide a context for using DNA typing is the TV series “La Casa de Papel” (“Money Heist”) of Álex Pina.

This activity is easy to replicate in a school context and the use of readily available lambda DNA allows to minimize the costs. It can be used to approach several subjects of the biology curriculum, like DNA molecule characterisation, genetic material organisation and distribution, action of the restriction enzymes and DNA manipulation techniques. The main focus was on learning DNA-based techniques like DNA profiling and genetic testing, associated to the basic and frequent molecular biology laboratory procedures. The techniques used include the preparation of agarose gel, the electrophoresis and the interpretation of the DNA profiles obtained.

Additionally, the laboratory procedure of this activity was tested with a small sample of six secondary school students from the city of Oporto. A pre and a post-test were applied concerning the theoretical basis of the practical work. In general, student’s grades increased in the post-test (pre-test mean=54.7%; post-test mean=70.7%), but no significant differences were observed. The results of this preliminary test may be due to the small size of the sample but it is intended to be reproduced in larger classes.

Keywords. Agarose gel electrophoresis, DNA profiling, Laboratory practice teaching, Restriction enzymes, RFLP (restriction fragment length polymorphism).

1. Introduction
1.1. Historical background

The most recent history of forensic biology associated with DNA manipulation techniques dates only to the second half of the 20th century. The first case using DNA manipulation techniques was conducted in the UK in the 80's by Professor Alec Jeffreys of the Leicester University. This case involved the death of two 15-year-old girls, Lynda Mann and Dawn Ashworth, who had been raped and murdered [1].

Initially, the authorities did not relate these two crimes, investigating them as independent murders, although they were very similar. Analysis of DNA from semen present in the genitals of the two girls resulting from the rape, suggested that they had been abused by the same person. In 1987, a man confessed the murder of Dawn Ashworth and was arrested, later he was accused of both homicides. However, after the analysis of the DNA profile, he was exonerated, leaving the case unsolved [1].

However, the police were convinced that the real rapist was a local man. Consequently, the authorities required blood samples from all men, of a certain age group, from three villages near the places of the murders. These samples were analysed using a combination of blood typing techniques and various DNA locus analysis. Finally, Colin Pitchfork confessed the authority of the crimes when confronted with forensic evidences. This was a pioneer case, where the potential of DNA profiling techniques was introduced as one of the most important tools of forensic investigation [1].

1.2. DNA and its forensic importance

The deoxyribonucleic acid, often known as DNA, is an extremely important biological molecule. This molecule contains all the genetic information responsible for the cellular processes and the identity of living organisms [1].

In the case of human species, this molecule is found mostly in the nucleus of the cells. However, a small portion of the human DNA is found in the mitochondria, but because of its origin being only maternal it is treated differently in forensic studies [1-2].

The main forensic techniques are based on the size and sequence of the DNA used for the identifications [2-3]. Although much of the human DNA sequence is the same for the entire population, there are small regions of highly variable sequences that allow highly reliable identifications. These highly variable regions are called DNA polymorphisms [4]. The DNA is extracted from various human tissues and fluids such as semen, brain, muscle, bone and teeth (used primarily for identification of incinerated remains) [2,5].

One of the techniques used - DNA profiling - includes sampling, extraction, purification and amplification, through PCR (Polymerase Chain Reaction), of regions with highly variable sequences of DNA, its analysis through the visualisation of the fragments using the technique of electrophoresis and, finally, the interpretation and comparative analysis of the results [4]. The precise identification of DNA can be threatened by several factors, both physical and chemical, that undermine the stability of this molecule [2,6]. The decomposition process can result in DNA fragmentation and/or structural alteration, compromising the possible identification [2,7]. These highly altered molecules, when used in the PCR technique, may lead to a low amplification rate or even to an incorrect profiling. Considering that human identification is often made through the analysis of DNA samples from scenarios such as homicides and terrorist attacks, highly degraded genetic material is frequently used [2,7].

The degradation of the DNA molecule is usually a consequence of natural processes of cell death - apoptosis or necrosis [8]. The DNA degradation may also be due to the action of external factors, such as elevated temperatures, presence of water, microorganisms or invertebrates, especially after rupture of cell membranes [2,6]. Non-enzymatic reactions are also responsible for the degradation of this molecule, such as hydrolytic reactions, DNA crosslinkages, oxidative reactions and radiation [2,7].

Alternatively, mitochondrial DNA is occasionally used for profiling, but the results obtained are less robust when compared to those obtained from nuclear DNA [10,11]. Another possibility is the use of PCR and QPCR (quantitative PCR) techniques to detect degraded nuclear DNA and, after that, proper techniques are used according to the level of degradation detected, allowing the analysis and identification [2]. Some techniques potentially capable of repairing degraded nuclear DNA are currently being investigated, which may lead to the complete overcoming of this problem [2,12].

1.3. Electrophoresis and its forensic utility

The electrophoresis is the migration of polar molecules, according to their electrical charges and molecular weights, along an electric field. This technique may be conducted in a distinct carrier media, such as filter paper, agarose gel, starch or polyacrylamide, among others. The medium must be chemically and physically inert, not interfering with the mobility of molecules. This technique is capable of separating several biological macromolecules, such as DNA, RNA and proteins [13]. In this paper, greater importance is given to electrophoresis in agarose gel, as this was the technique chosen.

In this work the RFLP technique was used to identify the DNA. As the name suggests, this technique is based on the analysis of DNA fragments of different sizes that are separated by electrophoresis giving a unique DNA bands profile for each individual [14]. The biological samples are digested by endonucleases that are enzymes that cleave the phosphodiester linkage of a polynucleotide chain, in specific sequences [15]. Different DNA sequences from different persons are broken in distinct sites resulting in DNA fragments of different sizes. Each enzyme cleaves the DNA chain in a distinct way [15]. Subsequently, the samples can be loaded onto the electrophoresis gel and the fragments separated by size. At the end of this procedure an electrophoresis gel with a specific DNA band profile is obtained [13].

This feature associated to the fact that DNA varies from individual to individual, makes the study of this molecule so important in forensic biology. Since DNA sequence is unique for each person, the electrophoretic patterns obtained are also unique. Thus, in a crime situation, the forensic biologist can use RFLPs technique and perform an electrophoresis with the DNA found at the crime scene, compare it with the electrophoretic sequence of the suspect's DNA and determine whether the two are exactly matched [1].

Currently, the FBI in the United States of America uses a system called CODIS (Combined DNA Index System) for DNA analysis found in different types of crime. This system crosses the DNA profiles of 13 highly variable regions of DNA for human identification. The 13 regions are: D3S1358, VWA, FGA, D8S1179, D21S11, D18S51, D5S818, D13S317, D7S820, CSF1PO, TPOX, THO1 and D16S539 [16].

1.4. Laboratory practice in biology teaching

Education, like science, is advancing. It evolves its vision, its purposes and methods, its interlocutors. In a teaching perspective framed in the new guidelines of science education, the educational contents are taught associated with an externalist view of science, with the construction not only of concepts (knowledge), but also of values, attitudes and capacities (competences) [17-18].

The purposes of science teaching have been based on three objectives: to know science (to understand scientific conceptual knowledge), to know how to do science (to be able to participate in the construction of scientific knowledge) and to understand the nature of science (to understand questions of philosophy, history and methodology of science) [19-21]. There are several ways to develop an education that meets these guidelines, one of them is through laboratory work.

Several authors defend the practice of laboratory and experimental work in the science classroom. Laboratory practice is considered as an enabler of the development of competences, attitudes and values, allowing the achievement of objectives such as increasing students' motivation, learning scientific methodology and developing scientific attitudes such as rigour, persistence, critical thinking and creativity [22].

2. Procedure

It should be noted that this work consists in the simulation of DNA profiling. In the real procedure actually used in forensic investigations, the different DNA samples must be subjected to the action of the same endonuclease(s). Otherwise they cannot be compared. In this way, students should be told that the DNA samples were all digested by the same mix of enzymes.

Respecting the aim of this work, a laboratory activity was assembled, which consisted in the accomplishment of a DNA electrophoresis in agarose gel and following interpretation of the obtained DNA profiles.

During the laboratory class, the students had the opportunity to perform the assembly of the laboratory apparatus necessary to carry out the agarose gel electrophoresis of DNA from λ bacteriophages cut by *Eco*RI, *Hind*III and *Eco*RI+*Hind*III endonucleases.

It was asked to students put themselves in the role of a forensic biologist and imagine that they end up receiving a strange request from an inspector. They should compare the DNA of 4 objects found during the investigation of the Mint assault: sample 1 – a spoon; sample 2 - a button; sample 3 - a cup; sample 4 - a car steering wheel. The spoon has DNA from a known suspect. Afterwards, the students interpreted the obtained electrophoretic profile. The electrophoretic profile obtained allowed to identify *El Profesor* as the match for the spoon DNA sample, according to the plot of the fictional series *El Casa de Papel* (chosen scenario)

Additionally, to evaluate the impact of this laboratory procedure in the cognitive domain of students, a pre-test and a post-test were applied in a small group of secondary school students, according to a pre-experimental design supported by the quantitative methodology. The pre and post-test were validated by two specialists in biology teaching.

The group of students used in this study is classified as a convenience sample and was composed by six students from the scientific-technological course of a secondary school of the city of Oporto (Portugal). This sample included 5 male elements and 1 female element, all 12th grade students.

The administration of the pre-test occurred previously to the laboratory class and it was composed by seven questions regarding the laboratory techniques discussed. The post-test, applied at the end of the laboratory class, consisted of the same questions as the previous one. The data were analysed statistically through the IBM® SPSS® Statistics 25 version software. The Wilcoxon statistical test was performed to verify whether there were significant differences between the results of the pre-test and of the post-test.

2.1. Material and Methods
2.1.1. DNA samples

The DNA used in the laboratory class is not human. It consists of the products of the enzymatic digestion of λ bacteriophage DNA by the *Eco*RI, *Hind*III and *Eco*RI+*Hind*III enzymes. Three different DNA mixes were produced according to the following digestion schemes:

- Mix 1: λ bacteriophage DNA + *Eco*RI;
- Mix 2: λ bacteriophage DNA + *Hind*III;
- Mix 3: λ bacteriophage DNA + *Eco*RI + *Hind*III.

It should be noted that this work consists in the simulation of DNA profiling. In the real procedure actually used in forensic investigations, the different DNA samples must be subjected to the action of the same endonuclease(s). Otherwise they cannot be compared.

2.1.2. Preparation of sample tubes for students

The sample tubes for students were prepared as follows (Figure 1):

- **S#1 (sample 1) tube:** 3 μL of Mix 1 + 2 μL of loading dye + 5 μL of sterile water;
- **S#2 (sample 2) tube:** 3 μL of Mix 2 + 2 μL of loading dye + 5 μL of sterile water;
- **S#3 (sample 3) tube:** 3 μL of Mix 3 + 2 μL of loading dye + 5 μL of sterile water;
- **S#4 (sample 4) tube:** 3 μL of Mix 1 + 2 μL of loading dye + 5 μL of sterile water.

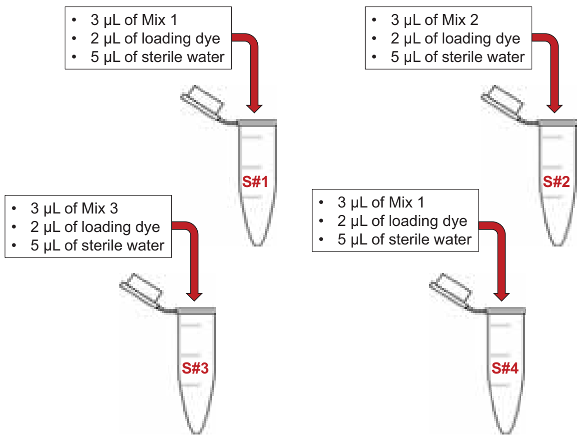

Figure 1. Scheme of preparation of the tubes with the different samples for the students

2.1.3. Preparation of agarose gel

In the laboratory activity, 50 mL of 0.8% agarose gel (w/V) was prepared. The buffer used was buffer SB (sodium borate) [23]. After the gel solution cooled lightly, 2 μL of the GreenSafe Premium dye by NZYTech were added directly onto the agarose solution.

2.1.4. Loading the wells of the agarose gel and Electrophoresis

In the first well gel, 2μL of a DNA ladder (GeneRuler™ DNA Ladder Mix, ready-to-use; #SM0333; Thermo Scientific) were loaded. The remaining wells, corresponding to the different samples, were loaded with 5μL of DNA, according to Figure 2.

The gel was run at 160 volts for about 25 minutes and then visualised using a UV transilluminator.

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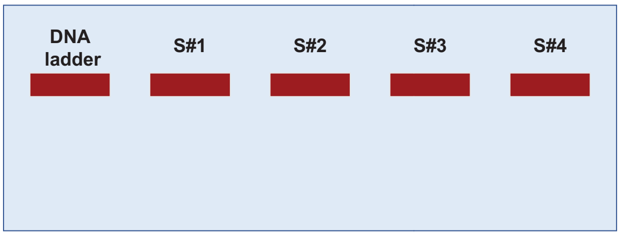

Figure 1. Scheme of the electrophoresis gel wells according to the experimental design. Label: S#1 - a spoon; S#2 - a cup; S#3 - a cup; S#4 - a car steering wheel

3. Results
3.1. DNA profile result

After the electrophoresis, the following DNA profiles were obtained (Figure 3).

Figure 3. DNA profile obtained through the electrophoresis

3.2. Pre and post-test results

After responding to the pre and post-test, the data were analysed. The students obtained a mean of 54.7% in the pre-test and a mean of 70.7% in the post-test. The Wilcoxon statistical test was performed and no significant differences were observed between the pre-test and post-test results ($Z=1.604$; $p=0.109$).

4. Discussion
4.1. DNA profile discussion

By visualising the DNA profile (Figure 3), it is possible to conclude that the sample collected in the car steering wheel (S#4) has the same DNA as the sample from the spoon (S#1). In this way, the DNA belongs to the same person. In the chosen scenario, *El Profesor* discovers that *Helsinki* does not disposed of the car that *Tokyo* and *Rio* used in the visit to the Mint before the assault. *El Profesor* arrived at the car scrap and tried to clear all the traces of the car but forgot the steering wheel. At the same time he incriminates *Berlin*, putting a button with his DNA. *El Profesor* does not stop here and goes to the house where the assault was planned and places several evidences with DNA of strangers, between them is a glass that *Tokio* used. Inspector *Ángel* was suspicious about *El Professor* because he was always close by the investigation and was involved with Inspector *Raquel Murillo*. When he met the inspector at the cafeteria, *El Profesor* said he was producing cider in a nearby shed. *Ángel* did not think twice and appeared in the shed, leaving *El Profesor* apprehensive about this unexpected visit. *Ángel* ends up stealing a spoon that *El Profesor* had used.

Thus, through the forensic essay, it is possible to allege that *El Profesor* is one of the main suspects of the assault.

4.2. Pre and post-test discussion

A pre and a post-test were applied concerning the theoretical basis of the practical work. In general, student's grades increased in the post-test (pre-test mean=54.7%; post-test mean=70.7%), but no significant differences were observed, after the Wilcoxon statistical test.

However, the results suggest that the application of this type of laboratory work has a positive impact on the development and consolidation of conceptual content in students.

The results of this preliminary test may be due to the small size of the sample but it is intended to be reproduced in larger classes.

4.3. Laboratory procedure discussion

The use of DNA already cut by restriction enzymes makes this procedure faster and lesser expensive, making it easier to implement in the classroom. Yet, this activity can be supplemented from the procedural point of view, if the teacher chooses to cut the DNA. However, in this case the teacher should alert that the mix of enzymes is the same in all samples.

The idealization of the activity was guided by the choice of cheaper but equally efficient materials. Therefore, it should be noted that the electrophoretic buffer used was SB, instead TBE buffer or TAE buffer. This buffer is much less expensive than the others and it produces sharper bands. Additionally the electrophoresis can be run at higher speeds than can gels made from TBE buffer or TAE buffer [23].

5. Conclusion

In order to increase students' interest and motivation for science curricular content, it becomes necessary to rethink teaching strategies, bringing the young students closer to school and science. These strategies should be thought with the ambition of promoting intense student involvement, encouraging the articulation between theoretical knowledge and practical-procedural aspects, allowing a deeper development of the students' competences. In this way and according to a socio-constructivist perspective of science education, laboratory work is a teaching strategy that supports the development of significant learning of the students.

Thus, this work aim is to contribute to the development of laboratory work in the science classroom, serving as a support for teaching practice. In addition to being thought in order to facilitate its implementation in relation of the economic and logistical limitations of schools, this document links a subject of student interest (forensic practice) to a familiar scenario (a very popular television series), enabling a better scholar learning.

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Hands-on Genetics in Primary School

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Abstract. Curiosity, motivation, critical thinking and initiative are some of the skills that should be promoted by science education in primary schools. The project described in this paper has the aim to approach scientific research and methods to primary school by inviting a group of students to visit a University science center where they have the opportunity to take part in some activities.

Keywords. Activities, *Drosophila,* primary school, science education.

1. Introduction

An important part of science education in schools is to stimulate curiosity and scientific interest in students. Practical classes, field activities and school trips provide good opportunities for students to learn in a more dynamic and entertaining way than they usually do in an everyday lesson, enriching their education by promoting basic but essential scientific skills such as initiative, motivation and critical thinking.

The purpose of this work was to approach scientific research to primary school education by inviting a group of students from 9 to 12 years old to visit the facilities of the Department of Genetics at the Faculty of Biology of the University of Barcelona and participate in some activities related to genetics and developmental biology.

In these activities, students had the opportunity to learn some basics about *Drosophila melanogaster*, one of the main model organisms used by research groups in the department.

2. Taking a close look to *Drosophila*

Drosophila is one of the principal model organisms used in developmental biology and genetics, for all the advantages it presents. It has a relatively short life cycle and females lay eggs at a very high rate, so large amounts of embryos can be obtained to carry out different experimental approaches [1]. Moreover, its genome is completely sequenced, numerous genetic modification techniques are available and there is a very significant degree of evolutionary conservation between *Drosophila* and humans which makes the fly a very useful tool for the study of the pathogenic mechanisms of diseases [2].

To introduce the fruit fly, the students were first shown some images and received a brief explanation of its morphological and biological characteristics. Afterwards, in a laboratory, they learned how to use the equipment for working with *Drosophila* and were encouraged to use it themselves to observe living flies.

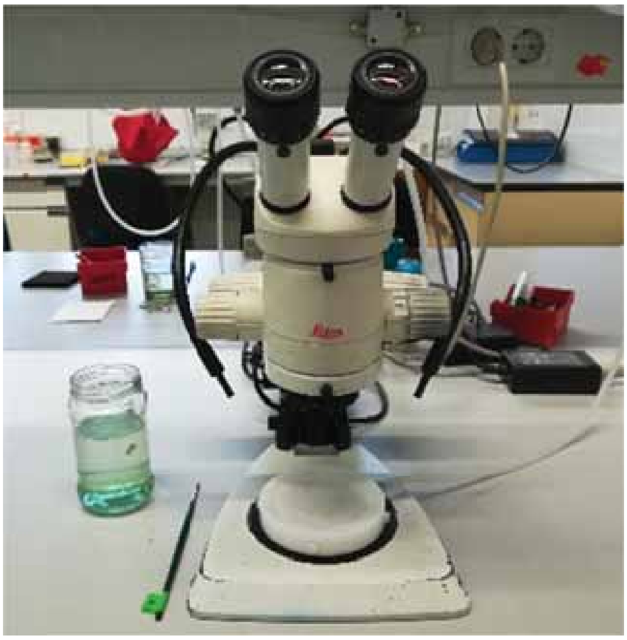

Figure 1. Equipment for working with *Drosophila*

2.1. Set-up for work with *Drosophila*

The equipment required for working with *Drosophila* consists of several elements (Figure 1):

- Stereomicroscope and light source: to observe flies at low magnification
- Porous pad connected to CO_2: CO_2 that comes out of the pad anesthetizes the flies preventing them to fly away, still keeping them alive.
- Paint brush: to gently manipulate flies when anesthetized.
- Fly morgue (RIP): a bottle containing ethanol to discard flies.

2.2. Life cycle of *Drosophila*

Fruit flies, as all holometabolous insects, undergo a four-stage life cycle: egg, larva, pupa and adult [1]. After fertilization, the embryo develops for 22-24 hours and then turns into a first instar larva. After one day, it develops into a second instar larva, and after another day it turns into a third instar larva. This larva develops for approximately 30 hours and then turns into a pupa, which undergoes a metamorphosis process for about 4 days, and after this time, the adult fly emerges. So, the whole process from embryo to mature adult takes about 10 days (at 25ºC) [3].

In this activity students were given plates with embryos, larvae and pupae so they could observe and identify the different stages of the *Drosophila* life cycle.

2.3. Differentiation between males and females

Some experimental approaches with fruit flies, such as crossings, require distinguishing between male and female flies.

In this activity, students learned the differences between males and females by observing basic morphological characteristics, such as size, sexual organs, body shape or pigmentation (Figure 2).

Females are usually bigger than males in body size. Males have a rounded abdomen with a uniformly dark pigmentation at the rearmost segments, while the female abdomen is more pointed and has a narrow dark band of pigmentation in each segment. A particular characteristic of males is the presence of a sex comb in both forelegs, which is a small patch of bristles that appear as a little dark mass [4].

2.4. Observation of mutants

One of the main advantages of working with *Drosophila* as a model organism is its genetic tractability and the many tools available for its genetic modification [2]. As a result, numerous mutant stocks of flies are at one’s disposal.

In this activity, students observed four different mutant flies:

- Curly: flies present curled wings
- White: flies present white eyes
- Ebony: flies present a darker body color than the wild type
- Eyes absent: flies have no eyes
- Vestigial: flies with very small wings

When looking at them for the first time, students weren’t told which characteristic was affected in each mutant. They were asked to compare them to wild type flies to try to identify the differences.

Figure 2. Lateral view of a male (top) and a female (below)

3. Acknowledgements

We would like to thank the Department of Genetics, Microbiology and Statistics of the Faculty of Biology for letting us use one of the labs to carry out the activities. We also thank all the children for their active participation.

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Hands-on Science Activities for Children Aged from 6 to 10: Perspectives from Partners of the Outreach Project

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Abstract. The outreach project Scientia.com.pt has been implementing regularly hands-on activities for children from 6 to 10 years under the venture “Ciência p’ra que te quero”. The project aims to show that science is everywhere and in everyday life, alerting children to how science happens and to how we can use, learn and/ or adapt it to our daily routine.

In 2018 “Ciência p´ra que te quero” is conceived and designed on behalf of the “European Year of Cultural Heritage” and has sustainability and patrimony as the main themes. The addressed topics for the current year cover subjects such as “Is your house sustainable? Let’s save the Cultural Heritage”; “The sustainability of liquids that are also patrimony” or “Food – from sustainability to patrimony”, among others. Usually, a set of 5 – 6 simple and small hands-on experiments is performed monthly in a public library environment. Each session begins with a theoretical but informal presentation that allows to know children’s´ perceptions, believes and knowledge about certain topics while explaining and/ or clarifying the important scientific concepts. Subsequently, volunteers start the hands-on activities with small groups of children. These volunteers, mostly undergraduate biology and biochemistry students, have an essential role in this project, once they are the key and the connection between science & scientists and the participating children.

At the end of each session, children and volunteers are asked to fill a questionnaire regarding their opinion about the session, which gives useful information that can lead to changes and improvements in further activities.

This work aims to show another perspective of the “Ciência p´ra que te quero” project, namely the point of view of (i) the volunteer PhD science student that accepted to make and present the topics during each session presentation, (ii) the volunteer students that conducted the practical activities, (iii) the project mentors, (iv) the library staff and also the (v) feedback from the children engaged in the activities as well as from their parents.

Science communication is getting more and more importance nowadays as the media use loads of unfiltered and untreated information, and shows therefore unreal or non-understandable information to a non-conscientious public. Overall, the team feels that showing science to children with hands-on activities is a way of approaching important and current subjects in a pleasurable, appellative and efficient manner, making children more aware of their surroundings.

Keywords. Children, hands-on science activities, science communication, patrimony and sustainability.

1. Introduction

The outreach project Scientia.com.pt has been implementing regularly hands-on activities for children from 6 to 10 years under the venture “Ciência p’ra que te quero” [1-3]. The project aims to engage children in science in a pleasurable, appellative and efficient manner.

Science communication can be defined as the use of the appropriate methods to produce awareness, enjoyment, interest, opinion and/ or the understanding of science, of general public or field related people [4]. In recent years, and probably due to the immense unreal and incorrect science information that appears in media, science communication is getting more attention from scientists. However, it is still a long way to go to implement a coherent and working science communication system. Some universities, already aware of the importance of teaching science towards the general public, other students, media or even scientists, offer specific courses about this topic and encourage undergraduate and post-graduate students to improve their skills in science communication as an important tool for their studies and future work [5-7]. Outreach programs, studies and projects from different institutions [8-11] show not only how important it is for students to learn science communication, but also how explaining complex concepts to children can improve the talker's understanding of the problem/ topic. In addition, it was also shown that younger students and children have increased interest on STEM (Science, Technology, Engineering, and Mathematics) after STEM related hand-on activities [8-11].

Explaining science to children can be a hard job as their understanding on basic terms is limited. However, hands-on activities allow an easier description of science related topics using models and practical activities. Joining that with the face-to-face communication can offer several benefits. And a relevant role is recognized on science students when acting as tutors, as it was already shown that student tutors can have better performance than experts in that field when explaining concepts to other students, using hands-on activities [12].

Science communication is turning into a more pertinent topic in current days, and it is important to alert non-conscientious public. In our point of view, the best way is to start with children, making them aware of science, and helping to build a more alert society in a different and dynamic manner.

2. Hands-on activities

The sessions under the venture "Ciência p'ra que te quero" are performed monthly in the public library Biblioteca Lúcio Craveiro da Silva (BLCS) with children from 6 to 10 years. Volunteers, mostly undergraduate biology and biochemistry students, are the key for such activities, as they enable the connection between science and scientists and the participating children. During meetings between the volunteers and the mentors of the project (teachers at the School of Sciences of the University of Minho), the topic of each session and potential activities are discussed. After choosing 5 or 6 hands-on activities highly connected with the given topic and adapted to children's age, the volunteers are responsible for structuring a protocol and test it before the session day. The opening oral session, recently taken over by a post-graduate student, is also discussed during the meeting. Such short oral presentation is essential to address the given topic, providing basic information about the planned activities and discussing current, relevant and important topics in science. At the end of the session, all participants and volunteers are asked to fill in a questionnaire regarding their opinion about the session and also about suggestions to improve future activities/ sessions.

In 2018 "Ciência p´ra que te quero" is conceived and designed on behalf of the "European Year of Cultural Heritage" [13] having sustainability and patrimony as the main themes. The addressed topics and a short description of each activity are presented below.

2.1. Is your house sustainable? Let's save the Cultural Heritage

The first hands-on session of 2018 introduced the main theme "European Year of Cultural Heritage". For that, the sustainability of our own houses was the chosen session theme. Different activities were planned during the meetings with the volunteers as well as prepared and tested in advance. The proposed activities were based on small and easy demonstrations regarding our daily lives, in order to encourage children to look closer to their daily routine and think about possible and small changes to improve the sustainability of their houses.

Energy is not always an easy topic as it is hard to explain it to children. A good activity for that is the use of static electricity to move small pieces of paper sheets (Figure 1). That allows kids to produce their own static electricity and make paper of different shapes move, thus understanding the principle of energy and movement.

Keeping on with the energy topic, the alternative energies were also addressed. To demonstrate one of the main alternative energies (wind), a small paper propeller was built by the participants (Figure 1), which was connected to a rope and a small paper object to make it move.

An important topic, and not much addressed, is the recovery of rainwater. With used/ old materials brought by the participants in previous sessions, small house models were built recycling such materials. The aim of this activity was to understand how the systems of rainwater recovery work, exploring different ways to do it and think about the possible usage of the recovered water.

Figure 1. Details of some of the activities of the first "Ciência p´ra que te quero"

Food waste is a huge issue when it comes to sustainability, as 1/3 of the produced food is not consumed [14]. Composting domestic organic waste is therefore an environmentally friendly option. The children participating in this activity constructed a composting system inside a reused plastic bottle. The top part of the bottle was cut and used as funnel to drain the liquids produced by the composting process through a layer of small stones. Different layers of organic waste intercalated with soil were created to give rise to the process.

One of the biggest threats to the preservation of cultural heritage, such as statues and buildings, is acid rain. The acidic properties of acid rain can damage constructions exposed to it, as it affects most of the materials used. Not only buildings and statues are affected, but also sea life, such as fishes and corals. To make it visible for children, some see shells were submersed in water with vinegar and/ or a NaCl solution. Vinegar and NaCl promote the corrosion of the shells and after some time it is possible to observe the caused damages, imitating the ones caused by acid water (Figure 1).

2.2. The sustainability of liquids that are also patrimony

As already mentioned in the previous activity, there is much more patrimony apart from statues and buildings. Landscapes and traditions are Cultural Heritage too. During the second session of the year 2018, we chose the broad designation of liquids to be the focus of our theme as an important part of national and international patrimony. And Portugal is known worldwide for its wine, olive oil, and landscapes comprising rivers and beaches. For this reason, a small showcase was prepared, with some of the Portuguese liquids considered as patrimony: wine from different grape varieties, olive oil, honey and different kinds of bottled water.

Bees are the producers of one of the most valuable Portuguese fluids: honey. Apart from its use as food, honey has a wide range of other applications, from medical to cosmetic [15-16]. Bees have its own and particular way to produce honey, in honeycombs consisting of hexagonal forms – a shape that uses the least amount of material (wax) to hold the most weight of honey. In this activity and by using models of different geometrical forms to create patterns, children were invited to find out which geometrical pattern (circles, squares…) best fits honey production, and why (Figure 2).

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Among the different characteristics of liquids, density is one of the easiest to show. A colourful tower of densities was built inside a jar or bottle with liquids of different density that kept separate in layers (Figure 2). Additionally, small objects (clips, chalk stick…) were added into the tower to observe how fast/ slow they move down the liquids column and in which layer they stopped.

Figure 2. Details of some of the activities of the “Ciência p´ra que te quero” of March

Another characteristic of fluids is viscosity. When the so-called non-Newtonian fluid suffers an external tension, it can change its properties. To show a fluid of this type, water was mixed with maize starch and an abrupt force was applied to the mixture. With this activity children could observe how the characteristics of the liquid changed by just changing its viscosity.

Soil has diverse and several important roles. From sustaining flora and being habitat for masses of organisms, it also has an important role in containing, draining and filtrating water. Different types of soil, from different regions or places, have different permeability capacity. In this sense, different types of soil, from sand to clay, were tested in funnels for the capacity to drain or contain water during about 15 minutes.

Wine is a liquid, considered a drink, very relevant to the Portuguese economy, and of worldwide recognized quality. It is also an important part of the Portuguese culture and traditions. Wine fermentation comprises several steps that can take several weeks to occur. However, it is possible to simulate the alcoholic fermentation process in a shorter time using ripe grapes and yeast.

During this activity, fresh baker yeast was added to a few macerated grapes inside a reused glass bottle. A balloon was tired to the bottleneck and sealed (Figure 2). After some minutes it was possible to observe the inflatable balloon by the CO_2 produced during the fermentation process. It was also possible to smell the characteristic aroma of wine at the end of the session, by taking out the balloon from the bottleneck.

Water cycle (included in scholar curricula) is probably one of the most addressed topics when it comes to liquids. However, it is not always easy for children to understand how it occurs. Recycling and moving water around the globe is the main aim of the water cycle, and it can be easily recreated as a small and portable model. Using a round container with an empty mug inside (surrounded by water) and covering it well with cling film, creates an environment favourable to condensation. The produced drops of water fall in the mug and it is easy to observe the water level increasing inside the mug, and getting lower around the mug, which allows explaining part of the movements of water in our planet.

2.3. Food – from sustainability to patrimony

Along with the house and liquids, food and cultural aspects related to its preservation and confection are considered a patrimony too. As mentioned before, 1/3 of produced food is wasted, which means that we produce much more food than we actually need, but, at the same time a great number of people go hungry. This issue raises the pollution rate and other associated problems, as green house effect or contamination of soils and water. It is important to teach and raise children's awareness not only to eat healthy and in a sustainable way but also show them how food is produced, preserved and processed. The activities chosen aimed to aware children of what and how they are eating and how they can make small changes in their routine to live in a more sustainable and healthy way. A healthy and balanced diet is mainly based on the food circle. For more awareness of eating in a conscious and healthy way, a food circle was dissembled to enable the participants to build it back from scratch (Figure 3).

Figure 3. Details of the Food Balance Wheel used in the "Ciência p´ra que te quero" of April

Most people do not know that a calorie is a unit of energy. Therefore, explaining it to children in an interactive game may be a good option. With pictures of different Portuguese traditional dishes as well as fast food options, and the number of calories in separated cards, the participants were asked to associate each number of calories to each dish. Additionally, different amounts of food, healthy and unhealthy, corresponding to the same number of calories were presented to the participants so that they understand that the amount of food is not always directly related to the number of calories nor to the effect on health. Finally, the children were invited to draw a balanced and healthy dish according to the number of calories and food (nutrient) types that they should be taking in per meal.

Food preservation methods can vary from the traditional salt, smoke or sugar, to more modern solutions based on chemical preservatives, extreme temperatures or type of packaging. Natural food spoilage is promoted by microorganisms, namely fungiand bacteria, and occurs frequently if food is fresh or non-processed. Different slices of processed loaf bread were kept at different environments during some days before the activity to show that it takes longer to spoil processed bread than fresh food products.

Apart from the more theoretical information given in the activities listed before, also two more practical applications of the acquired knowledge during this session were offered to the participants. One of the activities was to make fresh cheese using simple ingredients as milk and lemon juice.

Other practical application consisted in baking a mug cake in the microwave. For this (funny and delicious!) activity, usual ingredients were substituted for healthier ones and mixed together to bake for a couple of minutes in the microwave. The ingredients used were oats, eggs, banana, brown sugar, almond milk, cocoa and/or cinnamon for a healthier and alternative snack in addition to the fresh cheese also prepared during the session.

As mentioned before, food is part of Portuguese traditions and culture. Therefore, a showcase with different Portuguese food products was prepared: honey on the honeycomb, cheese, bread and cod (Figure 4), among other products.

Figure 4. Showcase with some of Portuguese food products that are also patrimony

3. Participants and Statements

After each session, children and volunteers are asked to complete a questionnaire. In this anonymous questionnaire gender and age are asked for statistics purposes. The hands-on activities of this project are designed for children aged from 6 to 10 years and gender independent. From January to May, close to half of the participants were male and the other half female (Figure 5), most of them at the age of 8 (28%) and 10(24%) (Figure 6). A total of 44 children participated in the three first sessions of "Ciência p´ra que te quero".

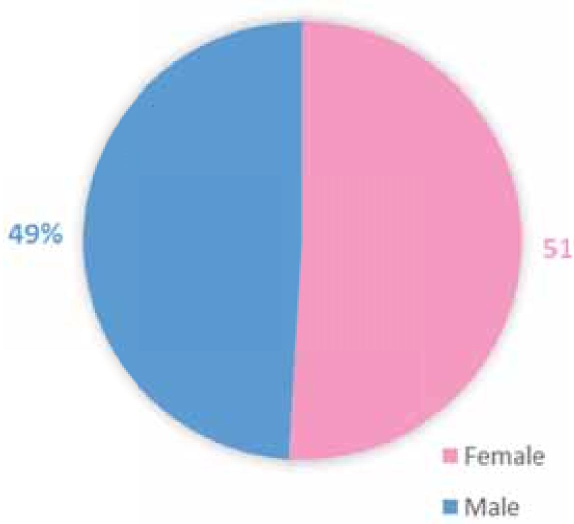

Figure 5. Gender distribution of participant children

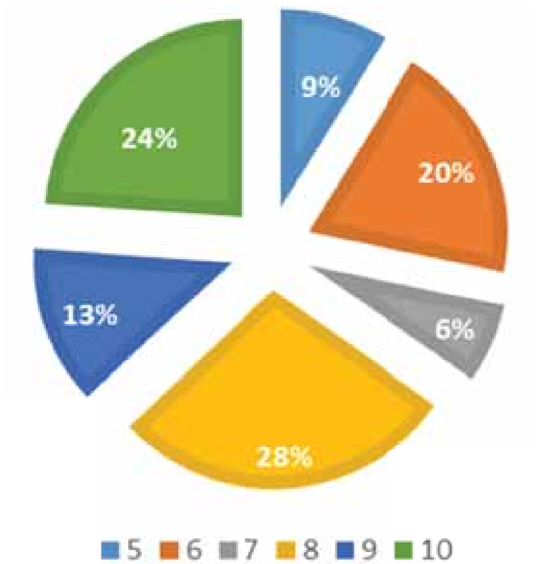

Figure 6. Age of the children participating at the first 3 sessions of "Ciência p´ra que te quero"

The majority of the participants stated that they liked the sessions, mostly because they like to learn new things. Furthermore, they showed interest in participating in further related activities. As it is an optional activity, non-associated to school and during the weekend, parents are the main responsible to register and bring their kids to the activities. The great rate of participants and the increasing number of requests for participation in the event, shows that parents are also more concerned about science and how important it may be in their children's life and future. Parent´s perspectives are thus also important for the project and its mentors. According to a participant´s parent:

> "*This monthly activity takes place in a very pleasant space and is suitable for the target audience. I bring my son to participate in this activity whenever I could, and he will just fail if there is another unavoidable event. The chosen activities always address very interesting topics and can be further discussed at home. The great advantages I see for children are: the fact that they can learn content often taught in class context, which is usually very theoretical and here they can experience, see, touch, feel, smell…, children have contact with university students and imagine themselves in their place; acquiring very useful knowledge for their future life; shape future men and women with a greater civic and ecological awareness; sharpen their interest in learning, discovering and research. I also see advantages for university students: the need to adapt the work for a group and an audience with the need of a different language; seeing themselves in the place of their teachers and thus understand better the difficulty teachers sometimes have in their job; skills acquisition in dealing with children in an educational environment; CV enrichment; strengthening the working group with activities outside the classroom context. In summary, this activity is so positive that in my opinion all schools should have access to this type of projects. It would be a very important step to improve students' grades in science related fields in school and increase the interest of children of*

their surroundings and acquire responsible practices in the use of our natural resources."

