Hands-on Science

Science Education with and for Society

Edited by

Manuel Filipe P. C. Martins Costa

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The Hands-on Science Network

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Foreword

Science Education with and for Society

The decisive importance of Science on the development of modern societies gives Science Education a role of special impact.

Society sets the requirements rules and procedures of Education defining what concepts and competencies citizens must learn and how this learning should take place. Educational policies set by governments, elected and or imposed, not always reflects the will and ruling of Society.

The School as pivotal element of our modern educational system must look behind and beyond imposed rules and regulations and persistently seek a permanent and open relation with Society, in all its dimensions, assuming and defending its crucial role on the development of Society and humankind.

Aiming to contribute to an effective implementation of a sound widespread scientific literacy and effective Science Education in our Schools and Society at large, the Hands-on Science Network promotes a number of meetings and conferences open to the widest range of contributions on different pedagogic approaches with the common goal of promoting an effective learning of Science.

This book gathers a number of interesting works presented at the 11th International Conference on Hands-on Science held in Aveiro, Portugal, July 21 to 25, 2014. The different chapters covers a wide range of topics including different strategies on connecting school' science education with society and on synergetic relations between Society and Science Education, reports on good practices on formal as well as non-formal or informal science education, ICT tools, IBSE, active learning and hands-on pedagogy. We believe that the materials herein are a rather useful tool to assist teachers and educators as well as all interested in Science Education and its impact on the development of our Societies.

Vila Verde, Portugal, July 7, 2014.

Manuel Filipe Pereira da Cunha Martins Costa
Editor in chief

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Foreword

Inquiry Based Science Education

Formal Science Education: the Role of Schools and Universities

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Non-Formal Science Education: the Role of Outreach Programs, Science Centers and Science Museums

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From Teacher Training to Inquiry-Based Science Teaching: Analysis of the Case: "The Reflection of Light" with Primary School Children

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Abstract. *Inquiry-based science teaching, although addressed in the curricula of various countries and suggested by some international organisations, continues to have a very low expression in the teaching practices of the majority of primary school teachers. In this sense, we have organised several continuing training courses in order to encourage these education professionals to promote this approach to science teaching in the classroom, with the children. As part of this training process, teachers put into practice, with their students, the didactic knowledge they have developed, in order to become aware of the virtues of an inquiry-based approach to children's learning. Through the implementation of the activity "Reflection of Light", in this article, we intend to analyse the process of teaching and learning promoted in a 3rd grade class by one of the teachers participating in the training courses.*
The analysis of the process shows that the teacher in training carried out a successful didactic integration of the inquiry-based science teaching approach recommended for children. In turn, the children also developed a good understanding of the contents of the activity explored in the classroom.

Keywords. Formal, informal and non-formal education, natural science activities outdoors, IBSE methodology.

1. Introduction

Inquiry-based teaching is suggested by the science curriculum guidelines of many countries and its use in science classes is recommended by several international reports and studies [1, 2, 3]. For example, the US *National Science Education Standards* were developed by the *National Research Council* to "promote a scientifically literate citizenry". These Standards frequently encourage the use of inquiry in science classrooms, defining it as "... a multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyse and interpret data; proposing answers, explanations and predictions; and communicating the results" [1, p. 23]. Inquiry can also be defined as the "intentional process of diagnosing problems, critiquing experiments and distinguishing alternatives, planning investigations, researching conjectures, searching for information, constructing models, debating with peers and forming coherent arguments" [4, p. 518].
Inquiry has a variety of definitions. In a recent review of the research conducted between 1984 and 2002, Minner *et al.* [5] argue that the term inquiry, depending on its focus, refers to at least three distinct categories of activities: what scientists do; how students learn; and a pedagogical approach employed by teachers. The

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National Research Council [1] identifies five essential features for classroom inquiry: a) learners are engaged by scientifically oriented questions; b) learners give priority to evidence; c) learners formulate explanations from evidence, d) learners evaluate their explanations in light of alternative explanations; and e) learners communicate and justify their explanations. These features may vary in the amount of detailed guidance provided by the teachers. Thus, there may be different inquiry approaches, depending on the degree to which teachers structure what students do. These approaches are sometimes referred to as "guided" versus "open" inquiry. Guided inquiry teaching can be more focused on the development of particular science concepts. Open inquiry, on the other hand, will afford the best opportunities for cognitive development and scientific reasoning.

In science education, inquiry teaching reflects the concerns of Dewey, who, as early as the beginning of last century, considered that there was too much emphasis on facts and not enough emphasis on science in the development of thought and attitude of the mind. For Dewey, the student should be actively involved in the learning process and the teacher should take on a role of facilitator and guide. According to Drayton and Falk [6, p. 25], “The inquiry-based approach to science education [...] introduces students to science contents, including the process of investigation, in a context of reasoning, which gives science its dynamic nature and provides the logical framework that enables the understanding of scientific innovation and the evaluation of scientific claims. Inquiry is not process versus content; it is rather a way of learning content”. Inquiry teaching is an approach that enables the learning of concepts and the development of process skills [7, 13]. Thus, the alleged opposition between content and science process skills is a false dichotomy, as: “science process skills, on the one hand, and knowledge and comprehension, on the other, intensify each other in an interdependency that generates higher levels of process skills and higher levels of knowledge and comprehension” [8, pp. 58-59].

An inquiry-based learning environment promotes opportunities for children “to learn science, to learn how to do science and to learn about science” [1, p. xv]. Science inquiry encourages the development of problem solving, communication and thinking skills, as students will pose questions about the natural world and then seek evidence to answer their questions [9]. The ability to question, hypothesise, design investigations and develop conclusions based on evidence gives all students the problem-solving, communication and thinking skills they will need to claim their place in the 21st century world [1]. Inquiry-based science teaching not only contributes to a better understanding of scientific concepts and skills but, because science inquiry in the classroom is carried out in a social context, it also contributes to the children’s social and intellectual development [10].

Research shows that, when involved in inquiry activities, children are more actively engaged in their learning; they use and develop skills acquired from other curricular areas, including language and mathematics [10, 11, 12] and they develop a positive attitude towards science [13]. In addition, inquiry helps children to create “habits of

mind” [10], which are transferred to other experiences and learning contexts.
This science teaching practice has proven effective in increasing the students’ interest and achievement levels at both primary and secondary levels [5], while, at the same time, stimulating the teachers' motivation [14].
However, in the majority of European countries, the reality of classrooms is that these approaches to science teaching and learning are still only implemented by relatively few primary school teachers [15, 16]. Several causes have been identified, including the realisation that teachers have insufficient scientific knowledge on the contents they need to approach with the students and limited conceptions on inquiry-based science teaching and its pedagogical approach in the classroom [13, 17, 18].
In Portugal, the situation is no different. Although the science curriculum of primary education suggests a teaching practice in which students should be "active observers, with the ability to discover, investigate, experiment and learn" [19, p. 102], such a teaching practice is still only occasional, with only a residual expression in the teachers' pedagogical practices [8].

2. Objectives

In order to address the previous concerns, several continuing professional development courses (CPD) for teachers were held in the city of Braga – Portugal. These courses aim at improving their scientific and didactic skills, enabling them to promote an inquiry-based science teaching approach in the context of the classroom.
The training included the analysis and discussion of various lesson plans including science activities, which they can implement with their students. Based on the case of the "Reflection of light” activity, this article aims at describing and analysing the teaching and learning process promoted with children aged 7 and 8 years, by a teacher who attended one of the training courses.

3. Methodology and training contexts

The training course took place at the beginning of this school year and was attended by 23 primary school teachers. The training process was developed in two sequential contexts, according to the following scheme:

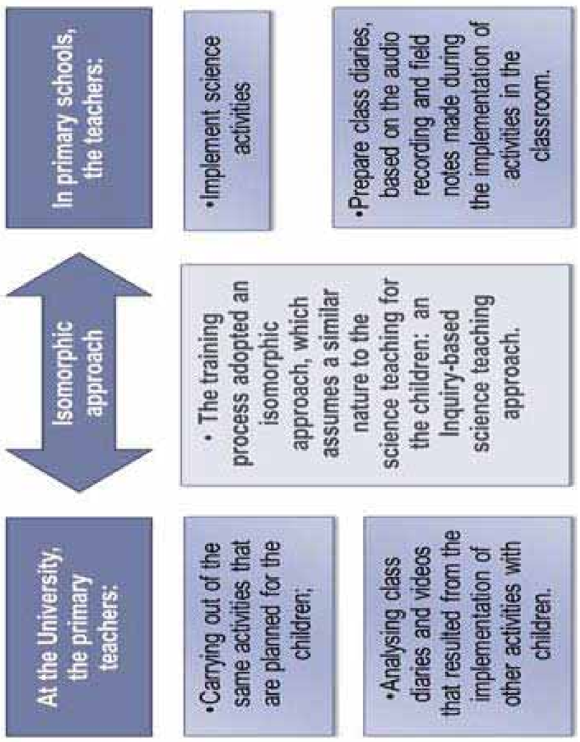

Figure 1. Methodology and training contexts

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At the University, the training process adopted an isomorphic approach, taking on a similar nature to that of the scientific exploration perspective advocated for children [20, 21]. According to Sá, "there is no way to make teachers and educators understand a learning process which they have never experienced themselves other than actually make them go through this process, as apprentices" [21, p. 57]. In this training context, theoretical approaches emerge and develop from concrete practical situations, through: a) the carrying out, by the trainees, of the same activities that are planned for the children, b) the analysis of class diaries, prepared as part of an action research process conducted by the second author of this paper during the implementation, in classrooms, of several science activities with the children, c) and the viewing of video recordings of scientific inquiry activities implemented and explored with children in these levels of education. As an integral part of this training process, the teachers put into practice the knowledge acquired in the training context. For this, inquiry science activity plans were supplied, which, in addition to the necessary materials and learning goals, contain guidelines on to how to explore these activities and induce in the children a reflective attitude towards the proposed learning activities [22].

In primary schools, teachers implement these science activities, according to the science teaching and learning perspective addressed in the previously described training context. During the exploration process, the teachers prepare class diaries [23] – descriptive and reflective narratives prepared based on audio recordings and notes taken during the implementation of the activities in the classroom.

4. Results

The following is the analysis of the teaching and learning process promoted in a 3rd grade class by one of the teachers who attended one of the training courses. The analysis focuses on the class diary prepared by the teacher following the implementation of the "Reflection of light" activity.

4.1. Class diary content analysis

Students are arranged in small collaborative groups. The lesson begins with the following questions:

A. What happens when the light of a flashlight hits a mirror? And a cardstock?

Each group has on their table a mirror and a cardstock target, propped up with plasticine.

The groups make predictions.

- In relation to the mirror, the prevailing prediction is that the light will be reflected: "the light hits the mirror and comes back" (Bruna); "it hits it and comes back" (Luís); "it reflects back" (Simão). Others make predictions using the knowledge acquired in previous classes: "the mirror is opaque and the light comes back" (Diogo); "opaque materials reflect light" (Lara).
- In relation to the cardstock, predictions are divergent. Some argue that it does not reflect the light: "On the cardstock, it does not come back" (Eva); "the light will stay there" (Guilherme); "it hits and stays on the cardstock" (Gonçalo); while others maintain that the cardstock also reflects the light: "If the cardstock is opaque, the light also has to come back" (Joel).

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B. What must we do in order to see what will happen?

The students suggest ways to test their predictions. Excerpt from the class diary:

The majority of the students simply suggest "try it". However, some suggest a way to test their predictions: "We can point the flashlight at it and see if the light comes back. First, we point it at the mirror and if the light appears here on the table, it means it comes back" (Leonardo).

They test the predictions and make observations.

Each group of students is given a flashlight. The flashlight is covered with opaque paper, which has a slit in the middle. The students focus the light that passes through the slit onto the mirror and then onto the cardstock. Their observations are consistent with the idea that light "comes straight back" when pointed at the mirror; but in relation to the cardstock, they have doubts.

C. What are the differences between what is happening with the mirror and with the cardstock?

They reflect on their observations.
Excerpt from the class diary:

There is an apparently unanimous idea that both materials reflect light, but in a different way. "It is different. With the mirror, we see a clear line of light on the table, but with the cardstock, that doesn't happen" (Joel); "with the mirror, the light comes straight back and, with the cardstock, it comes back only a little bit" (Daniela); "the light hits the mirror and then comes straight back to the same place, in a straight line. With the cardstock, it does not seem to be hitting only this place (the table)" (Diogo), "With the mirror, the light comes straight back, you can see it here on the table" (Ângelo); "it goes straight, we learned this in the last lesson. Then it also comes back in a straight line" (Bárbara).

D. Will you be able to receive the light reflected from the mirror on a cardstock target?

They test their ideas and communicate observations.

On their tables, groups assemble a device similar to that depicted on Figure 2, in order to make the cardstock target receive the light reflected from the mirror.

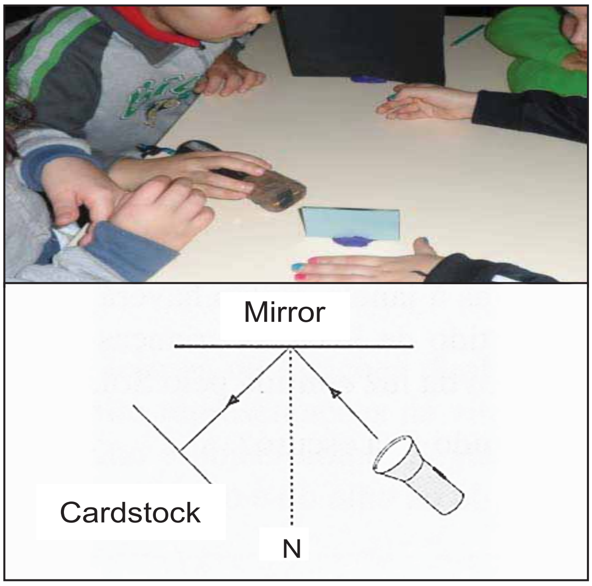

Figure 2. The assembled device and students testing their ideas in groups

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After the test, the following comments were made: "the mirror has to be in front of the cardstock and the flashlight has to be in front of the mirror" (Francisca); "We pointed the flashlight at the mirror and the light reflected onto the cardstock" (Eva); "the cardstock has to be in front of the mirror, because the mirror reflects back" (Simão).

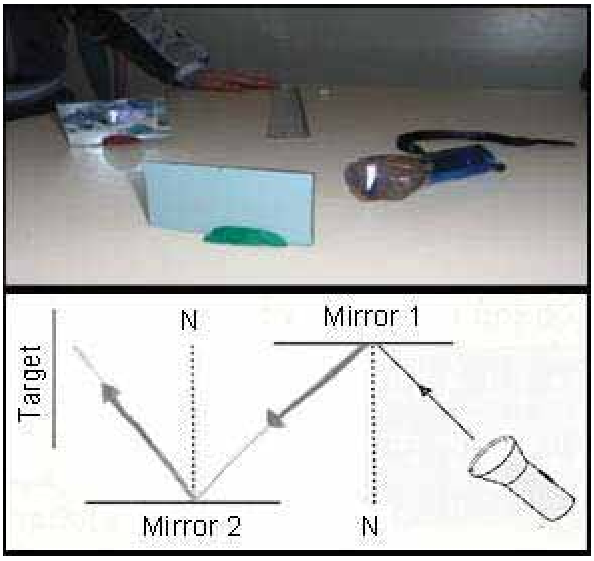

Figure 3. Example of a record made by the student

E. Will you be able to receive, on a second cardstock, the light reflected by the mirror?

They infer that the cardstock does not reflect light like a mirror. Excerpt from the class diary:

After several attempts, the groups are unanimous in stating that they are not able to receive the light reflected by the mirror on a second cardstock: "It does not work, but with another mirror it would. There would have to be two mirrors" (Eva). "Why do you think it is not possible?" – I ask. "Because the cardstock does not reflect" (Eva); "First, the light hits the mirror and reflects onto the cardstock but, afterwards, the light does not reflect from one cardstock to the other" (Daniela). "The mirror only reflects onto one cardstock and the cardstock is not the same as the mirror" (Leonardo). At this time, I explained that, because the cardstock is not smooth like the mirror, it reflects light in all directions. Therefore, we are not able to make the light appear on the other cardstock – diffuse reflection – whereas the mirror reflects light in a well-defined direction – specular reflection.