During the first months of 2018, 29 volunteers took part on the project. A slight difference in volunteers´ gender was observed, being females more predominant than males (Figure 7), but this result somehow corroborates the prevalence of females seen at the university courses in which volunteers are enrolled (Applied Biology and Biochemistry).

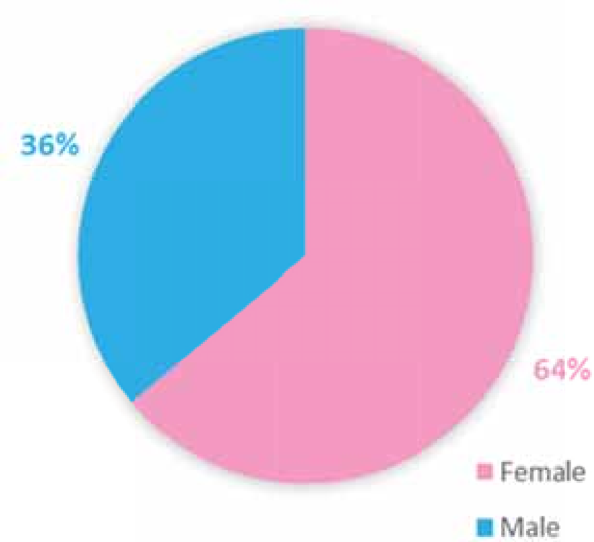

Figure 7. Gender distribution of the volunteers enrolled in the first sessions of the "Ciência p´ra que te quero!" 2018 project

In what concerns volunteers´ ages, most of the students are undergraduate and aged between 18 and 22 (Figure 8).

All the volunteers describe their participation as good and very good and would recommend the participation in these activities to other students.

Moreover, the majority affirmed that the involvement in the session motivated them to participate in further similar activities. And the majority too share the feelings of one of the volunteer students, who said:

"(…) *The activities allowed me to develop my ability to simplify and transmit scientific knowledge, and in some cases demanded from me quickness to answer the most unexpected questions. I greatly enjoyed this opportunity that drew my attention to a very important topic: the need to communicate science* "

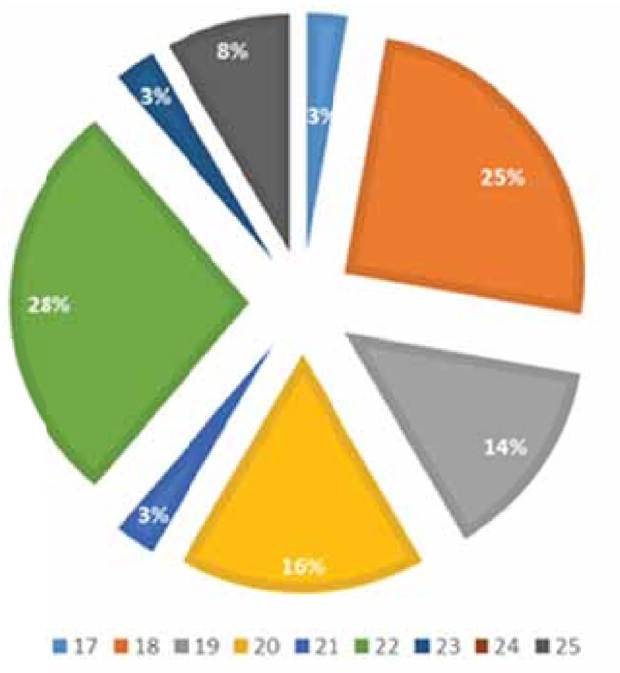

Figure 8. Age of the volunteers

For the BLCS staff, "Ciência pra que te quero" is a success and also a wining project. According to two of the library employees that each Saturday witness the hands-on session:

"The "Ciência pra que te quero" activities, besides having registered a great demand by children, fact that unequivocally explains the success of this initiative, in my opinion, is of central importance in the dissemination of science among the youngest. The simple and playful presentation of nature and practical life as a source of scientific learning and in complementarity with science teaching in basic education, becomes an asset in the reinforcement of initiatives of scientific nature, inherent to the School's Educational Projects."

"The success of this activity is due essentially to awakening in the children's public the interest in scientific culture. There has been a growing interest in participating in this activity, not only because of its importance, but also because of the joyful, fun and stimulating practice with which the teachers and their undergraduate students carry out the "Ciência pra que te quero", in multiple themes."

To conclude these set of partners´ opinions, the point of view of the volunteer PhD science student responsible for the initial oral talk couldn´t be laid aside:

> *"As a post-graduate student (in a science related field) taking over the oral talks, I got a different point of view about the project and the hands-on activities. Before conducting these talks in the first months of 2018, I also was a volunteer part of the project in the previous year. Science communication is a crucial field in science that should be part of student's curriculum and thought at under and post-graduate levels, as disseminating science properly is as important as the actual research work. When it comes to teach science to children, I think that it is an effective way to instruct and alert people to STEM as it can change, in an early stage, their ideas about science related fields and may have an impact in their future choices. Moreover, not only children may benefit from that, but also the volunteers: as they improve their communication skills for general and younger public; the mentors: as they can disseminate their message to younger people and aware them for science; the parents of the participant children: who can also learn new concepts, tools and activities to perform in the future at home with their kids. Regarding the oral conversation it is, in my opinion, a must before the session. Apart from my initial difficulties due to the change from the usual public (field related and older people) to children, talk to children and discuss current and relevant topics with them was tricky, yet gratifying. Most of the children like to participate actively in the discussion and create a great environment of ideas exchange, that enable them not only to learn new concepts in a dynamic manner but also to improve their skills, such as in giving opinion and ideas and use of arguments. The increase of the volunteers' engagement in and with the activities has also been evident. This shows how science communication is getting more important and interesting for them. To conclude, I can affirm that this project has improved several of my skills and allowed me to go out of my comfort zone. It also helped me in changing my mind about the importance not only of science communication but also of some current questions often ignored. It is great and yet expected to see the success of such projects that can only reach this level due to the engagement of all the participants, volunteers and partners."*

From the given statements, it is possible to conclude that this project has a relevant and positive impact in all the participants and partners. In general, all agree that this initiative is a successful one. The School of Sciences of the University of Minho is well known for its scientific diversity, where research, transfer of knowledge and educational projects play a valuable role of interaction with society in general. The mentors of the project, teachers of Sciences, have long been engaged in outreach projects and assume this work as one of their main missions, considering that similar and science-related activities are important and should continue tobe available, namely for children. But the success of "Ciência p´ra que te quero" does not rely in the team experience rather being due to the commitment of all the partners involved.

4. Final considerations

The main aim of "Ciência p'ra que te quero" is to bring science closer to children and make them aware of what is around them. The improvement of science communication skills of science students is also an important spotlight of this project mentors, aiming to engage science students as active volunteers in each session. The number of volunteers and their engagement in the activities has been increasing from session to session. It started with students volunteering to help in the hands-on activities during the sessions at the library to a deeper involvement, namely during the preceding weeks as they were challenged to create the monthly advertising posters and to participate in the meetings for discussion of the topic and possible activities, as well as troubleshooting. The project mentors believe that giving independence and responsibility to the students improves their creativity and helps them developing several other desirable transversal skills. Consequently, better and more interesting activities can emerge.

Most of the volunteers participated more than once in this kind of activities and show interest and motivation to continue engaged in projects of science communication. More recently, also the oral opening session was taken over by a post-graduate student, who accepted this feat with enthusiasm, answering the project mentors invitation. For both volunteers, communicating science to children seems therefore to be a great way to learn how to communicate science to public in a scientific and correct, yet understandable way. This former oral conversation reveals tobe imperative, as it allows to call the topics of the session, which can then be discussed, with children making questions and sharing their own ideas and changing their mind about some myths, beliefs and lies spread around about science.

After these few activities during the beginning of the current year, it was possible to observe that children are able to absorb a lot of knowledge from hands-on science activities. Also, the training given by the student volunteers seem to have a great impact in the connection between the participants and the activities, as it seems often easier for other students who are currently also learning the addressed topics, to explain concepts in an easier and clearer manner. Apart from the importance for the participant children, also the positive impact on the volunteers is a plus. Most of the volunteers decided to participate regularly in the project and reveal high engagement when it comes to plan, prepare and mentoring activities. This can have further positive implications in their future studies or work regarding science communication and how they present and spread their work in science.

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Hands-on the Bacteria: A Journey to Human Microscopic Flora

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Abstract. In this work we present a set of experiments directed to students of the 4th year, to present them in a very playful way tthe world of microorganisms. More than hearing a lecture or watching a video, students have learned about bacteria in general and on their own particular natural flora handling and seeing these germs.

It is well known that directed discovery has positive effects on retention of information compared to traditional direct instruction. Thus, students are encouraged to play with bacteria making drawings with *Staphylococcus* epidermidis and to evaluate hand hygiene efficiency as the most important measure to avoid the transmission of harmful bacteria and prevent infections associated with health care.

Although some children were more successful washing their hands than others, at the end of the sessions everyone shouted: It is very important to wash hands!!!!

Keywords. Bacteria, encourage scientific skills, hands hygiene, new approaches to old techniques.

1. Introduction

Scientific education at the earliest grades is supremely important, but in most classrooms it gets short shrift. One of the priorities of Colégio Valsassina (Lisboa independent school) is to develop in the students competences in scientific areas that are transversal to other areas of knowledge, contributing to the development of the students' knowhow, scientific skills, observation and critical analysis of the results.

In this way a partnership between Faculdade de Farmácia da Universidade de Lisboa and Colégio Valsassina was established and the experiments reported on this paper were performed with students from the 4th grade of the first cycle, to introduce them into microorganism world and its impact in health.

These experiments intend to allow the students contact with concepts and materials in a very interactive way, based on the statement that learning by direct discovery is a major way to achieve knowledge [1]. The lesson started with a short discussion about some theoretical concepts about microorganism world: "what are bacteria: good and bad bacteria" and "how bacteria grow in nature and in the laboratory". Then the students start performing the experiments that are described at section 3.

2. What are bacteria?

Microorganisms or microbes are living cells that are too small to see with the naked eye. It includes viruses, bacteria, protozoa, yeasts and fungi. Microorganisms and their activities are vitally important to virtually all processes on Earth, and they affect every aspect of our lives – they are in us, on us and around us.

Bacteria are microscopic, unicellular organisms (Figure 1) with no organized nuclei that have inhabited the Earth for about 4000 million years (hominids appeared about 4 million years ago) [2].

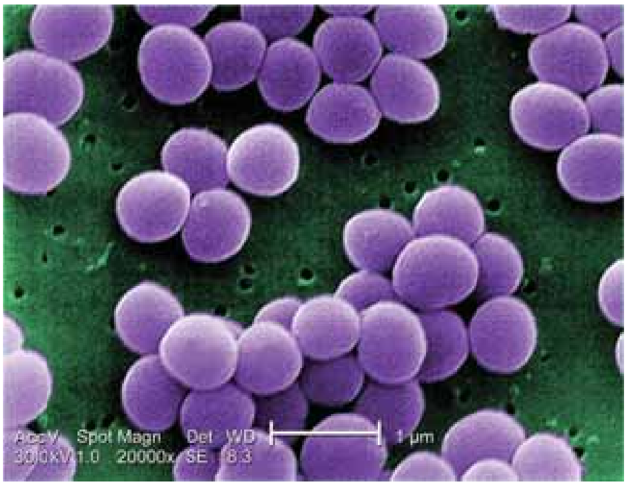

Figure 1. ***Staphylococcccus epidermidis*[3]**

2.1. Good and bad bacteria

Among the general public the most popular concept of bacteria is generally connected with infection, disease and death. Indeed, for centuries bacterial infections were the major cause of infant and child mortality worldwide. The introduction of antibiotics to treat the infections, vaccination for prevention and education of the people to improve hygiene, significantly decrease the mortality related with bacterial infections [4].

Nevertheless the majority of bacteria present on the planet are harmless to humans and some are highly beneficial.

Bacteria play key important roles in nutrient cycling, biodegradation/ biodeterioration, food spoilage, cause and control of disease and biotechnology. Thanks to their versatility, microbes can be put to work in many ways: making life-saving drugs, the manufacture of biofuels, cleaning up pollution, and producing/processing food and drink [5-7].

2.2. The importance of human normal flora

The human body is home to millions of beneficial bacteria. The normal flora influences the anatomy, physiology, susceptibility to pathogens, and morbidity of the host. In a recent paper Sender et al. [8] estimated that the number of bacteria in the body is actually of the same order as the number of human cells ($3.8 \cdot 10^{13}$ bacteria vs $3.0 \cdot 10^{13}$ human cells) and their total mass is about 0.2 kg.

Without bacteria we would not survive. They help us digest our food, produce vitamins, and occupy niches that would otherwise be available for competing pathogens. We house millions of bacteria in our skin, nose, mouth, and gut, namely:

- up to 500 species can be found as normal oral flora
- a milliliter of saliva can contain as many as 40 million (4×10^7) bacterial cells
- 108 bacterial species in cecum (the initial part of the colon) per milliliter and many of these species are different from those found in the mouth
- 25 to 500 million bacterial cells per square inch of skin, representing around 1000 different species of bacteria, mainly Gram positive (staphylococci, micrococci, diphtheroids) [9-10].

3. Playing with bacteria

In this paper we propose several experiments to promote a first contact with bacteria, allowing the students to understand how bacteria grow in a laboratory. In an unusual and creative way, the children drew on surface of a culture medium agar. Later they "saw" their own hand bacteria and understood the relevance of hand hygiene to avoid the transmission of harmful germs. The experiments have a 2 x 90 min duration.

Figure 2. Students of the 4th grade at Colégio Valsassina Laboratory

3.1. Drawing with bacteria

3.1.1. A new way of inoculate *Staphycoccus epidermidis*

To each student a sterile disposable loop, a Columbia agar plate + 5% sheep blood (CAB) and a previously incubated culture of *Staphycoccus epidermidis* ATCC 12228 were given. Plates were incubated at 37 ºC for 24h. The agar surface worked as a sheet of paper and the loop as a feather pen (Figure 3).

Figure 3. Students drawing with *S. epidermidis*: agar surface worked as a sheet of paper and the loop as a feather pen

3.1.2. Results of the drawing experiment

All the students were amazed with the results of their draws with bacteria. After 24h the bacteria had grown and the figures come real. Some of the results are presented on Figure 4.

3.2. Do you know how to wash your hands?

Hands are the main pathways of bacteria transmission. It is quite relevant to sensitize young children about the importance of a good handwashing.

Each student had two CAS plates marked with “before” and “after” handwashing. The student pressed the hand on the agar surface before and after washing hands (Figure 5). After 24h incubation of the plates the students returned to the laboratory to observe and analyze the results. After 24h incubation of the plates the students returned to the laboratory to observe and analyze the results.

Figure 4. Some draws realized by the students

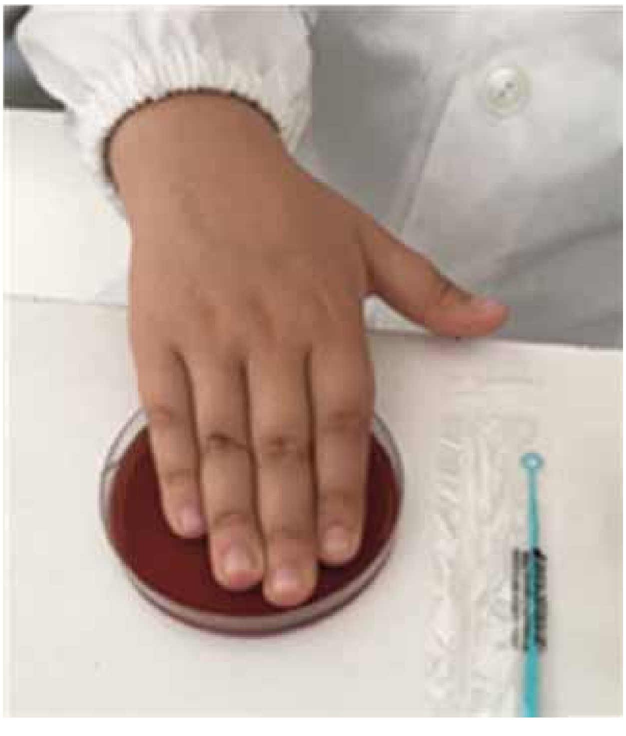

Figure 5. Students inoculating de CAS medium

3.3. Results of the handwashing experiment

Next day the plates were shown to the students and they were able to observe the colony forming units (cfu). They were encouraged to analyze the variety of the flora of their hands and the efficiency of hand washing. The results are shown in Table 1 and Figures 6, 7 and 8.

Figure 6. Hands of student 10 (before and after wash)

Figure 7. Hands of student 2 (Before and after wash)

Figure 8. Hands of student 8 (Before and after wash)

The children were actually surprised by the number of colonies on the plaques and noted differences in color, shape and smell of bacterial colonies.

Analyzing the data presented in Table 1, most students reduced bacterial content after hand washing (66%) and 43% had a reduction in the number of colonies above 50%. Two examples of efficient handwashing are shown in Figures 6 and 7. On the other hand, 34% of the students had a poor technique and there was no visible change in the plate count after and before (Figure 8).

Table 1. Colony forming unit (cfu) before and after handwashing

Student	Before	After	Bacteria decrease
1	144	140	3%
2	424	208	51%
3	36	18	50%
4	110	60	45%
5	138	118	14%
6	86	98	-14%
7	55	27	51%
8	449	490	-9%
9	148	96	35%
10	600	85	86%
11	125	69	45%
12	600	289	52%
13	68	41	40%
14	600	245	59%
15	309	261	16%
16	67	18	73
17	132	108	18%
18	107	120	-12%
19	82	32	61%
20	348	234	33%
21	54	6	89%
22	92	46	50%
23	125	127	-2%

4. Discussion

To access the learning process, an inquiry was completed by the students at the end of the activity. The results are displayed Figure 9, graphs 1-7.

The analysis of the graphs presented in Figure 9 revealed that all proposed goals have been achieved. The students were very enthusiastic and curious about the subject.

The positive impact of the model teaching-learning through the experimentation, observation, reflection and discussion is clearly deduced from Figure 9 (graphs 1-4). Most of the children learned the concepts presented and transmitted them to other people, which reveals the internalization of the acquired knowledge (Figure 9 graphs 5-7).

These experiments might be adapted to the natural science class of the 6th grade, since microorganisms are part of this class program.

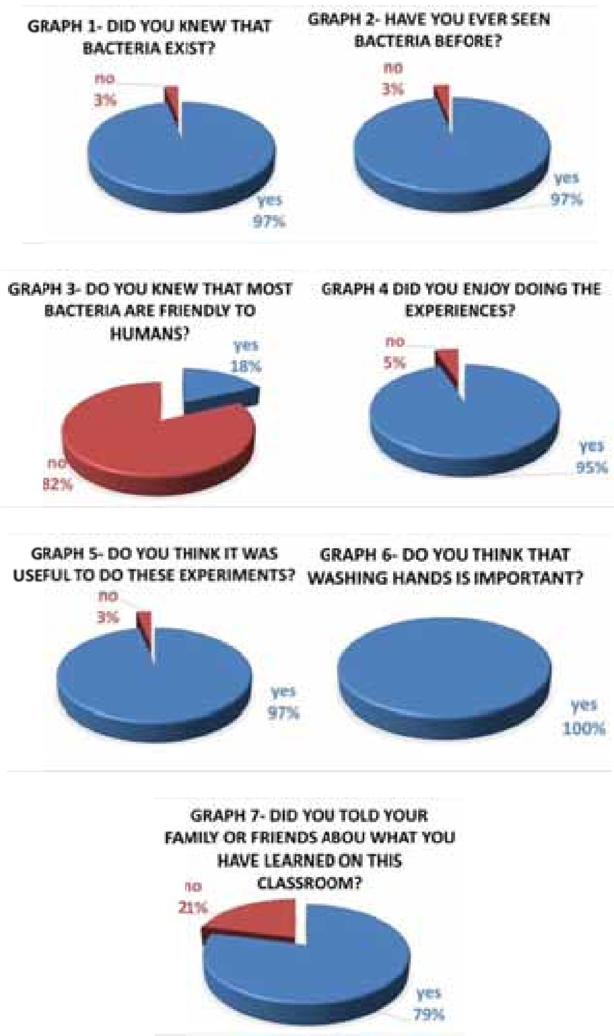

Figure 9. Evaluation of the activity by students

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III Week of Sciences. Evolution of a Community Educational Project

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Abstract. This initiative of the Science Week was born from an idea of the Department of Education three years ago. Since then it has been celebrating each year in the month of April. This event was organized jointly from the beginning along with the teaching staff of the schools of the municipality. Later students were interested in the different activities.

From a simpler and more compact format, requests and suggestions were emerging that were incorporated by consensus. This has made the experience evolve each year by acquiring a new dimension in content and organization. In this last edition, together with all the activities carried out in previous editions, we had news such as the Student Congress, a photography contest, a didactic classroom for the youngest, institutional presence of the University of Santiago de Compostela, as well as the presentation official of a didactic game of the creation of a professor of the locality.

On this occasion we show that with very limited resources, with creativity and also, with the collaboration, involvement and participation of the entire Education Community, from a small local administration, without specific competences in the educational field, it is possible to achieve:

- Provide Science to the whole neighborhood.
- Showcase interesting projects outside the School Centers.
- Make students see science as something fun, creative and a possible future option.
- Find that the students acquire protagonism from the science of a transversal way dominating the scenic fear, elaborating scientific texts, negotiating subjects and contents ... All of which contribute to their personal empowerment.
- Emphasize the role of women in the world of science, the problems they find, struggling to eliminate gender stereotypes related to science.
- To obtain a greater relation and cooperation between the different directions, professorships and students of the educational centers.
- Take a party to the streets of the municipality, whose main protagonist is science.

The result of all these objectives is the participation in this Congress of a representation of students that accompanies this delegation, which participated in the Congress held in Ponteareas and also make a presentation.

Keywords. Non-formal education, science fair, community education, participation, interdisciplinary, transversal, municipalities, congress of students.

1. Introduction: Ponteareas

Ponteareas is a small town in the south of the province of Pontevedra, 30 km away. of Vigo and 12 of the Portuguese border with Monçao.

We have 23,000 hab. 11,000 in the urban center and the 12,000 remaining divided between 23 parishes in rural areas.

In Ponteareas we have 4 institutes, 5 public pre-primary and primary schools and 2 subsidized schools and a grouped rural school (CRA) that has 7 units in different parishes, with an average of 15 students between 3, 4 and 5 years. The closest university is in Vigo (with additional campuses in the cities of Pontevedra and Ourense), and our students are also enrolled frequently in the faculties of Santiago de Compostela.

2. Science Week

2.1. Origins

The initiative of the Science Week was born from an idea of the Department of Education, newcomers to the city government in June 2015. From 2016 onwards, it was celebrated every year in the month of April. This activity largely replaced many of the deficiencies at a scientific level and in a transversal relationship with the teaching and school centers we had in Ponteareas.

The aim, therefore, of this presentation is to show that this initiative, which is so important for the educational community of our City Council, is possible to be carried forward in any Spanish municipality or even in any other country. And, of course, it will be so beneficial, creative and fun that it will have multiple positive effects on the students and faculty of the School Centers.

From the Education Council we were maturing this idea and presented it to all the directions of the School Centers at the beginning of the 2015/16 academic year, involving all the teachers and students and making them also participants in the idea.

With a very limited budget without subsidies of any type of other administrations, the first edition of the Science Week has come to light thanks to the selfless collaboration of the Educational Community and the people who participated as speakers and disseminators. Subsequently, students interested in the different activities were joining us.

From a simple and more compact format [1], requests and suggestions were emerging that were incorporated by consensus. This meant that the Science Week had been evolving year after year and acquiring a new dimension in content and organization.

2.2. Third Edition

Between the 9th and the 14th of April, the third edition was held this year. In spaces as diverse as the Municipal Auditorium, the Conference Room, the central sqaure of the town, the hall of acts of an institute, a convent and the Gardens of the City Council. This is because the city does not have a fairground or similar that makes possible a single space where to carry out all the organized events, but instead of causing great prejudice, it has given the possibility of valuing different spaces that allow greater closeness to science of the whole vicinity. Thanks to this, science went out to the streets.

This year 2018 was the ideal time to expand the offer of activities at the request of the different sectors of education. Events such as conferences, the seminar of professors, visits to companies, the creative space "Get closer to Science" and the essential Science Fair were consolidated. The Museum "Science in motion" has been present in all editions due to its success, directed by Xesús Fernández and supported by the UVigo School of Mines [2]. And we incorporate novelties such as a congress of students, a photographic contest, a didactic classroom for the youngest, institutional presence of the University, as well as the presentation of a didactic game created by Professor Xabier Prado that accompanies us today and will give a presentation on his creation in this Congress.

Figure 1. Seminar for Teachers

Figure 2. Science Fair

Figure 3. Game presentation – 11 Towers

It is interesting to realize that with very limited resources, with creativity, and also with the collaboration, involvement and participation of the whole Educational Community, from a small local administration, with no competencies in the educational field, it is possible to achieve great things.

Figure 4. Teaching Unit

3. Opportunities

The Science Week offers us many opportunities that should be valued:

3.1. Bring Science to the whole neighbourhood

Through the conferences in which scientists and researchers of recognized academic background participate. In activities such as the Science Fair or "Come Closer to Science", where they participate in the works and experiments that students develop and present.

3.2. Showcase interesting projects outside the School Centers

It is important for the Department of Education to value school activities before mothers and parents and the rest of the Educational Community.

3.3. Make the students see science as something fun, creative and as a possible future choice

If we do not manage to make science an everyday issue, a high percentage of students will choose educational subjects that they consider more "easy", opting for this route only if it is essential to access higher studies that have this requirement.

3.4. Try that students become protagonists from science

In a transversal way, this will help them master scenic fear, develop scientific texts, improve writing and exposure, negotiate themes and contents ... Contributing to their personal empowerment and the growth of self-esteem.

3.5. Highlight the role of women in the world of science

Posing in evidence the problems that are found, eliminating gender stereotypes related to science.

3.6. To achieve a greater relationship and cooperation between the different sectors of the Educational Community

The close relationship between the Directors, the professors and the students of all the School Centers is important.

3.7. Make Science a Feast

Bring to the streets and places of the municipality a great activity, whose main protagonist is Science.

4. Valuations and evolution of the experience

As in previous years, also in this year 2018 the ranking of the activities by the educational centers and the general public was very positive. The comments were received in many different ways and were collected in surveys completed by the public and the students in the different events, as well as in the schools.

We have been learning and improving in each edition thematic and organizational aspects from these comments, both from the public and from the participants and collaborators. And with the expansion of the events, the management of the material, time, personnel and necessary resources has been also gradually more complicated, and this meant that we had to adapt to the new circumstances.

This new situation was saved thanks to the involvement of the municipal personnel assigned to the Department of Education and to new collaborators and volunteers who felt that the project was also his and they participated in a very active and dynamic way.

At the level of economic resources, the Department of Education has opted to support this event directly within the possibilities of the Local Administration, making the Science Week a Star Project, a reference in the whole Autonomous Community.

5. Congress of Students

The result of all the objectives achieved in the last Science Week is the participation in this Congress of the representation of students that accompanies this Delegation of Ponteareas, who participated in the Congress of students held in April and will present here in Barcelona their presentation.

Alba Presa, Aida Rodríguez and Ana Nogueira will talk about the future that is foreseeable for the Science Week, and if they think that it can be relevant in other places and interesting for their neighborhoods. There will be students like them, who have to decide in next editions, what activities should be included in every event and which others that do not interest them. What lecturers should participate, what museums they want to visit or what outings they want to do ... and the Teaching Department ... This councilor will be there to accompany them ...

Figure 5. Science Museum for Children

Figure 6. Students playing with City Councilors

6. Conclusions

The Week of Sciences is a set of very dynamic, fun and educational activities that take place during a week and that involves decisions and their organization throughout the Educational Community.

After analyzing the past three editions, success is complete among educational centers, but also among the population of Ponteareas in general that participates in all open activities.

Figure 7. People at the Science Fair

Figure 8. Students at the Science Fair

Figure 9. Audience at the Conferences

From the Department of Education that directs and coordinates the event, we are clear about its continuity in the future in our City Council, and we consider it necessary that these types of activities exist in more municipalities throughout the country, since the benefits it faces both for students, teachers and parents have been demonstrated.

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Not forgetting the dissemination of science and educational scientific projects that has been achieved among the neighborhood outside the academic environment.

7. Acknowledgements

I want to thank personally the collaboration of the Ponteareas Educational Community, the Directions of the Centers, the teaching staff and the students. Also the great support that I always find in the students´ parents and their Associations (ANPAS).

Thanks to all of them to believe in this idea from its very beginning and turn it into a great future project, where everyone's suggestions are taken into account and there is room for the participation of all educational sectors.

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Management of a Laboratory by Means of Digital Tools

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Abstract. When teaching science at any level, the experimental part that occurs in the laboratory is very important, both for teaching staff and for the student. Therefore, a good laboratory management, as well as the elements that make it, becomes an essential task. An inventory must be aware of all reagents and materials used in any experiment. To be able to facilitate all this work, and have a visual, fast and effective system, it is proposed the creation of a digital laboratory control system.

Keywords. Digital tool, inventory, management, laboratory.

1. Introduction

Currently the use of smartphones, tablets and different electronic media is very important, almost essential both in the personal and professional fields, and in the school and university. Taking advantage of these tools of the 21st century, we can create different management and control systems in an easy way, which can be useful for the teaching staff, the laboratory technician, or the students who are using it at that time.

With a simple table in Excel format, all the equipment can be inventoried, knowing the state in which they are located, or their location. It is also applicable to glass or plastic material, as well as with all reagents, incorporating different sections where the degree of danger can be specified or the precautions to be taken when using it.

The main advantage of this system is that can be extrapolated to any laboratory of any level; be it of primary or secondary school, or any University department. Once created, and with the relevant revisions, it will not only allow complete control of any element within the laboratory, but also allows a good traceability of any experiment, as well as a total control of expenses at all levels [1].

2. Inventory

The first step before moving the system to a digital template of any format will be the inventory of the entire laboratory, divided into three parts; equipment, material and reagents

You must create an intuitive reference system, and then a record sheet of them (Figure 1).

It should be noted that this inventory must be carried out exhaustively, without neglecting equipment accessories supplies or computer packages, since they are also part of the laboratory [2].

Figure 1. Equipment room inventoried

2.1. Equipment

The first field to be introduced will be the laboratory equipment. This field ranges from any equipment that is necessary for any experiment, to security elements such as extractor hoods or storage elements such as refrigerators or freezers; where all the drawers or separations of the same will be marked, since there are many reagents that must be kept under specific conditions (Figure 2).

The teams will present a reference created according to the needs of each center, and will be individual for each team. If the equipment is in a specific room or closet, a specific numbering must be included for each room or closet of the laboratory (Figure 3).

For example; if you have all the microscopes in locker 1, it will be included in the template as " equipment01-locker1". This way the user will know quickly and easily where the equipment is. You can create sub-sections including the equipment status, maintenance and revision dates, which can be entered in the table in link format and when the information is displayed, the required information appears.

Figure 2. Freezer inventoried

Figure 3. Centrifuge inventoried

2.2. Material

With the laboratory material will proceed in the same way; all the material will be counted, and it will be organized in appropriate cabinets or spaces in the laboratory, indicating the total amount of articles and their location (Figure 4).

This procedure will not only allow a quick preparation by the student or the professor of any experiment, but also will allow to control all the material at the end of the course, and assess the loss or breakage of the same, being able to make budget estimates to adjust it in later sessions.

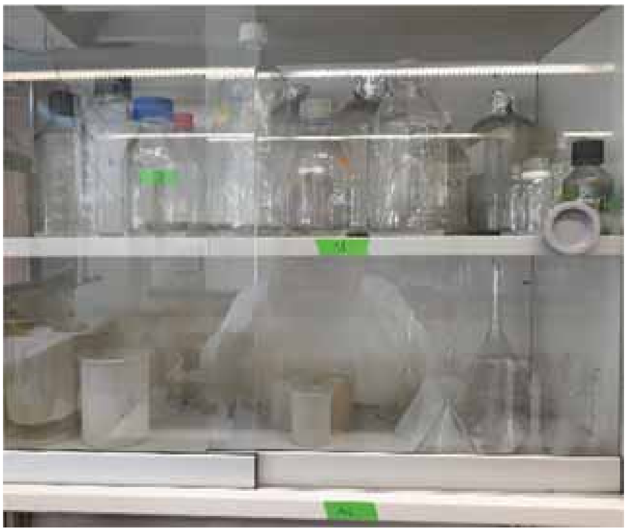

Figure 4. Laboratory material inventoried

2.3. Reagents

The control of reagents will be a bit more complicated since you have to take in account different factors such as hazard, storage and durability. It is recommended to use a simple numbering for any laboratory reagent, and then write down the reference of the space where it has been stored; either and extractor hood, a cabinet for flammable reagents, a warehouse, a refrigerator or a freezer (Figure 5).

Figure 5. Reagents inventoried

It is recommended to make simple tables in each space, which can be consulted by users, for, with a quick glance, to know if the reagent that is being looked for is in said space or not. With this system it will be possible to control the total stock of laboratory reagents, and consequently to be able to place orders for replacement or reserve as the time progresses, while never having a minimum stock of the reagents necessary for any experiment.

3. Digital tools for the creation of the laboratory management system

Currently there are multiple and different digital media that allow the creation of a laboratory management system. All of them are valid, but capital and time available will mark the type of support to choose [3].

3.1. Web and app tools

The use of the internet is becoming more frequent, and nowadays there are different means to control the laboratory. If you have enough capital and time, the creation of a web page will be the best option to consider. This system allows the consultation of any student or teacher through a computer, smartphone or tablet. In the same way, it can be kept-up-to-date quickly, but it requires a constant dedication to update, and an initial capital investment to create it. On the other hand, if you prefer to have a mobile application, there are different supports already created and free, such as.

3.1.1. GLPI

It is a resource manager with a very friendly interface. Makes the life of the administrator simpler. Everything will be stored in a database to which we can access from any point. Manages a history of maintenance and programmable actions. In addition, sum notifications by email to be all the time aware of what happens.

3.1.2. Simple Inventory Management

It is a free application designed for iOS integrated with a program called Cashier Live that makes a permanent monitoring. It has a barcode scanner, which facilitates all the handling even while on the move.

3.1.3. ABC Inventory

This is a simple experience and that is precisely its objective. You can use it from any central computer that controls all. Your organization allows you to classify for all the categories that we need such as brands, companies, currencies, managers, credits, currencies, employees, species, and so on.

3.2. Spreadsheets and databases

In the laboratory, it is customary to work with different programs such as Excel or Acces, included in the Windows Office package.

When the user knows these programs, even if they are applied in a different way, they have a minimum knowledge, and therefore, the management system can be made more easily. Furthermore, this method does not imply an extra expense, since the program is already available, and its maintenance and updating only takes time.

When making a table in Excel format, you can send the file by email and read it in any digital support, such as those mentioned above (Figure 6).

Figure 6. Spreadsheet of the laboratory management system

Consequently, both students and teachers from any smartphone can search for any item with the search engine, which the same program includes (word search) and in this way find the material, equipment or reagents necessary for your experiment

In case of Acces, it requires a deeper knowledge of the database system, but on the other hand, it allows the entry of multiple fields within it, which will give the user greater specificity when creating the database, thus having much more information than could be provided by a table in Excel format.

4. Conclusion

The inclusion of the laboratory's inventory and management system is a very useful tool for all laboratory users. Teachers can include the Excel files or database in the center's

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campus, where students can consult said tables, or download them, and thus, be able to prepare everything necessary for their experiment autonomously. It also allows the teacher to have full control over any element of the laboratory, knowing at all times the status or availability of them, which in the future will allow a better management of laboratory resources, and consequently a benefit for all users of it.

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Nursing Informatics Project: Implementation and Outcomes

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Abstract. Medical information systems are taking a leading role in the information support of healthcare services. This allows suggesting that both new nurses and healthcare practitioners currently employed would need training as users of this kind of software. As a result, teaching medical information systems is becoming mandatory in medical educational institutions.

The paper presents a project which expects to improve healthcare status in Ukraine through educating nurses and other patient care providers to use "Doctor Eleks" medical information system. Project activities are described. Specifics of teaching "Doctor Eleks" basics to different populations of learners are addressed. Educational values and project outcomes are summarized to determine the project impact.

Keywords. Nursing informatics, medical information system, workshop, training, nursing education.

1. Introduction

The "Nursing Informatics" project [1] was developed by faculty, IT specialists and cardiologists from three institutions located in Lviv (Ukraine): Krupynsky Institute of Nursing and Laboratory Medicine, "Doctor Eleks" software engineering company and the Heart Rhythm Center, and supported by a grant within the Small Grant Program for alumni of the US government-sponsored exchange programs.

In the course of the project implementation another four institutions joined: Cherkasy State Technological University, Pirogov National Medical University in Vinnytsya, Horbachevsky Ternopil State Medical University and Ukrainian Academy of Printing.

The purpose of the project is to decrease the gap between actual need for nurses and other healthcare practitioners proficient in informatics who are currently entering the healthcare industry and the actual state of nursing informatics education in Ukraine by introducing real life nursing scenarios and "Doctor Eleks" (DE) medical Information system (MIS) into practice of informatics teaching.