F. Do you think we can reflect light from one mirror to another?

They predict the path of the light between the two mirrors. Excerpt from the class diary:

The class is unanimous in answering "yes". A second mirror is distributed to the groups. When questioned, the students correctly predict the path of light between the two mirrors: "The light hits the mirror and then comes back, and we are going to put the mirror… here!" (Joel's group); "the light comes from the flashlight this way, hits this mirror (the first one) and then it goes onto this one (the second mirror)" (Daniela).

They test their predictions and interpret the observations made. Excerpt from the class diary:

"The light goes this way, this way and this way" – referring to the trajectory of the light between the two mirrors. "Then what figure does the light form?" – I ask. "It is like a reversed "V" (Diogo); "It always makes a "V" and the mirror is always at the tip of the "V". "If we put another mirror, we get another "V" (Simão).

They record the light path on their individual record sheets.

They infer and communicate the path of light between the two mirrors. Excerpt from the class diary:

"How did you draw the path of the light?" – I ask. "We drew it from the flashlight to mirror 1. And then from 1 to 2 and then onto the target" (Leonardo). "And how are the lines?" – I ask. "The lines are straight" (Bruna). "They are straight and make sort of a "V" (Ângelo). The majority of the students drew the light path correctly. The comments within the groups revealed a good understanding: "The light comes and goes like this, perpendicularly" (Joel); "it reflects from the mirror and makes a perpendicular line onto the other" (Lara); "the line that goes one way is similar to the one that comes back" (Bruna); "from one mirror, it reflects onto the other and then it goes from that one onto the cardstock" (Diogo).

They identify regularities, recognising that light is reflected according to a certain rule.

Through successive questioning, the children are stimulated to think about the rule that governs the reflection of light. From the drawings they made in their records, they infer that the dotted line drawn perpendicularly to the plane of the mirror, divides the angle formed by the incident and reflected rays into two equal angles. Excerpt from the class diary:

Figure 4. Periscopes built by the students

"The light comes (reflected light) the same way as it goes (incident light)" (Ângelo). Some fail to understand Ângelo's reasoning. Bruna clarifies her colleague's idea: "when the light is hitting at an angle, it is reflected with the same angle". "It's like an axis of symmetry, it is here, dotted on the diagram" – adds Eva. "The line on one side must be equal to the line on the other side, because they are symmetrical" (Daniela). "It is like there is always symmetry in the middle of the two lines, the one that goes and the one that comes" (Lara). Joel, in conclusion, states: if the light goes in a diagonal, it also comes back in a diagonal, with the same angle. Their ideas are already quite mature and so I mention the fact that the angle formed between the symmetry axis (normal) and the incident ray is equal to the angle formed between the symmetry axis (normal) and the reflected ray.
The students build a periscope and make observations.

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5. Final considerations

The analysis of the class diary shows, on the one hand, that the children are capable of overcoming complex challenges of a cognitive nature when these are approached in a collaborative context, of stimulation and freedom to express their thoughts. Thus, they become active and reflective subjects in the learning process [24]. On the other hand, the social interaction generated among the children and between them and the teacher, promotes higher levels of learning. This is consistent with Harlen, when he refers that “interactions among students and between students and teachers are needed for inquiry-based learning, with the teacher having a key role” [7, p. 2]. In this process, the teacher, through of a process of questioning, stimulator of thought and action in the students [8], supports their individual and collective cognitive activity [25, 26]. Through this process of questioning [26], guided by the teacher, students are able to reach higher levels of comprehension and develop better reasoning skills, which they would not be able to achieve without support.

All this, as supported by Sá [8] and Harlen [7, 13], entails great personal and intellectual involvement by the student and is closely dependent on an intervention intentionally guided by the teacher, which aims at promoting in students both the construction of meanings that are more consistent with reality and the development of scientific process skills. In this sense, the analysis of the class diary also shows that this particular teacher accomplished a successful didactical integration of the inquiry-based science teaching approach recommended for children. The intentionality with which teachers conduct their educational action is in line with a reflective practice, in the way they regulate and provide feedback to the children's joint cognitive activity, through continuous questioning, which stimulates reflection and action.

Lastly, we would like to say that the training of teachers should endow them with a specific know-how, geared for their future educational action, namely as to how to explore the different curricular topics along with the children. The development of this knowledge should be promoted, through a continuous training process based on the data and tools that emerge from research undertaken with children in a classroom context. Research should offer these professionals fruitful elements to support their educative action. In this sense, the analysis presented in this article of explorative activity “Reflection of light” may constitute a training tool for teachers which enables them to, in similar contexts, evoke and promote an identical process of exploration with their students.

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Hands-on Conceptual Teaching of Physics of Music

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Abstract. *In our effort to bridge the gap between fine arts and science, we have created a conceptual hands-on physics course that addresses the physics of sound, music and some basic musical instruments and provides the platform for even non-science majors with minimal algebra skills to develop a conceptual understanding of the physics of music and build simple musical instruments. We present here the general layout of this course focusing primarily on the hands-on aspect of its delivery. The course is an introduction to physics as it applies to the art and science of music and consists of a mixture of lecture and laboratory-like hands-on experiences and an instrument building project. The hands-on experiments are designed with musicians and non-scientists in mind and cover the topics of the course.*

Keywords. Physics, music, hands-on activities, inquiry-based.

1. Introduction

The physics of music and musical instruments is closely related to the physics of waves and sound and in particular on the combination of concepts related to stationary waves and the phenomena of resonance. We have created a conceptual hands-on physics course that addresses the physics of sound, music and some basic musical instruments and also provides the platform for non-science majors with minimal algebra skills to build simple musical instruments [1]. The course offers in the world of music, an opportunity for students to explore the richness of many diverse musical instruments created through history so that they can understand and demonstrate that the physics behind their construction can be broadly similar [2]. The fundamental concepts taught in this course are an introduction to physics as it applies to the art and science of music and its delivery is through a mixture of lecture and laboratory-like hands-on experiences and an instrument building project. The hands-on experiences are designed with musicians and non-scientists in mind and cover the topics of the course which include vibratory motion, waves and properties of waves, measurement of sound intensity and loudness, analysis of frequency spectrum of sound, resonance and beats, human voice, human ear, room acoustics, echo and reverberation, music and musical scales, standing waves in a string, interference, wave pulse, harmonics and overtones, open and closed tubes, physics of string, wind and percussion instruments etc. Students can as a result appreciate a direct link between the relevant fundamental concepts as applied to the five categories of musical instruments [3] (Figure 1):

a) Idiophones, made with materials that can naturally vibrate to create resonant sounds.
b) Membranophones, where the sound is created by the vibration of a

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stretched membrane covering an opening and can produce two dimensional stationary waves.

c) Chordophones where sound is produced by the vibration of different strings stretched between two points.
d) Aerophones, where the air in an open cavity produces stationary waves.
e) Electrophones, where sound is produced by electrical means.

Figure 1. Instruments: a) woodblock; b) tambourine; c) violin; d) bagpipe; e) digital organ

In addition, this course also makes students be aware of and appreciate the possibility of converting diverse materials and tools that may be useful in other areas into musical instruments (Figure 2). The use of such diverse materials to create musical sounds has been part of the cultural history of music and musical traditions all over the world [4]. The course has been designed so that students are able to create a musical instrument capable of producing tones or percussive effects pursuant to the acoustic principles discovered during class including standing waves in strings, and membranes, closed or open tubes, and resonant chambers. Grading is also based on the extent to which the acoustic principles discussed in class are used in the creation of these instruments.

Student competencies tested in this course are:

1) Demonstration of an understanding of scientific method of inquiry.
2) Demonstration of the physics principles governing simple musical instruments.
3) Writing of concise reports in the correct format.
4) Recognition of the differences between propagation of standing waves in string versus membrane media.
5) Development of an ability to control sound in different environments.
6) Analysis and demonstration of the ideal environments for music performance.
7) Examining the difference between echo and reverberation control.
8) Designing and building a string, wind or percussion instrument.
9) Performance and description of the functions of designed musical instrument to a variety of audiences.

Both lectures and lab-like experiences in this course are taught in a laboratory setting so that students spend the greatest amount of time possible in experimentation and experience with the lab materials. Occasionally, field trips are set up to experiment sound and music in different environments. Students are provided with all the construction material for their musical instruments and this instrument building project is usually done in small groups of two or three students. After building their instruments, students travel to local schools to demonstrate them and also explain the relationship between the instrument and the basic physics concepts that have been applied such as how a sound pipe is an example of an instrument related to Bernoulli effect or justify why larger instruments make lower frequency sounds than smaller ones. This is a required part of the course.

Figure 2. Objects working like instruments: a) can; b) bottle and wood spoon; c) scallop; d) pine cone; e) horseshoe

2. Hands-on activities for classroom

Amongst the many activities that can be used for making knowledge of music and physics, more attractive is that of hands-on activities, that can be found usually at "interactive" science and technology centres. In this case an understanding of natural processes is carried out via direct observations and experience. We list here some of the demonstrations that can be used for a course of this nature (Fig. 2):

a) Scientific method of inquiry: We have used a solenoid connected to a galvanometer and magnets of varying strengths so that students can discover the basis of Faraday-Lenz's law of electromagnetism and associate it with the fundamental physics of an electric guitar (an electrophone) [5-6].
b) Wave motion: Transverse and longitudinal waves with slinky. A long spring can be used to see transverse waves, in which the perturbation in the medium is perpendicular to the propagation; and longitudinal waves, where the directions coincide [7-8].
c) Beats: Sounding simultaneously tuning forks of slightly different frequencies beats can be produced. Musicians can easily identify beats as they are familiar with them while tuning instruments. This is a great tool to introduce the concepts of wave superposition. A beat is a phenomenon generated by the superposition (interference) of two acoustic waves, each with a frequency that is different from the other but very close to it. A familiar example are the pulses produced by sound waves coming from two tuning forks with frequencies that are almost the same but not identical. The outcome is a note or tone whose intensity varies back and forth between a high intensity value (loud volume) and a low intensity value (quiet volume) [9-10].
d) Speed of sound: Resonance apparatus where one partially fills the resonance tube with water. Sound a tuning fork over the open end of the tube and adjust the water level until the tube resonates at the same frequency. As the water level changes in the tube, a standing wave is

produced with an antinode at the top of the tube and causes resonance. The speed of sound can then be calculated using the water level and the frequency. This introduces the concepts of standing waves in open and closed tubes, nodes and antinodes [11-12].

Figure 3. Hands-on activities. Explanation in text

e) Loudness of sound and sound intensity: Using a decibel meter and simple introduction to logarithm to introduce the concept of intensity of sound. Sound intensity is an objective quantity that can be measured by means of different instruments (for instance with an oscilloscope). On the other hand, sound feeling (of a subjective nature) is a physiological perception which differs from person to person and approximately varies almost logarithmically with the intensity [13-14].

f) Frequency spectrum of sound: The relationship between the frequency of a standing wave and the length of a tube with open ends can be analyzed with a corrugated tube which rotates at different speeds [15-16].

g) Standing waves in a string and harmonics: Mechanical wave driver, sine wave generator, string, mass set to study an example of a simple oscillating system, a standing wave produced on a stretched string and its harmonics. It can also be used to show the relationship between tension in a string and frequency and relate it to the tension in guitar strings and the frequencies generated [17-18].

h) Standing waves in a membrane: A metal plate is held at its centre point over a frequency generator and harmonic excitation is applied to it at different frequencies. The stationary waves produced are easily seen by placing sugar or sand on the plate. This is because the small particles locate themselves at the nodes caused by the vibration, which correspond to those points at which they are at rest [19-20].

Other activities can be carried out, that relate wave tension and wave speed, demonstrating room acoustics (echo and reverberation; measuring background noise with a decibel meter, focusing sound (parabolic reflector in an auditorium), etc. Information for teachers that explains the fundamentals of the activities can be found in many different sources [21].

3. Results and conclusions

The paper presents some examples of hands-on activities as tools to facilitate an easy conceptual learning of the physics concepts applied to music and musical instruments and how they can aid students to design musical instruments. Several simple and well-known hands-on activities are introduced with the aim of improve student grasp of the theoretical concepts that could otherwise be difficult to comprehend for students in humanities and fine arts who have limited math background. We also present some of the instruments designed by our students (Figure 4).

Figure 4. Designing and building simple instruments in classroom

Learning by doing helps students develop cognitive processes as well as the sense of curiosity and creativity. The classroom becomes a place where students search by themselves, building knowledge, working with objects and real materials. There are many sources where they can find inquiry-based activities with clues that give them the opportunity to explore them, with the objective of designing and building simple instruments based on the physics of musical scales and the physics of vibrating air columns, strings and membranes, with commonly available material such as wood, fishing line, wood glue, tapes, PVC pie, rubber, tape, etc. Examples of typical instruments that have been built are ordinary flutes, Pan flute, bar harmonics, guitars, PVC pipe organs, didgeridoos or drums. For students, the hands-on activities performed in this course complement their interest and understanding of the physics of music and lead them to work in a practical and experimental way on a particular concept. This they may not acquire by only reading books or notes or by through on-line simmulations [22-24].

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The Alga Who Wanted To Be a Flower. An Outdoors IBSE Model on Plants Evolution

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Abstract. *Identifying the main stages of IBSE implementation, an activity tested at the University of Coimbra Botanic Garden will be presented. In the cold greenhouse, a story is dramatized to young children that recognize the main morphological characteristics of the five major plant groups, corresponding to the hand five fingers, identifying and freely organizing specimens. Firstly, recognizing the question/problem: HOW to engage young children to the world of plants, regarding to WHAT they know and their curricula demands. Then, the multidisciplinary work design, approaching to everyday-life situations with social meaning and valuing methodological pluralism. Finally, evaluation of the student learning, reproducing this "game" and the "evolution song".*

Keywords. Formal, informal and non-formal education, IBSE methodology, natural science activities outdoors.

1. Introduction

Every life experience has a formative effect on the human being, in the way one thinks, feels and acts. One of the most important contribution resides in what and how we learn through the educational processes, both in formal, non-formal and informal settings, being science education outdoors initiatives proficient to feed and stimulate the science-specific interests of either adults or children [1, 2, 17].

Natural science activities outside classroom through Education programs in Botanic Gardens is an instructive practice of excellence facilitating the process of teaching-learning of knowledge. Having a living space as study environment, educational activities in the garden are guaranteed dynamic and very enriching, for the immense availability of educative resources and the direct contact to real models and authentic, engaging and often surprising natural phenomena examples [2].

Besides the diversity of plants collections, most of the times unique, Botanic Gardens hold other living, historic and architectonic patrimony, that is accessible and can be used to engage all kind of publics to natural science and other knowledge acquisition, enhancing general literacy improvement.

In reality, during a visit to an outside site, such as a botanic garden, there are a huge amount of teaching-learning resources and tools to be used, as well as further educative challenges are offered for teachers, educators and learners.

Nowadays, there seems to be some consensus by the scientific community dedicated to educational research relating to inquiry as the essence of science education [1, 9, 12, 13].

Inquiry-based science education (IBSE) means students progressively developing key scientific ideas through learning how to investigate and building their knowledge and understanding of the world around [Wynne Harlen, 2011 cit. in 4], changing the attitude from the teacher/educator who explains everything to a facilitator who supports the

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students in finding their own solutions and provides help whenever needed. It is about to perceive the progression from teaching science, as an activity concerned mainly with accumulating unchangeable knowledge, to appreciating science learning as a student centered process of constructing and acquiring knowledge [1, 4].
Inquiry-based science education has its roots in hands-on science experiments carried out in the classroom and outdoors also provide a range of opportunities to deliver high quality IBSE case studies [1, 4].
Although centered in learner, the IBSE method absolutely requires coaches to be well prepared, confidence, knowledgeable and sure on how and when using the educative resources, organizing the proper environment for the student learning acquisition process. IBSE activities are open to a broad auto orientation of the student, what augments the level of possible unexpected designs, interpretation and results, that accordingly ask for a teacher and educator prepared and prompt efficient guidance and reaction. Knowledge is naturally constructed by student, according to the evidences, "au moment". This increases the student's unforeseen creativity and interpretations, to be properly corresponded by teachers and educator's good preparation and assistance [2], enlarging the teaching-learning universe and framework.
During the implementation of strategies based on inquiry, it is possible to identify three main stages, as questioning, work methodologies and final evaluation [9,10,13]:

1. Focus on the question/problem to investigate, either in coach or learner perspective; the mobilization of knowledge already built and at the same time the construction of other, allowing the progress of the problem resolution by introducing inter-and transdisciplinarity to understand the world in its entirety and complexity.
2. The design, including multidisciplinary to recognize the biosphere in its globalism and to propose some team work, with situations points, repetition, reflexion and synthesis on the situation. Teacher or educator must summarize and prepare to develop and find a communication plan with good methodological and assessments strategies. The relevance of the approach to everyday-life situations with methodological pluralism as strategies work, standing out by its relevance, the experimental work; teacher has key role as organizer and promoter of a working situation conducive to knowledge building processes and helping critical thinking of students.
3. Finally, the educative evaluation to get the individualization of student learning and should be regulating and guiding; to assess whether or not it was achieved an appropriate response to the question-problem posed and how the process was developed.

Performed since a long time at the University of Coimbra Botanic Garden [3] and included in the Coimbra Inquire training for the trainer's Course [4], "*The Alga who wanted to be a Flower"* is an outdoors IBSE model on Plants evolution, recently published as a five bilingual versions book [5] (Fig. 1) under the Inquire educative European Project [6].

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Primarily devoted to 3-5 years old children and using an extremely lightweight scientific language, played and applied either in botanic gardens or elsewhere, this IBSE activity is meant to provoke children to construct elementary botany knowledge and to be consciousness that plants are living beings and important for Life on Earth.

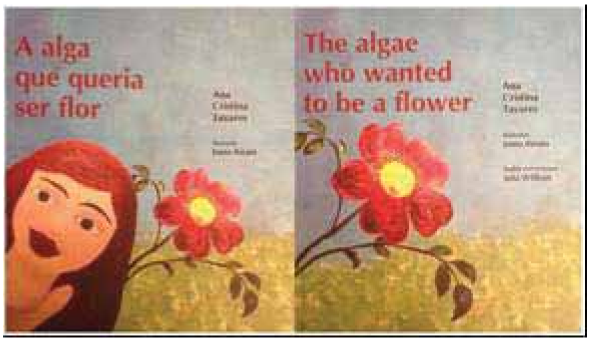

Figure 1. The "*Alga who wanted to be a flower*" bi-lingual educative book

Through a simple plants evolution story, or theater, with a ludic, involving and motivating approach and environment, this lesson, as an educative "botanic" performance, will be presented, identifying the main stages of the IBSE methodology implementation.

2. Material and Methods

The preparation of this lesson following IBSE methodology is described in detail in the Coimbra Inquire course manual [4], with a guide to develop educational materials, composed of four sections: an overview of the lesson, the student activities, the educator's guide and the evaluation questionnaire.
Focused on examining tried and tested practical ideas in botanic gardens and other natural environment locations, the theme will be described as a testimony of my own experience, following step-by-step the phases of IBSE method implementation.
Considering "*The Alga who wanted to be a Flower"* three main IBSE steps, the first was to identify the problem/question:

1-HOW to engage the very young children to the diversity, importance and the wonderful world of plants, regarding to WHAT children know about and WHAT their curricula demands.
This was a recurrent issue that pursuit me, regarding one of the most important educative goals that I considered ought to be attained through the Botanic Garden educative program, to awake the very young children to the world of plants.
On the other hand, if it was possible to teach and learn the life cycles and identify the key differences and the evolution of plant main groups with high-school students, by exploring the living models of the cold greenhouse, then certainly it would be possible to find a way, a method, to reach the main plants differences and evolution to the very young children.

2 - Then, the work methodologies: HOW can children investigate the question and find resources and approaches?
In the case under study it ought to be a very simple, easy and pleasant activity design, key requirements to gain young children's attention, reaching children 'world and interests first of all and trying to behave and think like them.
WHAT do all children like to know about? A story!
Indeed, if everyone likes a nice story, every children really love stories.

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Valuing methodological pluralism, using a theater or a story *in loco* with nature, seemed to be the perfect scenario for the plants to appear like the artists, mixing imagination with reality, as strategies work, to better reach and enhance children active-minds.

So, this lesson was meant to provoke children care to the world of plants, understanding they belong to the world of people too, by approaching to everyday-life situations, with social and special meaning for children, using simple examples, such as "…*a plant with cones. Like a Christmas tree".*

Following this steps and inspired by the atmosphere of the Garden' cold greenhouse (Fig. 2), full of different plants, a small stream and a statue named *Botanica* (Fig. 3) - the truly science of plants - a story was spontaneously designed and set to music to the very young children, like in a theater, supported by my previous educative experiences background in the garden and mobilizing personnel childhood memories:

Figure 2. The Coimbra Botanic Garden' cold-greenhouse

Figure 3. The "*Botanica*" statue surrounded by a diversity of plants

"Once upon a time there was an Alga that lived in a pond in the garden's greenhouse.

One day she had a dream: of turning into a flowering plant!

And on that day she woke up very disturbed and began looking at the greenhouse plants. She realized that they were all very different. Some had beautiful flowers...
Some were big, some were tiny. And there were many colours…

Some plants were tall… others small…

From that day on her greatest desire was to become a Flowering plant!

"- How will I accomplish this dream?"- she thought.

At the edge of the pond she noticed Botany, her companion on the greenhouse, a tall beautiful lady, with flowers in her hands and hair, who knew many stories about plants from around the world.

"- I know! I'll ask Botany to help me! "

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And she called:

"- Miss Botany, Miss Botany!!
It´s me, the Alga of the pond. "

"- Good morning Alga, how can I help you?" - responded Botany.

And the Alga told how her dream had become her greatest desire.

Botany replied:

"- To become a Flowering plant, Alga, you will have to climb the evolution path through the world of plants. Are you ready for this adventure? "

"- Yes, Botany, yes, help me so that I can, one day, become a Flowering plant!"

And Botany turned her into Moss: a tiny flowerless plant that grows on rocks, bark or wet ground.

Alga loved her transformation!

After a few years with no flowers… she asked Botany for help again.

Alga that had become Moss now become a Fern:
A plant with roots that reached into the ground with tall leafy fronds.

But there were no flowers.

And again she asked Botany for help.

And then the Algae that had become Moss that had become a Fern became a plant with cones.

Like a Christmas tree, tall and handsome with leaves all year long and with many pretty cones, full of tasty nuts.

And the Algae that had become Moss that had become a Fern that had become a Pine was excited by her transformation. But no flowers appeared!

And again she asked Botany for help.

And then the Algae that had become Moss, that had become a Fern, that had become a Pine, finally became a Flowering plant: with bright red petals and yellow anthers.
She had a beautiful perfume which helped her play with the bees and butterflies.

And so the Alga that had become Moss, that had become a Fern, that had become a Pine, that had become a Flowering plant, thanked Botany and was forever happy.

So happy that her song became known throughout the greenhouse:

"Alga, Moss, Fern, Pine, Flower ...! Alga, Moss, Fern, Pine, Flower...! "

Sing with me, with one hand, plant evolution:

"Algae, Moss, Fern, Pine, Flower ...! Algae, Moss, Fern, Pine, Flower...! "

"With one Hand, plant evolution...!"

As the story is evolving, children recognize the main plant morphological characters of the five major plant groups' examples pointed out through the greenhouse and they can easily distinguish and after

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collecting and freely organizing specimens on their own, individually or as a team work.
Learning the names corresponding to each of the five hand' fingers, children sing: *"Alga, moss, fern, cone, flower ...! With one Hand, plant evolution!*"
At the classroom, or in other outside green spaces, the story and new knowledge on plants importance, identification, diversity and evolution can again be redirected on other questions, exercises and reflexions, and present and debate in a plenary by teacher and the students.
3 - Finally, to assess learning, encompassing concepts, skills, attitudes and values. The assessment of the educative products and process, reporting the achieved knowledge, redefining questions and communicating results.
Can learner present solutions to the proposed question and got the new concepts?
Can they reproduce them reflecting on it and do they feel happy, comfortable and empowered with the new activity concepts and knowledge?
Do they want to repeat or to expand this activity "game" again?
Methodological and assessments strategies can include questionnaires, produced work and observations to support the educative evaluation of the student learning.

3. Results

Children easily understood and spontaneously repeat this "game" using diverse plants (Fig. 4), happily reproducing the "evolution song", answering some questions and writing and creating the same or other new botany stories, illustrations and plant collections of their own (Fig. 5). All the children learned and were able to identifying the plants main characteristics and "group" name, as well as the order on the evolution path.

Figure 4. The "*Alga-flower*" evolution exploration story: hands-on in the Coimbra Botanic Garden' cold-greenhouse

Other exercises are further developed in the garden, elsewhere with new plants and at school garden and classroom.
New tasks are proposed to enhance further experiences and the students' knowledge cohesion, like propose a contest for best contribution on illustrations on plants evolution, the best story on plants, the best song, theater, plants collections and whatever inspiration, creativity and imagination demand and could produce. New IBSE cycles of teaching-learning processes are so constructed and progressing, as well as multidisciplinary knowledge and skills acquisition and development.
Using IBSE methodology of education by research, teacher and educator stimulate students to build learning by promoting

personal concepts reconstruction with changing attitudes and values.

Figure 5. The "*Alga-flower*" evolution story created by a four years old children

4. Conclusions and reflections

The described educative methodological strategies on this very simple IBSE model worked well, being sustainable and easily reproducible both in formal, informal and non-formal settings.
Also, whatever activity is well succeed with children can be easily adapt to public of all ages, adapting (or not) the content and discourse to the people characteristics and needs, as happened to this one too.
What IBSE criteria worked well and why?
This educative model had shown several benefits, being possible to summarize twenty four advantages, underlying the best IBSE approaches:

1. Sustainable - wastes no money nor anything; minimum of material resources, only need the plants, or models of them.
2. Can be run inside or outside classroom.
3. It can continue producing new educative cycles, crossing multidisciplinary, art, music, new stories, illustrations, plant collections....
4. Transversal to all public of all ages - adoptable to deeper knowledge concepts and to every scenario and public.
5. Student build new knowledge on prior knowledge and through evidences.
6. Student apply knowledge in unusual contexts.
7. Student think creatively and develop the desire to learn.
8. Student get use on reflective practice.
9. Student develop social skills and communication.
10. Lasts forever, as long as the plant kingdom.
11. Reproduces the main concepts and characteristics of the five main plant groups.
12. It reflects plants evolution.
13. Provokes active mind and uses hands-on and heart-on competences.
14. Uses different methodologies and strategies.
15. You can create upon it: You can write a book, compose a song or make a theater.
16. It has a moral story with attitudinal meaning.
17. It is simple and beautiful – like plants - gathering people attention and curiosity.
18. It is easy to understand, remember and reproduce.
19. It leads to reflexion and repetition of the main science concepts.
20. It is dynamic and never run the same way.

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21. You can use it to apply in new circumstances and check out your knowledge – it is challenging and provocative.
22. You can share it and translate to everybody and easily to every languages.
23. It links with day-by-day social events with social meaning – crossing daily cases.
24. It can be a lesson, a workshop, a plenary issue, an ending point or a starting question - an open question - it is an IBSE model on plants evolution.

By simple tasks, as this story on plant evolution, or during other more complex activities [2], through IBSE undertakings learners always experience the enthusiasm of resolving a question on their own [1, 4].

Yet, as ever, the explainers (teachers or educators) must be aware on the current scientific theories and facts on the Biology subjects addressed.

Currently, it is commonly accepted the 3 Domains classification of Woese [15]. DNA and RNA analysis showed that instead of the 5 Kingdoms exist, in reality, 3 Domains (or empires): Archaea, Bacteria and Eucarya [15].

Algae, either unicellular or multicellular, form part of two different kingdoms. Kingdom Plantae include Phylum Chlorophyta (the green algae) and Phylum Rhodophyta (the red algae). The other phyla of algae belong predominantly to the Kingdom Chromista, Phylum Heteronkomtophyta, as classification of the major groups of algae and other aquatic organisms [16]. Phylogenetically, green algae are at the origin of land plants or commonly known as vascular plants. The “essential evolution line” - algae, moss, fern, pine, flower – although using a very simple and common language, is correct, as well as the main plant morphological characters that children can easily distinguish.

The taxonomic accurate names and the evolution and classification current understanding, that teachers and educators should be aware of, will later be achieved whith more older students, trough explainers deepening and broadly on knowledge and details and students’ progress on new questions, leading to the science facts understanding and generally accepted.

As learning numbers or alphabet letters, firstly simply five of each, young children, oriented by teachers and educators, will later on comprehend the immense world of arithmetic, mathematics and different languages.

The same for plants, only identifying plants by main characters as five major groups and comprehend their evolutionary path, on “*The alga who wanted to be a flower”* science activity and transversal practice, possible to be performed in six lingual versions [2].

Outside educative spaces and resources are stimulating and very inspiring for all protagonists of the teaching-learning process, especially enhancing the motivation and interests of both coaches and learners [7, 8, 11, 17]. Using any outdoor living space, Botanic Gardens, parks, public, private or school gardens, educative processes here are about interacting directly with living organisms (mainly plants): observing natural phenomena, formulating questions, approaching to every-day life situations, linking evidence to explanations and finding appropriate solutions to explain observations and address new questions or problems, following IBSE methodology steps, “naturally” [7, 8].