The project program includes a variety of activities of significant educational and research value tailored to the needs of nursing education (undergraduate, graduate and continued) and in-service training.

2. Project activities

The project program includes a number of educational activities offered to students and healthcare professionals. Additionally, some forums and a contest were carried out.

2.1. Classroom practice and in-service training

Teaching MIS DE user skills has been integrated into curricula at a few educational institutions. Syllabi are both specialty and degree-specific.

At Pirogov National Medical University in Vinnytsya, medical students who are future doctors and dentists take a general course of medical informatics. They study DE basic modules and workplaces including EMR (Electronic Medical Record), Patient, Record Office, Doctor, Laboratory, Hospital, Administrator within this course. At Cherkassy Medical Academy, senior nursing students take a special course titled "Medical Information Systems" which focuses on MIS DE.

Medical graduates are expected to work with a pre-installed MIS DE. The system customization requires learning MIS DE as software. System administrators are educated at Cherkassy State Technological University. Administrator responsibilities include professional deployment, customization and support of MIS DE in a specific environment of a particular institution.

Currently in-service training is available for medical and IT customers. Physicians, nurses

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and hospital managers study MIS DE user skills at the Center of Advanced Medical Training in Cherkassy. Trainees benefit from MIS DE implemented in Cherkassy Heart Center in 2015.

IT specialists can get a certificate of MIS DE administrator at Cherkassy State Technological University. The University developed a 90 hour continued education course followed by a certification exam. Distance learning mode is also available. Successful trainees get administrator certificates issued by "Doctor Eleks" company. We may mention that informatics teachers from Cherkassy Medical Academy were ones of the first certified DE administrators.

2.2. Consumer health leaflet contest

A consumer health leaflet is an efficient tool nurses and doctors can use to communicate with patients. To develop a quality leaflet one must have both advanced graphics design skills and nursing knowledge. A special training session was conducted to explain the participants how to structure a leaflet material, to use basic design elements, and to separate primary data from secondary one.

Figure 1. Tooth-brushing tips for children

The consumer health leaflet contest became one of the most interesting events of the project. Participants were encouraged to submit leaflets on topics of their interest. Totally 11 works were submitted by students, teachers and nurses. These leaflets were put on the online vote through the project website to select the best works. Totally 530 persons took part in the voting.

The four best leaflets were printed, 300 copies each, and delivered to authors as their awards. It is worth mentioning that the best works were the co-operation result of informatics and nursing teachers/students. Figure 1 presents #1 leaflet with tooth-brushing tips for children.

Though the vote was anonymous, we asked nursing students about their selection criteria they were applying while making choices. A collective answer was that content is more important than a design.

2.3. Nursing informatics workshop

A 2-day workshop (22-23 March, 2018) became a central event of the project due to the importance of issues announced in the workshop program. More than 60 participants came from 19 cities in Ukraine (Figure 2). They were informatics and nursing teachers, students, IT researchers, nurses, hospital managers and healthcare administrators.

Invited speakers delivered 10 presentations to consider the issues which are of priority in today medical education and healthcare practice. These are:

- the healthcare system reform in Ukraine;
- the role and position of MIS in the healthcare industry and e-Health system in particular;
- a roadmap for MIS implementation in a hospital, in a city and rural areas;
- a model of nursing informatics syllabus;
- teaching MIS DE to different populations of learners such as medical, nursing and IT students; healthcare practitioners; informatics teachers.

Figure 2. Home location of participants

The workshop trainings were conducted at Lviv Children Hospital where MIS DE was implemented in 2008. Workshop participants benefited from advice and inputs from the Hospital nurses and doctors who have become experienced “Doctor Eleks” users (Figure 3).

Figure 3. Training at Lviv Children Hospital

Real time demonstration of how the hospital staff uses MIS DE to document the delivery of patient care was followed by a tour around the Hospital, and the participants could access MIS DE from any workplace.

3. Educational value

The project has significant educational value as a path to proficiency in nursing informatics and medical information systems in particular.

Figure 4. Student volunteers at the workshop

At the classroom, students and on-the-job trainees engage in a variety of activities designed to make them more aware of how they can apply MIS DE in patient care practice. The activities range from discussions on daily routines typical for nursing practice to simulating these routines with MIS DE. Informatics teachers will benefit from using the project instructional materials.

The project workshop provided good opportunities for a group of 3-year students, who were members of the local organizing committee to acquire service experience and improve communication skills (Figure 4). They applied their informatics knowledge to keep workshop records; design badges, posters, invitation forms etc; process the survey data. Additionally, they have field practice during the workshop training.

At the community level, the project promotes awareness of improved healthcare quality which the application of medical information systems would involve. The project aim concerns the initial target group in a direct way; however the need for quality nursing is also the shared problem secondarily of many health care consumers served by this group who will benefit from improved informatics competencies of their healthcare providers.

4. Project outcomes

In order to understand more about a professional impact of the project, we carried out a survey to determine participants’ opinions. During the workshop, survey forms were completed by 52 participants. Workshop organization rating was 5 (91% respondents) or 4 (9% respondents), rating scale 1-5. They reported that the workshop attendance was a useful contribution to their professional activity. In written comments, participants recommended to integrate teaching MIS DE into nursing/medical education and in-service training. Also the need for annual workshops was highlighted.

The workshop was followed by a new forum organized within the 4th International Conference on IT Application in Education, Science and Engineering (Cherkasy State Technological University, May 17-18, 2018). A special “Medical Information Systems” section presented some new aspects concerning MIS DE implementation in medicine and education.

The project instructional materials are summarized in a “Doctor Eleks” tutorial which describes the nursing history; illustrates an implementation of “Doctor Eleks” medical information system (example - medical services of armed forces in Ukraine) and gives recommendations on using “Doctor Eleks” to simulate real nursing scenarios in a classroom.

MIS DE was chosen for consideration because it is the most implemented system by now. Besides, it is a perfect example of software based on innovative programming technology. Since most of patient care documenting is made by nurses a special accent is put on nursing-related topics.

5. Conclusions

Medical information systems are central to healthcare services today. Hence, teaching medical information systems is becoming mandatory in medical educational institutions which requires re-designing informatics syllabi at all levels of nursing education.

Practical tasks developed in the course of the project realization could partly cover a semester informatics course at an undergraduate senior, or first-year graduate level to make practicing with medical information systems a part of curricula.

6. Acknowledgements

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Open Science Schooling: One Experience of EXPLORATORI

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Abstract. In this work it is presented the experience of the research group: EXPLORATORI natural resources from near 25 years. The use of Science, Technology, Engineering, Art and Mathematics (STEAM), and Open Science Schooling (OSS) methodologies have characterized the most important activities of this Group.

Firstly, it is important highlights the difficulty for secondary schools and science teachers to engage these methodologies in practical experimentation.

Secondly the paper shows several practical examples applied in some different Secondary Schools and Erasmus+ projects in development.

Keywords. Learning, secondary school, STEAM, engagement in science and technology.

1. Introduction

Encourage “open schooling” where schools, in cooperation with other stakeholders, become an agent of community well-being; families are encouraged to become real partners in school life and activities; professionals from enterprise, civil and wider society are actively involved in bringing real-life projects into the classroom [1].

Students in Secondary school develop resistance towards science learning and science careers.

The European Commission considers this one of the most important challenges to innovation and economic growth.

State of the art research agree that the disengagement in science takes place in secondary school and typically when the students are from 12 to 15 years old, indicating that science resistance is strongly linked to the development of the students’ identify and personality [2].

An Open Schooling approach, maybe based in science learning processes with strongly links to the students’ participation in real-life science challenges in society and to participation in real research and innovation circles.

Open Science Schooling (OSS) is almost exclusively a theory, a concept used in research and policy-making. This makes it very difficult for secondary schools and science teachers across EU to engage in practical experimentation [3].

In this sense, EXPLORATORI Natural Resources (EXPLORATORI) apply this methodology in their activities.

2. EXPLORATORI activities

The “EXPLORATORI” is a project from the Barcelona Knowledge Campus (BKC), presented by the “Universitat Politècnica de Catalunya BarcelonaTech” (UPC) and the Berga Town Council. The main objective of the project is to bring science closer to secondary school students, their teachers and the society in general. To achieve this goal, the “EXPLORATORI” organizes activities related to scientific and technological topics, with application of Science, Technology, Engineering, Art and Mathematics (STEAM).

More specifically, the “EXPLORATORI” project aims to contribute to:

- Engage secondary school teachers and students in science and technology, in order to promote scientific and technological vocations.
- Match supply and demand for qualified workers with STEAM skills and knowledge.
- Stimulate young people’s interest and attitudes in STEAM subjects and careers.
- Strengthen links between research and education.

The “EXPLORATORI” organizes activities and projects related to scientific and technological topics, with a common background: Engage secondary school teachers and students in science and technology, in order to promote scientific and technological vocations. These activities are classified in three sections.

2.1. EXPLORE Courses

It is a project addressed particularly to current science and technology teachers in Secondary level education (25 years of experience). The specific purpose is to provide tools for teachers to be used afterwards in their lectures with students. The singularity of this action consists in the fact that the theoretical lectures are complemented with sessions on site and workshops. These courses are accredited by the Department of Education of the Catalan Government (Generalitat de Catalunya).

The theory and practical lessons take place in “El Berguedà” region, located at the north-centre of Catalonia. Each course covers different aspects of the topic selected, from different disciplinary perspectives simultaneously. This multidisciplinary design activity is in line with the STEM education model. (See pictures of practical lessons in the country [4]).

2.2. Knowledge Fair

The Knowledge Fair is a two-day Science Communication Event at Catalonia (8 editions). The specific objective is to introduce the most recent science and technology research projects held in the UPC university, as well as in other research institutions (nine research groups), to young people. These projects involve a broad spectrum of science and technology topics, such as natural resources or medical issues.

Figure 1. Students visiting Knowledge Fair

Each research group is represented in the Fair by at least two PhD students. The close age between them allow providing participants with an enriching exchange of their academic experiences that surely promote to the creation of new scientific and technical vocations. (See pictures: [5] and in the Figure 1).

2.3. Catalonia Young Talent FORUM

The objective of this action is to reward the best 40 students of the 4th course of “ESO” and 1st course of “Batxillerat” and promote science and technology interest among secondary young students (4 editions). The central topic in the first edition has been “Water in Earth” and prominent figures and scientist had participated.

This enabled the participation of students from different regions and cities across Catalonia. This action took place in the city of Berga over a four-day period. (See pictures: [6] and in Figure 2).

As one example, over the last school year, some 750 secondary school teachers and 14,000 students attended or participated in an activity organized by the EXPLORATORI.

Figure 2. One group of students working in the FORUM

3. Application examples of Open Science Schooling in Secondary School

The activity developed for the EXPLORATORI across the years has conducted this research group to initiate several projects with Secondary Schools, with a clear use of Open Science Schooling methodology.

3.1. SAVEnergy

This is a project with the aim to save energy at homes of young students of Secondary School. The project has been developed in three schools:

- 2017 Inst. Guillem de Berguedà / Inst. Serra de Noet from Berga.
- 2018 Inst. Pere Fontdevila from Gironella.

Figure 3. Mobile App to control energy consumption

The Project is a clear application of OSS methodology:

Non formal learning: The devices [7] are installed at students' homes --- Implication of the family

Implication of local society:

- Knowledge: University - High Schools – Teachers – Families.
- Political agents: Local - Regional - National.
- Industry / Business / Research & Development.

The goals of the project are *empowering the High School:* the Secondary School is key because the goal is that young students because becomes the driving force for change and engages their families in this goal.

The topic is Technical, but with several social implications: economical saving, social awareness about power consumption and sustainability. The use of e-learning is fostered: use of one mobile App (see Figure 3) and a virtual platform [8] in order to use the gamification, achieving challenges, rankings

3.2. ScienceGirls

The Erasmus+ project, ScienceGirls: Teenage girls as co-creators of science learning engagement, will contribute to encourage the wider participation of girls in STEAM activities with a particular focus on Science. The project engages the girls in three major challenges:

- How we feel science
- Science in real-life
- Visions of early science engagement

The participants are two universities and seven Practice partners with 80 girls are from eight different countries: England, Catalonia, Romania, Italy, Slovenia, Lithuania, Turkey and Greece.

Figure 4. The Girls in YoMo 2018

Young people are increasingly disengaged from science learning in schools and this is causing great concern in the European Commission and among other global players. The aim of the ScienceGirls project is to elaborate one guide in order to contribute to the Science Learning Innovation Agenda of European Commission, through practical experimentation in secondary school with the participant girls. Clearly, work needs to be done to change people's perceptions so that girls see themselves in science and technology related careers.

The project is developing from 01/09/2016 to 31/08/2018. The Figure 4 shows the participation of the 80 girls in Youth Mobile 2018 (YoMo).

3.3. Open Science Schooling

The Erasmus+ project Open Science Schooling: Fostering re-engagement in science learning through open science schooling, includes the following innovations (basic Open Science Schooling didactics):

- Engages students in REAL-LIFE science challenges in the society.
- Engages schools and students in practical science collaboration with resources in the community, including research, science, innovation and social resources and stakeholders.
- Offers students direct participation in epic, immersive and exciting missions.
- Invites cross-subject and cross-class approaches.
- Offers students with different learning styles a variety of practice oriented work forms very different from traditional theoretical and laboratory-based science teaching, also benefitting less academic learners.
- Provides students with the opportunity and resources to develop a different image of what science is and what science could be for them, linking in much more narrative ways to the identity and personality of the young students.

The participants are three universities and six Practice partners with 60 young students from eight different countries: Finland, Catalonia, Romania, Poland, Portugal, Lithuania, Israel and Greece. The project is developing from 01/09/2017 to 29/02/2020.

4. Conclusions

The activities of the EXPLORATORI were studied in a PhD Thesis [9] in order to evaluate their impact on the young people. The results show that the most impressive activities are when the students are achieving activities outdoors their classroom.

Also in the ScienceGirls project, that now is in train of obtain the final results and guide development, it is clear that the most epic experiences for the girls are when they work in real-life issues.

In conclusion, the methodology Open Science Schooling maybe a very good way in order to engage young people in Science and Technology, with the goal to increase the vocations in these fields.

5. Acknowledgements

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Erasmus+ Program: 2017-1FI01-KA201-034702 Open Science Schooling: Fostering re-engagement in science learning through open science schooling.

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Plastics and Biodegradation: What is a Bioplastic?

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Abstract. Nowadays, society has the opinion that plastics are a threat against the planet. To solve this belief, it is of upmost importance that students of all ages understand what a plastic is and what are the solutions that currently exist given the problematic with plastics. This article aims to explain the solution given by the plastics industry to solve the problem with plastics accumulation/contamination: the so-called bioplastics, which are plastics that can biodegrade. In relation to biodegradability, an easy example which is well-known by many people is the composting of plastics.

Keywords. Biodegradation, bioplastics, compostable plastics, plastics, polymers.

1. Introduction

Polymers, also called macromolecules, are large molecules which are formed by many units, called monomers, which keep repeating along the whole molecule following different patterns (Figure 1). Polymers cover a wide range of physicochemical properties [1] that differ vastly compared to the corresponding ones of the monomers constituting a macromolecule. Polymer Science is a subfield of Materials Science and Chemistry which studies the properties and thus the applications of polymers.

Direct examples of polymers are found in living organisms like proteins or DNA, whereas two examples of polymers present in materials are polyethylene (PE) (Figure 1) and polyvinyl chloride (PVC).

The well-known plastics are materials that, although they are constituted mainly by polymers, they also contain other products which serve to enhance polymers with new properties, making the final combination usable by humans [3]. Plastics can be obtained from petroleum or natural gas and, at the same time, they can also be derived from renewable biomass resources.

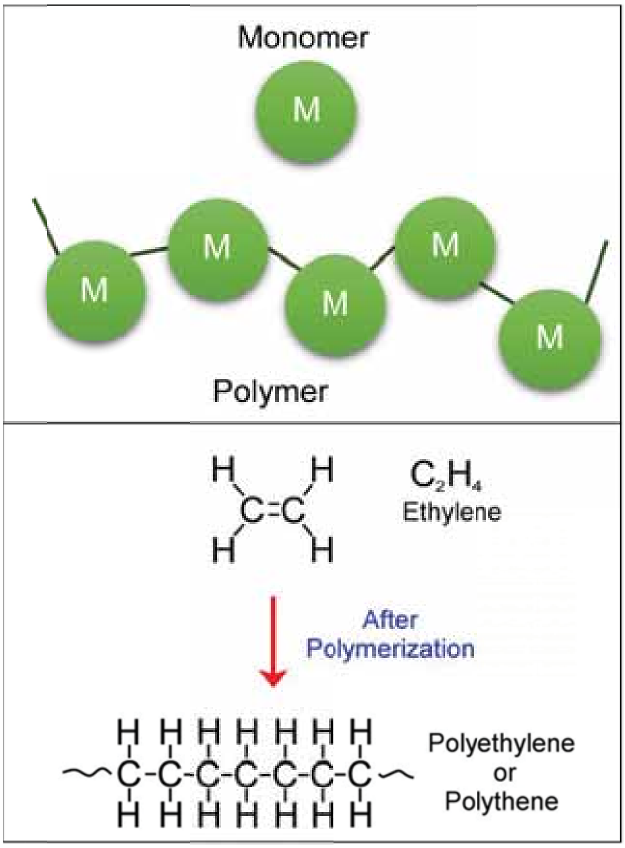

Figure 1. Simple visual picture of what polymers are with polythene as an example (extracted from [2])

2. Environmental concerns: biodegrade-bility as a solution

Nowadays, there are important concerns about the nature of plastics and its ability to biodegrade. This means that some plastics can be disintegrated by bacteria, fungi, or other biological means, whereas other plastics do not. The problem consists in the fact that many plastics are discarded in places where they should not be thrown away such as the sea, forests, etc. Since most plastics do not biodegrade, they accumulate in the environment, causing an important problem called plastic litter.

As a consequence, many people have the conviction that plastics are a serious problem, this being a half-truth. The problem does not underlies in the properties of plastics (in this article we will not discuss anything about the potential harm of plastics additives because it would end up in a new text), but in the fact that many people cast off plastics where they should not (Figure 2).

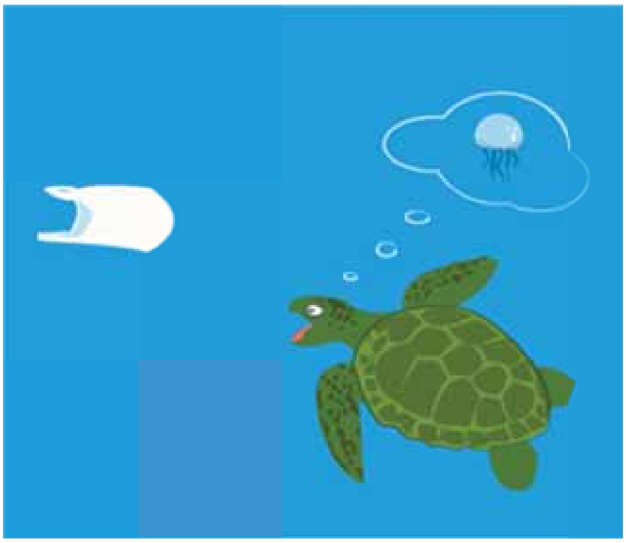

Figure 2. Consequences of the accumulation of plastics in the sea. Extracted from Reference [4]

In this article, we will focus in how to teach children of all ages the solution given by researchers and companies of the plastics industries to overcome the environmental problems associated to plastics. In a simple and concise sentence, we will talk about how to explain what a bioplastic is.

3. What is a bioplastic?

When teaching Polymer Science in Chemistry or Materials Science lectures, it is of upmost importance to clearly define what a bioplastic is. Therefore, it is important to notice that:

1) There are plastics that are obtained from petroleum that do not biodegrade.
2) There exist plastics that are obtained from petroleum and that do biodegrade.
3) One can obtain plastics from renewable resources that do not biodegrade.
4) There are plastics that are obtained from renewable resources that biodegrade.

The definition that is recognised today is that a bioplastic is a plastic that can biodegrade and/or is obtained from renewable resources [4] (Figure 3). Examples of bioplastics are polylactic acid, polyhydroxyalkanoates, cellulose, lignin, and plastics based on starch, among others. It is important to remark that plastics derived from petrol that can biodegrade are also considered as a bioplastic although being obtained from fossil products. An example of this are the polycaprolactones, which can be used in many sectors like packaging, adhesives, and coatings, among others.

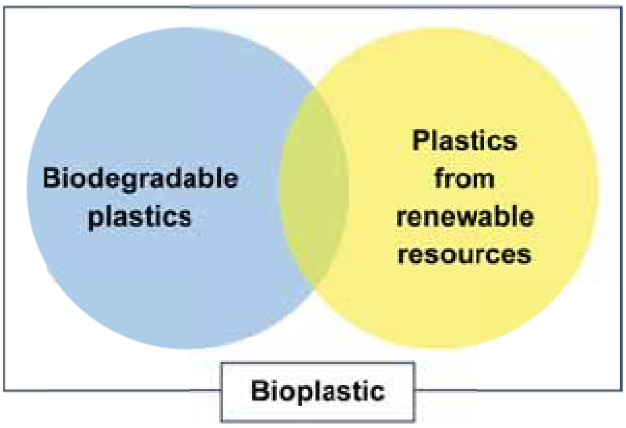

Figure 3. Properties that must satisfy a plastic to be considered as a bioplastic

The concept of bioplastic can be explained to children of all ages. More precisely, for primary education pupils it is important that they understand that there are two classes of plastics, the ones that biodegrade and the others that do not (at the first stage, it is important to skip the raw materials by which plastics have been obtained). For secondary education pupils and higher, it is possible to explain the sources of the raw materials as well.

4. And what is biodegradability?

Biodegradation happens when a bioplastic biodegrades due to the action of microorganisms and their enzymes. Due to this natural process, carbon dioxide, water and biomass are produced in aerobic conditions, while methane (CH4), water and biomass are obtained in anaerobic conditions. Therefore, bioplastics can be literally considered as food for microorganisms (Figure 4).

In relation to the controversy about plastics litter, it is important to notice that, to avoid large amounts of non-biodegradable plastics that accumulate in the environment, the use of single-use plastics is going to be limited in the European Union. This implies that new alternatives must appear, that is, new better designed materials that comply with the Europe Union rules.

This concept is a technical one and pupils from high school and vocational education can understand it. In relation to secondary

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education pupils, the ones in the last courses which have studied some Chemistry and Biology concepts can understand the principles behind it.

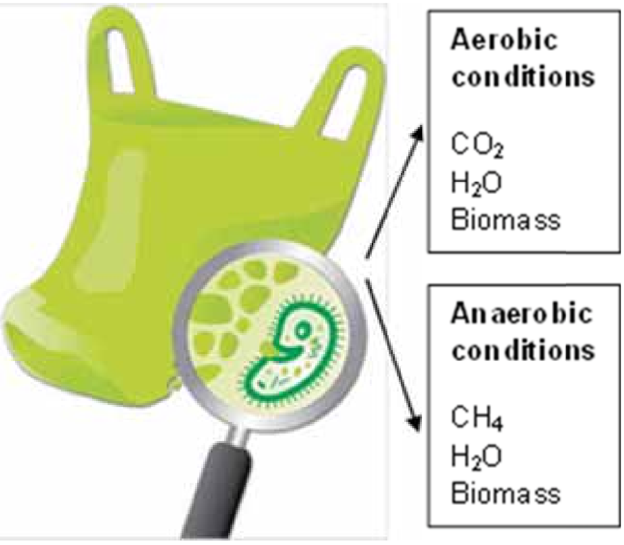

Figure 4. Illustration of plastic biodegradation. A part of this figure has been extracted from Reference [4]

5. Composting: a clear example of biodegradability

Although the concept of biodegradability is easy to comprehend, it is not easy to quantify it. Nonetheless, there exists a process, called composting, which happens when organic matter, including biodegradable plastics, decompose, forming the components explained in Section 5. This process allows one to recycle organic materials and produces a soil conditioner.

In relation to compostable plastics, it is considered that, to be compostable, a plastic must biodegrade more than 90% in less than 6 months. Consequently, all compostable plastics are biodegradable, but not all biodegradable plastics are compostable because their biodegradation takes longer than a composting cycle.

Due to its complexity and the difficulty of concepts, composting can only be taught to pupils of high school and vocational education because the children in primary and secondary education have not yet studied the necessary theory that leads to a full comprehension of this concept, which mixes Chemistry, Biology, and Environmental Sciences.

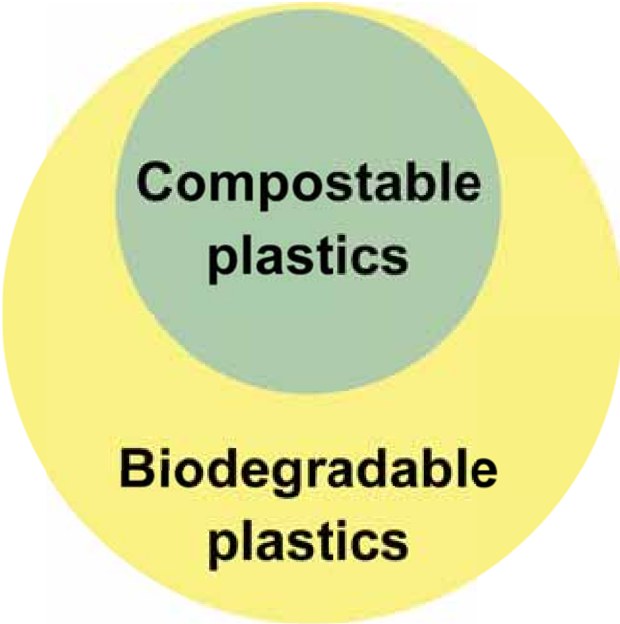

Figure 5. Scheme that denotes that some biodegradable plastics are also compostable

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Predictive Microbiology in a Non-Formal Science Education Context: Understanding Food Preservation Techniques

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Abstract. Predictive microbiology is a major opportunity to introduce youngsters to science of food preservation and food safety. In this study, we report a hands-on activity using *ComBase* to engage high school science students (15-16 years-old) in discussing real-world issues using scientific evidence. Moreover, it is expected to enhance participants' perception about the importance of bioinformatics and computational biology. This dry lab proposal revealed a positive impact on participants' knowledge on food microbiology and food preservation techniques, while promoting youngsters' citizenship education. Insights into participants' perceptions about the importance of computer applications to biological research were also gathered.

Keywords. Bacteria, bioinformatics, food preservation, predictive microbiology.

1. Introduction

Food preservation involves the design of procedures to maintain the organoleptic properties and safety of perishable foods as long as possible [1]. Food safety and storage has been an ancient human activity. In fact, the early food preservation techniques such as drying, smoking, salting, chilling and heating are millenary, and have preceded the optimization of other methods technically more demanding [2].

In the nineteenth century, Pasteur' studies strongly contributed to understand the microbial nature of food spoilage, and therefore were decisive to improve food preservation methods [2]. The scientific advances made established the foundations of modern food preservation methods, frequently characterized by technologically complex solutions. Altogether, these techniques are essential to increase food preservation, to allow the global trade of food goods and to raise consumers' confidence. Nowadays, food preservation is a highly interdisciplinary field of applied science with and enormous societal impact [1].

Beyond the importance of food preservation strict sense, food safety is a major concern of stakeholders of agri-food production and supply chain. Not surprisingly, currently many studies are focused on food borne pathogens which might lead to serious illnesses or even be lethal. *Listeria monocytogenes* and pathogenic strains of *Escherichia coli* are particularly important food borne pathogens, commonly associated to several outbreaks. When these food poisoners bacteria are present in food products, they may pose a high risk for public health.

In Portugal, an outbreak of *Listeria* probably associated with cheese, occurred between March 2009 and February 2012. The outbreak resulted in 30 infected people and 11 deaths [3]. In 2018, Austria, Denmark, Finland, Sweden and the United Kingdom have also reported 32 cases, with 6 deaths, caused by a *Listeria* outbreak probably due to frozen corn that was produced in Hungary and packaged in Poland [4].

Regarding *E.coli*, in March 2017, a multi-state outbreak in the United States was studied. The possible cause for this incident was a nut-free substitute for peanut butter. 32 people were infected, being 12 of them hospitalized. 81% of ill people were younger than 18 years-old [5]. In 2011, the consumption of sprouted seeds and beans has been implicated in *E.coli* outbreaks in France and Germany [6].

The mentioned examples highlight the importance of studying bacteria and the dynamics of their growth in order to avoid severe human health problems due to outbreaks. In this regard, modelling the growth or inactivation of bacteria in foodstuffs in response to extrinsic factors (e.g. temperature, oxygen concentration) and intrinsic factors (e.g. pH, NaCl concentration) is the objective of predictive microbiology. This research area, which integrates microbiology, mathematics, and computer science, is nowadays instrumental to food industry [7-8].

Predictive microbiology takes advantage of bacteria growth databases to validate the robustness of predictive models, contributing to a more accurate assessment of microbial risk [9]. *Pathogen Modelling Program* [10] and *ComBase* [11] are two open access web-based applications which are frequently used in food industry by risk assessors and food microbiologists. These applications allow users to define factors inputs and observe model outputs in informative graphics [9].

The design of educational activities to promote the use of these computer-based platforms in the classroom is a major opportunity to introduce youngsters to science of food preservation and food safety. By stressing the importance of food safety and the need of actions in order to prevent foodborne illnesses, recent studies highlight the importance of more educational actions dedicated to food production practices taking into account the consumers' lack of knowledge on food safety [12-15]. It is reported that TV and radio programs are the main vehicles to share information with consumers about food safety issues. However, educational initiatives promoted by governmental entities are crucial as they are seen by the consumers as more trustable [12,16-17]. Moreover, there are reported benefits of food safety and food preservation educational programs in the consumer's acceptance of new food preservation techniques, such as food irradiation [18-20].

According to the importance of this issue, food preservation techniques and its relationship with real-word issues such as food production, food trade and public health, are addressed in middle and high school level according to the Portuguese curricula [21-23], but also according to the Next Generation Science Standards for engineering, technology, and applications of science [24-25].

1.1. The activity

In this work we propose three activities identified bellow using *ComBase*. These exercises were designed to estimate the growth/inactivation behavior of two well-known foodborne bacteria, *Listeria monocytogenes* and *Escherichia coli* aimed to foster knowledge about food safety and preservation techniques:

1st *ComBase* activity - Evaluate *Escherichia coli* growth in food matrices under different conditions of temperature, pH and NaCl.

2nd *ComBase* activity - Compare *E. coli* and *L. monocytogenes* growth in the same food matrix.

3rd *ComBase* activity - Determine the minimal lethal temperature required to inactivate *E. coli* and *L. monocytogenes*.

These activities focus on determining how extrinsic (temperature) and intrinsic factors (pH and NaCl) affect bacterial growth on food matrices, and on how these factors can be controlled to improve food preservation and increase food safety.

By accessing computational resources routinely used by food industry professionals, as *ComBase*, the ambition of these activities is to engage youngsters in discussing real-world issues using scientific evidence and foster their scientific literacy regarding food safety, food borne pathogens, public health and food preservation techniques. In addition, it is expected that these *in silico* exercises may enhance participants' perception about the importance of mathematics and computer science to tackle biology related questions, which one might generally designate as bioinformatics and computational biology.

2. Methods

2.1. Participants

The three *ComBase* activities within the scope of this study were implemented in July 2017 with 26 participants (high school science students with 15 $\pm$ 0,98 years old). At the time the activities were carried out, the participants (8 males and 18 females) had just finished their scholar year: the 9th (*n*=20), 10th (*n*=3) and 11th (*n*=3) grades.

These activities were implemented during a non-formal science education summer project designated "*Bacteria, Antibiotics and Resistance: let´s find out the links?*" within the scope of Junior University (*UJr*). This initiative of Porto University joins each year a few thousands of participants between 10 and 18 years old, split through dozens of summer-courses crossing thematically all scientific fields and planned according their school levels and background knowledge. The courses are hosted at different Faculties during four weeks of July and two monitors, usually undergraduates or graduated students, are

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allocated to each summer-course of 16 participants [26]. *UJr's* organizing committee and a board of Faculty members where the activities are performed, analyze all the activities proposals and decide regarding their approval.

To join this summer project the participants have to register using an online form available at the *UJr* site. The first sixteen candidates to complete the registration are automatically selected after the payment of a registration fee of 80 euros (*per* week).

In what concerns this study, in the beginning of the activity, each participant was invited to take part in this study after being introduced to its objectives. Students were informed that the participation in the study was not mandatory, so they could perform the activities without taking part in the study. All the data collected were processed and analyzed anonymously.

2.2. Data Collection

The assessment of activities impact on participants' knowledge about food microbiology, food safety and preservation, as well as their interest towards the use of computational resources to address life sciences questions, was carried out by a mixed method approach with a pre/post-test design to obtain a more robust appraisal of the results [27-28]. The pre/post questionnaire included closed questions (dichotomous and Likert-type scale format) and open-ended questions (Figure 1).

The survey was complemented by naturalistic observations, which were aimed to identify misconceptions and evaluate participants' interaction and engagement. All descriptive and inferential statistical analyses were carried out using IBM Statistical Package for the Social Sciences (SPSS) version 24 [29]. The content analysis of qualitative data included an inventory of concepts referred in the pre- and post-test [30-31].

2.3. Data Analyses

Questionnaire data were recorded, codified and categorized. All descriptive and inferential statistical analyses were carried out using IBMS' Statistical Package for the Social Sciences (SPSS) version 24.

Questionnaire

Q1: Have you heard about Bioinformatics?
Yes __ No __

Q2: Classify Bioinformatics according the following goals *(1 – Not important to; 5 – Very important to)*:
a) Gene identification
b) Storage of genomic data
c) Observation of cell structures
d) Study of tridimensional structure of proteins
e) Study of phylogenetic relationships between organisms
f) Study bacteria growth

Q3: Classify as *True or False*:
a) The access to bioinformatics platforms is always paid
b) Bioinformatics tools are freely available to the public
c) Programming skills are needed to use bioinformatics tools
d) Bioinformatics resources include essential tools to optimize food preservation techniques

Q4: Which type of interaction between bacteria and food goods do you know?

Q5: Give some examples of food preservation techniques used to inhibit bacteria growth.

Q6: Which are the main causes of food spoilage that you know?

Q7: Rate your agreement regarding the following sentences (*1 – I totally disagree to 5 – I totally agree*):
a) The growth of microorganisms accelerates food spoilage
b) Food goods are spoiled by the same microorganisms
c) Food preservation techniques ensure sterilized food
d) There are food preservation techniques to preserve food goods

Figure 1. Questionnaire used in this study

Given the sample size and the nature of the research, i.e., quasi-experimental study, non-parametric tests were used: Wilcoxon test (paired samples) and McNemar test (dichotomous variables). In addition, an "*effect* *size test*" was carried out through the calculation of correlation coefficient (*r*) [32].

In what concerns the qualitative data, a content analysis of the responses provided to each question was carried out. In the present study, this analysis included an inventory of concepts referred to in the pre-test and post-test.

It is important to mention that after deciding to analyze the data through non-parametric tests, complementary analyzes were also performed with parametric tests for critical analysis and validity.

3. Results and Discussion

3.1. Observation Records

During the implementation of the activity, participants worked in pairs or alone, according to their own choice. All the activities were supervised by two monitors, who were last year undergraduates in biochemistry and hired as monitors for this summer project by *UJr*.

While performing the exercises, youngsters discussed the outputs retrieved by the experiments and helped each other when some doubts came up. It was interesting to observe that participants were enthusiastic about the information they were finding in *Combase*. Curiously, participants also discussed between each other questions such as: "*Are the optimal growth conditions similar for all bacteria species*?" and then they autonomously tried to find an answer by searching for information at *ComBase*.

Monitors guided the participants through the workflow of the activities and encouraged participants to discuss, for example, about intrinsic and extrinsic factors that influence bacteria growth, highlighting the connection between the exercises performed and industry procedures of food preservation and safety. During this discussion an important comment was made by a participant: "*Ok, we can manipulate the conditions to avoid or to inhibit bacteria growth in food, but what about the organoleptic properties of the food goods?"*. The discussion lead to the conclusion that *"We can't just add salt or change pH adding vinegar to preserve the food good because the taste will not be the same! We have to find an alternative…*"

Participants' were challenged to present the results to their labmates, which has stimulated their scientific argumentation skills.

3.2. Questionnaire Analysis

This study showed that participants recognize metabolic activities (fermentation; aerobic respiration) as the main processes by which foodborne microorganisms mobilize the required nutrients and energy for growth (Q4) (Figure 2). An exact McNemar's test determined that there were no statistically significant differences in the proportion of this notion between pre- and post-test (*p*=0.45).

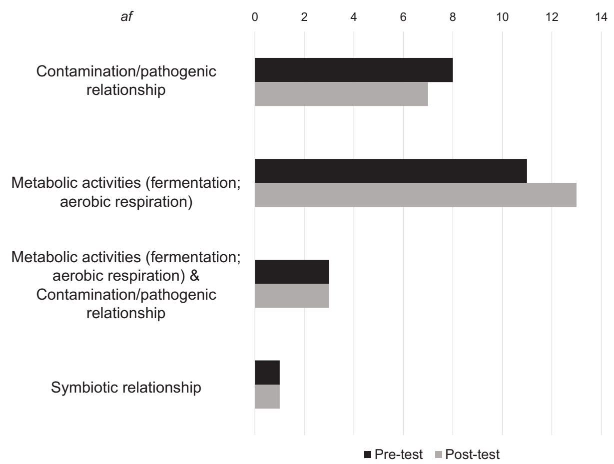

Figure 2. Examples of participants' answers to the question Q4: "*Which type of interaction between bacteria and food goods do you know*?"; af - absolute frequency

This association between foodstuffs and bacteria seems to align with participants school knowledge, since these themes are extensively addressed in the curricular contents of science classes at different grades [22,33-34].