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This easily happens especially with childhood, as apprentices' beginners, the perfect time to link children's first thinking and reflection to Nature and to the importance of plants for life sustainability [11, 17].
IBSE features values the pre-existing knowledge and a new open and team /social perspective of teaching, where both teacher and student individualities are taking in account, respecting each uniqueness. Enhancing coaches professional as well as personal talents, as "In each teacher there's is also a person" [18, 19], it is important for better develop the educative activities, that teacher and educator convoke all their skills, memories and competences, linking and empowering the emotional, affective and intellectual knowledge of personnel experience.
Studying Nature outdoors according to these IBSE methodology features brings great advantages to educative practices on Biology or related areas, thus supporting the groundwork of teachers, educators and students [7, 8].
This happened in the inspiring day when I was provoked in the cold greenhouse and believed that could construct one evolution story to let young children be affected by the dreams and perseverance of one alga and its adventure through the world of the very different and beautiful plants.
Not underestimate what is simple and basic; it may contain tools and principles to facilitate access to what is complex - and the opposite is much more difficult to succeed.

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Hands-on Experiments to Develop Students' Creativity and Critical Thinking

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Abstract. *Hands-on science activities have an unrivalled potential to help students develop their creativity and critical thinking, provided they are practiced in a minds-on, inquiry-based fashion. Another advantage of the hands-on approach is the extra motivation and professional progress of the teachers.*
Examples are reviewed of successful practicing hands-on science in various academic environments.
Mostly low cost experiments in Physics, those activities were supported with computer and advanced multimedia tools when justified.
Transformation of entertaining Physics tricks and Physics toys into highly instructive educational projects required from the students and their instructors much of an alternative viewpoint. Examples of students' spontaneous observations and creative solutions are given.

Keywords. Multi-disciplinary students projects, hands-on and minds-on educational experiments, efficiency of education, development of creativity, development of critical and alternative thinking.

1. Introduction

Development of students' creativity and critical thinking is among the priorities of modern education. A presented series of low budget experimental activities is focused on the transition from the involving hands-on activities to the creative and instructive minds-on projects. Reported examples of class demonstrations/labworks and students' educational research have been practiced in various academic environments with a lot of positive feedback.

Although included experiments are technically in the frames of the university Introductory Physics course and courses of Physics at basic and high school, their analysis often involves and improves knowledge of Mathematics, Biology, Physiology, Chemistry, Engineering Design, skills in logics, arts and team work.

For every observed phenomenon the model is looked for and suggested. The check/proof of the model and comprehension of its predictions is the key point of those creative activities. Solutions of many the presented experimental problems are definitely counter-intuitive, which supports the improvement of critical thinking of the students.

Computer multimedia, including video-measurements, is used in the presented activities wherever appropriate. Incidental observation of Physical phenomena on the Internet is another efficient application of modern technology.

Open-ended by nature, reported activities leave place and imply for their further development by the practicing teachers and students. Importantly, not only the teachers get additional professional motivation when mentoring hands-on projects. The students'

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parents may also gain a lot when involved into their kids' creative activities.
Not the least it is necessary to notice that critical thinking is regarded as a positive alternative approach to either solve a perplexing problem or to cast a fresh view onto the seemingly obvious phenomena.

2. Advanced multimedia in low-cost hands-on experiments: Heads-on collisions of real objects

Heads-on collisions, being the basic material of any introductive Physics course, are also perfect for the creative students' projects.
Inspirational video-presentation of Mats Selen [1] could be recommended for the starter. Arguably the most impressive demos of the series are those of elastically colliding bodies not touching during the collision. That is achieved by placing strong magnets onto the dry-ice pucks sliding on (effectively above) a smooth surface.
Detailed computer-based studies of bouncing of a single elastic ball off the horizontal surface are performed in [2]. There, account of different mechanisms of energy dissipation sufficiently improved fitting of model dependences to the observed motion of the ball.
Step next in the thrilling inquiry-based studies of elastic collisions could be an arrangement of several colliding bodies (Newton's Cradle is an example).
Impressive result of multiple collisions of the balls comprising the *Astroblaster* toy are explained in terms of conservation of momentum [3]. The important role of the coefficient of restitution is demonstrated in ideal and real cases. Real-life experimental results may be compared with a computer model of the toy represented by an interactive *Java* applet. Same mechanisms account for the no less impressive behaviour of the stack of two balls dropped onto the solid floor; see Fig. 1 and Fig. 2. Right halves of the figures show the highest elevation of the upper ball after the collision.

Figure 1. A basketball and a touching smaller rubber ball dropped onto the floor

Parameters of the experiment were chosen to provide for the upper ball (encircled in the figures) rise only slightly above its initial position after the collision with the lower one, Fig. 1.
Keeping in mind that the duration of the lower ball's encounter with the floor is about *0.02 s* [4], we repeated the experiment with

an initial shift between the basketball and the upper ball. That was supposed to let the balls meet heads-on at the maximum (opposite) velocities to guarantee higher rise of the upper ball. This suggestion is proved experimentally in a very impressive way (Fig. 2).

Figure 2. A basketball and a smaller rubber ball dropped simultaneously onto the floor with some initial distance between them

More critical approach requires the realistic model of the motion of dropped and colliding balls to account for the different conditions of air resistance acting on the upper and lower balls. Indeed, the basketball efficiently screens the upper ball which as a result moves faster and experiences an additional mid-air collision, revealed by a fast camera video. This is a nice example of the totally justified use of an advanced technology in an essentially low-cost hands-on experiment.

3. Importance of creative students' observations

All around themselves students may observe intriguing, often incredible phenomena of nature proving that thrilling Science, Physics in particular, is not hidden in the lab; it is literally everywhere.
Inspired by a success of the project [5] we collected creative observation of our students interested in shadows.
It is also very instructive to capture 'incidental' Physics episodes that were not supposed to be. An excellent example of an occasional Physics toy, the famous tippie-top [6, 7] could be watched on *YouTube* [8]. Certainly, that video clip was uploaded not for the sake of the background Physics of it. Characteristically, involved football stars appreciated only the absurdity of the incidentally torn ball reshaping into a sort of a spinning dumb-bell. Although tippie-top sort of behaviour is obvious there.
More interest towards Physics, specifically, to the equilibrium of coupled forks ([9], p.81), is displayed by the creators of the '*Rieka*' videoclip [10]. They must have included this demo on purpose, with some additional meaning implied. Not going deep into

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psychology, we present some ultimate versions of the old nice forks&toothpick demonstration (basic idea courtesy of Abraham Salinas).

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Water Condensation: An Inquiry-Based Approach to Science Teaching with Primary School Children

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Abstract. *This paper is the result of a pedagogical intervention project carried out at a primary school. The intervention took place in a 4th grade class (n=24) and involved an inquiry-based approach to the teaching of the curricular topic "water phase changes". The project employed an action research methodology whose main objectives were: a) to promote inquiry-based science teaching; b) to describe and analyse the process of the construction of meanings related to the phenomena under study, and c) to evaluate the learning acquired by the students. At the end of each lesson, a class diary was prepared. This is a descriptive and reflective narrative based on the field notes and audio recordings made during participant observation in the classroom. This paper analyses the scientific meaning construction process that occurred in the classroom, based on the analysis of one of these diaries, on the topic of "water condensation".*

Keywords. Water condensation, inquiry-based science teaching.

1. Introduction

Very early on, children manifest a natural curiosity and interest in knowing and making sense of the world that surrounds them. The teaching of sciences should take advantage and enhance these natural qualities of children, as they constitute the necessary support for active and meaningful learning in the classroom [1, 2, 3]. The goal is to "educate" the children's natural curiosity in order to develop more systematic, deeper and autonomous thinking patterns [4]; stimulate them to pose questions and look for possible answers for what they do and see; enable them to devise ways to test their ideas and thought strategies; to share and discuss their own theories and explanations with others [5, 2]. Unfortunately, the traditional educational system works in a way that generally discourages the natural process of inquiry. Thus, the meaningful exploration of inquiry-based science activities stands as a privileged means to convert classrooms into places of leisure, satisfaction and personal fulfilment, as they allow the creation of a learning environment where children learn and do things they really enjoy [3, 6]. A stimulating and challenging learning environment, which can be provided by exploring inquiry activities, is essential for the children`s social and intellectual development [7, 8, 9].

Inquiry-based science education in the early years of schooling is, therefore, vital to help the children: understand the world around them; learn to obtain and organise information; develop ways to discover; test ideas and use evidence; and develop positive attitudes towards science [2, 10]. On the other hand, it can also help children develop very different thinking skills early on [11], e.g., scientific thought, critical thinking, autonomous problem solving and metacognitive skills, which are likely to be transferred and applied to other contexts

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and learning situations [7, 8]. Finally, we could say that inquiry activities in science classes also offer a privileged context for the use and development of other fields of knowledge, specifically oral and written language and mathematics [2, 3].
Science education is, therefore, of great importance for children, as it promotes the development of processes, concepts and basic attitudes that will be indispensable for subsequent scientific learning [2, 10].
The importance of science for children has been widely recognised in the science curriculum guidelines of many countries, which, like some international organisations, have also recommended inquiry methods for its approach.
However, in the majority of European countries, the reality of classroom practice is that these methods are only being implemented by relatively few teachers [12] [13].
In Portugal, the situation is no different. Although the primary education science curriculum suggests a teaching practice in which students should be "active observers, with the ability to discover, investigate, experiment and learn" [14, p. 102], this teaching practice is still only occasional, with only a residual expression in the teachers' pedagogical practices [3].

2. Objectives

In order to address the previous concerns, a pedagogical intervention project was developed, with the aim of promoting an inquiry-based science teaching practice in the approach to the curricular topic “water phase changes”. For that purpose, several lessons were planned and implemented in the classroom.

Thus, the specific objectives of this paper are: a) to describe and analyse the teaching and learning process promoted in the classroom during the exploration of one of these lessons, and b) to assess the learning acquired by the children.

3. Methodology

The science teaching project adopted an action research methodology and was carried out with a class of the 4th year in a Portuguese primary school, located in the city of Famalicão.
The class was composed of 24 students, 13 boys and 11 girls, aged between 9 and 10 years. For two months, 5 lessons were taught on the curricular topic "Water phase changes”, amounting to a total of 10 hours of intervention in the classroom, as presented in the following table:

Lesson subject	**Duration**
Solid, liquid and gaseous materials: What are the difference?	2:00 Hours
Fusion and solidification of water	2:00 Hours
Water evaporation.	2:30 Hours
Condensation	2:00 Hours
Water cycle	1:30 Hours
Total	10 Hours

Table 1. Lesson subject and duration

For each topic addressed, a teaching and learning plan was prepared, containing the following elements: i) learning goals; ii) materials needed for the groups to carry out the planned activities; iii) guidelines for the

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teaching and learning process; and iv) an individual record sheet for each student.

Each lesson, which corresponds to one action research cycle, begins with a teaching and learning plan, which is implemented flexibly, according to the teaching and learning processes generated and promoted in the class reality. The lessons were taught by the second author of this paper, who, in collaboration with the class teacher, played the role of both researcher and teacher.

The data generated in this intervention were collected using two complementary methods: the field notes made by the researchers and the audio recordings of the lessons. This raw data were subsequently compiled in the form of detailed narratives including the most relevant events that took place in the classroom – the class diaries. These constituted the main method of recording data and, simultaneously, a strategy for reflection and for the modelling of the teaching and learning process [15, 16].

This paper aims at describing and analysing the process of teaching and learning promoted in the classroom based on the class diary about water condensation.

With the purpose of assessing the learning acquired by the children, a questionnaire was prepared and administered two weeks after the pedagogical intervention.

4. Results

4.1. Class diary content analysis

In small collaborative groups, the students investigate water condensation in different contexts: a glass with water and ice cubes and fogging up the surface of a mirror using their breath.

G. What ideas do the students present regarding the destination of the water that evaporates?

The lesson begins with the following question:

- *Does water that evaporates ever come back to Earth?* Excerpt from the class diary:

"I think it does. That is the water cycle. Water falls from the clouds. The wind makes it go back up into the clouds and then it falls from the clouds again" (Ana); "I think it's like this: water is in the sea and in rivers and it evaporates; then it rises all the way up there and forms the clouds. Then, the clouds are pushed by the wind and when they get too heavy, they let the rain fall, which returns to Earth again "(Rodrigo); "Water rises and then falls in the liquid state" (Diogo).

The student's answers demonstrate the knowledge that water that evaporates will someday return to Earth in the form of rain – water in liquid state. The student's justifications contain the idea of the natural water cycle. However, none of the students mention the possibility of water coming back to Earth in the form of snow or hail - in the solid state.

- *Does the water that evaporates only come back to Earth in the form of rain?* Excerpt from the class diary:

Some answer "yes", while others, after a moment, state: "Snow is also water" (Diogo); "water also falls in the form of pellets, which is..." (Inês); "hail!" - Says Rodrigo. "It's water in the solid state" (Rafael).

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When questioned, the students contemplate the possibility of solid precipitation, in the form of snow or hail. Some add that it is water in the solid state. In previous lessons, the students had already studied the phenomenon of the "solidification" of water, and were now able to mobilise the knowledge acquired in those classes.

H. Students' ideas regarding the existence of water vapour in the air of the classroom.

– *Is there water in the air of this room?*

Some students simply answer "yes". These answers are probably triggered by some impulsivity. Only two students present explanatory ideas:

a) There is no water in the air of the room, because we can't feel it: "No, because if I do this with my hand (waves her hand), I don't feel any water" (Ana).
b) There is water in the air of the room in the form of vapour, because the water that evaporates does not go to the clouds right away: "If water evaporates, it has to go somewhere before reaching the clouds, so there has to be water here" (Rodrigo).

When prompted to give an individual comment, most of the children suggest the first idea (17 *vs.* 7), but after hearing these notion, the idea of the existence of invisible water in the air of the room (water vapour) begins to gain momentum: "Then there is water vapour here! But you can't see it" (Tatiana).

I. Development of the concept of condensation.

C_1. If there is water in the air of this room, can it be extracted in the liquid state?

– Students suggest ideas.

Some students suggest that it is impossible ("I don't think we can do that" – Inês), while others argue that it is possible, but they admit to not knowing how to go about it ("I think you can probably do it, but I don't know how"–Rafael). Following this communication of ideas around the class, some of the students suggest, as a possibility, a situation that occurs often in the classroom in cold and wet days - wet walls, due to the condensation of water vapour.

C_2. If we put some ice cubes in this glass of water, what do you think will happen?

– Students make predictions.

Their predictions are not consistent with the purpose of the question: "The water will be "icy" (João); "The glass will have more water" (Carolina); "The ice will melt" (Daniel). Once the question was rephrased, the dominant prediction was that the outside of the glass would get misty after the ice cubes were put in the water.

– They make suggestions and test their predictions. Excerpt from the class diary:

What do we have to do to see what will happen?" - I ask. The groups answer that they need to "experiment". Each group puts some ice cubes in the glass containing water and I refer to them that we need to wait a bit to see what will happen.

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C_3. Introduction of a new context of condensation: fogging up a mirror.

- The students make predictions. Excerpt from the class diary:

While the process of condensation is occurring on the outer wall of the glass, a new context is introduced: "What will happen if you breathe against this mirror?" - I ask. "It will get foggy" (several students).

Students are unanimous in predicting that the mirror will get foggy from the breath.

- They test their predictions.

The students find that, when breathed on, the mirror gets foggy – water vapour that passed to the liquid state: "...it's like water in the liquid state, except it's in very tiny particles" (Ana). Some students relate the fogging of the mirror with a situation that occurs frequently in everyday life – fog in the bathroom mirror when taking a bath: "My bathroom has a very large mirror and when I'm showering, it gets all foggy" (Rodrigo).

C_4. We then turn back to the glass with ice, now all misty.

- They observe and reflect on the evidence.

Spontaneously, the students focus their attention on the glass containing water and ice cubes, now with the outside wall all misty. The first comments begin by noting that the glass "is foggy", "is wet" and "is moist". When questioned, they showed no hesitation in stating that it is water in the liquid state: "It's water. If I touch it, my finger gets wet" (Maria); "but it is not in the gaseous state, because that water can't be seen. This is water in the liquid state" (Rodrigo).

Figure 1. The fogged up mirror

C_5. Where did the water that fogged up the glass come from?

- The students interpret their observations and outline explanations.

Figure 2. The misty glass

The first explanations suggested by the students seem to contemplate the idea that the water droplets that appeared on the outside of the glass came from inside of it. Others reject this possibility, stating that the

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liquid water came from the water vapour contained in the air of the classroom: "I think it's the water on the outside, in the gaseous state, that touches the glass and fogs it up"; "I think there has to be water in the gaseous state and something cold" (Pedro).

Subsequent answers, influenced by the preceding ones, show an increasing level of mental elaboration; "Oh, I know! The water in the gaseous state that floats around in the air hits the glass, which is cold, and the moisture that water leaves becomes noticeable". There are also those who relate the present situation to what happened in the previous one, in which they breathed against the mirror: "So it's like the mirror! The air we breathed out touched the mirror, which was a bit cold and it got fogged up".

C_6*. *What do you think is necessary for condensation to occur?

- The students infer what the two condensation contexts have in common. Excerpt from the class diary:

"There has to be something cold" (Carolina). "The air in the room is warmer and the glass with iced water got cold, which created moisture" (Rafael). Diogo goes further and states that: "There has to be water in the air and a slightly colder place." All the students seem to agree with their classmates' explanations and some rephrase: "We know that there is water vapour here and we had the glass, which was very cold; then, when water vapour hit the glass, it turned into water in the liquid state" (Rodrigo); "There has to be a cold place that the water vapour touches and becomes liquid" (Guilherme). I refer to them that the passage from the gaseous state to the liquid state is called "condensation".

Students are encouraged to think about what was in common in the two condensation contexts – breathing against the mirror and the glass with iced water. Throughout this process, some of the students only refer the existence of a cold surface. Others, on the other hand, refer the simultaneous existence of water vapour and a cold surface that causes it to cool down. The term "condensation" is introduced, to put a name on the knowledge acquired.

- They transfer this learning to explain everyday situations. Excerpt from the class diary:

What happens to grass, sometimes, even though it did not rain?" - I ask. "It gets wet" (João). "It gets full of water droplets". (Rafael). "Why does that happen?" - I ask. "Because of low temperatures and water vapour" (Afonso). Why is it that, in the winter, we see a kind of "smoke" coming out of our mouths when we breathe, and the same does not happen in the summer? "Because in the winter, when we breathe out, our air is warmer and the temperature is colder, so that's why we see the "smoke" coming out" (Tatiana). "We only see it in the winter because of the temperature change; the air that comes out of our mouths is warm, and outside is very cold, which makes the water in the air pass from the gaseous state to the liquid state" (Rodrigo); "It's our warm breath that touches the cold air and changes to the liquid state" (João P.).

Without any major difficulties, the students mobilise the learning acquired in class and apply it to familiar everyday situations, which is revealing of the deep impact this learning had on them.

- They orally summarise the knowledge acquired. Excerpt from the class diary:

We had "a glass of water and we put ice in it so the glass would get cold. Then, the glass started getting misty on the outside, because the water that exists in the air of the room, in the gaseous state, touched the glass and changed to the liquid state "(Ana M.); "This is called condensation" (Rodrigo); "Then we breathed against a mirror. As the air coming from our mouth was warm and the mirror was colder, the mirror got fogged up" (Carolina).

4.2. Assessment of the student's learning

Three weeks after the class, two questions about water condensation were included in an assessment test. The following table presents the learning outcomes achieved in those questions:

Questions	Answers marked
1. Is there water, in any form, in the air of the classroom?	
a) Yes, there is always water vapour in the classroom.	21 (87.5%)
b) No, there is only water vapour in the air of the classroom when it rains.	2 (8.3%)
c) No, there is only water vapour in the air of the classroom when it is cold.	1 (4.2%)
Total	24 (100%)
2. For condensation to occur:	
a) It must be sunny.	1 (4.2%)
b) The water vapour needs to be cooled.	19 (79.2%)
c) The water vapour needs to be heated.	4 (16.6%)
Total	24 (100%)

Table 2. Scores obtained in two questions included in an assessment test

5. Final considerations

The data contained in the class diary takes on the nature of a sample of the learning acquired by the children, not allowing for any illations about the degree of individual learning achieved by each one. However, the combination of that learning with the data obtained in the two individual assessment questions shows that most of the children in the class acquired a solid knowledge about the phenomenon of water condensation. According to Coll and Martín [17], an evaluation that is based on the consideration of an instant situation is unreliable, as it does not take into account the dynamic nature or the temporal dimension of the meaning construction process. In this sense, the results obtained in the two individual assessment questions, three weeks after the lesson, also allow claiming that this learning was significant, as opposed to memorisation, which is quickly forgotten.
The construction of this knowledge started from the children's own initial ideas and their identification was an integral part of the teaching-learning process. The analysis of the class diary shows that most of the children consider that: a) water that evaporates only returns to the Earth's surface in the liquid state, i.e., as rain. Generally, they do not contemplate the possibility of solid precipitation, such as snow or hail; b) there is no invisible water – water vapour – in the air of the classroom. The children's difficulty in accepting that the air around us contains water vapour is, according to Sá [3], a major obstacle to their understanding of the phenomenon of condensation. According to the author, this difficulty lies in the fact that, when

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questioned about where water goes when it evaporates, the children rarely mention the air and, instead, state quite often that the water goes to the clouds. According to the children's explanation, there is no change in the physical state, as water in the clouds is already in the liquid state; c) the formation of water droplets on the outside of the glass is related to the presence of the iced water in it. Regarding this aspect, the ideas of some of the children seem to admit the possibility of those water droplets coming from the inside of the glass.

In the development of new ideas that are more consistent with reality, it is essential that the children take on an active and reflective role. In the present case, we can see that the children: a) communicate and discuss their ideas and personal theories with each other and with the teacher, both in small and in large group contexts; b) make predictions about what will happen when they put ice cubes in a glass with water and when they breathe against a mirror; c) test their predictions and produce evidence; d) interpret observations and construct explanatory theories based on the evidence obtained; e) reflect on their theories, in order to assess their conformity with evidence; f) construct theories that are more consistent with evidence; g) relate different observations in order to identify the phenomenon of condensation in the various contexts and conditions in which it occurs; h) transfer the learning to explain everyday situations in which the phenomenon of condensation occurs; and i) orally summarise the knowledge acquired.

The observation that the glass containing iced water becomes misty and the consequent discussion and critical assessment of the theories proposed to explain that observation constitute key moments in the development of the concept of water condensation. The quality of the concept is further enhanced by the experiment in which they breathe against the mirror, which led the students to conclude that what was in common between the two experiments was: a) a cold surface in contact with air containing water vapour; and b) the observation of the forming of water droplets on that surface.

However this entire process, as advocated by Sá [3] and Harlen [18, 2], entails great personal and intellectual involvement by the children and is closely dependent on an intervention intentionally guided by the teacher, which aims at promoting in them both the construction of meanings that are more consistent with reality and the development of scientific process skills. In this sense, the teacher plays a key role. The teacher, through a process of questioning that stimulates the children's thoughts and actions [3], supports their individual and collective cognitive activity [19, 20]. Through this process of questioning [20] guided by the teacher, students are able to reach higher levels of comprehension and develop better reasoning skills, which they would not be able to achieve without support.

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Creativity in Early Science Education. A Case Study

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Abstract. *The importance of creativity in education is recognized and is mentioned in Portuguese educational policy documents.*
The need and importance of science education to foster students' creativity was the main driving point of this study.
This qualitative study aims to reveal the potential for creativity and the role of Inquiry Based Science Education in preschool and early primary education.
The fieldwork was documented by the use of sequential digital images capturing detailed interactions; field notes supplemented by audio recording later transcribed; and an overall timeline.
This communication presents a set of data analysis in relation to one case -application of one hands-on IBSE activity in one classroom. The case study herein reported contains different episodes, documenting examples of mathematics learning through the lens of creativity.

Keywords. Creativity, IBSE, primary school, science teaching.

1. Introduction

In a world lead by technological innovations, creativity is a critical component; human skills and people's powers of creativity and imagination are key resources in a knowledge driven economy [1].

Creativity is not restricted to special people or to particular arts based activities, nor is it undisciplined play, it is however, particularly difficult to define. It has been defined as "*a state of mind in which all our intelligences are working together*"…involving *"seeing, thinking and innovating"* [2].

And isn't science all about reasoning? Yes and no, because proving something requires logic, but first of all someone has to have an idea.

In the context of the classroom, developing opportunities for children to *"possibility think"* their way forwards is consequently critical. This will involve engaging the class in an issue or subject and helping them ask questions, take risks, be imaginative and playfully explore options as well as innovate [3].

"Creative teaching is a collaborative enterprise which capitalises on the unexpected and variously involves engagement, reflection and transformation, patterned at such a rate as to invite and encourage a questioning stance and motivate self-directed learning. Creative learning involves asking questions, exploring options and generating and appraising ideas" [4].

This investigation was carried out in the context of a master thesis about creativity in the teaching/learning of sciences, from preschool to primary school, and we present the outcomes from a specific case among all the case studies. The case study reported contains three narrative episodes, documenting examples of mathematics through the lens of creativity.

A narrative episode in this case was defined as a written narrative account that describes an event or series of connected events but which forms a coherent story by itself. In this

study, the episodes will illustrate creativity in science and/or mathematics in the early years. These were drawn from selected observations and supported by information gathered through several types of data.
The findings of this qualitative study aim to reveal the potential for creativity and the role of inquiry in the classroom realities of primary science and mathematics education. Seeking to find children creativity in maths at this level, a primary school class was challenged to solve three tasks.

2. Instruments and methodology

2.1. Instruments

From a wider range of instruments used to record and to analyse the data collected, in this case we report only on the field notes [5], photographs [6] and the interviews made both to the teacher [7] and to some of the children [8] in the end of the lesson observed.

2.2. Methodology

The objective of the observation during this activity is to illustrate at least three episodes of children creativity [9].
The notes taken include a timeline along which the observer records the development of the activity: the teacher's actions and speech, the children's interventions and comments, the actions taken and the events happened.
The latter processing of these field notes from different observers, together with the pictures taken, enables to better identify and to characterize the quested creativity episodes.

The interviews include the observation by the teacher and the children of a sequence of pictures relative to one or more moments identified as having creativity.

3. Characterization of the class

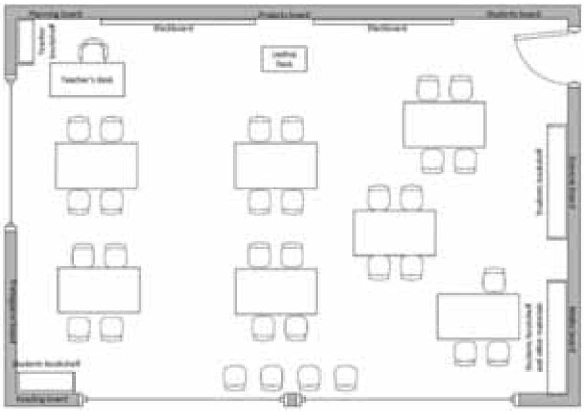

Figure 1. Classroom map

The school, placed in Braga, in northern Portugal, is a private education educational catholic institution covering four levels of education: preschool, primary school, 2nd and 3rd level of basic education; the students in a total of 600, are aged between three to fifteen years old. The class in this case has twenty seven students (seventeen boys and ten girls), with average age of 8 years old.
The classroom is wide with perfectly identified functional areas capable with suitable materials (Fig.1).

4. Narrative episodes

4.1. Wolf, sheep and cabbage

The aim of the problem was to move the wolf, sheep and cabbage to the opposite

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shore of the river. It got more difficult though because when the man was not around the wolf would eat the sheep, the sheep would also do the same when alone with the cabbage. This involves the use of knowledge of food chains to solve the problem – analysing possibilities and predicting if there is more than one solution.

The teacher introduced the well-known problem 'Wolf, Sheep and Cabbage' on the blackboard, and explained the rules of the game to the children. The children had to carry the wolf, sheep and cabbage on a boat from one side of the river to the other, one by one. The conditions were that 1) if the wolf is left alone with the sheep, it will eat the sheep; 2) if the sheep is left alone with the cabbage, it will eat the cabbage; and 3) the wolf will not eat the sheep and the sheep will not eat the cabbage if the farmer, who is sitting in the boat, is right nearby to side of the river that they are on.

Using the paper cut-out models of the wolf, sheep and cabbage that the children had made and painted previously, and an origami boat that they created at the start of the game, they were encouraged to work in groups to solve the problem.

Throughout the activity, the children collaborated with their peers to think of different possibilities; to try out the different potential solutions; and to give reasons why certain ideas would not work.

The whole class reached conclusions and solved the problem presented in the beginning, and had the opportunity to verify their solutions against the online version of the game, which is available freely on several websites. The uses of ICT allowed the children to experience and represent the same problem in different ways.

Opportunities for creativity

The context of the game provoked children's imagination and the informal and fun nature of the task motivated the children to become engaged in the problem. Working in groups encouraged children to articulate their ideas and reasoning. Children collaborated in sharing and discussing different ways to solve the problem.

Children's problem solving skills were fostered as they suggested and modelled different potential solutions and gave reasons why certain ideas work or would not work. Children used and developed science skills such as predicting, observing, analysing and describing, demonstrating scientific or mathematical creativity in generating alternative ideas and strategies and reasoning critically between them. They also had to make connections between the combinatorial / mathematical aspect of the task and their knowledge of food chains.

Illustrative extracts from data

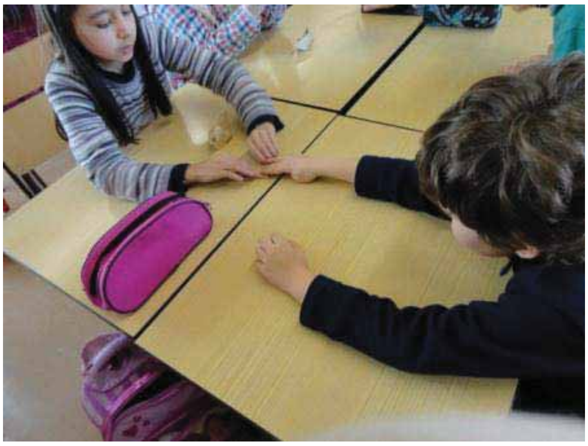

Figure 2. An example of children collaborating and giving reasons

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Figure 3. Examples of children explaining why certain ideas would work and would not work

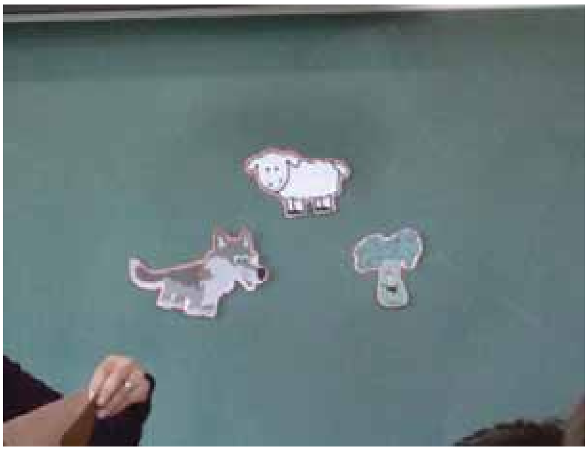

Figure 4. The informal and fun nature of the task helped in engaging children

Child L: *The sheep eats the cabbage.*
Child R: *The sheep has to go first because the wolf doesn't eat the cabbage.*
Child R: *If we took the sheep first, then the cabbage, then the sheep will eat the cabbage.*
Child R: *So we have to leave the sheep and bring the cabbage back.*
Child R: *If we took the cabbage in first place, the wolf will eat the sheep.* (…)
Child G: *First we take the sheep across, then we go back and get the cabbage, then we take the sheep back and take the wolf across, then we take the sheep across*

Reflecting on learning

Child LA: *With this activity we learned that to solve a problem we have to make relationship between what we are 'analysing'.*

Figure 5. The integration of ICT for children to verify their solution

4.2. Buttons episode

The aim of the problem was to transform a triangle formed by buttons in a hexagon, just moving two of the buttons of the initial form. Mainly maths sciences were present. Students have to: know geometric plan forms like triangle and hexagon; apply mathematics in practical situations including translation of objects and (plan) geometry – recognizing geometric forms (triangle and

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hexagon); problem solving – analysing possibilities and predict if there was more than one solution.