Regardless this evidence, participants acknowledge chemical oxidation as the main cause of food spoilage, in the pre-test (Q6) (Figure 3).

An exact McNemar's test determined that there was a statistically significant difference in the proportion of the notion "*oxidation*" between pre- and post-test (*p*=0.04). In the post-test, participants mentioned more frequently notions related with both bacteria and fungi contamination. However, there were no statistically significant differences in the proportion of the notion "*contamination*" between pre- and post-test (*p*=0.29). According to Trexler and Roeder [35], students can refer "*air*" and "*humidity*" as causes of food spoilage because they did not have the depth of vocabulary needed. In this scope, these terms were interpreted as being particularly suitable matrices for dissemination of "*bacteria*" or "*germs*", the true responsible for food spoilage. In fact, in our study, before the activity, students tended to dismiss explicitly microbial contamination by mentioning environmental conditions as the main causes for food spoilage, giving as an example chemical oxidation. After the activities, participants were more insightful in indicating microbial contamination as a significant cause of food spoilage.

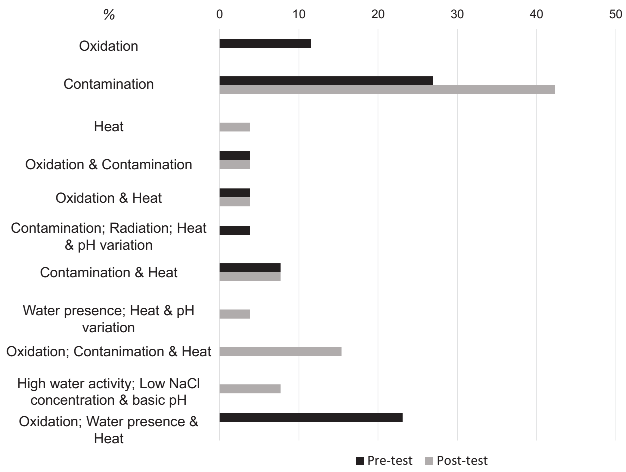

Figure 3. Examples of answers to the question Q6: "*Which are the main causes of food spoilage that you know*?"

After the *ComBase* hands-on activities, participants agree that "*The growth of microorganisms accelerates food spoilage*" (Q7 - a) and acknowledged the importance of "*Food processing techniques to preserve food goods*" (Q7 - d) (Figure 4). However, differences between pre- and post-test are not statistically significant (Q7 – a: Z = -1.46, p=0.14, r = - 0.29; Q7 – d: Z = -1.9, p=0.06, r = - 0.39).

Although there are no statistically significant differences, the changes in the answer's average values, suggest that participants awareness about food spoilage and food borne illnesses by specific bacteria such as *E. coli* and *L. monocytogenes*, has been improved. This finding meets scientific evidence about food illness, due to the risk of infection by the proliferation of these agents in the human body after consumption of contaminated food [36].

On the other hand, participants tend to disagree that "*Foods are spoiled by the same microorganisms*" (Q7 – b) (Figure 3). A Wilcoxon signed-rank test showed that there were not statistically significant differences in the frequency of this notion between pre- and post-test (Z = -0.78, p=0.44, r = - 0.16). This notion aligns well with data showing that food matrices can be differently contaminated by microorganisms, depending on the chemi-physical properties of the food good. Furthermore, participants tend to accept the scientific evidence highlighting the wide diversity of microorganisms that, under some conditions, can contribute to food contamination and spoilage [37].

It is interesting to note that participants seem to recognize the difference between food preservation and sterilization, once they tend to disagree with the sentence "*Food preservation techniques do not ensure sterilized food"* (Q7 – c). However, the difference between pre- and post-test is not statically significant (Z = -1.26, p=0.21, r = - 0.26).

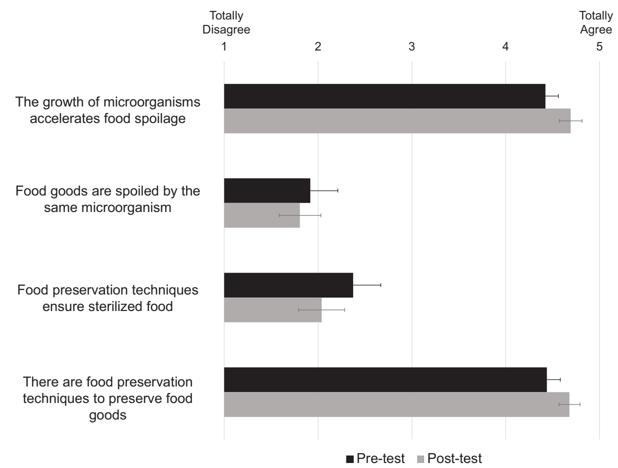

Figure 4. Students ranked their agreement with the listed notions regarding food spoilage and preservation techniques (Q7)

Regarding food preservation techniques (Q5), it is noteworthy that in the pre-test, participants pointed out low temperature processes (e.g. "*cooling*", "*freezing*") as the main food preservation techniques (Figure 5), implicitly dismissing the importance of other food preservation methods such as the use of chemical preservatives and modified atmosphere packaging (Figure 5). These outcomes were expected as low temperature processes are widely known and frequently used as a domestic food preservation practice.

However, studies have emphasized consumers' bad practices regarding temperature control of domestic fridges and handling leftovers, highlighting the need to promote educational approaches dedicated to food safety practices [16,38]. Although no specific assessment was made, after the exercises the participants seemed to recognize the importance to use correctly the fridge, respect the expiration date of perishable goods, and carefully handle leftovers. Furthermore, in the post-test, although participants kept acknowledging low temperatures as a key extrinsic factor used to inhibit bacterial growth in foodstuffs, the frequency of the notions related with the "*use of bacteria growth inhibitors*" and "*the preservation* of *food by a modified atmosphere*" increase significantly from pre- to post-test, according to McNemar's test (p=0.01, p=0.02; respectively) (Figure 5).

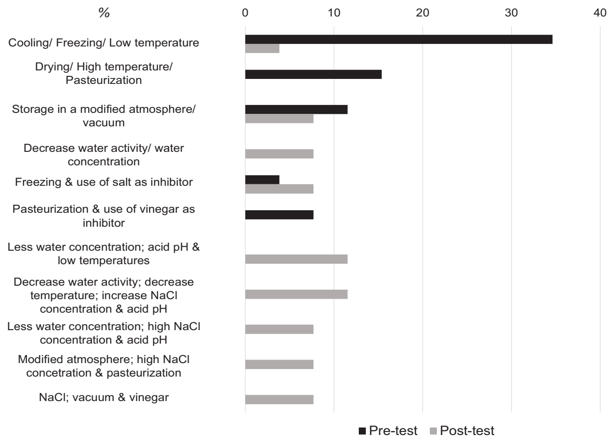

Figure 5. Examples of answers to the question Q5: "*Give some examples of food preservation techniques to inhibit bacteria growth*"

These results suggest that participants become more aware of the chemical bacteria growth inhibitors available, including natural compounds as oil and plant extracts which benefits are currently being highlighted [39-41]. In this regard, the activity described by Fonseca & Tavares [42] is a good example to combine up-to-date scientific research issues with hands-on educational practices.

Taking into account that the proposed activities were centered on computer resources using *ComBase* to understand the impact of food preservation techniques on microbial growth, it was important to assess participants' perceptions and interest about computational biology tools and bioinformatics.

The results showed that most participants had never heard about bioinformatics (Q1) (Figure 6). Although there were no statistically significant differences between pre- and post-test, after the activities the participants could highlight the potential of computational biology and bioinformatics to store data (Q2 – b) (Z = - 1.76, p = 0.08, r = - 0.39) and to study bacteria growth (Q2 – f) (Z = - 1.79, p = 0.07, r = - 0.36) (Figure 6). In fact, predictive microbiology software's use databases and mathematical models, both framed within the scientific fields of Bioinformatics and Biomathematics [9].

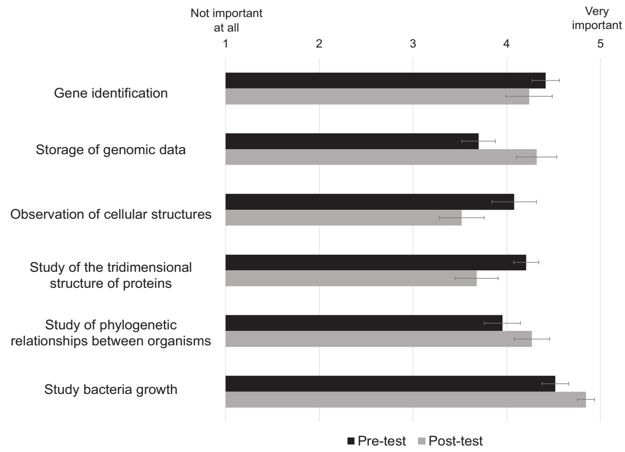

Figure 6. Notions regarding bioinformatics applications that participants agree with (Q2)

Beyond the knowledge acquired regarding food spoilage and preservation, with these activities the participants were able to address the importance of mathematics modelling and computer sciences. When challenged with specific questions regarding these issues, participants were able to overcome misconceptions such as *"One cannot freely access bioinformatics tools"* (Q3 – b) or *"Programming skills are needed to use bioinformatics tools"* (Q3 – c). A McNemar's test determined that there was a statistically significant difference in the proportion of these two notions between pre- and post-test (p=0.04, p<0.01; respectively) (Figure 7). These results are particularly meaningful for elementary and high-school teachers once the use of bioinformatics-based activities in the classroom is a unique opportunity to conciliate biological data with experimental *in silico* work, allowing students to get acquainted with open-access data, and with freely available computer applications running in personal computers (PCs) and web browsers with user-friendly interfaces. This is an education paradigm still poorly explored but essential to dower youngsters with reasoning skills to face the technological revolution that we live in [43]. In the context of this summer project, learning from scientists or through scientific tools about food spoilage and contamination using online applications, was a great opportunity to increase their interest in emerging areas such as genomics and genomic information [44]. Moreover, youngsters realize that biologists might easily take advantage of bioinformatics, although their background is different from a bioinformatics technician [45]. Nowadays, there is an increased awareness to develop data analysis software that provide bioinformatics functionalities to biologists without requiring prior knowledge on computer science [46-47].

When addressing the importance of bioinformatics resources to food industry, students recognized that "*Bioinformatics resources include essential tools to optimize food preservation techniques*" (Q3 – d) (Figure 7). A McNemar test revealed no statically significant differences between pre and post-test (p=1.00). However, there is an indication of the positive impact of the implemented activities as reported in previous studies [48].

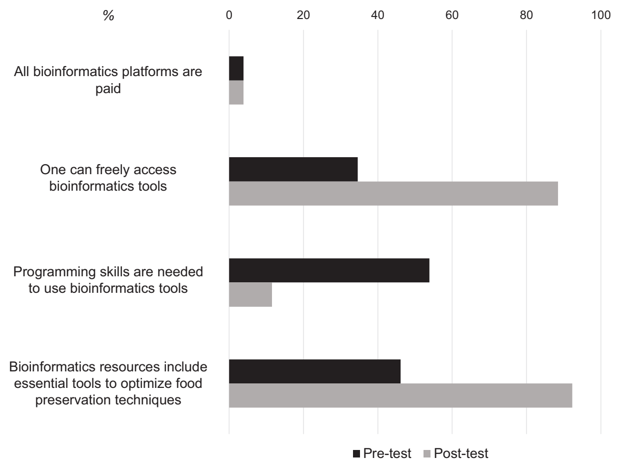

Figure 7. Percentage of statements regarding bioinformatics that participants classified as true (Q3)

When enquired about the questionnaire, participants acknowledged its importance at both assessment moments (pre – and post-test) and considered that it was easy to understand (Figure 8).

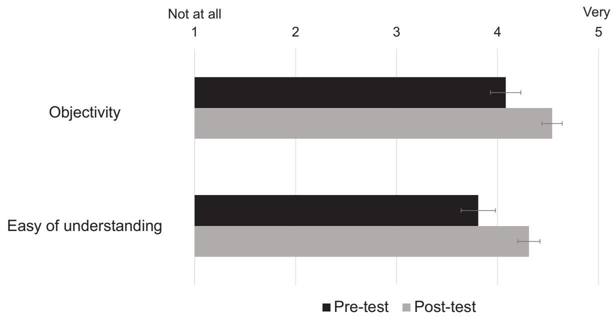

Figure 8. Questionnaire assessment by students

4. Conclusions and Future Perspectives

Overall, these dry lab activities revealed a positive impact on participants' knowledge about food microbiology and food preservation techniques, while promoting youngsters' citizenship education. In addition, the data gathered with this study provided insights into youngsters' perceptions about the importance of computer applications to biological research. These conclusions are in line with recent studies on the added value of *in silico* activities in the classroom, as a motivational driver to address other curricular themes, namely gene regulation and evolution [49], involving open-access bioinformatics resources and time-efficient exercises.

5. Acknowledgements

The authors are grateful to all the participants of the first edition of the activity "*Bacteria, Antibiotics and Resistance: let's find out the links?*" (*UJr* 2017) and to Leonor Martins for the fruitful comments made on the manuscript. Ana Sofia Martins is supported by a fellowship from Fundação para a Ciência e Tecnologia – FCT (SFRH/BD/112038/2015).

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Scenarios and Scenes of Opera for STEAM Creative Learning. Workshop Global Science Opera with Experiences for Classroom Implementation

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Abstract. The Scientific Opera into classroom promote creativity and STEM knowledge (sciences, technology, engineering and mathematics) together with Art. Scientist Opera scenarios make up an interdisciplinary work, mobilize and educate in emotions, train communication and language skills, and develop scientist subjects in today's society [1] with IBSE (Inquiry Based Science Education) methodology [2].

The Opera gathers diverse forms of artistic expression: opera's script, the social context, scenic proposals, instrumentation, choreography, choirs, recitative text, musical composition, musical interpretation and song, dance, costume design, scenic pictures, whose presence is evident; and also allows teachers to introduce to innovative ways to conduct their science classrooms.

Creations Project [3] achieve the goal to promote new strategies and methodologies to guide the student's creative learning [4] process in the curricular context and involving around 30 countries of the world in Global Science Opera, GSO [5]. It's one of the projects Scientix Community [6].

The workshop is focused on STEM subject present in previous operas GSO editions: *Skylight* in 2015 International Year of Light, *Ghost Particles* that make up the universe in 2016, *Moon Village* to survive Earth in 2017, *One Ocean* saving the seas in the process of realization in 2018.

Keywords. Arts, Community for science, Creative learning, cross-disciplinary, IBSE, STEM curriculum, Science education, Science Opera.

1. Introduction. Opera into classroom

Opera is a play incorporating the elements singing, acting, dancing, costuming, pictures, body expression. The Scientific Opera into classroom promote creativity and STEM knowledge (sciences, technology, engineering and mathematics) together with Art.

Several studies and numerous opinions of important artists from Hemingway, Marisa Meyer (former CEO of Yahoo), also the creators of MediaLab from MIT, or Frank Gehry the architect Guggenheim, support the counterintuitive idea that limits trigger creativity [7-8].

The workshop "experiences for classroom implementation of the STEAM Opera" offer teachers continuous training, reference activities, dramatization exercises, provide art resources, knowledge Creations Project. Under this perspective contents won't be only the goal of the class work but also the tool and the way to enhance multiple skills and the multiple intelligence types. of those who are our students today, and tomorrow European citizens. Questions that students pose to themselves are the principal thread of STEM contents and concepts with creative scenarios. In this way classrooms changed into labs to experience emotions and space that surrounds us, and enhance communication skills starting. We assisted students in building knowledge by de use of bodily expressions Verbal and non-verbal communication and individual uncertainty lead them to assertiveness, because creative work enhances the validity of all contributions; disruptive participation could be a value in our classrooms. Creations Project established a pan-European network, with the objective of building a Global Science Opera each year. Creations provide teachers training and resources (Figure 1).

The incorporation of professionals specialized in artistic disciplines, the participation of image, sound and technology technicians (Figure 2), recognized researchers, management organizations and Universities collaboration give wings to the classrooms beyond classical borders. Art and Science are sometimes far away. The combination of these two areas can enhance cross-disciplinary thinking and raise students' interest in both

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STEM and art subjects. No bonders, no frontiers in knowledge with STEAM activity.

Figure 1. Training activity Creations Summer School. 2015

Figure 2. Technical assembly work. 2017

2. STEM approximation through the elements of the Opera

Opera is essentially a play in which music and sung predominate instead of spoken. This singing is combined with the other theatrical elements of drama, dancing, costumes, sets, staging, lighting, title, libretto, musical composition, “recitative”, “aria”, argument, social context, scenic proposals, instrumentation, choreography, choirs, expression of emotions (Figure 3).

Nevertheless STEM contents are present throughout the History of the Opera. Among the most unique and ancient find The Elements, published around 1713, with allegorical characters such as Air, Water, Fire, Earth, Time and Aurora.

Figure 3. Ghost Particles performance. 2016

2.1. The Moon presence into the Opera elements

We propose as main workshop objective acquiring resources to prepare the draft of a scientific Opera. In this section we provide evidence of STEM topics in operas containing the Moon as a protagonist in some one element cited previously that we can identify on the development of the plot.

2.2. STEM in the Opera with the Moon

The Moon is an astronomical body that orbits planet Earth and is Earth's only permanent natural satellite. It is the fifth-largest natural satellite in the Solar System and also is the reference subject in poetry, novel, cinema, painting, and through the Opera.

In the study of the Moon presence in different Operas, we will refer the year, the composer, the type of Opera with meaning within the social context, and the scientific content specifying, if possible, the moment in which we can find it in the referenced version.

- 1777, Josep Haydn. *Il mondo della luna*. Singspiel. Opera bufa. The title, Il mondo de la lluna, offers singular arias (O luccente moon). We find astronomy contents [9] focus on Moon (min 6), the description (min 11:03), presentation a avant-garde artefact telescope (min 12:50), physical laws (min 58:45).
- 1791. Wolfgang Amadeus Mozart. In The Magic flut, a folkloric and popular drama, the Moon is present with The Queen of the night [10].
- 1831 Vinzenzo Bellini. Norma, drama, with a prayer to the goddess Luna

asking for peace and help against the evil of the druids in (min :24) [11].

- 1875. Charles Offenbach, Le Voyage dans la Lune, bufa,iInspired by the Earth and the Moon by Jules Verne; present an Astronomical Observatory (min 28:) [12].
- 2008. Kaija Saariaho, drama. History and Society. The life of the Marchioness Èmilie du Châtelet (1706-1749), mathematician, physicist and lover of Voltaire reveal personality of a scientific woman and nobility in the eighteenth century, and her letters to Voltaire inspire the argument of the Opera Emilie. An example is Scene VIII developing contents: the orbit of the moon, the gravity, the ebb and flow of the tides and more [13].

3. Global Science Opera experiences. Creations Project

Creations is a project funded by the European Union. The goal is to develop creative approaches based on art for an engaging young people in science classroom.

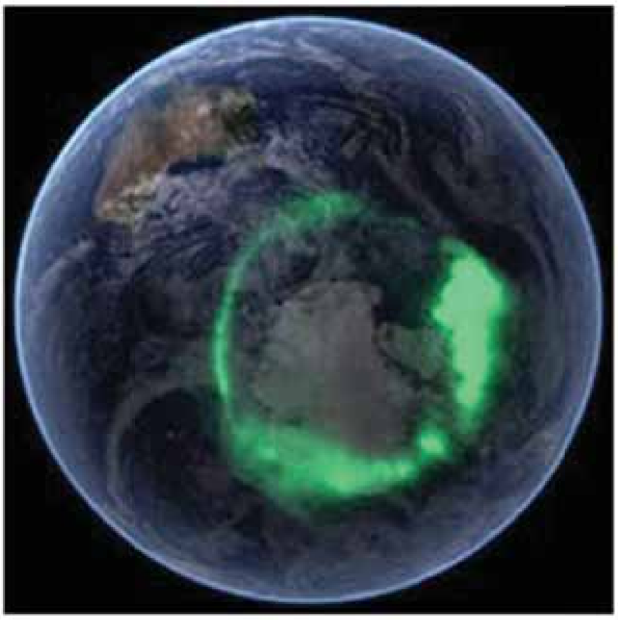

Figure 4. Earth observation from Moon. NASA's ceded image and HOU collaboration

First proposal, Skylight, focused around the celebration of the international year of light. Second edition worked with the support of CERN. More other International Organizations are added every year providing different kind of resources (Figure 4).

Figure 5. Webinar Oceanographic Institute of Malaga

Schools, universities, scientists, teachers, artists and students are engaged in a collaborative work. Scientix Community provides resources facilitating interaction among the participants; the webinar, an online conference (Figure 5), amplifies the information channels, brings the experience of researchers to the students and provides the added value of the interaction.

Figure 6. Global Science Opera productions

Global Science Opera productions [14] are Skylight in 2015, Ghost particles that make up the universe in 2016, Moon Village to survive

Earth in 2017, One Ocean in 2018 saving the seas (Figure 6).

Figure 7. Primary and Secundary students

Summarizing, we have the opportunity educate a new generation of scientifically literate European citizens while they develop artistic skills, and inspiring young people to choose for science and technology careers (Figure 7).

4. Acknowledgements

The author thanks all students, teachers, schools (Madrid, Barcelone, Bilbao, Valencia, Málaga) research and university institutions, for their active participation in each edition GSO, Creations management team, and Scientix Community for promote collaborative actions for Science Education in Europe.

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Science and Society: Reaching Readers with a Focus in Communication

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Abstract. Scientific literature is often hard to read and understand, being unreachable for the lay public and students. Even though magazines and newspapers make science more readable, sometimes it is oversimplified and the concepts get corrupted. As a result, the standard human being refuses to read science, and the bravest ones might end up spending more time than desired. This can even happen to any scientist when they try to read the research from a different field. While it seemed reasonable to just accept that this is the way science is, we rather asked ourselves: "Is it possible to communicate science more easily while keeping the scientific rigor?". And the answer was yes.

The conclusion was supported on one main argument: style. Everyone knows that a best-seller novel should have a curated style, introducing facts and characters progressively to keep the attention of the reader. However, scientists hardly ever educate themselves in writing, and even when they do, they feel forced to keep writing in the same scientific style that obscures their sentences (such as overusing the passive voice), which ultimately affects the reader's attention and darkens the message they want to spread.

With this premises in mind, we launched the Catalan on-line magazine BQ Club (Biochemistry Club), with the support of the University of Barcelona. The magazine is designed to appeal high-school and university students, as well as the lay public. It is an on-going project in which our efforts are:

1) Make sure each and every sentence is comprehensible to reach all the public, assessing them with questions such as: Is it well-written? Is it necessary? Is it boring? Does it contribute to keep the attention of the reader?
2) Spread the kind of information we would have liked to have when we were students.
3) Entertain people through science.

At this point, the last number of the magazine can be accessed in [1], and in a nearby future BQ Club will also count with an independent website.

Keywords. Communication, education, text style, entertainment.

0. About us

We (Figure 1) are a team of recently graduated Biochemists (2015). Close to the students, continuously learning and concerned about communication and science, we are the editors-in-chief of BQ Club and we are willing to bring entertainment, opportunities and science to students and society in the way we would like to receive it.

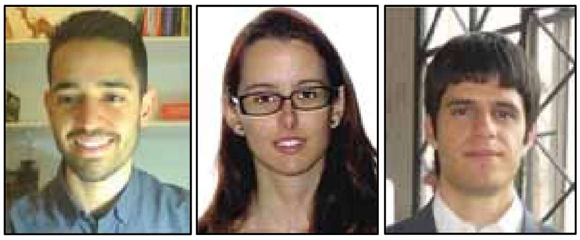

Figure 1. Editors-in-chief of BQ Club

Dr. Novell (Figure 2) is the director of BQ Club. He has always been deeply involved in bringing opportunities in Biochemistry to young students, continuously pushing to get the best from them.

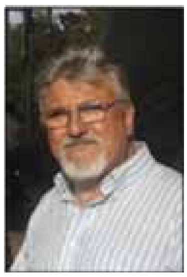

Figure 2. Director of BQ Club

1. Introduction

We, modern humans, use a wide variety of channels to communicate. All of them evolved, trying to be appealing while transmitting a message. In the radio you might hear scientific

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content, and it is easy to follow as long as the presenter keeps an active tone of voice. The same happens in TV, where you can find an extra positive point: images capture our attention *per se*. Even scientists have dived into the music world to bring us versions of known songs with instructive lyrics. When referring to written media… "*Houston, we have a problem*". Texts do not have sound or moving images, just letters, numbers and symbols that lay embedded between four margins. Thus, good texts require special attention.

Thousands (maybe hundreds of thousands) of people have ever written a novel. However, few of them have been good enough to be translated and reach millions of readers. The reason is as simple as a single word: “style”. All good novels entertain with a message (a good story) using a powerful communication style that keeps the attention of the reader. When referring to science, a similar thing happens. Many of us are writing science, but most of the texts are difficult, dense or even boring. Few people have the natural ability to write “perfect” texts, and the same applies to scientists.

By definition, all scientists are writers (reports, proposals, papers, reviews, etc). However, virtually all of us lack education in communication. While universities need a more systematic method to solve this issue (it is reasonable to think that in the future it will be a mandatory subject), more and more scientists are getting concerned about it and starting to learn by themselves – which is also our case (see this highly recommended MOOC if you are also interested in scientific writing [2]).

Although we can see that science is getting closer to society, a gap still exists. Our goal is to contribute in closing this gap and BQ Club (Biochemistry Club) is our creation to achieve it. BQ Club is a digital Catalan magazine focused in publishing good science with a curated format and style, which counts with the support of the University of Barcelona. The topics cover the universe of biochemistry, molecular biology and any related science. Altogether, BQ Club is based on three ideas: communication, education and entertainment (Figure 3).

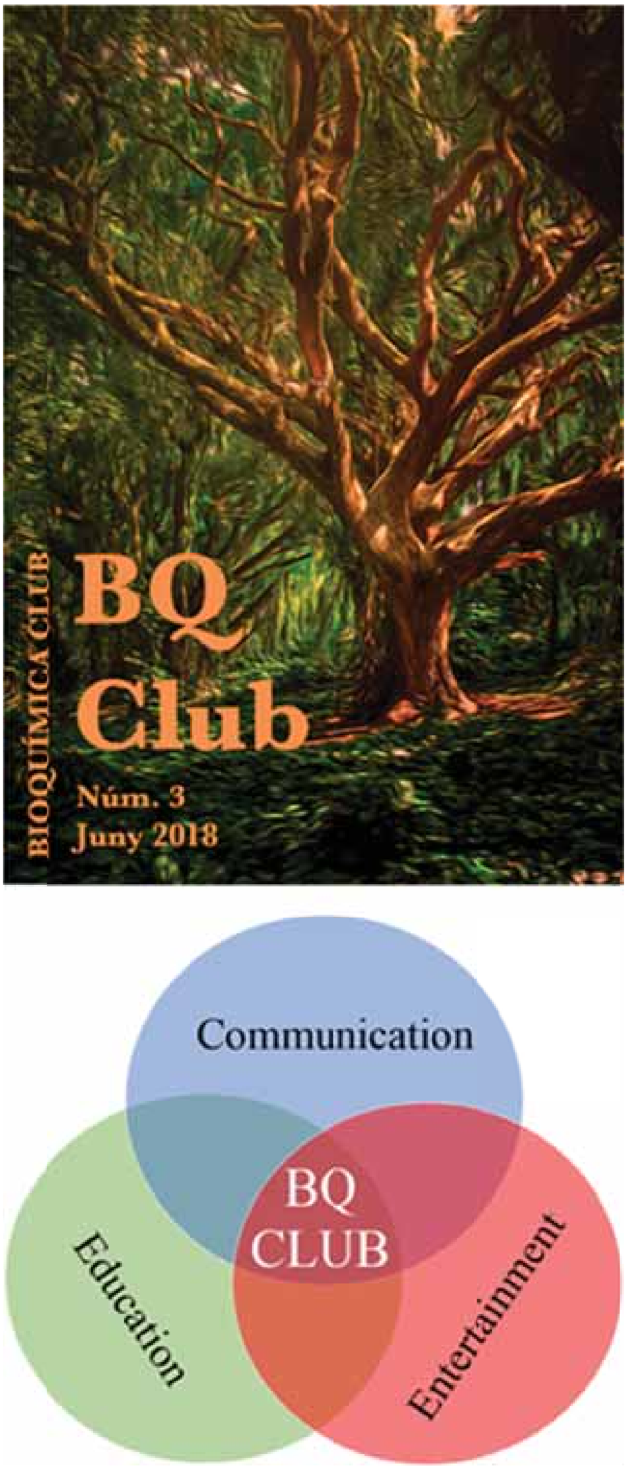

Figure 3. Above: The last cover page of the magazine (June 2018). Below: A diagram that represents the main ideas behind BQ Club

2. Communication

BQ Club is designed to achieve the best communication style possible. The detailed methodology jumps out of the scope of this manuscript. Nevertheless, we highlight three

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examples of poor style to give a small taste of what we take into account when editing our texts before publication.

2.1. The passive voice

"We propose a model […]" [3] is the first sentence of the Watson & Crick article that gave them the Nobel Prize. However, many scientists would have written "A model is proposed […]" because they avoid the active voice when writing science. The passive voice is invaluable when writing methods, but mostly unnecessary when introducing or discussing a topic. Today's texts tend to overuse it, which drives away readers' attention.

2.2. Boring verbs

One can find in the literature sentences like: "The experimental demonstration is the first of its kind and is a proof of […]". Here, the message uses the verb "to be" twice, when it could transmit the message better with: "The experiment provides the first proof of […]", which means exactly the same in fewer words and with a more engaging verb.

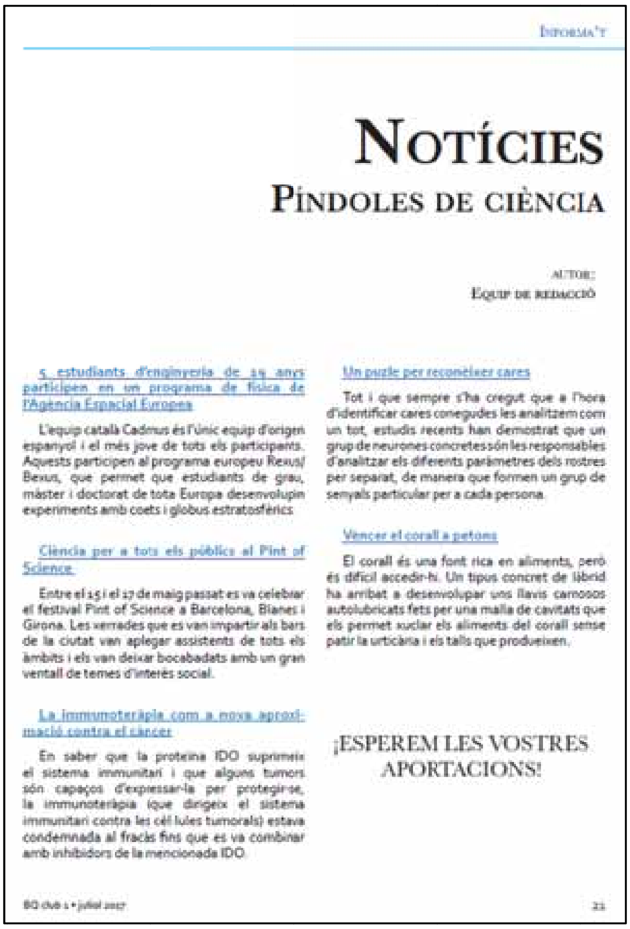
2.3. Wordy sentences

We all like a story that begins with the sentence "Once upon a time", since this evokes the classic stories of our childhood. Nowadays, a writer only uses that expression to give his story an archaic atmosphere. This kind of formal beginnings are outdated. "As it is well known" or "it should be emphasized that" are expressions we use to clear our throats when talking, but appear to be completely useless when writing (while they only make texts longer and convoluted). After removing these expressions, texts always keep making sense.

3. Education

Being recently graduated from university, we keep asking ourselves: What would we have liked to know as students? This question became central in our work and now we tend to select our material while thinking in current students (high school and university). In addition to the pure scientific texts, we designed three sections that aim to answer this question:

1) A lot of scientific events take place in Barcelona (and surroundings) every month, which represent enriching activities for students. In addition, Barcelona is becoming a bigger scientific spot in Europe. Our research centres and universities are involved in plenty of scientific advances, and knowing their activities is essential. These facts deserved a whole section of the magazine: the Calendar, in which we bring the near-future events and activities to our readers.



INFORMA'T

NOTÍCIES

PÍNDOLES DE CIÈNCIA

AUTOR:
EQUIP DE REDACCIÓ

5 estudiants d'enginyeria de 19 anys participen en un programa de física de l'Agència Espacial Europea

L'equip català Cadmus és l'únic equip d'origen espanyol i el més jove de tots els participants. Aquests participen al programa europeu Rexus/Bexus, que permet que estudiants de grau, màster i doctorat de tota Europa desenvolupin experiments amb coets i globus estratosfèrics.

Ciència per a tots els públics al Pint of Science

Entre el 15 i el 17 de maig passat es va celebrar el festival Pint of Science a Barcelona, Blanes i Girona. Les xerrades que es van impartir als bars de la ciutat van aplegar assistents de tots els àmbits i els van deixar bocabadats amb un gran ventall de temes d'interès social.

La immunoteràpia com a nova aproximació contra el càncer

En saber que la proteïna IDO suprimeix el sistema immunitari i que alguns tumors són capaços d'expressar-la per protegir-se, la immunoteràpia (que dirigeix el sistema immunitari contra les cèl·lules tumorals) estava condemnada al fracàs fins que es va combinar amb inhibidors de la mencionada IDO.

Un puzle per reconèixer cares

Tot i que sempre s'ha cregut que a l'hora d'identificar cares conegudes les analitzem com un tot, estudis recents han demostrat que un grup de neurones concretes són les responsables d'analitzar els diferents paràmetres dels rostres per separat, de manera que formen un grup de senyals particular per a cada persona.

Vèncer el corall a petons

El corall és una font rica en aliments, però és difícil accedir-hi. Un tipus concret de làbrid ha arribat a desenvolupar uns llavis carnosos autolubricats fets per una malla de cavitats que els permet xuclar els aliments del corall sense patir la urticària i els talls que produeixen.

¡ESPEREM LES VOSTRES APORTACIONS!

BQ club 1 • juliol 2017

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Figure 4. the News section of the first number of BQ Club (July 2017)

2) The News (Figure 4), which highlight the most remarkable scientific advances in the last months.
3) All students have questions they would like to get solved, but not always by a teacher. The section "Ask to BQ Club" opens the possibility to interact with us. We try to answer the most common doubts that worry students: how to look for grants or laboratory groups, how important are grades, whether we see sexual discrimination in our

environments… This section is open and we highly encourage students to send us their questions by email.

4. Entertainment

Science is fun. This is our message. And we blindly believe it. This is why all our texts are born fresh and easy to read. Some authors even add a touch of humour to their articles, which is appreciated.

Our science is accessible to the lay public. When a difficult scientific concept arises, the details are striped out from the text and included in a "Box". This way, any reader can follow the main text, and the detail is still available to the most curious minds. Therefore, the contents are reachable for non-scientist too.

The icing on the cake is the last section of the magazine, called literally "Entertainment", to share with our readers the funniest tributes to science. It adapts classical entertainment methods (labyrinths, word searches, etc.) with scientific content. Between the resources used in this section, our readers will find an ironic horoscope, pieces of scientific (or science fiction) literature and comic strips (Figure 5).

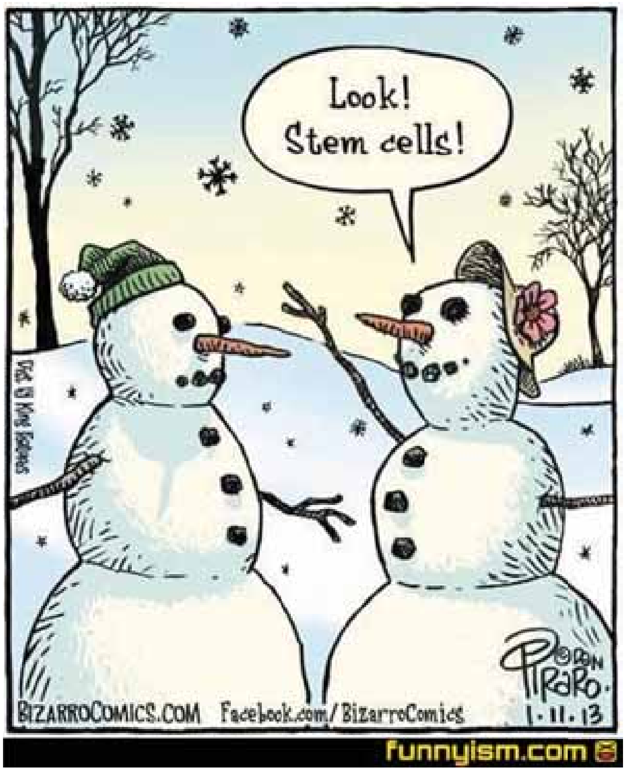

Figure 5. An example of a comic strip included in the first number of BQ Club (July 2017), courtesy of Dan Piraro

5. Conclusions

Scientific knowledge has been unreachable for most of the population for centuries, and our generations are the first ones in receiving education on it massively. However, scientific texts still inherit an archaic communication style, which often makes easy concepts difficult to understand. As a result, it is common that (non-scientists) people feel rejection towards science and ignore the positive effects of research in society (e.g. many politicians).