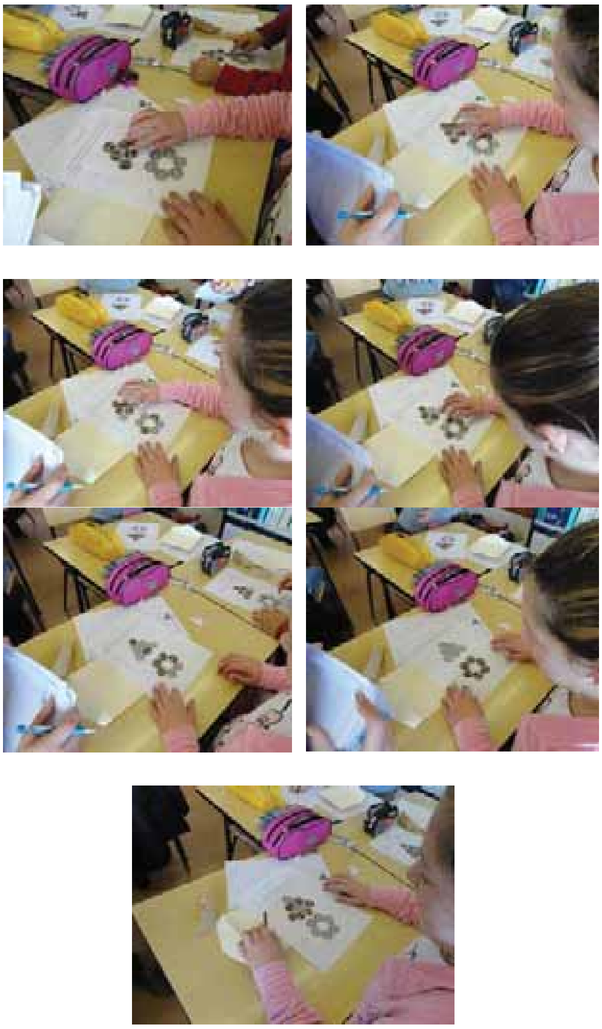

Figure 6. Sequence of the child steps to solve the problem with an alternative approach

There were a number of different areas of learning that the students were aiming to foster during the lesson – both scientific and non-scientific, like: develop read and interpret the problem; identify the rules and constraints; predict/anticipate results based on constraints; using the process of trial and error; discover the possibilities and impossibilities; share and justify inferences; interact within the group and between groups.

Opportunities for Creativity

One of the students suggested a different approach to the problem which consists in moving all the buttons to similar positions, between the two pictures, and in doing so she realized that only two buttons didn't have a correspondence in the hexagon figure, so she figured out that she would have to move those two buttons. Although the student hasn't solved the problem following the rules, her approach also shows some creativity, because she used imagination and innovative thinking. We see her doing what the activity is set up to do in terms of fostering the mathematical and scientific creativity. This example seems to be a case of a child generating everyday creativity through an inquiry meaningful to herself and generating original valuable outcomes.

Illustrative extracts from data

4.3. Marbles episode

The aim of the problem was to solve one worksheet focused on maths, reasoning. This worksheet was focused in concrete problems that were proposed for the students to solve. Mainly the contents in it focused arithmetic progressions, combinatory, set maths questions, and

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problem solving. There were a number of different areas of learning that the students were developing during the lesson – both scientific and non-scientific, like: develop read and interpret the problem; identify the rules and constraints; predict /anticipate results based on constraints; discover the possibilities and impossibilities; share and justify inferences; interact within the group and between groups.

The teacher introduced the problem: "*There are three types of marbles: normal, black and dampers, which are larger. Peter has a large collection of marbles: each damper has four normal and two black marbles. Knowing he has 14 black marbles, how many will be the others? And how many marbles has in total?"*

Opportunities for Creativity

This activity that appears to be a more routine exercise of maths skills of the students seemed to be one of the best examples of creativity during problem solving. During the activity it was registered a diversity of approaches to the problem, as shown by the worksheets collected from the students (Fig. 7, Fig. 8, Fig. 9 and Fig. 10).

All the students suggested their way of presenting the solution to the problem/question. Interestingly, some students used a formal analytical approach, and others use schematic approach, mainly, using (coloured) draws, showing multiple problem solving skills.

Using different methods all children reached the correct answer, despite the different approaches. This is a good example of mathematic and scientific creativity. The "correct answer" needed to be reached however children found their own ways to it.

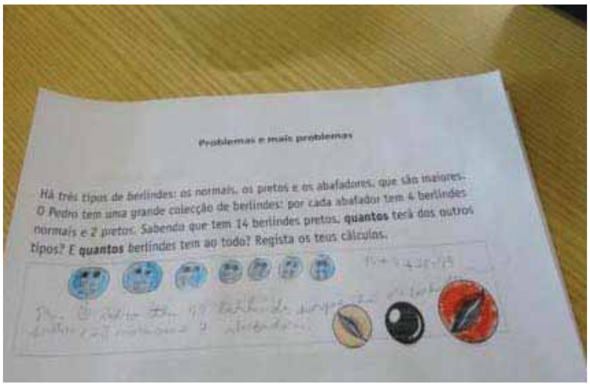

Figure 7. Schematic approach, mainly, using (coloured) draws

Illustrative extracts from data

Example 1

Child R: *I´m going to make some drawings… with the marbles on.*
Child A: *I´m trying that way too.*

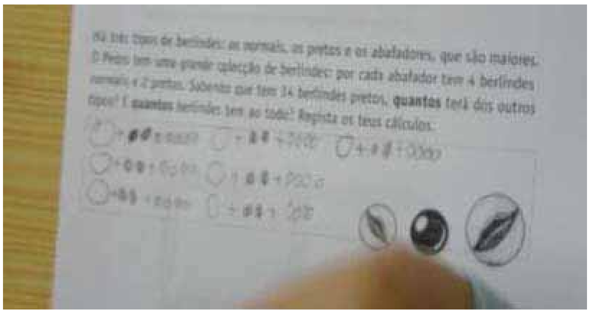

Figure 8. Schematic approach, mainly, using draws

Example 2

Child M: *I make some proportions, regarding all the marbles involved in the situation, like this: 1 marble damper, 2 black marble, 4 white marble, so next, 2 marble*

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damper, 4 black marble, 8 white marble, and so on until we reach 7 marble dumpers. Then we count all the marbles we need.

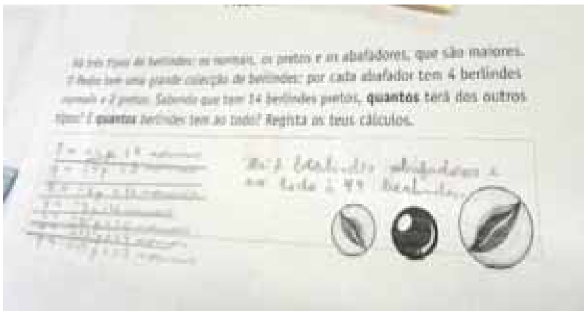

Figure 9. Formal analytical approach

Example 3

Child P: *The first marble damper has 4 white marbles and 2 black marbles, the second marble damper has 4 white marbles and two black marbles…the seventh marble damper has 4 white marbles and 2 black marbles. If we count all of it, there are 49 total.*

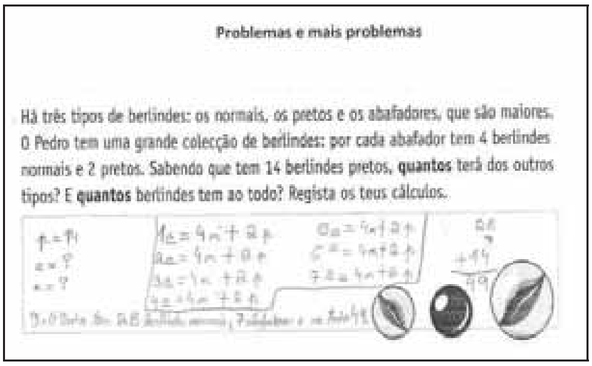

Figure 10. Formal analytical approach

There were many different approaches among the students, from schematic resolutions to analytical resolutions, which showed different approaches to the same problem, and creative dispositions such as problem solving skills, reasoning skills and connections making.

5. Summary and conclusions

The teacher initiated activities promoting the interest and curiosity of students, presenting problematic situations and discussing with students initially.

During the activities, the teacher was always careful to guide students in their learning and guiding them to a way forward, not invalidating the trials and errors of students in order to solve the problem. The teacher has many years of experience, which means she is very sensitive as to when to guide. She fosters reflection and reasoning, encouraging students.

These three episodes showed creativity through the encouragement of problem-solving and children's agency.

Teacher prepares her activity depending on students' interests, not forgetting the national curriculum and student achievement, looking to find activities that promote students' interest in mathematics and science and creativity.

Teaching approaches appear to provide children with a "starting point" from which they can ask questions, experiment, observe phenomenon and so on, mainly teacher provides guidance so the students can achieve the purpose of the activities proposed and building their network of knowledge. As noted, teacher has the ability to foster creativity.

Opportunities for the generation of ideas, for example, were fostered by rich motivating contexts for play and exploration.

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Dialogue and collaboration, fostered by use of group work and teacher questioning, played important roles in encouraging the processes of reflection and explanation. The potential of sensitive teacher scaffolding to extend inquiry was emphasized, particularly in relation to when to mediate and when to stand back in order to listen to and build upon children's creative engagement and the development of their ideas and questions. Across the episodes there were many examples of children observing and making connections. The teacher made reference to the importance of encouraging and supporting children's engagement in early years science and mathematics as an important starting point for learning. Also emphasised the need to foster motivation and collaboration and provide a rich environment with space and time for exploration and problem-based learning, underlining key role for teacher in encouraging reflection and making connections to promote children's conceptual understanding and the application of ideas.

As the teacher referred in the interview: *"creativity is important, because how more creative students are, more motivated they feel",* because she considers the fact that they can discover multiple paths to get to the result, gives them a great joy and takes them to get excited fostering the interest in these disciplines (maths and sciences). Teacher finds this relation between creativity, mathematics and science very important.

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Realistic Model-Eliciting Activities Based on IBSE. An Experience to Repeat

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Abstract. *This paper aims to illustrate how teachers can implement mathematical modelling activities in classroom using hands-on mathematical experiments based on Inquiry Based Science Education (IBSE).*
Ciência Viva de Tavira Centre promotes an in-service training course where teachers (from preschool to secondary level) learn how to experiment, create and apply Realistic Model-Eliciting Activities (RMEAs) in classroom.
During the first training course teachers developed related activities in class with students and the result was an increase in students' performance, motivation and understanding how mathematics is used in their daily lives.

Keywords. IBSE, Hands-on mathematical modelling activities.

1. Introduction

Students have little motivation for learning mathematics and frequently question its practical application. In order to solve this problem, efficient strategies to bridge school mathematics and the "real" world must be used. This, together with the need of translating real situations into mathematical language, developing reasoning and communication skills and detecting the hidden mathematics in objects or situations from real world, has promoted the use of Realistic Model-Eliciting Activities (RMEAs) in classroom. From these, hands-on mathematical experiments related with daily life activities can largely improve students' interest and the learning processes [3, 5].

2. Hands-on in IBSE

According to the recent theoretical approaches in mathematical education, there is a tendency to use less talk and chalk towards an increased use of lively programs based on several sources of information. This opens new windows to the students as individuals or as groups [2].
This live program can and should include challenges using real objects or instruments, situations of day-to-day or recent events. The day-to-day objects can be used, as they can be regarded as real-world applications of mathematics [2]. This promotes curiosity and motivation in students for the development of activities through real images, and increases awareness making visible the hidden mathematics [6].
In such activities, it is important that students really understand what they are learning, rather than just memorizing content and information.
Students need to directly experience the studied phenomena as this is essential to the understanding of concepts, given that children understand the world based on their own experiences [4]. Knowledge about the phenomena investigated must be acquired through self-exploration and reflection; furthermore, it is also essential that students are able of communicating the results obtained.

For children to engage in a research activity there must exist a prior understanding of the underlying issue/problem. In this regard, it is essential that the initial question has meaning to the student.
With activities based on IBSE, students are expected to develop different skills, such as making observations, raising questions, making predictions, outlining research, analysing data, and arguing their points of view based on the data and information available [7].
When performing activities based on IBSE, some aspects must be considered: the classroom must be prepared to allow access to the materials and the space should be adjusted to the activities. Students have to feel good and participate in all stages of the activity, from the hands-on part to the reflection, dialogue and written report.
The problem under investigation needs to be meaningful for the student, so that he or she has the desire to solve it.
The activity must begin with a discussion in class to clarify issues that arise and to identify the elements of the phenomena that are important to the study.
Group discussions help students clarifying their ideas, listening and respecting the others and reaching conclusions together. In this process, the teacher works a facilitator in the search for answers, by questioning the students without giving immediately the answers.

3. RMEA'S

Ciência Viva de Tavira Centre promotes an in-service training course where teachers from preschool to secondary level learn how to experiment, create and apply Realistic Model-Eliciting Activities (RMEAs) in classroom.
In the first edition of this course, all the worked activities were anchored to a real situation, known to students, where mathematics was not visible at first sight. With the development of the activity, the students had contact with the hidden mathematics, broadening their knowledge to solve problems of day-to-day life. The modelling activities used promote the development of three large skills in learning mathematics: problem solving, mathematical reasoning and mathematical communication.
The activities were presented to the students in three parts. First, a small text contextualizing the whole situation and describing the real situation, focus the students in a particular environment. In the second part of the activity, entitled "From experience...", the students collect and register specific data related to the situation under study, by building and/or manipulating physical objects. In the third part "... the model", the students are instructed to obtain a formal mathematical model (generalization) for the specific situation. Then, they relate the collected data and have to discover a formal relationship between the variables under study, in order to find a solution to the initial problem.
Finally, the students need to report the explanation of the experimental situation, the assumptions made, the operation performed, the results obtained, the evaluation of the proposed work and the difficulties experienced during the activity. This report is conducted in the classroom and completed at home if necessary. Despite the advantages of these methods, there are difficulties in introducing activities in realistic mathematics education.

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Claudi Alsina [1] points out that one of the main difficulties is the fact that the teachers are sometimes unable to overcome the doubts and problems that arise during the activity, and are reluctant to find alternative solutions.