Aware of this, many projects are using the radio, TV, music or even live events to bring science to the lay public, but it is still difficult to find attractive written science. BQ Club was born to fill part of this space. The magazine will count with 2 to 4 number per year, so that the maximum quality is guaranteed. For the moment, anyone can find the last number of the magazine in [1]. Furthermore, in a near future BQ Club will count with an independent website, where our readers will be able to read and download all the material of interest.

6. Acknowledgements

We acknowledge all our collaborators for making BQ Club possible.

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Science Education in Primary Schools: A Biomedical Research Institute's Perspective

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Abstract. The Institute for Research in Biomedicine (IRB Barcelona) is a world-class research centre devoted to understanding fundamental questions about human health and disease. In addition to conducting multidisciplinary research of excellence, one of the missions of IRB Barcelona is to maintain an open dialogue with the public about our work. IRB Barcelona's science engagement and educational programmes are aimed at different segments of the public, ranging from primary school students and secondary school students and teachers to general adult audiences. In this regard, IRB Barcelona has participated in the "Escoles Tàndem" (Tandem Schools) Project, run by the Fundació Catalunya-La Pedrera. This three-year educational project aims to use science and the scientific method as the backbone of innovative educational methodologies in the school.

Keywords. Education, innovative educational methodologies, science communication, scientific vocations.

1. Introduction

The Institute for Research in Biomedicine (IRB Barcelona) is a world-class research centre devoted to understanding fundamental questions about human health and disease. Founded in October 2005 by the Government of Catalonia and the University of Barcelona, IRB Barcelona belongs to the Barcelona Institute of Science and Technology (BIST).

One of the missions of IRB Barcelona, besides conducting multidisciplinary research of excellence, is to maintain an open dialogue with the public about our work. In this regard, since its very beginning, IRB Barcelona has designed and implemented a wide variety of engagement and education activities [1].

We believe that it is paramount that research institutes like ours organise outreach activities for the public. This approach serves a double purpose. First, it allows us to be open about the research we do (in part financed by public funds). And second, it allows us to foster scientific culture in society and scientific vocation among its youngest members.

As a high-level training institute, we provide young researchers with the tools and training opportunities to empower them to effectively communicate their research (Figure 1). Beyond communication to scientific audiences, we also seek to instil the importance of public outreach in our young researcher community.

Figure 1. An IRB Barcelona researcher talking to a primary school student in a science workshop at the Escola Montserrat in Cornellà

Our science engagement and educational programmes are aimed at different segments of the public, ranging from primary school students and secondary school students and teachers to general adult audiences.

IRB Barcelona has its own outreach programmes but also partners with a number of institutions, including the Barcelona Science Park, the Fundació Catalunya-La Pedrera, the Barcelona Institute of Science and Technology, and the Barcelona City Council, among others.

IRB Barcelona upholds the belief that interactions between researchers and society are mutually beneficial.

Consistent with this stance, we channel considerable efforts into maintaining an open dialogue with the public, thereby strengthening the bonds between science and citizens with the aim to contribute to a more informed society.

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2. Outreach activities with primary school students

It is thought that scientific vocations come about at between approximately 6 and 10 years of age [2]. Children of this age are therefore a logical target audience for a research institute such as ours. We want to ensure that these children do not lose their innate curiosity. At this key age, it is important to introduce science and the scientific method (observation, making a hypothesis, experimentation, and reaching a conclusion) as part of natural and daily thinking.

To this end, in 2015 IRB Barcelona joined the “Escoles Tàndem” (Tandem Schools) initiative.

3. The Tandem Schools project

Launched in 2011, the Tandem Schools programme [3] is an initiative run by the Fundació Catalunya-La Pedrera and supported by the Department of Education of the Catalan Government.

Tandem Schools is an innovative educational project in which schools partner with an institution of reference in a specific field over three academic years. During this period, work is done to singularize the school while implementing innovative pedagogical methodologies that aim to be sustainable in the long term.

Since its launch, the Tandem Schools programme has benefited 13 schools (primary and secondary) and 15 reference institutions in Catalonia, including the Escola Superior de Música de Catalunya (ESMUC), the Parc Científic de Barcelona (PCB), the Museu Nacional d’Art de Catalunya (MNAC), and the Teatre Nacional de Catalunya (TNC), among others.

Reference institutions belong to many different fields (music, science, mathematics, theatre, etc.), and they use unique expertise to transform their partner schools in a characteristic manner.

This specialisation of the school does not imply that the teaching of basic skills is omitted. On the contrary, specialisation becomes a key element in enhancing these basic competences.

3.1. Escola Montserrat in Cornellà

The Escola Montserrat [4], previously named Escola Mare de Déu de Montserrat, is a state school located in the neighbourhood of Sant Ildefons in Cornellà de Llobregat (Barcelona). Like most schools participating in the Tandem Schools project, the Escola Montserrat is considered to have a complex profile due to factors such as a local high rate of immigration and particular socio-economic context of the families in the area. It has one class per academic course, from pre-kindergarten PK3 (3 years old) to 6^{th} year primary school (12 years old).

Like many state schools in underprivileged environments, resources are first used to cover basic necessities and educational innovation is sometimes overlooked. Moreover, the state education system is plagued by administrative issues, such as frequent staff changes, salary cuts, and lack of material. In such a conditions, schools clearly find it difficult to innovate.

3.2. The Tandem project between Escola Montserrat & IRB Barcelona

The Tandem project between the Escola Montserrat de Cornellà and IRB Barcelona started in September 2015 and finished in June 2018. It was one of the first two Tandem partnerships between a science institute and a primary school, the other one being between the Escola Mossèn Joan Batlle and the Centre d’Estudis Avançats de Blanes-CSIC (CEAB), which started the same academic year. Previously, all the science-related Tandem projects had been with a secondary school as a partner.

The main objective of the Tandem between the Escola Montserrat and IRB Barcelona was to transform the school through science. It sought to boost academic results, provide added-value to the school, and strengthen social cohesion.

The Tandem project was a challenge right from the start. IRB Barcelona had no previous experience in such a long-term educational project with a primary school, and the school had no expertise in science or in new teaching approaches. To help bridge the gap between the school and IRB Barcelona, an educationalist was brought onto the IRB

Barcelona team. This figure has been crucial for the success of the project.

To meet the objectives of the project, the focus was placed on different areas: the school curriculum, teacher training on new methodologies (Figure 2), school infrastructures and, of course, student motivation and interest in science.

Figure 2. A session of training with the teachers of Escola Montserrat in Cornellà

The school curriculum was designed around science and the scientific method. The subject of "Medi Natural i Social" (Natural and Social Science) was the first to be modified, as a pilot test to then be able to make changes to other subjects (Figure 3).

Multiple hands-on science activities were organized in the new laboratory of the school (completely refurbished thanks to the project) and in different occasions during the year, some of them with the presence of IRB Barcelona scientists (Figure 4).

At the same time, the project encouraged the introduction of problem-based learning (PBL) methodology [5], a student-centered educational approach in which the children learn about a subject through the experience of solving an open-ended problem.

As a result, they not only develop deep content knowledge but in the process they acquire key skills like critical thinking, creativity, and enhanced teamwork and communication capacity.

Several other important concepts like the Multiple Intelligences tools were also introduced to cover the cognitive diversity present in the classrooms and to promote scientific thinking.

Figure 3. A student from kidergareten in a science workshop about liquids that do or do not mix

Figure 4. An IRB Barcelona researcher with students of the Escola Montserrat during a science workshop in the Cultural Week organized by the school

4. Conclusions

Overall, the Tandem project has been a invaluable experience for IRB Barcelona. It has showcased the challenge faced by a research centre when dealing with primary school students, but the same time, it has highlighted the rewards of working with this age group and the importance of targeting this audience.

We hope that the lessons learned during this project will allow both the school and the Institute to grow and prosper and that they will be useful for future initiatives.

5. Acknowledgements

IRB Barcelona acknowledges the Fundació Catalunya-La Pedrera for inviting us to participate in the Tandem initiative and for financing the project during these three years.

Special thanks go to the IRB Barcelona researchers who participate in the public engagement activities organised by the Institute, and in particular to those who have collaborated in the Tandem project.

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STREAM-Weeks in Primary School

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Abstract. This article discusses the experience of interdisciplinary learning in primary school, describes the specific form of organization of training:STREAM-weeks. During these weeks in primary school we conduct integrated lessons that allow children to become more familiar with the world around them. The author discusses the positive effects that teaching. The students managed to correlate scientific data with their practice, conducted a lot of experiments and expanded knowledge on topics.

Keywords. STREAM, science, primary school, questions, interdisciplinary teaching.

1. Introduction

The science is around us. We can feel its presence from the moment of birth. Each child knows and uses swings, carousels, trampolines, etc., but not every child knows what a pendulum, friction, elasticity are. How does it happen that everything so close to us and loved by children becomes so difficult for them at school? [1]. In addition, many children have already experienced many processes in their own lives. Every walk outside becomes a discovery! Moreover, children discover not only one specific element, but the entire chain of relations between objects, nature and people. Children already have rich experience of using the laws of nature, but they do not realize them. And they do not recognize them when they start studying these laws at school. But what should a teacher do? [2]. How to combine traditional lessons with the need of an interdisciplinary approach?

In the «Lyceum MIR» [3], along with traditional lessons, we conduct interdisciplinary weeks [4]. We started providing these weeks twice a year in secondary and high school, and this year we have also involved a primary school pupils. During these weeks the secondary and high school pupils carry out projects. And in primary school we conduct integrated lessons that allow children to become more familiar with the world around them.

2. STREAM

In our Lyceum we use the STREAM approach for interdisciplinary weeks [5]. Why do we use STREAM? (S-science, T-technology, R-reading, E-engineering, A-art, M mathematics). For children of this age (6-9 years), creativity and reading are among the most important components of the educational process. Without them, we can't do a single lesson. Consequently, all the children were interested in how to present science creatively.

3. Topics

Each STREAM-week lasts 5 days. This year, both weeks in primary school were united by the general topic "Four Elements". At the autumn STREAM-week we considered Fire, Water and Air, and in the spring week - the Earth.

Within the first week, the learners were divided into 4 workshops: "Workshop of the Fire Masters", "Workshop of the Water Masters", "Workshop of the Air Masters" and "Workshop of the Fairytales Masters". Fire Masters got acquainted with the properties of fire, learned to handle it safely, tried different ways of ignition and quenching. Teacher of Chemistry have held a master class for students during which they have been watching how different substances burn. Fire Masters created posters on the safe use of fire in everyday life and the layout of a fire engine.

Figure 1. "Workshop of the Air masters"

In "Workshop of the Air masters" children got acquainted with the properties of the air, its connection with fire, its composition, its role in the human life and in the life of the whole planet. They created ships with sails from different materials, various kinds of turntables, airplanes, parachutes, kites and launched

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lanterns. Also children tested whether it is possible to use parachutes with a hole (Figure 1).

In the "Workshop of the Water Masters" they also built ships, but with a different purpose. The pupils were interested in the material from which the ships were built. Which of the ships sails, and which sinks. Which ship is stronger: the one which was made of a foam plastic or a shell of a walnut. What kind of water is it easier to swim in: fresh or salty? How to use fresh water? (Figure 2).

Figure 2. "Workshop of the Water masters"

In the "Workshop of the Fairy Tales Masters" pupils even created a performance. Children wrote a legend about the Elements, created scenery and interactive competitions for participants of other workshops. The week ended with the Holiday of Elements, at which all the students demonstrated their acquired skills of using the elements.

Figure3. "The questions invented by students"

The second week was entirely devoted to the Earth and was held at the week of the Earth Day. This week was different from the previous one. On the first day, students heard only the topic and had to ask questions that would be answered within a week. These questions were related to the Earth, soil, planets, minerals, plants and animals (Figure 3).

Teachers acquainted the students with some facts about our Earth. Children watched the experiments on the composition of the soil and videos about sowing works.

On the second day, all the students went on an excursion to the planetarium, where they got acquainted with the theory of the Big Bang. They saw the place of our planet in the solar system and got acquainted with the constellations that are visible in our hemisphere.

After the excursion the teacher of Geography conducted an interactive presentation about the minerals of our region. On the third day, secondary school learners presented experiments with soil that have been recently conducted at a Science. On the fourth day, children planted flowers around the Lyceum, which they grew themselves from seeds in the classroom.

Figure 4. Children plant flowers

And the week ended with a big team Brain-Ring game. Students were divided into 4 teams and passed 4 rounds of various tasks with musical and dance pauses. All teams have

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received prizes in accordance with the place they won.

4. Conclusions

As a result of STREAM-weeks, students managed to correlate scientific data with their practice, conducted a lot of experiments and expanded knowledge on topics. A special impression was made by the creative approach to science, which helped the children to reveal their talents and at the same time to get acquainted with the laws of nature. Searching for answers to questions that pupils asked themselves or to questions asked by their friends was very inspiring for them. We started using this form of work in other lessons.

In the future, we plan to continue holding STREAM-weeks, because we discovered that the interdisciplinary approach is very suitable for combining science, practice and art. Now we are looking for topics for new weeks and we want to connect TRIZ-technology (Theory of Inventive Problem Solving) to them in order to amplify the inventive component [6-7].

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The Impact of Teaching and Learning from Exploring the Representation of Physics Laws and Their Historical Context: Kepler's Laws of Planetary Motion

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Abstract. In physics course, Kepler's three laws of planetary motion proposed in 1600s are famous and important. These works provided one of the foundations for Newton's theory of universal gravitation. However, the sequence of the first two laws was in reverse order, different from their historical context. Additionally, many figures of Kepler's laws in textbooks were not drawn to scale and thus overemphasized that the orbit is not circular but elliptical. It usually misled readers to believe these orbits of planets around the Sun are very elliptical.

Historical textual analysis, textbooks review, and one-to-one interviews with university students engineering majors are the approaches adopted in this study. Moreover, 4 hand-on activities are suggested. The perspective of historical textual analysis in this study promotes the understanding of the historical meanings of the physics laws, the curriculum design of professional physics teaching, and the improvement of the context of physics textbooks.

Keywords. Elliptical orbit, history of science, Kepler, misconception, textbooks.

1. Introduction

For the observers on Earth, the Sun, the Moon, stars and planets appear to revolve around Earth. Naturally, people regard Earth as the center of the universe. The drawings describing the universe before 17th century illustrate concentric circles to show this geocentric model (e.g. Figure 1). However, ancient astronomers find the planets go retrograde periodically from the perspective on Earth. For example, Mars is retrograde every two years for about two months. Figure 2 is the trajectory of Mars around Earth between1580-1596 described by Kepler. Ancient astronomers used the deferent-and-epicycle model to depict and predict the motions of the planets. In the model, each planet is assumed to move uniformly counter clockwise on a circle called the epicycle while the center of the epicycle moves along a larger circle called the deferent (Figure 3). Instead of adopting the geocentric model, Copernicus chose the Sun to be the center of the universe (Figure 4). He still used the deferent-and-epicycle concept to portray the motions of Earth and other planets revolving around the Sun.

In the early 17th century, German astronomer Johannes Kepler discovered the regularity of the planets' motions known as "Kepler's laws of planetary motion", based on the high accurate observations of his predecessor Tycho Brahe. Instead of the perfect circular motion of traditional deferent-and-epicycle model, even more amazingly he used only one ellipse to replace these numerous circular circles.

In textbooks nowadays, Kepler's first law, the law of ellipses, states all planets move in elliptical orbits with the Sun at one focus. The second, the law of equal areas, states the line joining the planet to the Sun sweeps over equal areas in equal time intervals. The third law is related to planets' periods: squares of periods are proportional to the cubes of their average distances from the Sun. However, the sequence of the first two laws was in reverse order which contradicts the historical context. Additionally, many figures of Kepler's laws in textbooks are not drawn to scale and thus overemphasize the orbit is not circular but elliptical.

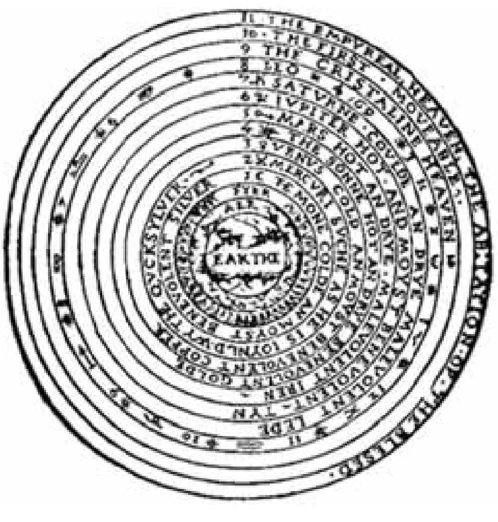

Figure 1. The Ptolemaic universe from Andrew Borde's *The First Book of the Introduction of Knowledge*, 1542

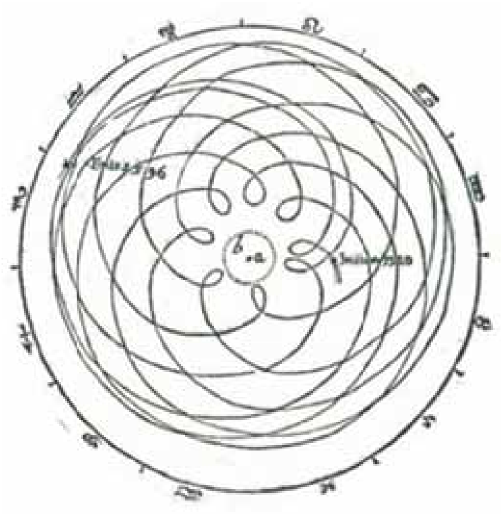

Figure 2. The trajectory of Mars around Earth between 1580-1596 from [1]

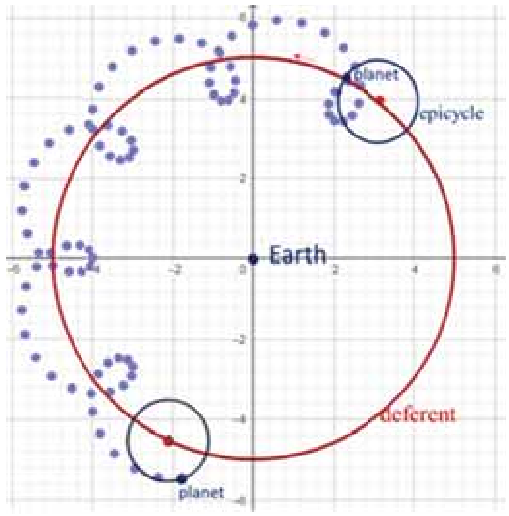

Figure 3. The deferent-and-epicycle model (simplified, by YJ Chiu)

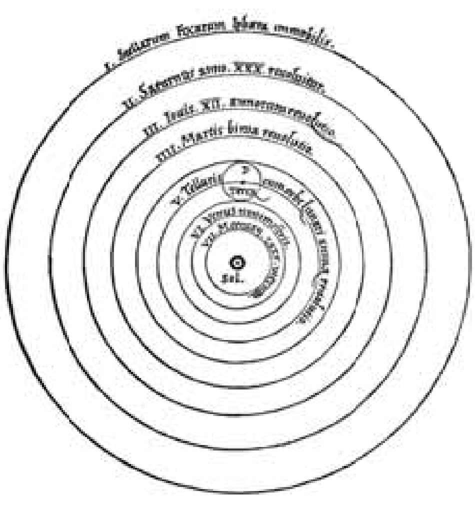

Figure 4. The heliocentric model from Nicolaus Copernicus' *De revolutionibus orbium coelestium*, 1543

2. The sequence of the first two laws

Unlike Newton's three laws, Kepler's three laws were not published in the same book. The first two laws describing Mars were published in *Astronomia nova* [1] in 1609. Ten years later in 1619, the third law, extending to all planets in the Solar System, was released in *Harmonices Mundi* [2]. Furthermore, in contrast to the historical texts, the sequence of the first two laws in textbooks is in reverse order [3]. The second law, about the equal area in the same time interval, was in fact arrived first. Then, Kepler found the orbit an ellipse, which is now called the first law.

To find out who first named the law of ellipses FIRST, this study examines two popular textbooks in the 19th century: *Outlines of Astronomy* by John Frederick William Herschel (1792-1871) [4] and *A Short History of Astronomy* by Arthur Berry (1862-1969) [5].

2.1. Herschel's *Outlines of Astronomy*

This book went through many editions: the first edition was published in 1849, and by 1871 the book had gone through eleven editions. The book was translated into Chinese in 1867, which became the first book that helped the Chinese to understand Western astronomy. The edition this study examines is the new edition published in 1875. In this book, the sequence of the first two laws corresponds to their developmental history. That is, the law of equal areas is the FIRST and the law of ellipses is the SECOND.

> To begin with the first law, that of the equable description of areas. (art.490)

> The second law of Kepler, or that which asserts that the planets describe ellipses about the sun as their focus, …. (art.491)

2.2. Berry's A Short History of Astronomy

The author Berry is well-known to historians of science through this book. Although this book contains elementary knowledge of astrology it is, indeed, a remarkably good book—one of the best books of its kind at that time.

In the1898 edition, Art.141, the law of equal areas is then marked the FIRST and the law of ellipses the SECOND (Figure 5). In addition,

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the developmental story of the two laws are in inverse sequence to their true historian contents.

This study is not sure who first called the law of ellipse FIRST. But, since this edition, the law has been generally regarded the FIRST up to the present.

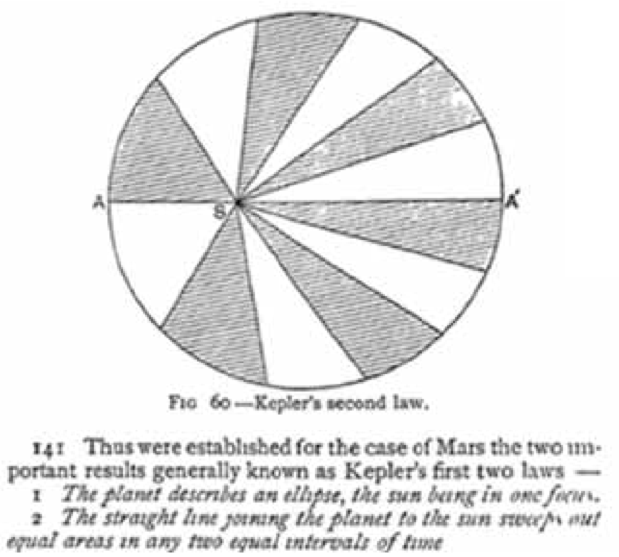
FIG 60—Kepler's second law.

141 Thus were established for the case of Mars the two important results generally known as Kepler's first two laws —

1 *The planet describes an ellipse, the sun being in one focus.*

2 *The straight line joining the planet to the sun sweeps out equal areas in any two equal intervals of time*

Figure 5. Kepler's first two laws from Berry's *A Short History of Astronomy*, 1898. (Art.141)

3. Kepler's progression of finding the first two laws

It is a big task for Kepler to determine the shape of the planetary orbits. Kepler challenged to Mars and called it the war with Mars. At the beginning, Kepler compared the observational data for the orbit of Mars with the theoretical results for the Ptolemaic, Copernican and Tychonic systems. Kepler concluded that based on the similar observational foundations, the three systems, in spite of different models, are in fact equivalent. Consequently, Ptolemaic system with Earth as the center cannot be seen as a total failure.

Among the three models, Kepler decided the Sun to be the center and then determined the orbit of Earth by a series of measurement. One important fact worthy of attention is that he did not yet find the orbit as elliptical at that time. Once the orbit of Earth is known, he constructed the Martian orbit by a complicated procedure which he named “Measuring the Heavens”. Finally he found the orbit of Mars was in an oval motion, and then identified it an ellipse path in fact.

Once the Sun is moved to be the center, the path of Mars become fairly simple. Earth and Mars both orbit the Sun, but at different distances. Every two years or so, Mars, Earth and the Sun form a straight line with Earth in the middle—an event known as Mars oppositions (Figure 6). The words perihelion and aphelion were coined by Kepler to describe the orbital motion of the planets. This summer in 2018, opposition occurs on July 27, and Mars will reach its closest point to Earth on July 31.

Figure 6. Mars oppositions 2010-2022

4. The shape of the planetary orbits

4.1. Planetary orbits are almost circular

An ellipse looks like a flattened circle. The degree of flattening is measured by a number called the eccentricity. There are two foci on the major axis for each ellipse. They separate as the eccentricity increases (Figure 6).

To emphasize the characteristic of ellipse, many figures in textbooks are grossly exaggerating and do not remind readers they are not drawn to scale. It usually misleads readers to believe these orbits of planets around the Sun are very elliptical. Actually, very different from the illustrations of elliptical orbits in textbooks, this elliptical orbit of Mars is nearly circular, and so is Earth's. That is to say, planetary orbits tend to be almost circular, except comets. For example, Halley's Comet has an eccentricity of about 0.967 (Table 1 and Figure 7).

Table 1. Planetary Orbits of the solar system

Planet	Eccentricity	Distance from Sun(AU) Perihelion	Aphelion	Average
Mercury	0.206	0.31	0.47	0.39
Venus	0.007	0.72	0.73	0.72
Earth	0.017	0.98	1.02	1.00
Mars	0.093	1.38	1.67	1.52
Jupiter	0.048	4.95	5.45	5.20
Saturn	0.056	9.04	10.12	9.58
Halley Comet	0.967	0.95	35.10	17.84

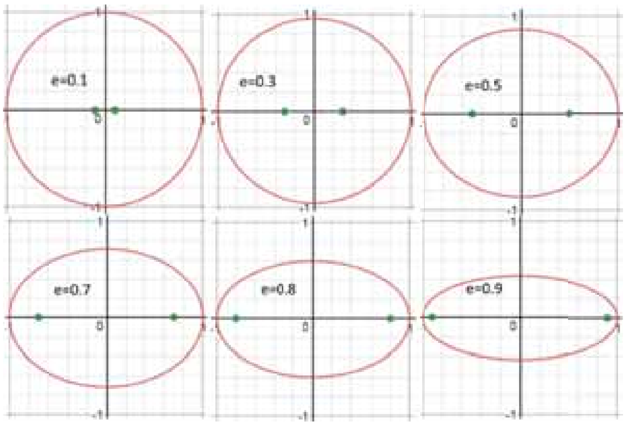

Figure 7. Ellipses of different eccentricity

4.2. Planetary orbits in textbooks nowadays

The keyword search “Kepler law image” indicates that almost no planetary orbits shown online are drawn to scale. In addition, this study examines 8 physics textbooks in hand and finds most of the orbits are not in their actual proportion (Table 2 and Figure 8).

Table 2. Planetary orbits in some textbooks

Textbook No	Code	Elliptical orbit of the first two laws eccentricity	position of Sun	Orbit shape the 3rd law
1	TBU_K	e= 0.81	error= 54%	circular
2	TBU_Y	e= 0.71	error= 31%	none
3	TBU_M	e= 0.25*	error= 0%	none
4	TBU_B	e= 0.41*	error= -13%	circular
5	TBU_H	e= 0.82*	error= 9%	circular
6	TBU_G	e= 0.67	error= 33%	circular
7	TBH_CW	e= 0.78	error= 33%	none
8	TBH_HL	e= 0.71	error= 36%	none

* This book remind readers that their drawings are exaggerated for clarity

Furthermore, these books present their ellipses with different eccentricities and mark the Sun in a wrong position. However, oddly enough, the orbits become circular when they depict the third law. Only three textbooks remind readers particularly that their drawings of the first two laws are exaggerating for clarity because if the orbits are drawn to scale, they look circular.

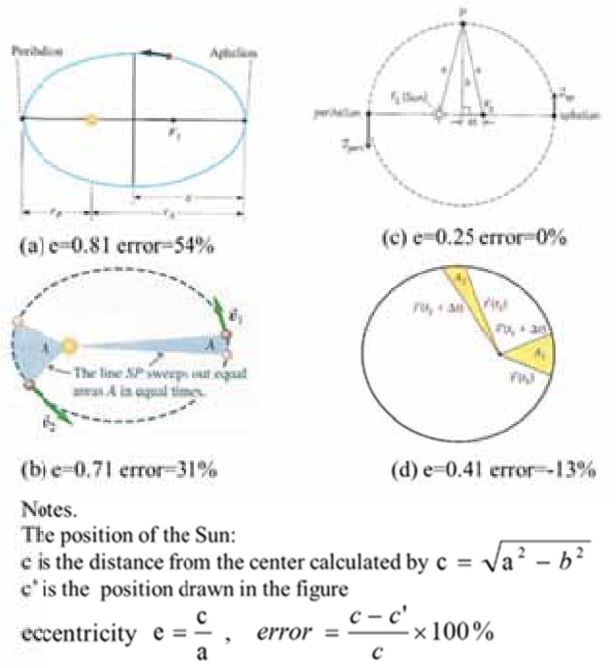

Figure 8. Some elliptical orbits in textbooks of Table 2

4.3. Students’ concept about the orbit of Earth around the Sun

To understand students’ concept about the orbit of Earth around the Sun, this study interviews 40 engineering majors. These students are asked to choose the most agreeable orbit on the questionnaire in Figure 9 and mark the position of the Sun in his selected orbit. The result is shown in Table 3.

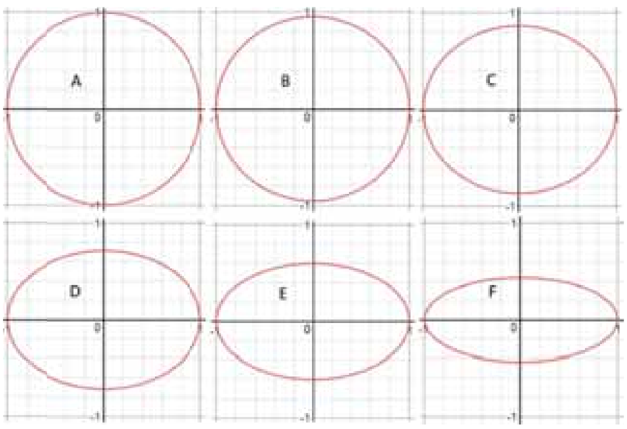

Figure 9. Six ellipses in the questionnaire

According the eccentricity of Earth on Table 1, the most agreeable orbit is “A” and the position of the Sun is almost on the center.

Students tend to choose apparent ellipse, and most of them mark the Sun's position wrongly. In conclusion, students do not know that the orbit of Earth are fairly circular. Besides, they mark the wrong focus position on the ellipse they choose.

Table 3. The results of the questionnaire

Orbit	n*	n**
A	0	0
B	7	0
C	13	3
D	12	1
E	6	1
F	2	0

* number of students (select an orbit from the six)
** number of students who mark Sun's position correctly

5. Conclusion and Implication

5.1. The history of science

The history of science introduced by textbooks often contradicts the real evolution of history [6]. In this study, the sequence of the first two laws was in reverse order in the late 19th century. It results in students' misunderstanding about the derivation of the three laws.

5.2. The importance of proportion in drawing

Most figures of Kepler's laws in textbooks are drawn exaggeratedly to emphasizing the orbit is not circular but elliptical and they seldom remind readers the figures are not drawn to scale. These misconceptions about planetary orbits have spread far and wide up to the present. The result of orbit test in this study calls attention to the importance of the correct figure proportion.

5.3. The disparity between the Martian orbit and a perfect circle

For most students, the disparity between the Martian orbit and a perfect circle is insignificant. However, Kepler appreciated the negligible disparity. It provides insight and inspiration to the world.

Therefore, it is more important to remind students of the significance of this slight disparity between the Martian orbit and a perfect circle than to have them do many exercises by mathematical calculation.

In the northern hemisphere, students have difficulty to understand why the season is winter when Earth moves near the closest point to the Sun, the perihelion. Once they learn that the actual orbits of the planets are fairly circular, the mistakes in comprehending the cause of seasons will reduce.

5.4. Hands-on activities

This study suggests some hands-on activities about this topic.

5.4.1. Drawing ellipses

Seldom students have experience of drawing ellipses. By the hands on experience of drawing ellipses, students can gain a better understanding about the concept of ellipses, including the degree of flattening and the positions of foci.

5.4.2. Tracing the planetary orbits

Tracing the planetary orbits according to the real data similar to Table 1 can help students construct the concept of the Solar System.

5.4.3. Tracing the paths of Earth and Mars

Teachers can guide students to trace the paths of Earth and Mars through using the data of Mars oppositions, as shown in the static Figure 6. If possible, an animation will be a better illustration of the orbits. This activity can lead students to comprehend the interactive relation between Earth and Mars.

5.4.4. Simulation modelling

Teachers can instruct students to construct modells for different systems through using big observational data [7]. These activities not only allow students to engage in modelling by simulation but also lead students to analyze Ptolemaic and Copernican models.

6. Acknowledgements

Special thanks go to the support and grants (MOST 105-2511-S-182-014) from the Ministry of Science and Technology, ROC, and BMRP922 from Chang Gung University.

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The Role of Non-Formal Learning in Scientific Education

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Abstract. Within the context of lifelong education, non-formal learning combines the intentionality and structuration of formal experiences with the flexibility of informal counterparts. As in any other learning process, education of science can benefit from non-formal learning activities such as summer camps, scientific unions or non-profit organizations. Focusing on my experience in voluntary summer camps, here I analyze how such community-based experiences influence the shaping of a scientific mindset. First, the direct contact with a different environment (people, nature) awakens a scientific curiosity to explore and understand your surroundings. This understanding will ultimately arise from the development of a critical thinking. Living together within a group is furthermore a socializing experience, which trains children to communicate and establish bonds between themselves. Finally, as a group leader, planning is also required to develop an activity program that fulfills the educative needs. All these competences and skills are of paramount importance in scientific education in order to effectively acquire, comprehend, and apply the formal curricular knowledge.

Keywords. Community, leisure, lifelong learning, summer camp.

1. Introduction

The concept of *lifelong learning* has been recently proposed to englobe the “lifelong” and “life-wide” nature of education, meaning that learning occurs throughout the whole life span and involving all contexts of our lives [1]. For this reason, in order to focus on the learner rather than on the formal educational institutions, the term *learning* is preferred over *education* [2].

From this holistic perspective, the process of lifelong learning can be divided into formal, non-formal, and informal learning. As defined by the European Commission [3-4], formal learning occurs as a result of institutionalized and structured education leading to academic certification; non-formal learning includes organized activities outside the formal education system, which are intentional from the learner perspective and do not lead to certification; and informal learning arises from everyday activities, intentional or not, related to work, family, or leisure [5]. On the second, it comprises experiences such as non-profit organizations, scientific unions, or summer camps, which will be the focus of this article.

As in any other learning process, education of science needs to engage not only formal structured curricula in schools, but also non-formal and informal components of learning. In this context, prior research suggests that non-formal science learning increases science attitudes and confidence [6–8], scientific reasoning [9], and interest in science [10-11]. These are essential elements in promoting interest towards learning [12] and developing a solid scientific literacy among society [13].

In this article, based on my experience as both participant and group leader in summer camps, I will analyze the role of non-formal learning activities in the development of four important facets of any scientific mindset: curiosity to explore and understand the environment, critical thinking, communicative abilities, and activity planning.

2. The contact with the environment awakens scientific curiosity

In a summer camp, the first impact to a child is the discovery of a new environment, which includes a new living place, generally away from big urban cities, as well as a group of other peers alike and instructors. Forcing participants to step outside their comfort zone triggers the curiosity to explore the unknown. In fact, from the scientific method perspective, the observation of the object of study is the first step towards the generation knowledge.

As a result, children are encouraged to wonder about everyday phenomena and the surrounding world. This is essential for any learning process to happen, so that it creates a thirst for knowledge as means of intrinsic motivation. Furthermore, connecting science to the everyday life makes the learner perceive it as relevant.

Figure 2. Hiking during a 14-years-old summer camp in Pineta (2017)

For example, summer camps often promote contact with nature, such as outdoors activities or hiking (Figure 1-2). In the latter, children learn how to survive with the essentials, making them wonder “What do we need to live?”, “Why?”, “Why is nature different in different places?”, “Why do we see the stars clearer here than in the city?”, etc. Apart from nature, participants also get the opportunity to know the instructors and other peers alike, giving them the chance to share their feelings and thoughts. Knowing people with different culture, traditions, social contexts… also forces them to emphasize and try to understand the unknown (“How is living in an orphanage?”, “Why is your friend sad?”, “What does it mean to be a Muslim?”).

Figure 3. Hiking during a 5-to-9-years-old summer camp in Alt Penedès (2017)

3. Developing critical thinking to pursue scientific knowledge

The action of breaking down our thinking into logical steps to elucidate our questions on how the world works is known as the science process. The learning of such skills starts in early childhood and develops gradually as children age [14]. However, science process is not unique to science, but to any everyday situation that requires critical thinking. The variety of activities in summer camps will therefore promote critical thinking in making children find out a way to achieve their goals.

Summer camp participants also understand that a right/wrong answer to complex questions does not exist, but multiple solutions are possible. In consequence, they struggle to develop a creative thinking to observe, measure, analyze, predict, experiment, communicate… until succeeding. One example of the previous is the activity in Figure 3, where the figure in the center of the circle changed depending on the angle of the observer, so that when describing it not everyone saw the same, but they were all right.

Figure 3. Reflection during a 7-to-9-years-old summer camp in Alt Penedès (2017)

Figure 4. Activity during a 7-to-9-years-old summer camp in Alt Penedès (2017)

Other illustrative activities are gymkhanas or role-plays, in which children are given some objective to fulfill. In Figure 4, they need to pass the water balloon as many times as possible before it breaks. “Is it safer to throw the balloon straight or lobbed?”, “What part of the balloon is the most fragile?”. Competition between group members can often add an extrinsic motivation in this process. Similarly, in group activities, participants also share common interests and goals, promoting the co-operation between them.

4. Networking and communicating science

One major success of summer camps is educating while also giving the learner the opportunity to have fun with peers alike. In this context, communication is essential to get along and explain oneself to the group. Living together within a group is therefore an extreme socializing experience, which trains children to establish bonds between them.