Another problem can be the age level of the students as the activities provided must fit their interests [4].

Perhaps one of the biggest problems in the implementation of such activities is still a problem of time management. Agenda impediments are often justified with the fulfilment of the curricular programs.

However, from the experiment carried out, a possible solution that can be proposed is to adjust the activities to curricular contents, bearing in mind that carrying out these activities is an opportunity for the pupils to develop skills and competencies that would otherwise be absent from their mathematics education.

4. An example: Well Construction

This activity was adapted for the second grade of primary school (7 - 8 years old children).

The situation: A toy factory wants to launch a new kit for building a well, with a precise number of bricks in each box.

The main purpose: students were challenged to find how many bricks would be necessary to construct a well with specific measures.

In the first part of the activity, the students constructed the bricks with specific measures, by using plasticine (Fig. 1); these were then glued on a cardboard with a specific perimeter (Fig. 2), in order to build a well.

Then they answered some questions based on the analyses of the constructed well. The challenges were: i) to calculate the number of bricks necessary to double the height of the existing well and ii) to indicate the mathematical relationship between the brick dimension and the well perimeter and height.

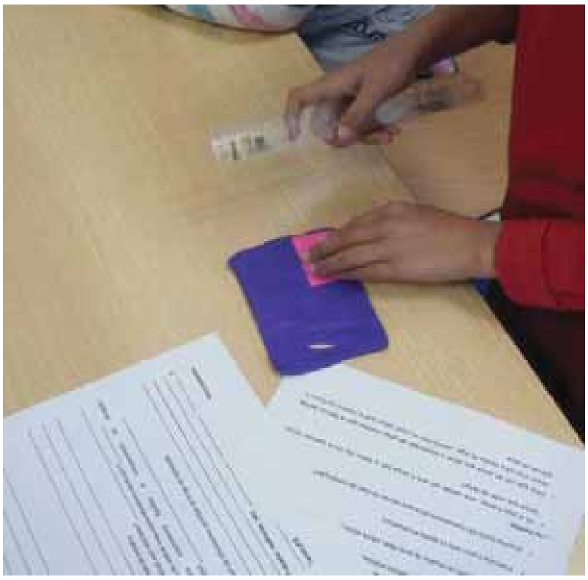

Figure 1. Constructing the bricks using plasticine

5. Conclusions

The activities presented to the students encourage and reinforce learning specific skills and knowledge of the subject, illustrating various concepts which, by their level of abstraction, could be more difficult to assimilate by the students. RMEAs are also useful to visualizing the contents in a more practical way, offering an exciting alternative to the traditional master session.

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Figure 2. Gluing the bricks on the cardboard

According to the teachers' reflection, this type of practice has some advantages for the development of important learning skills (problem solving, mathematical reasoning and communication), allowing students to extend their mathematical knowledge and to become participatory and critical individuals. During the activity, a strong interest and motivation was revealed by all the students, including those that usually don't collaborate in class.

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A Study of Integrated Metacognitive Strategy into Modeling-Based Inquiry Teaching

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Abstract. The *purpose of this research was to explore the effects of integrated metacognitive strategy into modeling-based inquiry teaching (MIT) for elementary school students.*
This research analyzed the effects of integrated metacognitive strategy into MIT and compared with their related characteristics as the reference of refining the teaching of science and technology. The participants of this research were made up of sixty five 5th grade students. The 30 students were in the experimental group, had received the teaching method integrated the metacognitive strategy, the 25 students were in the control group, had only received modeling-based inquiry teaching. These two groups had been taught the same teaching units, including Electrostatic, Thermal expansion, Atmospheric pressure and Light reflection.
In quantitative aspect, this research compared the abilities of modeling-based inquiry among each unit with analysis of repeated measures and use ANCOVA to analyze the effectiveness of learning between the two groups. According to the research result, students who had adopted metacognition strategy showed better abilities of modeling-based inquiry than students' in the control group only at the unit 4.

Keywords. Modeling ability, metacognitive strategy, modeling-based inquiry, transfer of learning.

1. Introduction

Scientific exploration requires a large number of thinking skills; however, scientific thinking is so abstract that students need explicit teaching to help them to learn science thinking strategy. Scientific model, the key to understanding the natural world, is an application between theory and concept. Over the past decade, models and modeling have gradually been recognized as an important approach to science learning objectives [1].
The research points out that one of the critical approaches is the scientific modeling to achieve the goal of science learning [2]. [1] Report indicates that models have many forms, including physical objects, plans, mental constructions, mathematical equations and computer simulations.
Modeling is a kind of inquiry and modeling learning which enables students to share their models and their perspectives. Nowadays science education focuses on scientific inquiry frequently; teachers commonly use models to explain ideas to students. However, for elementary school students, this method has yet to be developed and verified. The research indicated [3] that modeling-based inquiry teaching (MIT) should pay attention to teachers' guidance in the interpretation and communication phase, therefore, it is recommended that new research can further

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explore the integrated another science thinking strategy to enhance the effectiveness of learning transfer of modeling.

In summary, the purpose of this research is to explore the effects of IMSMIT (integrated metacognitive strategy into modeling-based inquiry teaching) mode for elementary school students. Therefore, this study investigates the questions below:

- How effective are four learning units with IMSMIT mode?
- How effective are between IMSMIT mode and MIT mode?

2. Overview of MIT and IMSMIT

The MIT (Modeling-based Inquiry Teaching) mode is based on the framework of MCSI teaching mode [4], which includes four phases in the teaching, “Question & Analysis”, “Prediction & Experimentation”, “Explanation & Interaction” and “Synthesis & Application”. The modeling process can be integrating metacognitive strategy into MIT mode has become IMSMIT mode. This study modifies four stages (shown on the Fig.1.), including: 1. Plan. 2. Monitor. 3. Evaluate. 4. Manage own learning.

Metacognition is usually defined as "cognition about cognition". According to the research [5], 7-10 year-old students who have absorbed clear science thinking strategy, their inquiry abilities are better than students in implicit teaching. From the information, we can infer that teachers should make use of explicit teaching to improve learning effects when students learn science thinking strategy.

Furthermore, the establishment of modeling metacognition requires refraction, which is abstract as well. Thus, students need teachers’ assistance to learn modeling metacognitive skill.

Explicit teaching is also known as direct instruction. In regard to the foundation of psychology, explicit teaching is a teaching strategy that doesn’t just adopt a theory of sect but combine the meaning of meaningful learning theory with information processing theory from Ausubel of behaviorism and cognitive psychology.

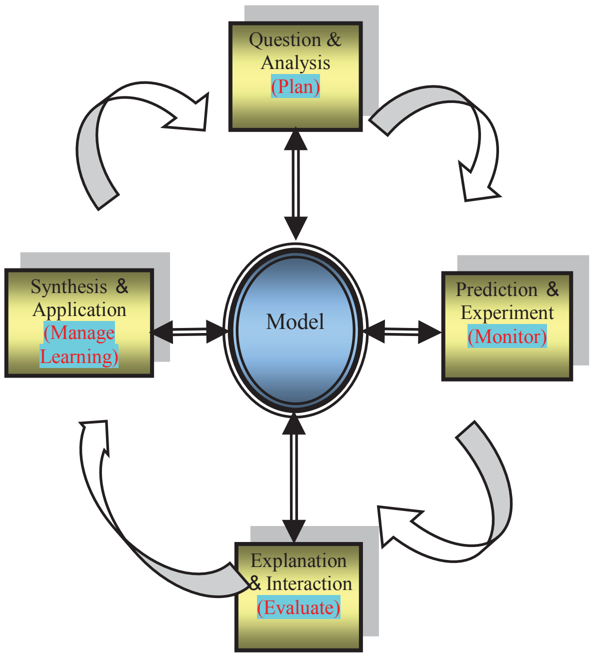

Figure 1. The framework of IMSMIT mode (modified from [3])

Scientific modeling combines two or more than two concepts and induce some relationships or patterns of knowledge. By doing so, the learning combines theory and conception and cross new knowledge. This way of learning is “lateral transfer” [3].

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3. Research Method

3.1.Experimental Design and Analysis

The participants of this research were made up of fifty five 5th grade students. The 30 students in the experimental group had received the IMSMIT teaching method, the 25 students were in the control group, had only received MIT teaching method. These two groups had been taught the same teaching units, including electrostatic, thermal expansion, light reflection and atmospheric pressure. Both two classes were taught by the same teacher who is an elementary school science teacher more than 30 years. By the way, he has a doctorate in science education and has published two papers about models and modeling, well versed in science teaching, as well as in the teaching mode had good communication with researcher. The real experimental design, nevertheless, is difficult in this experiment. Thus, we use quasi-experimental design in this experiment. In order to make a comparison of the modeling-based inquiry ability between experimental group and control group, we use analysis of covariance (ANCOVA). We take the grade of unit one which hasn't adopted metacognition strategy as covariate. It abides by the elementary assumption of analysis of ANCOVA, inclusive of normality, independence and homogeneity of variance. We make a further analysis, after we accomplish the homogeneity of with-in regression test.

3.2. Research Tools

In order to finish the purposes and answered the questions, this research developed and utilized some tools including, learning sheet and modeling ability Analytic Index.

3.2.1. Learning Sheet Development and Metacognitive Strategy

Metacognitive Strategy	Strategy Description
Plan ↓ Monitor ↓ Evaluate ↓ Manage	a. Set goals. Plan the task or content sequence. b. Check your progress on the task. c. Assess how well you have accomplished the learning task. Assess how well you have used learning strategies. Decide how effective the strategies were. d. Determine how you learn best. Arrange conditions that help you learn.

Figure 2. Framework of integrated metacognitive strategy and summary of learning sheet

Learning sheet can guide the students have a clear tasks and the students are asked to complete their learning tasks based on a printed learning sheet after listening to the teachers' instructions. But it cannot cause the imagination and creativity restrictions, to students drawing can lead to students' ideas, as well as the mental model. Finally, the establishment of an analysis of indicators, the MIT can based on the learn sheet to assess the effectiveness of learning. In addition, the study designs open-ended questions, which will allow students to follow the metacognitive strategies for plan, monitor, evaluate and management. The learning sheet of integrated metacognitive strategy was shown on the Fig. 2.

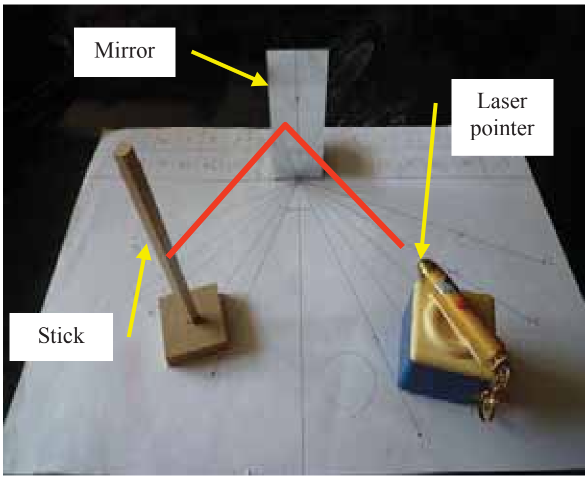

Figure 3. The experimental material and operating processes (Light reflection)

a) Drawing lines with different angles on a piece of paper and fixed the mirror's position on it.
b) A laser pointer stuck on a square box, and two diagonal lines exactly aligned above.
c) One student operated the laser pointer, shot the light to the mirror, and the other student moved the stick to find out the lighting point of reflection from the mirror.
d) At the same time, students could measure and record angles of laser light and compare the relationship between the angle of incidence and the angle of reflection.

Checking the Summary of Learning Sheet:

Predict the result of the experiment (Set goals). Write down (Plan):

a) Predicted
b) Because
c) After being the experiment, record the phenomenon. Moreover, compare (Check) the phenomenon students observed in the experiment with the prediction at question number one, and illustrate opinion in each term.
d) After discussing with teammates (Assess) and being guided by the teacher.
e) Explain the phenomenon of the reflection from the mirror? Explain and illustrate the relation between angle of incidence and reflection. How to (Arrange) conditions that help students learn.

3.2.2. Modeling ability analytic index

In order to assess elementary school students' modeling abilities, we must consider the ability of students, the levels of the Analytic Index cannot be too much. So, reference scholars define the Modeling Ability Analytic Index [3], and decided five levels in each modeling process.
The elementary school students Modeling Abilities Analytic Index separate into 5 levels then based on the 5-point Likert Scale to set up the Analytic Index shown in the table [3]. Waiting for the completion of each unit and according to the Analytic Index table, the two experts begin to assess the learning sheet.

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4. Research Result and Discussion

To answer the research problems, in the first phase, the researcher analyzed the effects of IMSMIT. In the second phase, the researcher compared the different learning effects with the experimental and control group.

4.1. IMSMIT Modeling Ability Learning Transfer

In the beginning, to explore the modeling ability and analyze learning effect within the different units of IMSMIT mode, we adopt one-way analysis of variance in dependent samples, which means using repeated measures options. The summary of statistics was shown on the Table 1. The F=4.942 and p=.003 <.01, it has reached the statistical significance.

Source	Sum of Squares	df	Mean Square	F	Sig.	Post Comparison
Intercept	27.300	3	9.100	4.942	.003**	U 3> U 1, U 4> U 1 U 4> U 2.
Error	188.467	29	6.499			

** p<.01, U=Unit

Table 1. Summary of modeling ability learning transfer

Next, the research analyzed the post comparison with LSD after it had reached the statistical significance. The results,

Unit 3> Unit 1, Unit 4> Unit 1 and Unit 4> Unit 2

showed that learning transfer of modeling abilities was slower. Although IMSMIT mode will not be effective immediately, it has made progress continually.

4.2. Comparison of Learning Effects

In order to make a comparison of learning effective between experimental group and control group, we make the score of the first unit as the covariate (pre-test) in the analysis of covariance (ANCOVA). After being tested by homogeneity of with-in regression, it obtained the F=0.361 and p=0.551 of tests of between-subjects effects and it didn't reach significance. Thus, it indicates that the experimental group and control group have homogeneity.
Moreover, we keep doing the ANCOVA to compare the learning effective of unit 2-4, than we got the diagram of the summary of ANCOVA. In the Table2, it was shown that the F=458 & F=2.956 at the unit 2 & 3 of in the ANCOVA. Besides, both of the experimental groups and control groups of the unit 2 & 3 do not reach significance. In the unit 4, F=4.722, p=.034 < .05, it was reach the statistical significance.

	F	Sig.		Partial Eta Squared
Unit 2	1.458	.233		.027
Unit 3	2.956	.091		.054
Unit 4	4.722	.034	*	.083

* P < .05

Table 2. The Summary of 2nd - 4th Units ANCOVA between Experimental and Control Groups

The consequence indicates that the score of unit 4 will be significantly different because of the different treatment. The partial eta squared merely 0.83, it was shown that the variance explained of the unit 4 only 8.3% and was belong to the lower of the learning effects.

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Based on the above analysis, the experimental group integrated into the modeling metacognitive strategy then students could learn plan, monitor, evaluate and manage their own learning. It means that student could facile the metacognitive knowledge and skill, than realize the skill of modeling-based inquiry gradually after they learn the fourth unit course. Though there was many researches point out the effect of metacognitive strategy is obvious, still some researches point that the learning effective progress slowly. For this research, we know the difference of learning effective after doing the four units.