Figure 5. Communication activity during a 5-to-9-years-old summer camp in Alt Penedès (2017)

In Figure 5, the participants of the summer camp need to express, at the end of the 7-day camp, their thanks and forgiveness feelings to other members of the group. In another effort to communicate themselves, Figure 6 shows a report of the events that happened during the previous day, which is published in a daily camp newspaper.

5. Planning the summer camp

At a later age, participants of summer camps often have the opportunity to take a step further and get actively involved as group leaders. Such a task involves the cyclic process of preparation, realization and evaluation (PRE, Figure 7). On the first, the group of leaders establish the set of specific learning goals to be accomplished by the children, which are defined based on their educative needs. All summer camp activities are then consequently prepared to achieve these goals. Once summer arrives, the program is executed, and the accomplishment of learning goals is finally evaluated. This is a continuous and circular process, so that activities need to be permanently adapted to match the established objectives.

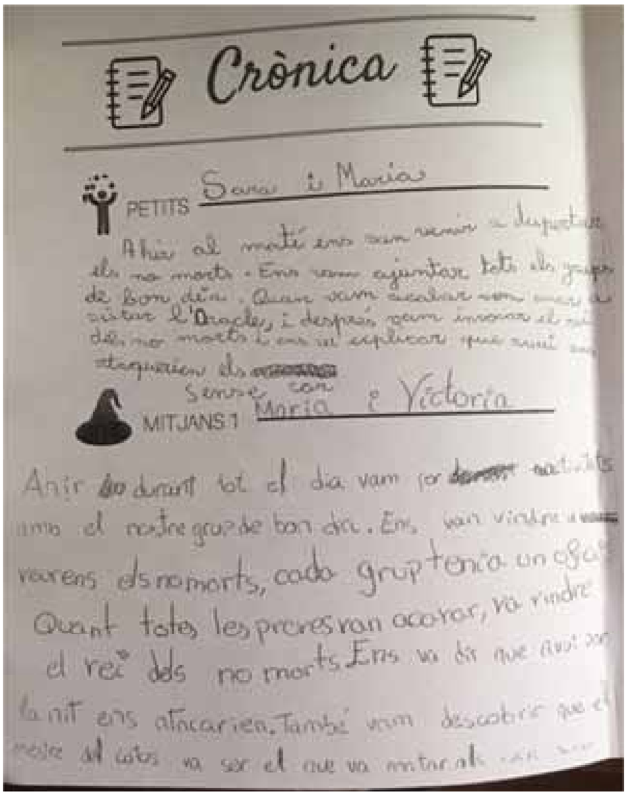

Figure 6. Report of the events that happened during the previous day written by 10-to-11-years-old participants of a summer camp in Pineta (2017)

Figure 5. Summer camps involve the circular process of Preparation, Realization and Evaluation of activities

Overall, the process of PRE of summer camps strongly resembles the scientific method of designing experiments, collecting results and drawing conclusions. One needs to creatively design the activities that fulfill the objective of your work, considering possible difficulties and alternative fallbacks. At the end, evaluation of the results is essential to redesign new activities in the future.

6. Conclusions

The lack of relevance of science education is one of the biggest problems many nations are facing nowadays [15]. In this regard, non-formal learning helps to understand concepts learned in school and promote the interest and motivation of students, which can ultimately affect their career orientation and increase the societal scientific literacy [16]. Efforts towards the recognition of non-formal education in the process of lifelong learning are therefore of paramount importance [17].

On the other hand, formal education has traditionally represented the “one-size-fits-all” paradigm, so that the whole diversity of learners need to adapt to the one established school curriculum. In this context, non-formal learning, which provides more freedom and flexibility to satisfy learner’s needs, constitute a potential complement to formal education. Recent efforts linking formal and non-formal learning in scientific education show successful results by fostering positive attitudes towards learning science [18-19].

In conclusion, the experience in summer camps, even not being directly science-oriented, triggers the construction of essential science process skills, such as observation, critical thinking, exploration, communication, and planning. Such skills promote a “minds-on” learning attitude, ultimately enhancing the motivation and understanding in formal education.

7. Acknowledgements

I would like to thank “Colònies Jordi Turull” (CJT), who gave me the opportunity to learn the potential of non-formal education [20]. All pictures in this article were taken during last year’s CJT summer camps [20].

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An Approach to Epigenetics through *S. marcescens* and the Application of Prodigiosin in Medicine

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Abstract. This work aims to be an introduction to Epigenetics just as to Biotechnology and Microbiology. Epigenetics represents a bridge between genetic and environmental influences. It possesses the ability to alternatively turn on and off genes, as though they were switches, and so to pass some of these changes to progeny. By doing that, however, DNA sequence remains the same [3]. For instance, a protein expression can be regulated by temperature, as in the case of the pigment prodigiosin in *S. marcescens*.

S. marcescens is a rod-shaped gram-negative bacteria in the family Enterobacteriaceae. It can grow in temperatures ranging from 5 to 40ºC and in pH levels varying from 5 to 9 (Figure 1).

One of its main characteristics is that of synthesizing prodigiosin, a reddish pigment formed by three pyrrole rings with absorbance at 535 nm [1].

Figure 1. *S. marcescens* observed by a SEM (Scanning Electron Microscopy)

An experiment was conducted with some cultures of *S. marcescens*. In laboratory, a culture grows in an agar plate, which is a Petri dish that contains agar and some nutrients, and it sets the ideal environment for bacteria to multiply.

For the carrying out of this experiment some specific tools were needed so as to extract and verify the presence of prodigiosin in a *S. marcescens* culture.

The first tool was a centrifuge, that is a rotating instrument by which -using centrifugal force- the denser components of a sample deposit at the bottom whereas the lighter ones remain in suspension.

The second tool was an incubator, as optimal temperature and humidity is required for a bacteriological culture to grow.

Lastly, the spectrophotometer (Figure 2), which is a device used for chemical analysis that measures the amount of light absorbed by a sample and its concentration based on wave length. The spectrophotometer projects a jet of monochromatic light through a sample and detects how many light has been absorbed.

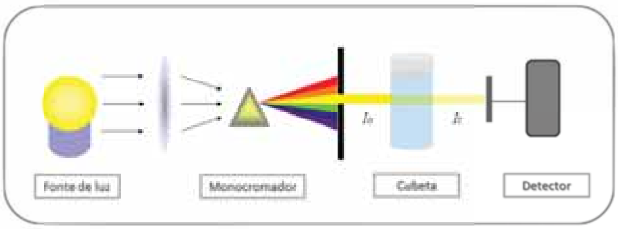

Figure 2. Diagram of an spectrophotometer

Figure 3. In the upper part of the figure you can see the cultures incubated at 37ºC and in the lower part, the ones incubated at 30ºC

From an initial culture of S. marcescens, we spread the bacteria to six different Petri dishes, three of which were put in an incubator at 37ºC while the others at 30ºC. After 48 hours, the cultures incubated at 37ºC did not show any sign of redness yet those incubated at 30ºC did (Figure 3).

Next, the extraction of the samples was made for each Petri dish and placed individually into an Eppendorf containing 900µL of alcohol (Figure 4).

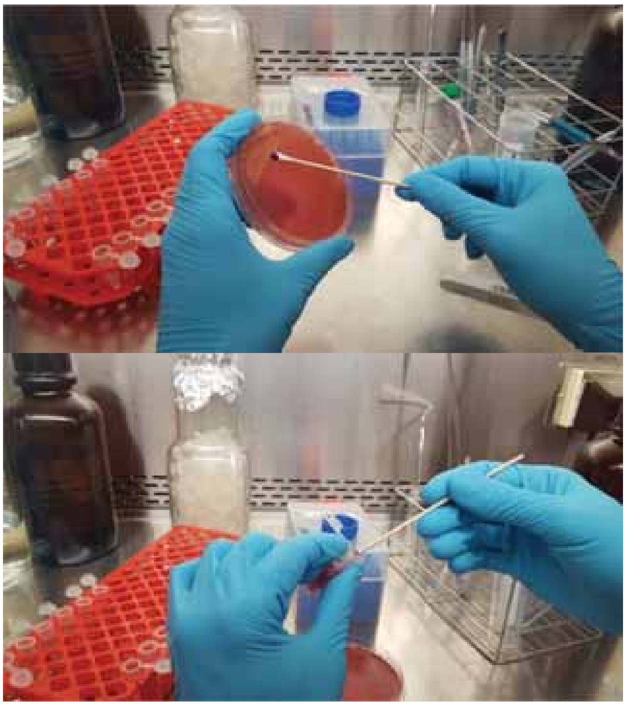

Figure 4. The procedure of extraction from the culture incubated at 30ºC

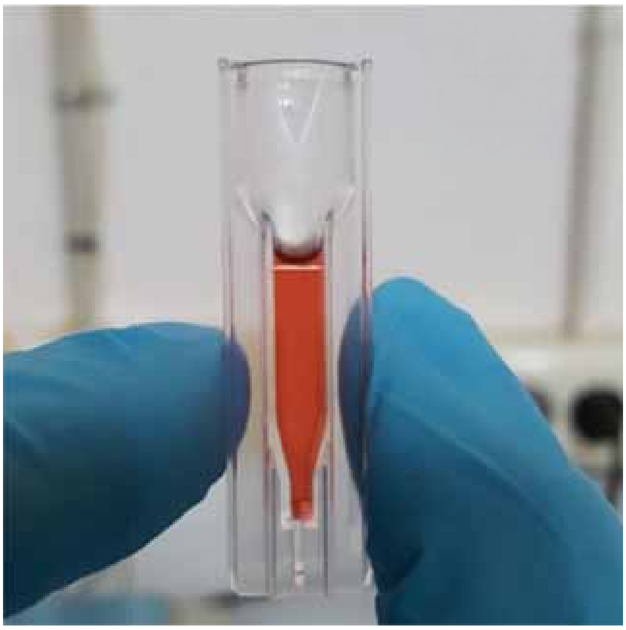

Figure 5. A cuvette with alcohol and prodigiosin

Then, the samples were centrifuged and its liquid phase was extracted and deposited into cuvettes (Figure 5) for being analyzed in the spectrophotometer.

Those bacteria incubated at 30ºC did not show any sign of redness at all, therefore prodigiosin had not been synthesized and the samples could be used as a control to calibrate the spectrophotometer. The results from the cultures incubated at 30ºC confirmed that the reddish substance present in them was actually prodigiosin, as the absorbance showed a peak at 534nm (Figure 6).

In conclusion, it can be affirmed that external factors influence genetic expression -and ergo the existence of epigenetics- as seen in the previous experiment regarding prodigiosin synthesis, which was found inactive at 37ºC.

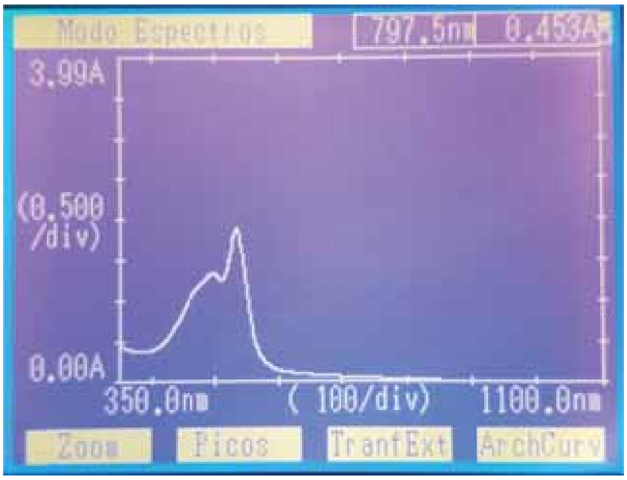

Figure 6. Graphic showing the absorbance peak of prodigiosin

Keywords. Biotechnology, epigenetics, prodigiosin, *S. marcescens*.

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Study of Efficiency of Enzymes in Laundry Detergents

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Abstract. Biotechnology is defined as the application of biological systems and organisms to technical and industrial processes [1].

A detergent is a chemical substance with cleaning properties. A laundry detergent composition is a formulated mixture of materials. Surfactants and builders are the major components of cleaning products. Surfactants are substances that reduce the surface tension of liquids, and builders are added mainly to reduce water hardness. Other components are bleaching agents, enzymes, and minors which remove dirt, stain, and soil from surfaces or textiles [2].

According to IUPAC, enzymes are macromolecules, mostly of protein nature, that function as (bio)catalysts by increasing the reaction rates [3].

Figure 1. Structure of protease from Bacillus cereus (1NPC)

Different enzymes are added to the detergents to improve their efficiency. Due is ability to catalyze specific chemical reactions, enzymes speed up the cleaning process.

Enzymes used in laundry detergents represent one of the most important application fields of enzymes. The major classes of detergent enzymes—proteases, lipases, amylases, and cellulases— provide specific benefits for application in laundry.

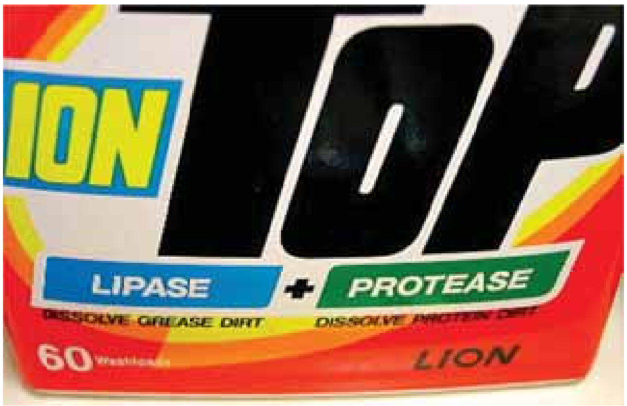

Figure 2. Example of the use of enzymes in detergent industry

Proteases, which are the most used enzymes in detergent industry, remove protein stains. Amylases are used to remove residues of starch-based food. Lipases decompose fatty material and Cellulases have results in color brightening, softening and soil removal [4].

Factors affecting the performance of different types of detergent formulation such as temperature, the kind of the stains, have been studied using stained cloths in different temperatures in order to measure the enzyme activity in the detergent solutions.

In this study, the topic enzymes in biological detergents will be developed with experiments based on its properties and components.

To determine the effect of different detergents considered in this study cotton clothes made of cotton were stained. The nature of the stains was: beetroot, coffee, lipstick, starch, paint, permanent, olive oil, blood, wine and chocolate.

Figure 3. Some stained clothes. Above, from right to left: beetroot, blood and chocolate. Below, from right to left: coffee, egg and paint

The stained clothes were washed in six different solutions containing water (solution 1), water with lipase and protease (solution 2), handmade detergent made with a bar soap and washing soda with lipase and protease (solution 3), economical and industrial detergent with unspecified enzymes (solution 4), industrial detergent with unspecified enzymes (solution 5), industrial detergent without enzymes (solution 6).

Figure 4. Magnetic stirrers used to wash the stained clothes

The clothes were washed for 5 minutes in the different detergent solutions (1L, 3g/L). A magnetic stirrer was used at 600 rpm as a washing machine. The action of the detergents was analyzed at 26°C, 40°C and 70°C.

The results confirmed that the detergent washing performance with enzymes at a high temperature added improved significantly for the specific stain soil.

26°C 40°C 70°C

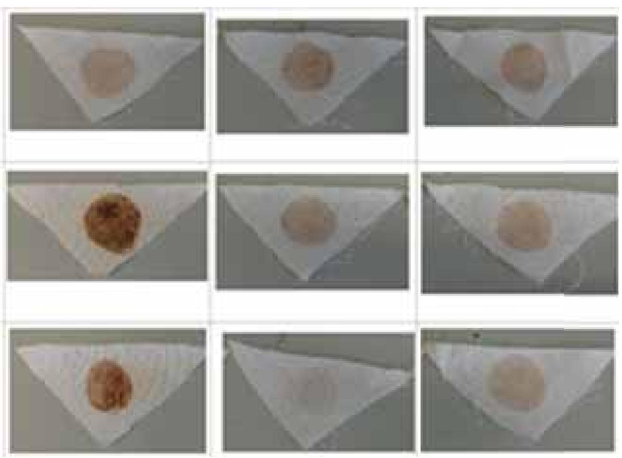

Figure 5. Example of the results. Chocolate stained cloths. Above: Industrial detergent without enzymes. In the middle: Economical industrial detergent with enzymes. Below: Industrial detergent with enzymes

Keywords. Detergent, enzymes, laundry, wash performance.

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Friction, Surfaces and Atomic Interactions: Hands-on Approach through Comprehensive Investigation of Gecko-Tape® Properties

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Abstract. Nanotechnologies daily hit the media, pointed out as the source for innovative technologies in life sciences, electronics, mechanical industry, etc. In addition to the huge, technological issue, which naturally appeals to student interest, nanoscience offers a novel and effective way to introduce students to modern physics. Indeed, at the heart of nanoscience and its applications is the idea that material properties, such as resistivity, optical absorption, etc. are essentially determined at the nanoscale: the ability to control the structure of matter at the micro- and nano-scale therefore, makes it possible to design and tune material properties almost at will. In selected cases, the properties of nanostructured systems can be investigated and manipulated even through simple macroscopic experiments – accessible at the early stages of scientific education – which can be used to highlight some of the key concepts in condensed matter physics and to effectively suggest that, even in the simplest phenomenology of matter, there is more to be understood than usually taught.

Following these ideas, we have started a project named NANOLAB [1], which aims at introducing nanoscience in school curricula. A few relevant thematic areas have been selected, typically focused on a given nano-material or technique, and for each area a small set of related experimental protocols have been developed. Among selected topics, the energetic issue - representing nowadays one of the big challenges for humanity – is very attractive for students, usually fascinated by renewable energies. In this area, a less known but also very stimulating topic is tribology, i.e. the study of friction, adhesion, wear and lubrication.

It is well known since Joost seminal report [2], that about one third of the energy used in the world is lost in friction [3]. The design of appropriate materials and surface treatments can significantly reduce these percentages: tribology represents therefore a strategic sector for industry and research. The understanding of surface interactions, starting from the nanoscale, allows to design solutions and new materials with optimal performance. At the micro- and nano-scale adhesion and friction directly involve atomic and molecular interactions and implicate the concept of real contact area, as opposed to geometric (or nominal) contact area. The somewhat counter-intuitive fact that - at the macroscale - frictional forces do not depend on the nominal contact area is known since Leonardo's studies and it is taught in all physics classes; this is related to the concept of surface roughness, which implies that the real contact points between the two surfaces are only the few protrusions which "touch" each others (i.e which are so close to each other on the nano-scale that their atoms actually interact). For usual materials, the number of these protrusions is fairly independent on the macroscopic nominal one. In the case of micro- and nano-structured surfaces, instead, their number may increase proportionally to the macroscopic area, so that Leonardo's law is not fulfilled anymore. Moreover, the possibility to adjust the relative inclination of surface protrusions, allows to vary the real contact area and, therefore, to tune adhesion: this is precisely what the Gecko does when climbing on smooth and vertical walls or running on ceilings, thanks the hierarchical micro- and nano-structured asperities of its feet.

In this work, we present a hands-on based teaching plan, which, starting from the energetic issues, introduces the main concepts and challenges of modern tribology. The core of the lesson is provided by a series of experiments, carefully designed to investigate the properties of Gecko-Tape®, a bio-inspired silicon film, which mimics the adhesive properties of geckos' feet. The Gecko-Tape® surface is characterized by a micro structured hexagonal lattice of high aspect-ratio pillars, which provides an extremely high shear adhesion, while maintaining an almost vanishing peeling force. This film can be easily purchased and extensively used in classroom experiments.

While in standard physics courses friction is usually presented as a trivial topic, and its classic laws are briefly reviewed, without any attempt to justify them from a microscopic point of view, recently a few didactic studies have highlighted how these laws encapsulate a host of interesting phenomena, which can be effectively investigated by studying friction experimentally [4-9].

We here develop these ideas, exploiting the fascinating properties of Gecko-Tape® to design an easy-to-implement lesson plan, based on throughout hands-on investigations, which encompasses both mechanical and structural characterizations.

The plan we have designed is structured as follows:

After a theoretical introduction of the basic concepts of nanoscience and biomimetics, students, in small groups, investigate the Gecko-Tape® properties without receiving any preliminary information. The investigation consists of three different sets of experiments, mimicking a "true" scientific research investigation:

a) Macroscopic characterization of the mechanical and adhesive properties of the material; these includes evaluating the differences between peeling and shearing geometries in adhesion and observing the differences between 'usual' materials (as in particular sandpaper) - which fulfil the Leonardo's law - and Gecko-Tape®.
b) Microscopic investigation of the film structure, both by means of direct observations with an optical microscope and by diffraction. The microscope is designed and built by students, exploiting the optics of a smartphone camera [10].
c) Understanding the microscopic mechanisms determining the Gecko-Tape® properties, with the aid of available simulation tools.

While each type of investigation is assigned to different groups of students, plenary sessions in which each group can present and discuss its results were planned. Eventually, the results of all investigations are merged in a comprehensive report, which has been used as a basis for subsequent peer-education sessions to classmates.

The proposed activity has been validated during a one-week stage, comparing the performances of two groups (15 pupils each) of highly-motivated students of the 4^{th} year of high school, specifically interested in physics (PHYS) and mathematics (MAT), respectively. While the PHYS group participate to the complete learning plan, the MAT group was only involved in a one-day peer-education session, during which PHYS explains both the theoretical aspects and the obtained experimental results, in a scientific-workshop fashion.

The effectiveness of the proposed teaching plan has been evaluated by testing the pupil knowledge and understanding of the relevant issues at different times during the stage: for the PHYS group tests were performed at the beginning, after the theoretical introduction, and at the end of the work, while the MAT group was tested at the beginning and after the peer-education session. The tests demonstrate the effectiveness of the proposed teaching plan, supporting both the crucial role of active learning and the effectiveness of peer education, both for peer students and mentors.

Keywords. Friction and tribology, nanosciences, optical microscope and diffraction, peer education.

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Hands-on Teaching Ideas from *Science in School*, the European Journal for Science Teachers

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Abstract. *Science in School* is a free publication that aims to promote inspiring science teaching by encouraging communication between teachers, scientists, and everyone else involved in European science education.

The journal addresses science teaching both across Europe and across disciplines: highlighting the best in hands-on teaching and cutting-edge research. It covers not only biology, physics and chemistry, but also earth sciences, engineering and health, focusing on interdisciplinary work.

The contents include innovative teaching materials, novel experiments and inspiring projects in science education, in addition to new scientific advances and interviews with inspiring scientists and teachers. Free print copies in English are distributed across Europe, and online articles are published in 31 European languages on the *Science in School* website [1]. The journal is published and funded by the international research organisations of EIROforum.

Science in School encourages the exchange of ideas amongst teachers, giving them the opportunity to help inspire others with their successful, practical activities to engage and challenge students. Along with scientists, teachers are a fundamental part of *Science in School*, through writing, reviewing and translating articles.

As an editor of the journal, I want to highlight the ways that teachers and educators can get involved with *Science in School*, and encourage them to utilise the valuable resources we publish, as highlighted by some of our readers:

> "I find *Science in School* particularly useful for getting new ideas and inspiration. I especially like reading about news in science and examples of how we can use the information in the classroom. In Sweden, it is very important to study science also in English since that is the primary language at the University and in University literature."
>
> *Eva Ask,*
> *Biology and Chemistry Teacher, Sweden*

> "As a science department, we keep referring to the *Science in School* journal, which proves to be very providential and mind-opening – excellent. Our students find the articles very interesting and are trying most of the experiments according to the respective ages. In fact, many students are asking me for copies."
>
> *Christopher Schembri,*
> *Science on Stage, Malta*

> "[…] My article in *Science in School* for the heart demo resulted in it being picked up by TED-Ed, which has now been seen 1.2 million times and I met a teenager who wants to be a doctor who told me that demo was not only used in school, but set as homework! They had to buy a heart and make it pump at home! So, I can honestly say that we've changed the world."
>
> *Edmond Hui,*
> *Network Manager, Teddington School, UK*

Keywords. Activities, experiments, free, hands-on, interdisciplinary, journal, materials, publication, resources, science, teaching.

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An Interesting and Reliable Approach to Learn Physics

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Abstract. An interesting and reliable approach to learn physics comprises six aspects.

1) It is critically important to translate mathematical equations, which describe various physical laws, into the language of daily life. Oversimplifying these translations becomes an obstacle to learn physics. A few examples are roughly presented.

2) It is important to create a concept map to learn a topic of physics: a concept map reflects how the physical knowledge is described, and therefore leads students to learn the topic. An appropriate concept map of a given topic makes it easier and more efficient to study this topic. An example related to thermodynamics is discussed to illustrate this point clearly.

3) We must be aware that any textbook has flaws and that they bother students. Science education is not an easy job; even in textbooks, some defects are unavoidable, but they confuse students.

4) Obviously it is a poor teaching method to try to teach students a calculation when they fail to understand a reason for that calculation. Before students understand a question, to teach the answer of the question is unreasonable. A demonstration of an essential law of physics, which is vital and interesting, helps students to understand a topic of physics before they attempt a related calculation. Several innovative instruments for physics education are presented in the lecture.

5) To have students form a research group to study a given topic is also a valuable and reliable teaching method. Learning by doing helps students who have varied background knowledge learn reliably something during that research. An airborne wind turbine, a Stirling engine and an electrical generator driven by ocean waves are three topics that are suitable for students on which to undertake research.

6) Although much time and resource are required, to make a micro-TV program for physics education also benefits students. A small section of a TV program is shown in the lecture.

Keywords. Mathematics equation, concept map, textbook flaws demonstration for physics education, learning by doing, science TV program

Hands-on Virtual Experiments. From Orientation to Implementation

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Abstract. 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 to learn about experimentation and scientific method in STEM (sciences, technology, engineering and mathematics) subjects in much more realistic environments. They are part of the irruption of the technologies in the classroom.

Can simulations be effective scaffolding tools that explain abstract concepts and provide an environment for discussion, exchange and construction of knowledge?.

Are online laboratories an increasingly widespread resource in the teaching of STEM subjects?. Which are the STEM competences that can be addressed by online laboratories?. Where could we search Labs online? which ones do we to implement the scientific method?

The use of a inquiry learning methodology IBSE (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 and train them competently.

Can online laboratories simulate on screen experiments that are traditionally performed in school laboratories? Do 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?

Do virtual labs develop basic investigative skills and allow to learn efficiently about scientific method [3]?

A workshop will give you answers to there STEM education challenges with new perspectives, innovative solutions and within the framework of the Scientix Community and the Golab project, designing experimentation material with online laboratories.

Keywords. Community for science, IBSE, STEM curriculum, online laboratories, scientific method.

Acknowledgements

European Schoolnet, international network that promotes the integration of STEM knowledge and technologies as an engine for improvement, and to respond to the need of professionals in 21st century in Europe [4]; Scientix, the Community for Science Education in Europe [5]; GoLab NextLab a European collaborative project [6].

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How "Street Chemistry" and "Street Physics" Settled at the National Technical University "Kharkiv Polytechnic Institute"

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Abstract. Recently National Technical University «Kharkiv Polytechnic Institute» (NTU "KhPI") actively supports and conducts activities based on STEM education approaches (Science, Technology, Engineering and Mathematics) aimed at popularizing natural, engineering and technical sciences among children and youth. Encouraging the love of creativity, developing spatial thinking and interest in innovations, teaching from early childhood develop engineering competencies in children, which in the future will be able to educate them a new generation of engineers and designers, scientists and technologists.

At the “open door” the STEM- events of NTU "KhPI" young scientists represent a variety of projects, among which are two very bright popular science project "Street Chemistry" and "Street Physics".

Within the framework of the project "Street Chemistry" visitors will talk about water, its properties and features, make analysis of bottled, mineral and tap water, determine its pH, TDS and the presence of heavy metals by electrolysis. The NTU "KhPI scientists teach the listeners to carry out an examination of the quality of wine and juices in "home conditions" by improvised methods, and also on the example of wine and juice find out how and why "color" chemical reactions are used in practice and much more.

Within the framework of the project "Street Physics" together with visitors are experiments on mechanics, molecular physics, electricity, magnetism, optics, oscillations. All those who take part in the demonstrations:

- can see the analogue of the first steam turbine, which was invented almost 2000 years ago;
- create a little lightning under normal conditions;
- find out when the fluid is boiling from the heat of its own body; heat the water "to tea" with Foucault's current;
- see the magnetic "levitation";
- transfer light to the hard-to-reach zone;
- hear and see how the metal plate sounds.

Keywords. NTU "KhPI", "Street Physics", "Street Chemistry", technical science, STEM education.

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Bionics and Scientoonics: Enjoy and Learn Science from Nature

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Abstract. Bionics some times called Biomimetics or Biomimicry, basically biologically inspired engineering is defined as a “New science that studies nature's models and then imitates or takes inspiration from these designs and processes to solve human problems". Prof. Janine Benyus [1] suggests looking to Nature as a "Model, Measure, and Mentor" and sustainability as an object of bionics. Bionics looks to nature and natural systems for inspiration. After millions of years of tinkering, Mother Nature has worked out some effective processes. In nature, there is no such thing as waste — anything left over from one animal or plant is food for another species. Human engineers and designers often look there for solutions to modern problems.

The fastest train in the world which has a speed of up to 200 miles per hour, Japan’s Shinkansen Bullet Train as a marvel of modern technology, is one such example of Bionics. But there was one major problem after its initial debut: noise. Each time the train emerged from the tunnel, it caused a change in air pressure that caused thunder-like sounds that were a nuisance from a quarter of a mile away. The train’s chief engineer, a bird-watcher, had an idea: taking inspiration from the shape of a King Fisher, a bird’s beak to make it more aerodynamic. The resulting design was based on the narrow profile of a kingfisher’s beak, resulting in a quieter train that also consumes 15% less electricity and goes 10% faster than before.

Sea shells are safe havens for the inhabitants providing protection against any predator and harsh environmental conditions as they are very strong. Sea shells are made up of chalk a brittle material so what makes them strong? By studying the nano structure of shells which are made in several years we can make high strength ceramics which are light yet very powerful. We can design turbine blades and engines. Tropical Morpho butterfly (Morpho sulkowskyi) found in Colombia, Peru and Ecuador and is famous for their stunning colours but these colours are changed in response to any change in the vapours. This is caused by the nanostructure of the wings scale which is capable of reacting and detecting to the gases in the atmosphere. This will help us to build more sensitive and selective sensors which can be used in metros, subways, stadium, sports arena, public concerts and gatherings for catching terrorists.

What is most important today is that people are not aware of the promises Bionics holds for the future. Author who has started a novel concept of science communication called scientoon (a new class of cartoons based on science to understand, learn and enjoy science [2]) and has delivered more than 1200 invited lectures in Asia, Africa, Australia, Europe and America and subsequently a new science called Scientoonics, will deliver a unique lecture using every slide as scientoon to create awareness about Bionics as what enormous future Bionics hold specially in the area of medical, pharmaceutical sciences, water conservation to climate change and thus helping in sustainable development for a better world.

Figure 1

Keywords. Bionics, biomimicry, biomimeetics, scientoon, scientoonics.

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Nurturing Innovation: Promoting Ethos of Creativity

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Abstract. Innovation is emerging as one of the major driving force towards advancements and strategic development of most of the developing countries. India's key aspirations through its flagship initiatives like "Make in India", "Digital India", "Clean India", "Skill India", "Smart City" and many others have opened up significant opportunities for increasing investments in India. In order to scale-up and sustain investments in India, apart from upgrading "ease of doing business" parameters, it is also very important to strengthen and scale up India's knowledge ecosystem in the areas of research & development, design, higher education, intellectual property rights, innovation and entrepreneurship through national and global knowledge partnerships. People are finding new ways and means to sustain growth and development. There is a global competition and the ones with new ideas are ruling the market. In this competitive environment, innovation is seen as the engine for inclusive prosperity and sustainable growth. In the past, lots of innovations have taken place both inside and outside of the labs. This process is still continuing. In spite of several research laboratories, innovative students need some platform to realize their imagination. President of India had already declared the present decade *(2010-2020)* as the decade of Innovation.

In India, over 55 science centers communicate science and technology, enhancing engagement, supporting science educators and improving public understanding of scientific issues. Collectively, these science centres reach out to over *15 million Indians* in cities and rural areas annually. These science centers are largely funded by the state and federal government hence they partner with selected government priorities and national needs. In response, the National Council of Science Museums which heads the network of science centers in India, assumed the responsibility of creating awareness on innovation, showcasing grass-roots level innovations and providing resources to support young students in innovative thinking and projects. It formalized a program for nationwide Innovation Hubs in 2013 under the *Scheme for Promoting Innovation, Creativity and Engagement in Science of Young People (SPICES).* So far 23 such Hubs have been launched and 27 more are under development.

Innovation Hubs are co-located in the existing Science Centres, Museums, non-formal education institutions that promote creativity & inspire innovations. These co-locations not only promote more effective utilization of these Science Centres but also redefine their usage and role in fostering problem solving and project based learning and provide hands on / practical learning and engagement in the process of science, technology and innovation. These innovation hubs provide a platform to our youth to engage in innovative and creative activities. The underlying idea is to promote scientific and critical thinking and problem solving ability and attitude through hands-on activities. These hands-on laboratories are equipped with moderate set of tools and scientific instruments. The major facilities of the innovation hubs includes (a) Hall of Fame (2) Innovation Resource Centre (c) Innovation Laboratories (d) Tech-Lab equipped with 3D printers, robotics, electronics & microprocessor programming facility for carrying out creative and innovative projects for practical and innovative applications & solutions. The major activities carried out in these Innovation Hubs are:- (a) Thod Phod Jod (Break and Remake) (b) Kabad Se Jugad (Build from Scrap) (c) Idea Box (d) Make Your Own Science Models / Kits (e) Real Life Problems Identification & Finding their solutions (f) Investigative Projects. The new ideas that are likely to emerge from these Innovation Hubs would benefit the society. Now in its fifth year, the Indian National Council of Science Museums' Innovation Hubs are showing strong results.

This deliberation shall describe the methodology, Membership, empowerment and other accessories responsible for growth and sustenance these effective Centres of creativity, this also would highlight the major output which have been achieved through the efforts of these creative places.

Keywords. Science Museums, Innovation, Creativity, Engagement.

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A Workshop on Learning to Create Scientoons for Science Education

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Abstract. Science education and research is facing now-a-days a tough challenge around the world. Many times, the way it is being taught, it looks very technical, less interesting and sometimes even boring. Educationists around the world including in USA are worried as students are opting for more lucrative career options in business, commerce and information technology. This trend is not a healthy one as no country can progress without the development in science. Now-a-days most of the scientific researches have become interdisciplinary and many experts from different background have to work together. To communicate to such different experts from various disciplines, is a real challenge.

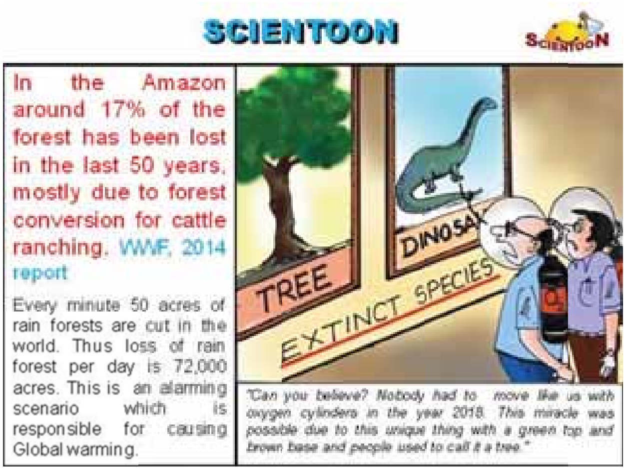

Figure 1

It is well said that a picture is worth thousand words. Cartoons are the combination of caricature and satire. Caricature means distorted drawing and satire means a humorous comment. If the subject of the cartoon is science then they are called science cartoons. Scientoons [1] are a new class of science cartoons, based on science. They not only make you smile and laugh but also provide information about new researches, subjects and concepts in a simple, understandable and interesting way. SCIENTOONICS is new branch of science, which deals with effective science communication using a novel class of science cartoons called scientoons. Scientoons have been recognized/appreciated all over the world by several international organizations including WHO, UNESCO, UNEP, Royal Swedish Academy, International Union of Pure and Applied Chemistry, American Chemical Society, Junior Chamber International (USA), DECHEMA, Germany and also by NCSTC (DST, Govt. of India), CSIR, Indian Science Congress Association and many more. European Science Festival 2008 held from July 18-22, 2008 at Barcelona, Spain, organized a full session on Scientoonics [2].

This Scientoon based audiovisual technique is more useful when a scientific program is undertaken for higher education/mass awareness on the subjects like environmental pollution, biodiversity conservation, Nanotechnology, DNA Technology and Human Genome, AIDS awareness and many other subjects and areas or for communicating among the various experts of different disciplines. Scientoons can fill a gap among the various experts.

This workshop is an attempt to show how to learn to create (live demonstration) cartoons then how to convert cartoons into scientoons so that complex subjects of science can be presented and effectively explained MAKING science communication/education/research more informative, effective, enjoyable, interesting and useful.

Keywords. Comics, science teaching, science education.

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Achieving Sustainable Development Goals (SDG) through Project-Based Curricula in Schools: The AQUASOIL Project Case Study

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Abstract. The concept of Sustainable Development was introduced in The Brundtland Report 'Our Common Future' [1], dated 1987, meaning to satisfy the needs of the present without compromising the ability of future generations to meet their own needs. This assumption guided the establishment of 2030 Agenda for Sustainable Development and its Sustainable Development Goals (SDGs). The 17 SDGs are universal and require the efforts from all the society stakeholders working together to end all forms of poverty, fight inequalities, and tackle climate change and environmental protection. Schools can have a key role in SDG implementation working with the community at a local level and ensuring at the same time that learners take informed decisions and responsible actions for environmental integrity, economic viability and a just society, as defined by UNESCO in its Education for Sustainable Development principles. MIP (Science and Technology Project Research Methodology) is an extra-curricular subject offered at Colégio Luso-Francês, a high school in Oporto (Portugal) in which students acquire hard and soft skills through Science and Technology project development, in order to solve a real problem. MIP is based on Project-Based Learning methodologies, widening the walls by learning beyond strict school environment. MIP Project-based curricula starts with setting up partnerships with Universities, Research Centers, Enterprises, and Local Organizations, that are somehow related to the project to be developed every year. The partners become formally a part of the learning process, as tutors. As MIP's evaluation is strictly formative, the instruments used to evaluate relate to the participation in academic conferences, science fairs, and the desirable application of the investigation conducted along the year in order to solve the problem the students choose to work in.

AQUASOIL is a three year project, aiming to develop a low-environmental impact hydrogel, polyacrylamide-free, that can be used to improve soil productivity in areas that have been more affected by extreme and severe droughts.

Hydrogels are hydrophilic colloids used as degraded land remediation techniques because they lead to an increment of the soils' water-retention abilities. Such materials - also referred to as superabsorbent crystals or water-retaining granules - when hydrated, increase to several times their original volume. The retained water is then released slowly into the surrounding soil, reducing the need for irrigation.

Commonly used for agricultural purposes typical hydrogels contain polyacrylamide. Besides absorbing up to 500 times their volume such polymers have an expiration time frame of 2 to 5 years, followed by a degradation process after that: depolymerisation into acrylamide units releases a lethal neurotoxin to the soils entering then into food chains.

The results obtained with AQUASOIL showed that the calcium sulphate-based hydrogel is able to hydrate soils for a significant amount of time. AQUASOIL hydrogel could be a real technology applied in real locations affected by drought and hunger around the world.

In HSCI Conference 2018 the authors will share the project cycle developed during the last 3 years at school. AQUASOIL project was awarded a honorable mention at the 4th National Science Contest *À Descoberta da Luz/ 8th Hands-on Science Fair*, which took place in Viana do Castelo, Portugal on the 25th of May. It also won the 3nd prize at the FCT Nova Challenge, which took place on the 8th of June in Costa de Caparica (Portugal).

Keywords. Learning design, project-based learning, formal education, collaborative work, tutorial teaching, hands-on science, hydrogel, acrylamide, drought, soil, SDG.

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Companies for a Better World

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Abstract. In this presentation, I am going to talk about homes that are created using wood and close that are made from recycled objects. The homes that are made by a company from Barcelona are sustainable and respect the environment. The clothes are from a company called Ecoalf.

NOEM is a company form Barcelona that was created by Rosa Vilarasau, who is economist. In 2009, she wanted to have her own company and that is why she created NOEM. She incorporates the sustainable values that she believes in. the other co-founder is Pol Guiu. He is a Mechanical Engineering. He had taken experienced wood prefabricated processes in French where he took the graduate. In NOEM Pol had created a technological challenge that combines his passion, experience and expertise.

In NOEM there are nine architects that design the homes and make them real.

Their projects are design houses made of wood. These are modern, ecological and prefabricated. This reach maximum energy with the most advanced eco technology.

They follow a process that is called NOEM process. It have six items. Firstly, they need to know who wants the house, want to have in his future home and proposal the best for him.

The second is that they adapt the home to how the person want to use it to be the most comfortable for him.

Third, they put in place the technology that allows them design and provide every detail, see the proposals and control the entire manufacturing process from the design phase to delivery.

Fourth: when all is design and they know the materials that they are going to use, they ensure the cost and delivery date to finish it. They commit to a cost and construction time.

Five: they shared everything that they do during the construction. It is because the person can enjoy the building from the beginning.

Finally, they are able to handle the interior design or whatever. They want to deliver the dream without any worry for the person [1].

Javier Goyeneche founded Ecoalf in 2009 because he was failed about the excessive natural resources and the number of waste produced by the contras. The objective was to create the first style products by recycled objects. He wants to prove that we do not have to create new natural resources because we have a lot of material.

To create these products they use plastic bottles, cotton, networks, tyres, coffee, wool and other things like that.

You can buy these products in shops that are in Madrid and Berlin or in the online shop [2].

These are only two of the companies that respect the environment to make this planet more sustainable.

This is important because we only have on world and we have to protect it. You can make many different things like recycle, reduce the plastic that you use every day or just turn off the water or the light when you are not using it.

While we do this, and the companies make things like this homes or recycling the plastics and other things that they find, all of us are reducing the footprint that we had created.

Keywords. NOEM, wood, maximum energy, prefabricated, green homes, advanced technology, ecoalf, recycled objects, ecological, footprint.

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Cooling Baths with Eutectic Mixtures as a Learning Support Approach to Understand Phase Diagrams

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Abstract. Water is an essential component for life, and thanks its molecular properties water can be found on Earth in the three fundamental states of matter: solid, liquid and gas.

The most phase changes of matter can be easily shown in classroom, ice melts in liquid water, which can be heated until its evaporation, water vapour can be condensed to liquid water when its cooling, and liquid water can be transform in solid ice by freezing.

Direct deposition of water vapour to solid ice or sublimating ice in vapour requires some complex laboratory equipment.

Therefore is easy to understand that these concepts are theoretically taught to secondary school students jointly with the triple point of water and phase diagrams at the chemical classroom; whereas plasma phase and non-classical states, these hardly ever described, are usually imparted at the physics classroom.

At that level, miscibility, freezing-point depression and the boiling-point elevation, thermodynamic properties including temperature, pressure, volume, entropy, enthalpy and Gibbs energy concepts are introduced to students.

Despite the fact, the demonstrations of the boiling-point elevation or the freezing-point depression are usually carried out commonly with water and salt or water and sugar; eutectic mixtures are rarely lectured in the secondary school.

However, binary eutectic mixtures are not only widely used in alimentary, pharmaceutical, and cosmetic industries, but they can be truly useful to help students to understand phase diagrams concepts.

A binary eutectic mixture is a solution consisting of two substances able to dissolve in one another that, liquefies at the lowest temperature of any possible mixture of these components.

The minimum freezing point for a set of components is called the eutectic point. A broadly used as a frigorific mixture is the sodium chloride - water binary system, which has one eutectic point circa -20°C when of salt is mixed with ice in a ratio 1:3.

When salt is added melts some of the ice and the temperature drops and as the mixture is colder than the ambient temperature, absorbs heat rising its temperature, which causes the salt to melt more of the ice to drive the temperature down again.

And so long as none of the phases is consumed, it reaches an equilibrium temperature that is independent of the starting temperature of the phases before they are mixed.

The process continues until all salt is dissolved or all ice is liquefied. In fact, this principle is frequently used to keep road safety in winter. During snow and ice events, trucks spread a thin layer of salt on roadways causing snow and ice melting and, in addition, reducing the chance of formation of new ice, even when environmental temperature decrease.

Keywords. Biotechnological practice, cell and enzymes immobilization, polymers, teaching.

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Eco-Friendly Periscope: "Hands-on Science" Fair Project 2018

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Abstract. Nowadays, we live in a modern digital world, in which new technology is almost totally in control. The world has become a global village, due to the impact of new technology and most of us are born as "digital natives". Nevertheless, it is crucial for us to know our ancestral backgrounds on which modern society was built upon, and all the remarkable inventions that are an important part of our historical and cultural backgrounds.

For instance, if you ask a teenager what a "periscope" is, he will probably tell you that "a Periscope is a live video streaming app for Android". The same will happen if you try to google it on the internet.

Based on both the importance of the greatest inventions of old times and the importance of light, within scientific phenomena, we've decided to recreate a real periscope, the old optical instrument, in order to show our colleagues its importance, through time and also to show and explain how it really works and how practical it was back then.

That's how we came up with our Hands-on Science Project – an eco-periscope; an environmentally friendly periscope, made of milk cartoons and small old mirrors.

The word "periscope" has its origins in two Greek words: "Peri", which means "around," and "scopus", which means "to look."- "to look around". A periscope has the ability to turn around in a circular manner, to view objects usually above ground or on the water's surface.

A periscope is an optical instrument that allows the viewing of objects that are not in our direct line of sight, without revealing who or what is using it. Periscopes have proven to be of great help to submarines to view above the surface of water. The main purpose of the development of the periscope in a submarine was to provide a way to see above the surface while still underwater. Periscopes were also used in trenches, during the war, to observe enemy movements without being seen.

A simple periscope only requires two flat parallel mirrors, fixed at an angle of 45o, in order to provide a perfect and clear image. A basic periscope consists of a long tube with two bends. Two parallel mirrors (A and B) are fixed at both bends, near the openings of the tube, at an angle of 45 degrees, facing each other. A ray of light entering through the upper aperture, strikes mirror A, at an angle of incidence of 45^{o}, directing the light of the object to the observer.

As you may understand, a periscope works based on the laws of reflection. The light from the object falls on one mirror (placed at 45o to the object) and is reflected. This reflected light in turn, falls on another mirror and is again reflected until it reaches the human eye.

The Navy attributes the invention of the periscope (1902) to Simon Lake and the perfection of the periscope to Sir Howard Grubb. Simon Lake used prisms and lenses to develop the omniscope, forerunner to the periscope. Sir Howard Grubb, designer of astronomical instruments, developed the modern periscope that was first used in Holland-designed British Royal Navy submarines.

Since the Second World War, the periscope has increased from 6 to 8 meters to 15 to 18 meters. Nowadays, the periscope is no longer used because it leaves a trace in the water, being detectable by the enemy.

One of the most widely used applications for periscopes is in medicine. They're a less obtrusive method for looking into the human body to detect illness and disease and are used in cystoscopes and endoscopes.

Keywords. Eco-periscope, hands-on, science fair.

Educational Constructions & Recycling

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Abstract. . This project presents the process of construction of an original recycling machine based on the developing Arduino system. The educational construction carries out games created by students using the educational cross surricular program Scratch 2.0, allowing at the same time the collection of recycling materials such as cans, batteries etc.

Apart from this machine construction, an online community of students and teachers has been created aiming at the supporting the construction process at all stages, providing instructions, facilitating the communication and the exchange of technical knowledge that allows the uploading of games, recording and monitoring the recycling materials collected.

Through this project students are able to gain knowledge about the developing system Arduino, learn about the procedure of designing and making of circuits, develop their programming skills and at the same time become an aware of recycling issues, recognizing the value of reusing materials and transforming “useless materials”, participate into team – cooperative procedures and develop their creative and artistic thought.

The website created for this project enables participating students of different apes to cooperate and create without geographical or social restrictions.

Keywords. Arduino, Scratch, Educational constructions.

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Edward Flatau (1868-1932) and His Contributions to the Development of Neuroscience and Neurosurgery

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Abstract. The 19th century was the time, when various sectors of knowledge have undergone a rapid development. Especially rapid growth concerned life sciences including neurology and neurosurgery. The majority of discoveries connected with these branches of medicine were made in Western Europe and in the USA. But some outstanding scientists, who had a significant contribution in development of world neuroscience lived also in Poland. It should be pointed out that in the 19th century Polish lands were under foreign partition. The development of polish science, culture and art was inhibited by governments of partitioning countries. Poles couldn't even use polish language at schools. Polish patriots, the elite of Polish society, fought and died during uprisings, had been imprisoned and sent to Siberia or they had to flee abroad. Despite such difficult political situation Poles studied (most often in western Europe or Switzerland) and participated in the development of science, more than once making discoveries on a global scale. Unfortunately, accomplishments of Polish scientists – nineteenth century pioneers of knowledge often remain unknown or forgotten.
One of the pioneers of neuroscience, who has inscribed in the history of neurology is Edward Flatau. He was born on 25th December, 1868 in Płock. After finishing the middle school in his hometown, Flatau studied medicine in Moscow. He received his medical degree in 1892. After graduation he worked in Germany. He was co-worker of world class specialists in the field of neurology, including Emanuel Mendel, Ernst Viktor von Leyden, Hermann Oppenheim and Hugo Liepmann. In 1899, in spite of an invitation to be a chair of Department of Neurology at the University in Buenos Aires, Flatau (as a Polish patriot) returned to Poland and started work in Warsaw. Initially Flatau was a neurological consultant at Infant Jesus Hospital, and in 1904 he became the head of the department of neurology at the Jewish Hospital. At the same time Flatau devoted to scientific work. Right after arrival to Warsaw he opened microscopic laboratory in his private flat. In 1911 he established the first neurological laboratory in Polish lands, and in 1913 he became the first head of the Department of Neurobiology of Warsaw Scientific Society. After Poland regained independence in 1918, Flatau re-establish Polish neurology and in 1919 he became the head of the Nencki Institute of Experimental Biology which was then part of the Warsaw Scientific Society. In the 1930s Edward Flatau got a brain tumor and died on 7th June, 1932.

The first and one of the most important scientific Flatau's works is "Atlas of the human brain and the course of the nerve fibers", published in 1894 when he was 26 years old. Atlas, the first modern description of the central nervous system anatomy was originally published in German, but during next two years it was translated to English, French, Russian, Polish. The Atlas considered photographs of fresh brain sections made by the author. Flatau also studied on a wide range of neurological diseases. He described torsion spasm in children (for the first time, in 1911) and the meningeal symptoms during tuberculosis (1921-1923), reported the first description of encephalomyelitis epidemica disseminate - currently known as Flatau-Redlich disease (in 1927). Moreover, Flatau worked on multiple sclerosis and migraine (the diseases that affected Flatau all his life). The next significant achievement of Flatau was discovery that the "greater the length of the fibres in the spinal cord the closer they are situated to the periphery", what is currently known as Flatau's law. These observations were the basis of Flatau's doctoral dissertation in 1897. It should be also pointed out that Flatau was one of the first supporter of the neuron theory, which proclaimed that nervous system is made up of discrete individual cells connected by nerves.

Edward Flatau was not only scientist in the field of neuroscience and brain anatomy, but he also, through all his life, served the people who cried for help at neurological hospitals. The attitude effort of Flatau during his work is

reflected most clearly in words of his friend – neurologist Samuel Goldflam, who said at the funeral of Flatau: “He was a work fanatic and he worked till he dropped”.

Keywords. 19th century, Flatau’s low, history of neurology, Poland.

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Eliminating the Misconceptions of The 5th Grade Students in The Subject ‘Fraction’ by Using Concept Maps

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Abstract. This research was carried out in order to determine the misconceptions of the subject "Fractions" in 5th grade math class and to eliminate these misconceptions by using concept maps. The data were collected through the focus group interview technique, semi-structured questions and the teacher’s diaries that were kept in application process. For every question, codes and themes were determined by systematically examining the notes that were computerized. The codes and the themes were compared by using co-observer technique and the reliability of the application was found %93. After the application school was determined, four students were chosen with the maximum diversity sampling. 1st, 2nd, 3rd and 4th Action Plans were prepared to eliminate students’ misconceptions with using concept maps. The themes which were determined for the questions asked in the interview in the light of the data collected from the students after the application were shown in the Findings part to support students’ answers. As a result, after reviewing the collected data, it was found that using concept maps to eliminate misconceptions of the students was effective, it made students eager to lesson and made them like Math and at the same time, while it made it easier to understand for the students who have understanding difficulty, it made the students who were good at Math get bored. Moreover, the using of concept maps caused some of the students get confused.

Keywords. Concept maps, misconceptions, students’ views.

NanoEducation: Aproaching Nanotechnologies to Primary and Secondary School

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Abstract. NanoEduca and NanoInventum are a pilot program to introduce nanotechnology education in high and primary schools in a systematic and thoughtful way. NanoEduca and NanoInventum are divided in different sessions: a) training sessions Introduction to Nanoscience and Nanotechnology ,b) Hands-on activities with commercial nanoproduts Nanoeduca and hands-on with the nanokits experiments and c) final Scientific contest

Keywords. Nanoeducation, nanotechnology, nanoinventum, nanoeduca, nanokit.

1. Introduction

NanoEduca [1] offers sessions for middle school teachers, mainly from the areas of science, technology and mathematics. The main idea of the project is to introduce nanotechnology in the classroom. Students will work on increasing human capabilities starting from nanotechnology, and around this activity on different topics around nanotechnologies.

Nanoinventum [2] is a scientific co-creation project, based on disciplines in Science, Technology, Engineering, Arts and Mathematics – STE(A)M – aiming to introduce nanotechnology in primary school. The main objective is to create a model for a nanorobot, based on the knowledge of different scientific topics, such as nanotechnology, matter, atoms and molecules, adapted to the curriculum. The project uses strategies like co-creation, design thinking and concept maps. The project seeks on one hand to involve students in the co-creation of research materials, thus getting to know a new technology for the future, and on the other hand, working together as a team, assimilating work in research and development that is increasingly based on multidisciplinarity, which favours interaction with other team members and audiences. The project's pedagogical approach works with different areas of the curriculum through didactic demo activities that attract the interest of school pupils and enhance their competences through reasoning, deduction, play and key roles. The project deals with a series of successive activities that are based on a didactic progression map and educational resources, with the aim of obtaining a nanoinvent based on a NANOROBOT that is able to develop an application for the future. Participants must submit a drawing or a model made with recycled materials with brief explanations of their proposals.

2. Objectives

- Form teachers, by as nanoeducators being able introduce nanotechnology concepts in the lessons without changing the curriculum.
- Bring teachers training and reliable sources of information, so they will have the background to stimulate questions and ideas from the students.
- Through "conventional" modules (chemistry, physics, biology, technology), help students becoming the most prepare workforce in nanosciece and nanotechnology. -Create a dialog with society trough teachers and students about challenges, advantages and threats of nanotechnology.

3. Metodology

- Develop course materials, with lesson plans, clear objectives, specific knowledge aims, curriculum links, hands-on activities, videos, assessment activities, etc.
- Develop different NANOKITS with hands-on activities used for intuitive explanations of nanotechnology concepts, technological processes and applications
- Introduce teachers to nanoscience and nanotechnology basic concepts through training activities
- Experimenting NANOKIT material in their own classes
- A final assessment activity. Evaluation questionnaire and class Poster

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EPIC: Experimental Work for Primary Teachers with Inquiry Collaboration

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Abstract. The Science Week is one of the thematic weeks organized by the Cedros College (Vila Nova de Gaia, Porto, Portugal) for students from 1st to 12th grade, or by students between 5 and 18 years old.

During this week, the students of the primary cycle of the school worked with "hands on science" and with the "heads in the air", the programmatic contents in an interdisciplinary way and through the methodology of Inquiry.

Within the framework of a Continuous Personal Development course, one internal training of teachers, called Ép1cA in Portuguese language or EPIC (Experimental work for Primary teachers with Inquiry Collaboration), and the development in the PLATON Project, inserted in an international initiative promoted by the NUCLIO - Interactive Nucleus of Astronomy in Portugal. In these encounters, the primary teachers involved had previous training in workshops where they built and shared motivating learning scenarios.

The commitment of the students during the science thematic week and the results of the application of this project were evident, and even surprising, in children so young, something always shared, and lived, together with their parents, active participants of the integral educational development. The methodology adopted, Inquiry-based Science Education, has been continuous whenever there is a need to carry out experimental activities, for example in the study of Environmental issues, but always focusing on horizontal and vertical work, also transversely and symbiotic work, for all stakeholders.

All students attended lectures presented by guests from various areas related to Science, as detailed in the official program, as well as performed several experimental activities. In the first cycle, the visits of teachers "of the elders", called these lectures moments "miCro" - interactive moments of Science with limited time, with 10 minutes of enthusiastic explanation followed by 10 minutes of challenging questions. Some of the questions had been worked out in the classroom context, with the construction of murals where the questions that had arisen were expounded. As a consequence, teachers from different areas of the science department were challenged to visit the different years in order to try to fill these doubts. In addition to the scientists, it was equally interesting to bring together Music, English and Physical Education teachers to work together with their "heads in the air", with this common theme, analyzing texts and films on the subject, experimenting with instruments of different types (such as test tube xylophones with support filled by water) and physical exercises to catch air after the analysis of one English song letter.

This week was a sum of challenges and achievements of its own, aimed at spreading Science inside, and outside, doors in a meaningful way to increase scientific literacy and promoting hands-on activities. One particular note was the amazing work of the primary activators, where these students never had been before the real protagonists of the scientific discovery, and the real promoters of experimental education, but through the written and designed recordings of home demonstrations with their families, this activity was a great success! The Science in the Cedros College was of 1st class, or rather, was the first cycle that became the main promoter of Science among the whole school community!

The teachers made some Inquiry Learning Scenarios (ILS), held together in the GRAASP platform, and with this output they can be reproduced in the next years, or even better, boosted with innovative ideas to improve newer scenarios.

Let's face the next challenges, like competing in national contests, present our work in other schools and in Science Fairs.

Keywords. Inquiry, Interdisciplinary, Primary Science, Scenarios, Experiments.

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Research on CO_2 and O_2 Concentration Variation in the Air

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Abstract. We present classroom activities to investigate the variations in oxygen (O_2) and carbon dioxide (CO_2) concentrations in the air in relation to combustion reactions, animal and plant respiration and sugar alcoholic fermentation. With these activities both the chemical and the biological point of view are enhanced during the different processes and work with O_2 and CO_2 gas sensors [1-2]. The activities are suitable for students between 14 and 17 years.

One activity proposed is the study of the variations of the two gases during the combustion of coal, an example of fossil fuel used by humans as energy source. A sealed chamber with gas sensors is used for data collection. Data is analysed using the Logger-lite software [3] and the students have to compare the graph slopes of the O_2 and CO_2 concentration variation over time in order to relate the consumption of one gas and the production of the other.

In another activity we propose to compare the respiration of different seeds in lethargy and in germination. Students should analyse the graphs obtained and explain the difference between them by linking respiration to combustion and to the obtaining of the energy required for vital functions.

In all the activities, the problem to study is presented to the students, the equipment and the materials available is shown and they are asked to design the experiment required to solve the problem. It is essential that students have a clear idea of the question that they are trying to solve, that they identify the dependent and independent variables of their experiment and that they keep in mind the rest of the variables that might be involved in it.

It is also proposed to compare the respiration of animals (for example flour worms, *Tenebrio molitor*) with that of plants (we have used spinach leaves). In this case, we ask students to calculate, based on data obtained and in relation to the theoretical breathing model,

$$C_6H_{12}O_6 + 6\,O_2 \longrightarrow 6\,CO_2 + 6\,H_2O$$

grams of oxygen consumed by worms flour and vegetables and grams of carbon dioxide that it form. Later they have to compare the expected data with the ones actually obtained and explain the possible differences observed.

The explanation of these results involves very different and relevant aspects. For example, respiratory reactions occur in the cellular interior while the data we are taking with the sensors are external to the organism, therefore, aspects related to the transport of respiratory gases that are very different in the case of animals (presence of the respiratory system) or vegetables. Another factor to take into account is the different behaviour with respect to the solubility of the two gases studied which will have an effect on its diffusion.

Another activity that can be carried out with this equipment is the study of alcoholic fermentation of sugars with yeast. We have proposed studying CO_2 production based on the type of sugar used and its concentration. Students compare the slopes of the different graphs obtained and explain the differences observed using knowledge about enzymatic dynamics. This experiment is an example of a life process different from the breathing used by living beings to obtain energy.

The activities presented can be consulted in the ARC, Aplicació de Recursos al Currículum [4].

Keywords. MBL, respiration, combustion, fermentation.

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Researching on the Effectiveness of Solar Protectors

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Abstract. We present a proposal for activities aimed at investigating the effectiveness of solar protectors: solar creams and sunglasses. The UVA and UVB radiation intensity values that sensors detect are compared when sunlight and various UV (UVA and UVB) light sources cross transparent surfaces impregnated with creams of different SPFs (Solar Protection Factor), different commercial brands and creams prepared in the school laboratory. The UV radiation intensities that cross glasses are also compared to determine their effectiveness as a filter for ultraviolet radiation. The students use Vernier UVA and UVB sensors [1-2] and the Logger-lite software [3]. In a less accurate but very simple and surprising way, the so-called solar pearls or UV pearls are also used to detect the effectiveness of the creams and sunglasses. These pearls experience colour variations depending on the incidence of UV radiation, the intensity, and the exposure time.

The approach to the activities is inquiry-based science education (ECBI) and the objective of the sequence of proposed activities is that the students, based on the analysis and interpretation of the results, should realize how important it is to protect themselves from the sun, and to make the correct decisions regarding the use of solar protectors.

In a warm-up activity, students research information from the sun cream about which substances are most commonly used as solar filters. They discuss several ways to classify them and as to how they protect skin from UV radiation.

The activities ask the students to formulate their research question, elaborate hypotheses, design and carry out experiments to find out which creams and which sunglasses are more effective for sun protection. In experiment designs, students identify which variables must be controlled, which are the independent variables and the dependent variables. They must perform a control test and compare the intensity of radiation, or the colour of the UV pearl in the control test without solar cream and the intensity measurements or the colour obtained with the different solar creams or sunglasses.

In the study of the efficiency of solar creams of the same commercial brand and same solar line, but with different protection factors, there are significant differences in the radiation intensity values that cross the sample between not using cream and if cream is used, even if creams have a low SPF. The differences are lower if we compare creams with different SPFs. It is therefore clear that the relationship between the value of the radiation intensity and the SPF is not linear. These results bring the students to look for information about what the SPF is and how it is determined.

Another proposed investigation is to compare solar creams of the same SPF of different commercial brands, of different price, expired, or with the container open for some time. Students make hypotheses, consolidate or modify them based on the results they have obtained. The loss of efficiency of the creams kept from one year to the next in an open container is checked and differences in efficiency depending on the type of filter they contain, the expiration date, etc.

Another task that students are asked to do is the preparation of solar creams in the school laboratory. From a base cream, different sunscreen creams are prepared. In the preparation of the base cream, students are asked to justify the procedure used, debating the differences between dissolutions and scattered systems, and particularly the differences in water/oil or oil/water emulsions. They are also required to justify the solubility or non-solubility in water or oily substances in the ingredients of the base cream in relation to polarity of the type of substance and composition. Students prepare creams with different solar filters and with different concentrations, and as such, they have to perform concentrations calculations and relate the concentrations with the value of SPF.

In the experiments with sunglasses, the students must interpret the results taking into consideration the difference between visual comfort in different environments, which is a parameter related to the colouration of the glass and UV protection. The UV protection is indicated in the sunglasses and surprisingly, even low-quality sunglasses tagged with the identification of UV filter, reduce to a great extent the UV radiation that crosses them. In the interpretation of the results of the efficiency of solar protection, students are asked to model the mechanism of action of the solar filter and therefore look for the properties of the substances that act as a filter and relate its structure to the mechanism of action. They also identify and interpret the changes that photochromatic pigments experience in the UV pearls, and in the glasses that change colour in the presence of UV light. This requires students to connect this knowledge with the interaction of matter with the energy and the changes that UV radiation can produce, and that does not produce visible radiation.

The activities presented can be consulted in the ARC, Aplicació de Recursos al Currículum [4].

Keywords. MBL, solar radiation, UVA, UVB, solar protection, solar filter, SPF, solar creams.

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The PRBB: A Large Biomedical Research Cluster Committed to Education

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Abstract. With six research centres totalling more than 800 life science scientists, the Barcelona Biomedical Research Park (PRBB) is the largest biomedical research cluster in the south of Europe. As such, one of our aims is to contribute to disseminate the scientific knowledge we generate, not only amongst the scientific community but also, and importantly, amongst the general population. In particular, we feel it's our duty to inspire the next generation of scientists by reaching out to students and young people.

With that aim, and taking advantage of the large critical mass of researchers we have – many of them young and very motivated – we organise a series of activities. These vary a lot in frequency, target audience (from young children, to high school students, to the general public) and format (from 2,500 people coming to the park in one day, to single researchers going to classrooms or schools visiting the centres to a newspaper sent by email or news shared by social media).

In this talk, we will give an overview to the PRBB's contribution to science education and we will present in detail some of these activities.

Keywords. Science education, informal learning, biomedical research.

Scientist Girls on-Drones: Growing the Future

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Abstract. This paper describes the development of a project of Drones' programming by girl students from the 6th grade of André Soares Middle School in Braga, Portugal. Drones will be used in the renovation of forests in Braga' region. The main purpose of this project is to address the need of promoting the active involvement of girl students in programming. Innovative techniques will be explored through the use of new methodologies and multidisciplinary teaching and learning with 5th to 9th graders together employing ground-breaking paths throughout collaborative knowledge. The idea of this project came from the recent massive forest fires which devastated a huge areas in Portugal, including in and around Braga, and raise awareness among the entire Portuguese population to this pressing issue. This critical situation was also followed by our Erasmus+ projects partners that gave us a special support.

In the aftermath of this natural disaster, there were initiatives and debates on what path should be followed in order to have a better responsive reaction on future catastrophes of this kind. Therefore, there was a major concern on recovering the entire lost forest area acknowledging the danger of losing soil's stability and fertility as well as biodiversity.

With no further delay, there were some initiatives promoted by several entities with the help of students who were part of the Eco-School project of André Soares School to contribute to Braga' reforestation program. This is an international programme of the Foundation for Environmental Education (FEE) that aims to empower students to be the change our sustainable world needs by engaging them in fun, action-orientated and socially responsible learning. This activity uses seed grenades developed specifically for this purpose. The students spread the seed grenade throughout the burnt forest area in order to plant a new generation of autochthonous trees. This campaign brought enlarged conscientiousness of the significance of this task because of the large size of the burnt forest area. With this vision imprinted in their minds, the students showed the will to study and search technological solutions to effectively address this problem. A group of students, mostly girls, showed some disbelief about using technology as an answer to this issue. The discussion about the presence of women in science rapidly came into our minds. According to UNESCO (2017) [1], science and genre equality are both key to a sustainable development. UNESCO also states that women are shut off from full collaboration in science and less than 30% of scientists are women. In 2015 the United Nations issued the resolution A/RES/70/212 [2] creating a huge step forward to a more equal participation of women and girls in science, focusing that they have a major role in science and technology and it is very important to keep encouraging and stimulating their presence, their work and their appreciation. Therefore we designed this project as a way to reinforce the inclusion of women in the world of programming and contribute to women's active participation in solving social and environmental issues, while at the same time to encourage girls to be active in science and technology.

In order gather funds to acquire the drones needed to make this project running successfully it was decided to present the project idea to the competition "Ciência na Escola" of Ilídio Pinho Foundation. With the approval of the project and the funding secured, these students got an extra motivation to create "Girl Scientists and drones: Creating the future". We bought two mini Parrot Mambo drones chosen for their robustness, easy ability to control and for their stability brought by their sensors technology. Using these mini drones encourages students to have a better interaction with programming platforms and leads students to a better understanding of hands-on technology and reflexive education developing science, technology, engineering and maths (STEM). These drones can be programmed using the Tynker language, a game-based platform system. Through visual blocs programming it was acquired basic programming knowledge in order to be applied on drone control. After structural knowledge acquisition, female students focused their efforts mainly on the exploration and development of reforestation through drones' use. This process revealed to be cognitive stimulant through the creation of metacognitive processes based on human experiences lived through hands-on. These experiences connect different scientific areas (maths, physics, technology and linguistics) and in this way students acquires different transversal skills through an interactive process in which they come together with the abstract and the factual in order to solve a specific problem.

The project herein reported results from an idea that through the use of drones and seed grenades we can plant new trees and give a new life to burnt forest areas in a more effective way. This project had the support and partnership of the Associação Hands-on Science Network and was also integrated and broadcast through the international partnership of the Erasmus + project "Got pollution? Be Solution!... Recycle".

Keywords. STEM, hands-on, creativity, Parrot, programming, minidrones, game-based, *Tynker*, Erasmus+, Eco-school.

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Using the Graphic Calculator to Study the Sound

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Abstract. Physics, in its search for reasons to justify natural phenomena, uses experimentation as a tool to disassemble and establish connections and, in that way, better understand concepts sometimes difficult and abstracts. When executing experiments in scholar environment it results even more relevant in the way that, when all students participate, the act of sharing results with their peers is one of the identity marks of modern science.

On this workshop, we intend teachers to perform a few experimental activities, designed for basic and secondary school levels, which connect experimental aspects related with sound with the basic concepts that describes progressive waves, such as frequency, wavelength, intensity and propagation speed. This way, teachers will be invited to take their student's place and develop few simple experiments, using specific equipment, in order to better understand the nature of this phenomenon.

In this scenario, intended to be of sharing, teachers following a set of experimental guides, will be able to exploit some of the potentialities of the TI (Texas Instruments) technology with its ability to integrate different sensors with acquisition and data processing capabilities, creating an easier phenomenon's visualization and understanding and a more stimulating learning atmosphere for students.

Keywords. Sound, wave, graphical calculator, sensors.

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SciSparks, How Do We Expose All High School Students to Science Being Made

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Abstract. In a post-truth era, where the difference between knowledge and belief is increasingly blurred, scientific reasoning and research mechanisms represent useful conceptual tools for young minds to apprehend our complex society. However, even in large metropolis in France, more than 2/3 of high schoolers have never encountered scientists. On the other end, it has been shown that only 10% of researchers are highly active in science outreach. How can we make the connection between the education system and research labs the norm and not only the exception for a few lucky schools? How can we expose all students to science being made? SciSparks (in French, Declics) is a program aiming at bridging this gap, by organizing at a large scale the encounter of research scientists and high-schoolers in personalized, memorable settings with a demonstrated positive impact on students, participating researchers, and teachers [1-2]. It has been tested on more than 3000 students in France in 2017, with 600 researchers participating. It is scalable to a whole country, at a moderate cost. This presentation will explain the reproducible methodology used, provide links to shared material, and give detailed results. It will also present ongoing tests to improve the program.

In the speed-meeting at the core of the SciSparks program, scientists have nothing to prepare and are present in a high school for a couple of hours. Those “Ambassadors” each discuss with seven successive groups of 5 to 6 students. Each student thus meets with 7 researchers, for 10 minutes each. These meetings are preceded by a short conference by a principal investigator (the “Captain”) explaining his/her personal trajectory, how a new knowledge was produced in the lab, including the process of peer review. After the speed-meeting, an informal encounter is set up between the Ambassadors and the participating teachers.

Despite their brevity, the variety offered and the personalized contacts those encounters provide is highly impactful for those young minds, in terms of in terms of citizenship by giving tools to understand how knowledge is produced, of discovering how research is practiced and finally on career orientation. The program notably resulted in a 5.7 fold increase in students declaring to know how scientific results become accepted knowledge, a 6.4 fold increase in students declaring to know how experimental results are validated, and a 3.8 fold increase in students declaring to know what basic research is. The effects of the program on students are evaluated by a short online questionnaire, before and after the SciSparks session. The questionnaire before the meeting also includes a short video presenting the set up and encouraging students to think about the questions they will ask scientists, and letting them choose the mission they will have to perform during the encounter (Journalists, Lab director, Friend or Criticial Thinking). The follow up questionnaire also includes open questions and mission related questions.

The program is also a tool to engage and train scientists not already much involved in science outreach action. Probably because of the lack of preparation time requested on their side, the program managed to attract in 2017 55% of participants who had not participated to a single science communication event or action. Moreover, more than 80% of researchers declare after the SciSparks session that they feel better at communicating their science. 97% declare they would recommend the program to their colleagues.

Finally, the program is the occasion to build more long lasting relationship between researchers and teachers. Indeed, before SciSparks, two thirds of the teachers declared they had no contact in the research field. After SciSparks, two thirds declared they had taken contacts that they would use again. Finally 35% of the participating teachers had already, the day of the program, started making tangible plans with at least one of the researchers. Those included research lab visits for students, training sessions, or a long term collaboration on hands on project.

On a last note, because of the diversity of researchers involved in each SciSparks session (a ratio of approximatively one for 5 to

6 students), 100% of the students encountered female scientists.

Keywords. Researcher's engagement, science literacy, high school students, SciSparks.

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The Effect of Vee Diagram Use on the Nature of Scientific Knowledge

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Abstract. The purpose of the present study was to investigate the effect of the use of Vee Diagram in inquiry-based science lab on the fourth grade science pre-service teachers' understanding on the nature of scientific knowledge. In the study, a quasi-experimental design was used with pre-test and post-test control group. In this scope, two sections were selected from the fourth grade pre-service science teachers as one experimental group (n=32) and one control group (n=32). While the pre-service science teachers in the experimental group performed the testing of hypothesis used in the inquiry-based science labs, the ones in the control group carried out closed-ended experiments. While the students in the experimental group prepared their experiment reports according to the Vee diagram, the students in the control group prepared their experiment reports according to the traditional laboratory report. Before and after the experimental application, the "Nature of Science Knowledge Scale" developed by Rubba and Anderson (1978) and adapted to Turkish by Kılıç, Sungur, Çakıroğlu and Tekkaya (2005) was applied to both experimental and control groups. The results of the current study revealed that the use of Vee diagram in inquiry-based science lab had a positive effect on the pre-service science teachers' understanding about nature of scientific knowledge.

This study is a part of the project of "18.KARİYER.95", supported by Afyon Kocatepe University, Scientific Research Projects Coordination Unit.

Keywords. Vee Diagram, inquiry-based science lab, pre-service science teachers, nature of scientific knowledge.

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Show Me Your Handy and I Will Tell You How a Good Science Teacher You Are

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Abstract. Mobile Learning is constantly expanding rapidly and internationally: It is forecast that by 2020, 75% of adult education will be through mobile phones or tablets. However, the national educational policy or Legislation prevents teachers from applying mobile learning in learning process. As a result, many European students are totally unprepared to face their immediate future.

This experiential workshop aims to demonstrate the great ease of use of portable devices by teachers, to highlight their enormous potential and to initiate teachers to dare the integration of these devices in the teaching process. It is also an opportunity for them to exchange their experiences and their knowledge about the implementation of Mobile Learning in the classroom.

Teaching approaches: The applications to be used and the corresponding scenarios to be implemented are selected in such a way that teachers can apply in practice modern teaching approaches, such as Differentiated teaching, Collaborative learning, Mixed learning, Microlearning, Flipped classroom and Gamification

Target group: The workshop is addressed to teachers who teach Physics in Primary and Secondary Education.

Duration and Structure of the workshop: The workshop takes two hours, where the participating teachers will take advantage of freeware software with excellent simplicity of use in order to:

- Take advantage of the sensors of their mobile phones, turning them into experimental devices
- Perform experiments in virtual labs and play physics games
- Experience the Augmented (AR) and Virtual Reality (VR)

It is important that all of the above software has already been used in the classroom for the past two years by the workshop's lecturer. At the end of the activities there will be a discussion / exchange of experiences from the implementation of mobile learning in the classroom.

Material infrastructure: The workshop will provide participants with a total of ten tablets or mobile phones to conduct the procedure. However, the BYOD (Bring Your Own Device) technique is proposed to allow participants to take advantage of their own mobile / tablet with which they are familiar. In this way, they will be able to store all the necessary software on their personal digital devices in order to take advantage of them in the near future.

Keywords. Mobile learning, science, augmentted reality, virtual reality.

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EvoKE. Empowering Science Literacy Stakeholders to Foster Understanding and Acceptance of Evolution

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Abstract. Changing the education culture to make it more hands on science oriented is a difficult task. How do we better connect the academic world, schools and teachers, for pupils and students to experience and learn not only results, but also the scientific process of producing new knowledge and critical thinking? EvoKE is a European based community that brings together researchers in evolution and education, educators in both formal and informal contexts, the media, and policy makers. By bringing together a variety of stakeholders with expertise in complementary fields of knowledge, we foster the development of projects to increase public scientific literacy on evolution, promoting numerous evolution-related projects, including outreach and the development of hands on activities that can be used by teachers. Currently, EvoKE has over 225 members from 29 countries, representing an important network for people wanting to find partners to build new projects or to disseminate existing projects. Are you interested in exploring the evolutionary perspective in your teaching, in finding partners to build one, or to disseminate it? Join us to find out more and become part of our community.

Keywords. Network, formal and informal education, science literacy, evolution.

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Examination of Inquiry Learning Perception of Secondary School Students in Science

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Abstract. The purpose of this study in which the general screening model of quantitative research methods has been employed is to examine the inquiry learning perception of secondary school students according to the various variables. For this purpose, 'Inquiry Learning Perception in Science Scale' which consists of 3 subdimensions and 22 items has been applied to 266 secondary school students selected by using simple random sampling. The normality test has been used to decide which analysis would be carried out and it was decided that the data are not normal. For this reason, it has been decided to use Kruskal-Wallis and Mann Whitney U. It has been concluded that the students have a high level of inquiry learning perception and the gender is a significant variable on inquiry learning. Female students have a higher perception about inquiry learning. It has been also concluded that the parents' educational statue plays an important role on the inquiry learning perception. The students with a parent who has a university degree have a higher perception than the other students. The results have also showed that the occupation of the mother is another important variable on inquiry learning perceptions. The students whose mother works in a state job as an officer have a higher perception on inquiry learning. The last finding of the study has revealed that the income of the family is an important variable, as well and this result is also related with the students private lesson statue as it has been concluded the students who has private lessons have higher perceptions about inquiry learning.

Keywords. Inquiry learning, perception, secondary school, students.

Exploring College Students' Healthy Conceptions from Representations of Drawings: Some Considerations of Healthy or Unhealthy

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Abstract. The concepts of healthy and unhealthy, such as illness or sick, have become important in health-related researches, intervention studies for citizens as well as for policymaking. However, conceiving the conceptions of healthy and unhealthy should expend to other aspects, such as biological aspects or medical aspects rather than only limit from social psychological aspects. "Draw-a-picture technique": is focused as a new view of the research of social phenomena and conceptions. In this study, college students' drawings as representations of their conceptions of healthy, unhealthy were conducted, and then, they were interviewed to reveal the differences among conceptions which described from their construct visual representations. A rubric with four dimensions: structures, behaviors, epistemology and functions, was applied for data analysis. The results were: first, the conceptions of healthy mainly focused strong body and smiling, very energetics, healthy, and able to move freely. Second, the conceptions of unhealthy mainly emphasized on overweight or underweight and sick body, having no energy or sick in bed, unhealthy, and not able to move freely. Third, multiple forms of representations on healthy or unhealthy were displayed. Fourth, illness and sick are confused with each other on the conceptions of unhealthy in Chinese. As a consequence, these results may toward to clarify the views of health and it opponents. Some major considerations regarding healthy, unhealthy could be revealed from their visual representations by exploring the drawings and descriptions of healthy or unhealthy among the four dimensions. Thus, some health-related interventions for citizens as well as some studies for researchers and policymakers could concern these conceptions.

Keywords. College students, drawing, health conceptions, representations.

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Promoting Scientific Vocations: How to Prepare the Researchers of the Future?

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Abstract. Fundació Catalunya La Pedrera (*Catalunya La Pedera Foundation*) has always been committed with promoting knowledge, education and research. In 2008, the Foundation launched its first program for young students with the aim of promoting scientific vocations in our country when science and technology careers where amongst the least chosen. *Youth & Science* is a three-year program that aims to encourage talented students to pursue careers in science and technology and a future as researchers. Every year, 50 students from Catalonia on their 10th grade are selected to become part of this experience. The three-part structure of the program includes a two-week science program on the first year, followed by the opportunity to join local/international research projects or programs at centers of their choice before entering university. The increasing demand of pre-university training in science and technology disciplines made the Foundation design a new program based on hands-on education that was named *Crazy about Science*. The program, intended for over 300 selected students in their 11th or 12th grade, includes different courses in STEM education that take place in leading research centers and institutions from Catalonia during the weekends of the academic year. After years of experience in the development of local science educational projects, the Foundation decided to expand its boundaries by designing its first international program intended for students from all over the world passionate about science. The *Barcelona International Youth Science Challenge (BIYSC)* program is a two-week excellence summer program that offers students from 16 to 18 years-old the opportunity to join a research team by working hand-on in cutting-edge scientific research. The program is structured in different challenges that students have to overcome to demonstrate its commitment, talent and passion for research. BIYSC was born with the aim to make Catalan research visible to young international students, and thus promote talent attraction in our country. Over the last 10 years, the Foundation has strived to offer innovative models of education based on hands-on multi-disciplinary research together with local and international research centers and institutions. Throughout this process, the Foundation has achieved the following fundamental values: to identify talented students through the collaboration of school teachers, to apply a rigorous selection process methodology, to implement innovative research training through real scientists mentorship, to promote multidisciplinary and transversal skills, and to engage researchers to play a key role in the dissemination of science in the youth.

Keywords. Scientific vocations, excellence, talent, science, technology, STEM, research, science educational projects, international, summer program, innovative education, hand-on education, research training, multidisciplinary, dissemination of science, *Youth & Science*, Crazy about Science, *Barcelona International Youth Science Challenge, BIYSC*.

Hands-on Electronics: An Indian Experiment

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Abstract. In the present context of the world, Electronics has become more a “Basic Science” than an applied science. Everyone has to have some minimum understanding of Electronics to survive in this highly technology driven world. The number of Electronic Gadgets that we carry on our person and use at home and our offices every day is mind boggling!

Again, there is only one way to learn to do anything in this world! Just Do It! That is the way we learnt as a small child, to walk, sing, dance, what have you! You cannot learn swimming by reading any number of books. You just have to get into the water! Why do we need to learn everything by actually doing or practicing? Well, while doing we tend to fail! Failures are most important in the whole learning process. When one fails, one starts wondering, “Why did I fail? What went wrong?”. That analysis leads to better understanding of the process! Hence at the time of failure a profound learning experience takes place.

In this paper we wish to showcase a very practical way of learning electronics, at least the fundamentals of semiconductor devices, Operational Amplifiers, Digital logic Gates and sequential circuits, etc. This is through a combination of Simulation and Practical hands on exercises. That too on desk tops, laptops, mobile phones etc. These learning Hands on Electronics modules are self-paced and assume just familiarity with English Language. These topics can be learnt almost without the help of a tutor or mentor. Of course, these can also be rendered in any other language of the world.

A few of the circuits will be demonstrated and discussed during the sessions.

Keywords. Experimental science teaching electronic.

Implementation of Euro4Science Strategy at School Level Projects. Case Studies and Evaluation

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Abstract. Euro4Science and Euro4Science 2.0 are two Erasmus + funded projects with the same educational strategy – using forensic sciences as inspiration to develop experimental and filed activities complemented with casefiles capable of motivating primary and secondary school students.

The “Euro4Science” strategy includes the use of a Forensic Educational Toolbox but it also triggers original proposals based on forensic themes from project work in a school built with contributions from students and teachers.

Teachers Training sessions occurred in Portugal, UK, Bulgaria, Greece, Poland, and Turkey. Following workshops, which included contextualizing the forensic sciences in an educational perspective along with practical sessions using the Forensic Educational Toolbox, we challenged trainees to develop work proposals adapted to the reality of their school systems and their schools contexts, in particular to identify the points of contact with the national school curricula and their specific calendars and realities.

Once at local schools (including partnership members and those others benefiting from training sessions) teachers with their students expanded activities with a great degree of flexibility, usually inserted in the special “school days” or “week of science” festivals.

Data on the receptivity to activities designed by the university (coordinator-partner, Univ. de Aveiro) are also presented and discussed.

Euro4Science 2.0 Erasmus + Grant 2016-1-PT01-KA201-022893

Keywords. Euro4Science, forensic sciences, educational kit.

The Simpsons Looking for a Sky without Light Pollution. *'Scuse Me While I Miss The Sky*

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Abstract. Light Pollution is defined as a type of pollution caused by the excessive or obstructive light/illumination created by us, contributing to an emptier and poorer world. A whole generation could not have any idea of what a starry sky is, unable to internalize what a constellation is or even identify the polar star or the larger bear. One loses a cultural and anthropological heritage created by civilizations and that allowed us to cross knowledge borders previously insurmountable.

This work focuses on the problem of light pollution but in an approach intended to both young people and adults, using a series of cartoons of well-known TV series - The Simpsons - on light pollution and related physical processes, demonstrating the effect of artificial light in our daily lives. This environmental concern is portrayed in The Simpsons episode 16 of season 14, " 'Scuse Me While I Miss the Sky", broadcast for the first time in 2003. In this episode, Lisa Simpson sees in astronomy a professional future and intends to explore the sky. In this search she realized that is not able to observe the night sky and the stars and realizes that it is our artificial illumination which prevents her from exploring the sky. The polluting particles in suspension in the atmosphere reflect and diffuse the light of the lamps, hiding the brightness of the stars. There are cases where even the clouds reflect the light from the artificial lights removing even more celestial magic. This research explores important physical phenomena on nature, optics and propagation of light, while portraying in a unique way a very problematic real phenomenon that many among us are unaware... In large extent this is an unavoidable fact just as it is also mostly impossible to listening to crickets in the city or to live following the solar cycles. This cartoon leads us to feel that this can be prevented not accepting that progress isolates us irremediably from nature. The right to an uncontaminated night sky, to enjoy the contemplation of the firmament, must be considered as an inalienable right of Humanity, at the same level of the rest of environmental social and cultural rights, due to the impact on the development of all people and also its repercussion on the conservation of biological diversity [1, pp.3].

According to Halpern, [2, pp. 7] The Simpsons present a perfect ground for science education. The objective is to use this episode as didactic-pedagogical material to aid in the process of teaching and learning. This way, we call children and young people's attention to the problem of light pollution with this episode, in which sequential situations are explored, including from the environmental social biological and all physical processes involved in light pollution within large urban centres. It is aimed at raising awareness to this problem linked to the excess of artificial light at night through the visualization of the cartoon. It is the desire of the authors to stimulate cognitive processes in which children and young people can understand and observe this present situation in everyday life, becoming aware that the effect of artificial light withdraws the ability to observe the sky in all its splendour, interfering with the environment.

Keywords. Light pollution, The Simpsons, light, propagation of light, nature, environment.

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What is Cancer? How do we study it? An *in vitro* and *in silico* Research

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Abstract. Humans, as any other living organism, are made out of cells, which contain the genetic code and all the mechanisms that we use to maintain alive. However, sometimes those complex mechanisms end up harming us due to, for example, unrepaired mistakes in our genome after cell replication (a vitally needed process to grow, heal injuries and age the way we do).

Sadly, we have heard or even have known somebody who has suffered an illness due to malfunction of some of our own mechanism, such as metabolism, network of chemical reactions which produce energy and biomass to grow and do our vital functions, and cell signalling, communication of cells which allow them to govern basic actions themselves or even communicate with others around them. For example, there is a famous illness which appears when a cell or tissue is able to do the following:

- Sustaining proliferative signalling
- Evading growth suppressors
- Avoiding immune destruction
- Enabling replicative immortality
- Activating invasion and metastasis
- Inducing angiogenesis
- Resisting cell death
- Deregulating cellular genetics

That illness is cancer. A devastating disease that is being studied in laboratories around the world to understand how all these alteration are produced, in which point of our mechanisms are located this mistakes and how to solve them or simply how to eradicate the illness without harming who is suffering it.

That is why I wanted to contribute to that with this high school project to divulgate about this illness, some computer tools that are used in the research and my own little research experience on the field.

Computers are tools used for many different things, but most people don't know how useful they are for biological research, and nowadays is used in many different fields, from genetics to metabolism. For my project I used a human metabolic model and I simulated it with the Optflux to predict the results of the experimentation.

Research that consisted in studying the metabolic effects of a compound in three cancer cell lines *in vitro*, at the laboratory, and using the data obtained from it to predict the results *in silico*, in a computer program.

The compound was β-hydroxybutyrate, which is produced in our liver to catabolise fatty acids in our tissues, and the three cancer cell lines were: a colon tumour (sw480), a lymphatic metastasis (sw620) and a liver metastasis (sw620-LiM2).

To study cell metabolism I prepared many cell cultures from which I measured cell proliferation, using a machine based in the Coulter principle, and concentration some metabolites, using spectrophotometry, at 0, 24 and 48 hours for each cell line.

Keywords. Bioinformatics, cancer, divulgation, research.

Use of a Handmade Phantom to Learn Ecoguided Cystocentesis Technique with Veterinary Medicine Students

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Abstract. The increasing need to teach practical skills to future health professionals, without patients, has led medical educators to look for alternatives that allow adequate training through different teaching tools.

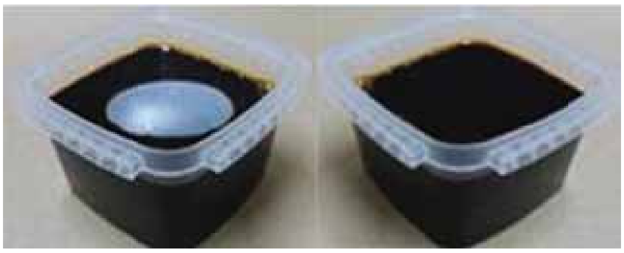

Figure 1. Phantom elaboration

Currently, educators can count on a wide amount of teaching tools, either virtual (like web-based education and virtual reality) [1] or training products (like surgical, resuscitation or procedures simulators) [2]. One of the disadvantages with the simulators, is the high cost [3] and in some of them, the durability.

Simulation and pedagogy have the potential to improve competency of health practitioners [4], in this case, allow recreating a normal bladder during a cystocentesis guide by ultrasonography, allowing acquiring mainly manual skills. The first step of this experience was to explain the students how to create the phantom. For this purpose, a guide was created, describing step by step how to do it, including pictures of the procedure.

The phantom was made of jelly mixed with black dye, covering half of a plastic box with the mixture, and then, a balloon full of water was located in the middle of the box. Once the jelly was solidified, the balloon was covered with more jelly-dye mixture.

As it can be seen in the Figures 2 and 3, there is a great similarity between both Figures, the one offered by the phantom and the one offered by a real patient ultrasound.

This kind of educational material can be undervalued for some students (as was seen during this practice). However, the main skill they can earn during the use of this phantom, is to get an adequate relationship of the syringe position in the ultrasound and at the same time to be able to get urine samples using one hand (while the other is holding the transducer).

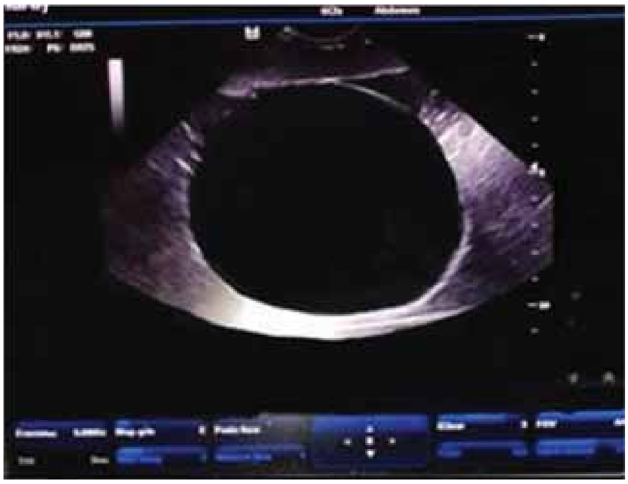

Figure 2. Phantom bladder ultrasound

The low cost of the materials to make this phantom allows teachers to use it as many times as necessary, actually other elements like fruits can be used to simulate mass puncture.

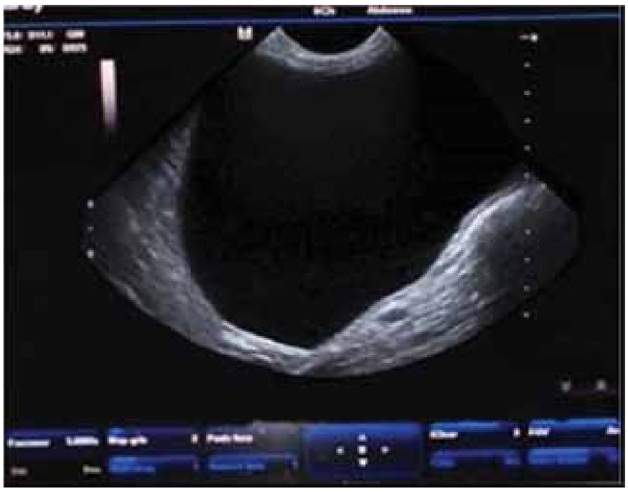

Figure 3. Canine bladder ultrasound

Keywords. Veterinary education, training phantom, teaching tools.

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Developing and Examining an Experimental Curriculum for Enhance "Green" Capability of Undergraduate Hospitality Students in Taiwan

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Abstract. Previous studies claimed that the success of a “green” business strategy mainly counts on cooperative employees. If hospitality and tourism employees have adequate level of "green" capability, they can help their companies obtain the competitive advantage by achieve the goal of going green effectively. This study developed a semester, 18-week course which centered the concept and practices of energy conservation and carbon reduction (ECCR) in the hospitality industry for undergraduate hospitality students in Taiwan. In addition, using a quasi-experimental design, the effects of ECCR curriculum intervention by different teaching strategies (i.e. lecture, service learning, and creativity skills) on students’ low carbon literacy, green creativity, and learning motivation are examined for three consecutive years. A total of 112 students selecting the experimental course at a university in northern Taiwan were participated in this study.

The results of this study showed that students receiving the ECCR intervention significantly enhanced their low carbon literacy, green creativity, and learning motivation. In terms of teaching strategies, service leaning was identified as the most effective teaching method for enhancing students' "green" capability as well as learning motivation. Furthermore, student feedback from the qualitative data analysis also confirmed that the experimental course increased their learning experience and interest. Finally, this study not only can help instructors successfully infuse ECCR concepts and applications in undergraduate hospitality curricula, but also can provide useful teaching strategies enhancing students' learning motivation and ECCR performance.

Keywords. Energy conservation and carbon reduction (ECCR), experimental curriculum, hospitality student, teaching strategy.

Polymerization Reactions a Practical Tool to Teach Biotechnological Concepts at Schools

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Abstract. The use of polymers to entrap cells, enzymes and organic molecules is a common procedure in chemical and pharmaceutical industries.

These gelling agents permit certain molecular permeability allowing both substrate and product exchanges at appropriate rates that are suitable for the proper functioning and viability of cells or the activity of the enzymes.

Immobilization is a general term that describes a wide variety of laboratory processes of trapping cells or particles using gelling agents.

These processes can be applied to virtually any type of enzymes, cell organs, microorganisms, animal and plant cells, or even some chemical substances.

Currently, immobilization is a technique widely used not only in the field of biotechnology, but also in the pharmaceutical, food, pharmaceutical, biosensor industries, and in the environmental field.

The selection of an adequate support is one of the most crucial decisions in the framework of the preparation of the immobilization process.

The selection criteria are as follows:

- Low cost;
- Insoluble, non-biodegradable and without or low toxicity;
- Provide a sufficiently large surface area for cells to have access to metabolites;
- High mechanical and chemical stability and high diffusion under the operating conditions of the process;
- It does not affect the activity of the cells nor induces cell lysis;
- Easy to perform
- Safety of recycling and / or disposal;
- Enough matrix flexibility to accommodate new cells.

Immobilization with sodium-alginate fulfils appropriateness these requirements, in fact, Immobilization by alginate is a simple, gentle and low toxicity method, suitable for immobilizing any type of cells, enzymes and a widely kind of chemical substances.

For that reason, due to its simplicity and low cost, the polymerization reaction with sodium-alginate is suitable for a practical session addressed to Secondary School students or in their first year of Higher Education.

Keywords. Biotechnological practice, cell and enzymes immobilization, polymers, teaching.

An IBSE Hands-on Activity for Middle School: Heat Maintenance

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Abstract. IIBSE is an impressive approach of learning science because the pupils develop their understanding by performing their self-designed investigations through it. In fact, when a problem has a meaning for a child and he/she takes part in developing it, the problem will get his/her own and he/she will be intended to solve that.The best platform for implementing the IBSE approach is through hands-on activities. One of the important contexts of science in middle school is heat, its transfer and its maintenance which is very crucial in some applications. We designed an IBSE hands-on activity in order to get pupils of middle school involved in the concepts of heat, temperature, conductivity, radiation, vacuum and etc. We asked them to imagine that one day the coffee machine of their college is broken and they cannot live without coffee so they need to make something like thermos flask to take their coffee from home. We arranged the students in groups of three or four. The steps of IBSE were carried out and the groups got ready to examine the prototypes. A plenty of different types of materials, useful or useless, conductor or insulator and in different colors with different radiances were provided in the backside of the class. They were given a 15-minute deadline to build their thermos flasks. When they were done, their hand-made structures were tested by some hot water and a thermometer in a 10-minute race. We wondered of the different ideas that they've used building their thermos flask. Thereafter, the last step of IBSE, building knowledge, was performed. Finally we asked them to extend the experiment and investigate how they can vacate their structure and what will be the result. As a result, the concepts of heat maintenance and heat transfer which weren't interesting topics before, were taught effectively by engaging pupils in solving a problem related to their everyday life. In fact, active learning process was carried out in an inspiring way.

Keywords. Hands-on, heat maintenance.

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From the Research Lab to the School: The Importance of Science Education at All Stages

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Abstract. Science communication is increasingly recognised as a duty of scientists. It is very important that the general public understands basic scientific principles. This understanding can help the society to make informed decisions, which can influence not only science policy making and funding but also the quality of life. The future of this educated society is now in the schools. Therefore, it is very important to educate our children in science, to trigger their critical thinking and to show them how to apply the scientific method. It is important that the training of these skills starts at an early age and accompanies the children along with their personal and career development. Therefore, science education initiatives should be present at all educational stages. Furthermore, they also help to further develop the interest and skills of pupils who are already keen on science and will potentially be outstanding scientists in the future. Here we will review existing initiatives for each level of education. We will also discuss the importance of training scientists in science education and science communication and how can they help teachers in this crucial task.

Keywords. Educational stages, science education.

An Electricity Generator Directly Driven by Ocean Waves

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Abstract. According to theoretical calculations and related physical laws, the mass and inertia of a working body must be minimized and the energy transfer must be simple and straightforward. The efficiency of energy transfer of a generator of electricity from chaotic ocean waves can be increased. Avoiding the mistakes delineated in many other such generators that have failed to be commercialized around the world, we designed a directly driven electrical generator from ocean waves, which has been formally proved to be superior and workable. Based on the results of experiments of several early prototypes of such directly driven generators, in this project we researchers further improve the directly driven generator. Using innovative mature techniques, which are reliable and accessible, we optimize and refine each of four main parts of this directly driven generator. These four main parts include the bridge-like platform, the working body, the linear generator and the management circuits. In this way we shall improve the directly driven electrical generator from ocean waves and then test its performance in a marine environment. The result of the research will assist interested countries to develop an ocean-wave energy-generator industry and to benefit the economy.

Keywords. Renewable energy, ocean wave energy, linear generator, working body.

An Exciting Hands-on Activity for Meaningful Teaching of Air Pressure

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Abstract. In order to make the learning process more efficient and interesting, the pupils need to engage and involve themselves in the related activities. Doing hands-on activities, let them get their minds on and obtain a meaningful understanding about the phenomena and concepts. There are some especial concepts like air and its pressure that are abstract and difficult to understand effectively. Here we report an exciting hands-on activity for learning the concept of air pressure. In this activity we need a bottle, some straws and nails. We get one short straw through the cap of a bottle that contains some water. Then we ask the students to predict what happens if they flip the bottle over. The water will come out of the bottle periodically because the pressure differs inside the bottle by exiting the water and entering the air alternatively. Thereafter, they will explore the answer doing the experiment and explain the reason of what they've observed by discussion in their groups. After that, we ask the students what will happen if we use two straws of the same lengths instead of one, or if we change the number or length of the straws or if we make a hole at the bottom of the bottles. They will repeat the activity and explore the answers. As a result, the students can explain the role of air pressure on the water exiting and get a meaningful understanding of air pressure.

Keywords. Meaningful learning, hands-on, air, air pressure.

Metabolic Enhancement of Escherichia Coli Metabolism: Improving Uptake and Degradation of Long Chain Fatty Acids

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Abstract. Metastasis causes up to 90% of deaths related to the presence of tumours. Recent studies have shown that metastasis can be initiated by over-expression of a fatty acid receptor (CD36). Also, it has been shown that metastasis development depends directly on long chain fatty acid (LCFA) dietary uptake, particularly palmitic acid (PA). Since most foods contain LCFA, it would be unfeasible its avoidance by dietary restriction, therefore developing a system capable of reducing its intestinal absorption could be a new approach to tackle metastasis. We plan to use synthetic biology to design a probiotic with increased fatty acid uptake and with PA specificity. By decreasing PA concentration in the intestinal lumen and consequently its absorption and blood levels, we expect preventing it from being used as an energy source for metastatic cells.

Keywords. Cancer, fatty acids, hexadecanoic acid, metastasis, palmitic acid, probiotic, synthetic biology.

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Examination of Life Skills of Teacher Candidates in Terms of Some Variables

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Abstract. This research aims to determine the opinions of teacher candidates regarding their life skills. Also, in this research, it was aimed to determine whether the opinions of the candidates about life skills differ according to gender, undergraduate program and class level variables. This study utilizes the survey method from amongst the non-experimental research designs, which is one of the quantitative research method. The scale was applied to totally 460 teacher candidates who attend to Education Faculty at Afyon Kocatepe University in Turkey. The data of the research were obtained by the "Life Skills Scale" . The obtained data were analyzed with the help of SPSS statistical package program. In order to investigate the distribution of data, a single sample Kolmogorov-Smirnov Test was applied and the skewness coefficients were examined. As a result of the research, it was determined that the opinions of the teacher candidates about life skills were positive.

Keywords. Life Skills, teacher candidates, education.

Developing a Scale to Measure Veterinary Medicine Students' Attitudes toward Biochemistry Lessons

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Abstract. Biochemistry in veterinary medicine education is one of the important basic courses. The behavior and sensitivities of the veterinary students related to the biochemistry course necessitate the measurement of their attitudes towards this course. There is a need for a measuring tool in order to make up for the lack of this area. The aim of this study is to develop a scale, which measures the veterinary student’s attitudes towards the biochemistry lesson. A substance pool was prepared to determine the attitudes of the students to this course. After expert opinions, 49 of them were designated as draft scale. The draft scale was applied to 220 veterinary students in Afyon Kocatepe University during 2017-2018 academic year. Analyses of the reliability and validity were then conducted. The final version of the scale has been created.

Keywords. Veterinary medicine, biochemistry, attitude, scale development.

STEM Magic Workshop

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Abstract. This project, "STEM MAGIC" is a magic workshop in which Science and conjuring tricks are mixed, and in order to get it we will use technological devices and tools simultaneously.

Magical effects are based on physical, mathematical and technological fundamentals but with an unexpected and surprising end so that moment we can only give an explanation: "This is magic"

The main aim of is to bring our students closer to STEM topics by using magic tricks. The secrets of STEM are shown to them in a new way enabling that some new technological terms of today's society will be understood by students, all within a fun atmosphere of imagination and suspense.

Keywords. STEM, magic, technology, maths, science, physics, engineering, performance.

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Development of Energy Conservation Technology College Education in Taiwan

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Abstract. This manuscript describe the development of college level teaching material of energy conservation technology, including short course modules and MOOCs (Massive Open Online Courses) material. A series of course modules of six to ten hours, related to energy conservation technology in the sectors of residential-commercial buildings and transportation has been developed by a group of professors from four colleges and experts from various industrial companies in the fields of energy technology, green building design, refrigerating air-conditioning engineering and vehicle engineering. These material has been developed through a series of projects supported by Ministry of Education of Taiwan. The subjects of these projects include: establishment of energy conservation laboratories, industry-university collaboration teaching projects, developing MOOCs for energy saving education, green-energy creative problem-solving project and competition. The outcome of these projects and teaching strategies were evaluated and discussed in this manuscript.

Keywords. Teaching material, energy, MOOC.

Inside the Body

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Abstract. This workshop will tie in with the paper given by Dr Tunnicliffe entitled 'What's Inside Themselves Young Children's Ideas Elicited through Analysis of Drawings'. It will be a practical where everyone can be involved in making a child sized moveable skeleton from rolled newspaper bones. The bones are linked together with treasury tags and hung onto a metal clothes hanger for support. An old T-shirt is suspended inside with the internal organs of the heart, lungs, kidney, liver and intestines attached to it. Children enjoy making the skeleton, identifying the bones and learning where the internal organs are situated within the upper body. Moveable hands can also be added to the skeleton.

We will also show you how to use everyday materials to show the size and development of a baby before its birth using seeds, a coin and grapefruit and an exciting way of showing a human baby's 'private pond' and a simple model of triploblastic animals, of which we are one, a tube within a tube.!

Come and try new ways of teaching about our bodies and more.

Keywords. Biology, drawings, children's understanding, research methods.

Examination of 'Canım Kardeşim' Cartoon in Terms of Preschool Values

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Abstract. The cartoons are used to transfer the social values while helping children to learn and to be taught as well as having fun. Cartoons have great importance in teaching human values. In this study, the values in the 'Canım Kardeşim', a Turkish cartoon, have been examined in terms of values in the preschool curriculum. The data have been obtained by note taking while watching the videos. The model of the research has been determined as a document review. Descriptive and content analysis have been used in analysing the determined value. As a result, the values such as helping, love, respect, kindness, responsibility, patience, friendship, cooperation and honesty have been determined. The common values, skills and objectives in the 'Canım Kardeşim', and in the preschool curriculum have been determined and it has been concluded that cartoons can be effectively used to transfer the values in preschool education.

Keywords. Curriculum, education, values.

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Polyphenols: Molecules with Biological Activity

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Abstract. Polyphenols are natural compounds found in plants with antioxidant properties, whose main feature is the presence of more than one phenol group in their structure. They react with free radicals avoiding the reaction of these with essential biomolecules (such as lipids, proteins or nucleic acids) and, therefore preventing oxidative stress.

During recent years, a number of studies have proven the beneficial effects of polyphenols on health, especially on the cardiovascular system. They show clear antiinflammatory effects and lessen the oxidation of low-density lipoproteins (LDL), therefore preventing illnesses such as atherosclerosis. Since cardiovascular diseases are the main death cause worldwide, polyphenols are substances of great interest for the scientific community.

The main objective of this project is to determinate the concentration of polyphenols in different infusions using the Folin Ciocalteau method so as to determine which infusion has the best antioxidant properties. Infusions have been chosen due to the ease to obtain the samples.

Keywords. Antioxidants, cardiovascular diseases, Folin Ciocalteau method, oxidative stress.

The Development of the Curriculum Fidelity Scale

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Abstract. The purpose of this study is to develop a five point likert scale called ‘Curriculum Fidelity’. For this purpose, a draft scale consisting of 65 items have been represented to the field experts and it has been decided that 15 items should be excluded. The remaining 50 items have been given to 249 teachers and the maximum likelihood has been used in the exploratory factor analysis of the scale in order to examine the structural validity. The remaining 28 items have been grouped into 3 factors. The explained variance is 62,753 of the total variance. The Cronbach’s Alpha value is 0.94. Furthermore, item-total, item-remaining and item discrimination have been found significant. After exploratory factor analysis, it has been found that goodness of fit indexes are acceptable according to the results of confirmatory analysis (RMSEA= .075; CFI= .90; RMR= .08; GFI= .79; AGFI= .76; NNFI= .89).

This study is supported financially by Afyon Kocatepe University Scientific Research Projects Coordination Unit.

Keywords. Curriculum, Fidelity, Teachers.

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Motivation and Learning in the Robot Championships

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Abstract. One of the competitions aimed at high school students with high prestige is the championship held annually in Olot, called Robolot. The championship consists of teams having to take 6 cubes located on the mat, without stepping on the black lines, in the minimum possible time. In this workshop different robot constructions are presented. The different models express the different ways that students can design robots to achieve the same goal. So, creativity is one of the values that is promoted. Students learn physics by having to understand concepts of speed, acceleration, friction forces and balances. They also get better knowledge about the operation of the gears. Another important aspect is programming. A simple championship is the best way to make students understand many STEM concepts.

Keywords. Creativity, learning by doing, pre-university students, robots, secondary education, robot contests.

Programming a PID Control with a LEGO Robot Intended for a Pre-University Course

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Abstract. Many robot contests aimed at high school students pose problems related to line followers.

You can program very different types of control for the robot to follow a line, such as the all-nothing control, step control, proportional control and PID control.

This presentation explains the mathematical basis of a PID control that can be understood by a student of a pre-university course. Integration is presented as sum of errors and derivation as error differences. It also explained how to adjust the values of the constants. These mathematical concepts are applied to the realization of the program for a line follower LEGO EV3 robot.

Keywords. Control, PID, pre-university students, robots, secondary education.

 ISBN 978-84-8158-779-1

An Impressive Inquiry Based Hands on Activity: Teaching Chemical Reactivity

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Abstract. Inquiry-based learning is an approach to teaching and learning that places students' questions, ideas and observations at the center of the learning experience. According to this approach, students attempt to make sense of the world around them, to make it predictable by looking for patterns and relationships in their experiences and through interaction with others. Metals have different chemical reactivity. The order of reactivity can be figure out based on the reaction of the metals with an acid, a chemical or water. Here we report an interesting hands on activity for meaningful teaching of metal reactivity. In this activity, students build some electric circuits with various fruits (such as a lemon, grapefruit, potato, tomato, and kiwi), low voltage LED, alligator clip leads, copper, zinc, iron and magnesium wires or thin plates. Then they will determine the most reactive metal and order of reactivity with comparison of the observations and results.

Keywords. Inquiry, chemical reactivity, metal, fruit battery, hands on activity, circuit.

The Aurora. Wonder and Science

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Abstract. The physical phenomenon associated with the appearance of the Aurora is fascinating besides the fact of being a truly spectacular phenomenon. Those who have experienced it never forget.... It is our firm believe that for its spectacular beauty, the aureole of mystery and magic that surround the phenomenon, its study and demonstration will be an excellent appellative way of presenting several and important interdisciplinary scientific concepts such as: the nature of the sun (the centre of our galaxy and of the life on Earth); the atmosphere; the earth' magnetic field; the magnetism, origins and manifestation; and the light generation mechanisms.

Keywords. Aurora, geomagnetism, solar winds, light.

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Linking Vision and Physics with Simple Hands-on Activities

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Abstract. The retinas of our eyes have a series of photodetectors with maximums of detection at around 440nm, 540nm and 570nm – these are the so-called blue, green and red cones. It is the combination of this process of photodetecting wavelengths in the retina and the complex workings of our brain that will eventually subjectively define the colour of an object in a process that depends on the illumination used. When one of these wavelengths is missing the perception of the complementary colours (cyan, magenta and yellow) appears. In fact there are many everyday situations (in the kitchen, on the street, in stores, ...) where we perceive these complementary colors mainly due to the elimination of one of the primary colors. A series of practical activities on vision and physics is proposed. The main objective of this workshop is to provide inspiration to teachers, in order to encourage experimental learning / teaching at different educational levels.

Keywords. Physics, experimental science teaching, hands-on activities, vision.

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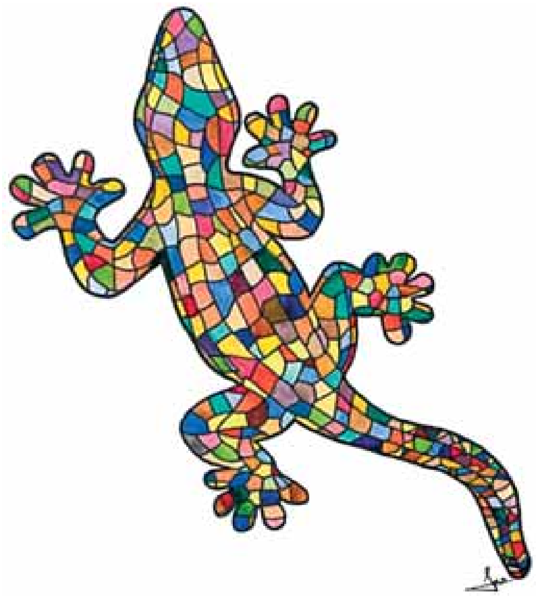

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