5. Conclusions & Recommendations

5.1 Conclusions

The purpose of this research was to explore the characteristics of IMSMIT mode for elementary school students by analyzing the learning effects of modeling ability in IMSMIT mode and comparing the differential learning effects with the experimental and control group.

In terms of the learning effects of IMSMIT mode, the learning transfer of modeling abilities had reached some the statistical significance. Although IMSMIT mode will not be effective immediately, it has made progress continually.

In terms of comparison of learning effects between two groups, in this research, we found the difference of learning effectiveness after doing the four units. Such unsatisfying result represents the research of IMSMIT, it's worthy to be improved and advanced.

5.2. Recommendations

The IMSMIT mode, teachers need more patience through several units to familiarize students with metacognitive knowledge about cognition and regulation of cognition.

Teacher how to develop the learning sheet which include guide student following the metacognitive strategy in each modeling phases, therefore, it is recommended that new research can further explore the characteristics of integration to enhance the effectiveness of science learning.

6. Acknowledgements

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The Use of Computer Simulation as an Object of Investigation in Inquiry Based Teaching

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Abstract. *Investigative approach in physics teaching is very effective tool that gives students the opportunity to try their self procedures used by scientists in investigation of the real problems. The appropriate object of examination can be an interactive computer simulation. The simulation "My Solar System" developed in University of Colorado Boulder was used for this purpose. Students of grammar school were invited to examine this own "pocket universe". The program simulates movement of 2 – 4 gravitationally bound bodies. The students can measure position, velocity and mass of the bodies versus time. The students' results, their activities and obtained skills are described in this paper.*

Keywords. Physics teaching, investigative approach, computer simulation.

1. Introduction

In the last decades Slovak universities feel a decline of interest in engineering study. The cause is not just that these professions are under-appreciated (the most popular jobs are economics, management, law, medicine, etc.), but also in the fact that students have insufficient knowledge and competence in mathematics and physics, which are a necessary prerequisites for successful studying the engineering disciplines. Although the professional level of the best graduates of technological faculties has increased slightly, the average graduate has worse outcomes and competencies in comparison with state of twenty years ago.

To improve this situation, the Ministry of Education adopted in 2008 school reform, which aimed, inter alia, to achieve a greater degree of creativity of students and reduce memorizing encyclopedic data. According to reform, schools were given the opportunity to split some of the teaching hours between subjects in its discretion, divide the class into two groups for laboratory exercises, but, on the other hand, the number of teaching hours for mathematics and physics was significantly reduced. Till yet, in the most primary and secondary schools physics is taught by traditional methods. Modern, efficient methods of teaching are not very extending. Therefore, the issue of increasing the effectiveness of physics teaching is still very important.

Teaching method plays crucial role affecting students' motivation to learn physics. There are many innovative strategies for teaching physics and large number of publications confirms its effectiveness [1]. The fundamental difference between the traditional approach (teacher gives students ready knowledge, and they receive their passive) and modern methods lies in the fact that modern methods require students to work hard and think throughout the lesson because they have to obtain new knowledge alone, or under the guidance of a teacher. In the past decades several new approaches appeared, such as investigative science learning environment - ISLE [2] problem-based learning approach - PBL [3], research

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based learning method [4, 5], project based learning [6, 7], inquiry based teaching [8] scientific inquiry method [9] and other. All these new strategies are similar to each other - their common goal is to help students develop understanding of the nature of physics, to support their creative thinking and to deepen their understanding of concepts.

2. Computer simulation in teaching

Physics is an experimental science and therefore experiment play very important role in the teaching. Both, demonstration experiments as well as class experiments have to be an indispensable part of the teaching. However, sometimes can be helpful use a computer simulation instead of experiment. The advantage of computer simulation is that reasonably simplifies physical reality, draws attention to the essential characteristics of physical phenomena and allows visualization also of those phenomena, which is experimentally very difficult if not impossible to observe. A lot of research shows a high efficiency of the use of applets and computer simulation in the teaching [10, 11]. Interactive simulation allows students to change the parameters of the phenomenon and observe the changes brought about, and so better understand the nature of the phenomenon. Therefore, such simulations are very effective tools for inquiry-based teaching.

Investigative approach in physics teaching is very preferable way how to make physics more interesting and attractive. In this approach, the students should, under the guidance of a teacher, investigate some physical phenomenon. The teacher asks students questions and guides them on the path to solving the problem. The students observe investigated phenomena, analyzed them and looking for pattern. They should be able to choose suitable parameters describing the phenomenon and measure them. Then, if it is possible, evaluating dependencies between physical variables and formulate it mathematically.

Of course, such approach requires several conditions: Studied physical phenomenon must be relatively simple, the dependence between parameters must be easy to express mathematically. Necessary experimental apparatus must be relatively inexpensive and available in multiple exemplars, because students must work in small groups (2 – 3 person). Desirable that the apparatus could be easily modified and allow to simply change the parameters of the experiment, so that students can examine different aspects of the phenomenon. Because the financial resources and experimental facilities of schools are limited, we were looking for a way to dispense with expensive apparatuses.

Therefore, we proposed to use instead of the real experiment to work with computer simulation. The appropriate object of examination can be an interactive computer simulation “My Solar System” (MSS) developed in University of Colorado Boulder [12]. The simulation is freely accessible and each student can work with it at home on his PC. The program simulates movement of 2 – 4 gravitationally bound bodies in the XY plane. Program allows the user to set mass of the body (arbitrary positive number) place the body to a point of arbitrary coordinates x, y (only integer) and enter his initial velocity vector v_x, v_y (only integer). The clock shows actual time (Fig.1).

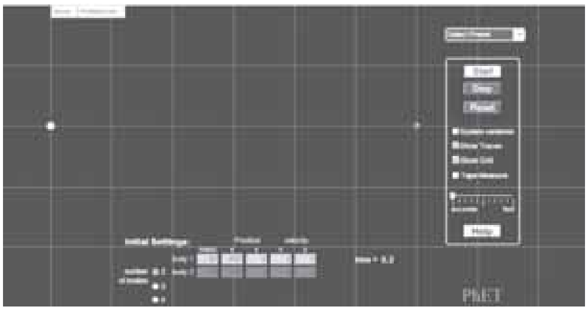

Figure 1. My Solar System

Simulation uses its own units; we named them 1T (tik) for time, 1L (lap) for length and 1M (mot) for mass. Button START run the motion and button STOP stop it. When START button is pressed again, it causes continuance of movement; button RESET returns the system to the initial state. When motion is stopped and cursor is put on the body position, program shows the coordinates and velocity components of the body. Similar to real experiment, these results are not absolutely precise. Accuracy of measurement of time, length and velocity is ±0.1 T, ±0.1 L and ±0.1 L/T respectively. Only mass we can know absolutely accurate. For the proper work with the program it is necessary to set off the SYSTEM CENTERED mode and set the calculation mode to ACCURATE.

3. Work with computer simulation “My Solar System”

The simulation MSS gives large possibility to work with students. There is a variety of tasks, from the simplest ones to complex tasks requiring independent investigative work of students. First of all, the students should be familiar with the program and learned to work with it. Students were encouraged to examine this own "pocket universe". In the next section we will describe briefly how it could look like teacher work with students of guided scientific inquiry.

The instructions were as follows: Imagine that you have just created the universe and you have chosen appropriate units of time, mass and length, so you can examine its properties. We will start with 2 bodies of similar mass (20 M and 10 M, or 20M and 30 M, 10 M and 50 M and so on). It is advantageous if each group of students will select a different combination of masses. Place the bodies on the x-axis, for example into the points (-400, 0) L and (100, 0) L. Initial velocity of both bodies should be zero. Start the program and observe the movement. Reset and start again. Start and stop the motion repeatedly and measure their velocity and position in various stages of movement. Write down intermediate values of time, velocity and position of both bodies. It is preferable to write it into Excel form. Find the position of a point where the bodies collide. How the ratio of the speed of bodies depends on their masses? Calculate (preferably in Excel) the distance traveled by each of the bodies and find how their ratio depends on the masses. The example of student’s results is shown in Tab.1.

Expected conclusion of students, formulated in words or formula is that the ratio of velocities is equal to the reciprocal ratio of their masses, i.e.

$$\frac{v_1}{v_2} = -\frac{m_2}{m_1} \qquad (1)$$

As a next step we will discuss students’ observations and conclusions. Edit the formula (1) so, that on the left side of the equation will be only variables related to the first body and on the right side related to the second body.

$$m_1 v_1 = - m_2 v_2 \quad (2)$$

t	0	6,9	10,9	13,6	15,3	16
m_1	50					
x_1	-400,0	-390,1	-373,5	-355,3	-334,4	-317,5
v_1	0	3	5,6	8,8	15,7	81,1
m_2	10					
x_2	100,0	50,6	-32,4	-123,4	-227,8	-312,5
v_2	0	-15	-27,9	-43,9	-78,4	-405,3
s_1	0	9,9	26,5	44,7	65,6	82,5
s_2	0	-49,4	-132,4	-223,4	-327,8	-412,5
s_1/s_2		-0,20	-0,20	-0,20	-0,20	-0,20
v_1/v_2		-0,20	-0,20	-0,20	-0,20	-0,20

Table 1. Measurement of velocities

Now we can define some physical quantity describing the movement of the body as a product of its velocity and mass – we name it momentum H = m.v. What is the physical meaning of equation (2)? At any point of time is the momentum of first body the same size but opposite direction as the momentum of second body. The sum of both momentums is zero all the time. Therefore, after collision the resulting body will have zero momentum, and, as a result zero velocity.
How will change the results of the experiment, when the initial velocity of the first body will not be zero, and will have, for example, value of $v_0 = 10$ L/T in x-axis direction? Trace the change in momentum over time. The results is

$$m_1 v_1 = m_1 v_0 - m_2 v_2 \quad (3)$$

So, step by step we will guide our students to the concept conservation of momentum, momentum as vector quantity and even to the concept of force and Newton's law of force. Why body changes its momentum? Because other body acts on it. We can define new physical quantity named force as a measure of acting of one body to other. Examine how quickly changes the momentum of the body. Repeat our first experiment with masses twice smaller. We can see that change of momentum is slower. Thus, it is reasonable to define force as a measure of change of momentum in time

$$F = \frac{\Delta H}{\Delta t} \quad (4)$$

The next situation, in which we can use MSS simulation, is measurement of acceleration and investigation how it depend on masses and mutual distance of bodies. Let choose the mass of first body m_1 = 0.001 M and second body m_2 = 100 M with initial velocities equal zero. As we know from first experiment, the velocity of second body will be 100 thousand times smaller than velocity of first one, and so we can neglect it. Second body will stay in its initial position. Place the first body into point (0, 0) L and second body into point (1000, 0) L. Run the program and stop it after few T. How we can measure initial acceleration of the first body? We expect that students know the formulas for uniformly accelerated motion and therefore they propose measuring of acceleration either from formula $s = ½ a. t^2$ or from formula $a = v/t$ (initial velocity is zero). Of course, it is necessary to discuss the precision of both methods. The students were encouraged to measure the initial acceleration of first body for various initial distances between both bodies (for example

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600 L, 800 L, 1000 L and so on). The example of student's results is shown in Tab.2.

x_2	t	x	v	a=v/t	a=2x/t²	R	a.R²
600	5,5	43	16,1	2,927	2,843	578	965542
800	7	38,8	11,3	1,614	1,584	781	974316
1000	8,9	40,5	9,2	1,034	1,023	980	986934
1200	10,5	38,3	7,4	0,705	0,695	1181	975769
1400	12,2	38,1	6,3	0,516	0,512	1381	980546
1600	17,4	59,5	7	0,402	0,393	1570	980541
1800	19,4	58,6	6,1	0,314	0,311	1771	981118
2000	21,9	60,8	5,6	0,256	0,254	1970	987767
2200	24,1	60,4	5,1	0,212	0,208	2170	987754
2400	25,6	57,3	4,5	0,176	0,175	2371	985897
2600	27,9	57,8	4,2	0,151	0,149	2571	988428
2800	29,6	56,4	3,8	0,128	0,129	2772	987718
3000	33,2	61,7	3,7	0,111	0,112	2969	984729

Table 2. Measurement of acceleration

Expected conclusion of students is that both method of the acceleration measurement give very similar values. Acceleration is proportional to mass of second body and inversely proportional to the square of its distance. Distance R between the bodies was calculated as an average value of initial and final distances, i.e. $R = x_2 - ½ x$. This dependence we can write by formula as

$$a_1 = G\frac{m_2}{R^2} \qquad (5)$$

where constant of proportionality G calculated from the last column of the Tab.2 has value $G = 9821\ L^3M^{-1}T^{-2}$. From this result we can easily deduce the gravitational law.

The simulation MSS gives us a lot of other possibilities for guided scientific inquiry. For example, from the values in Tab.1 we can calculate the kinetic energy of bodies and show, that sum of the kinetic energy depend on mutual distance of bodies as follows:

$$E_{kin} = E_0 + \frac{K}{R} \qquad (6)$$

where E_0 = -9906 ML^2T^{-2} and K = 4,978 x 10^6 ML^3T^{-2}. From this result we can easily obtain formula for potential energy in gravitational field and also gravitational constant.

4. Computer simulation as a testing tools

According to physics curricula for the grammar school, approved by Ministry of Education of Slovak Republic, the grammar school graduate should be able to formulate the problem in the form of questions that can be answered by experiment; to state a hypothesis; test the hypothesis experimentally in terms of control variables; plan a suitable experiment; suggest explaining consistent with the observation; analyse accuracy of measurement; indicate the validity of conclusions based on the number of observations; evaluate the full experiment, including the procedures used; transform the data presented from one form to another including mathematical calculations, graphs, tables.

In the framework of project KEGA we have tested ability of student to solve simple tasks on mechanics. The tasks were restricted on the 1D motion along X axis. Our research was conducted in several classes of grammar schools in Slovakia. The teachers provided us one teaching lesson for our

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work with their students. On the lesson, the students were familiar with the program and learn to work with it. Students were encouraged to examine this own "pocket universe".

The instructions were as follows: Imagine that you have just created the universe and you have chosen appropriate units of time, mass and length, so you can examine its properties.

Investigate the motion of two bodies lying on the x axis at a distance of 500 L from each other. Initial velocities both bodies are zero. Start and stop the motion repeatedly and measure their velocity and position in various stages of movement. How ratio of speeds depends on their masses? How ratio of distances traveled by each of the bodies depends on the masses?

The results were not very optimistic. The students were able to solve this task only with very intensive help of lecturer. On the other hand, amount of time for solving was very short (about 20-25 min). Students formulate right conclusion, but have not been able to justify it by calculations. We gave him also second task as home exercise. Time for solution was one week.

The second task was as follows: Suggest a way to measure the acceleration of the body. Make the analysis of accuracy of measurement and propose proper parameters of experiment. Investigate, how depends the acceleration of small body on mass of the big body and on their distance. Express this dependence by the mathematical formula and find the numerical value of constant in it. Use the MS Office Excell for the numerical calculations and eventually for graphs.

We hoped that second task would be solved more successfull because the students have enough time for solving. Our expectations have not been met. Nevertheless, since this task was optional, almost no one was willing to deal with it. Of course, our research deals only with small number of school and small part of students and we will continue it in future. Nevertheless, it indicates, that our grammar school students are not enough prepared for independent creative work.

5. Conclusions

Modern teaching methods are very effective way how teach science, especially physics more interesting and effectively. Investigative science learning and inquiry based teaching proved its ability to give students more complex knowledge and skills. The understanding of natural law is much deeper and more permanent than a traditional learning. Although the inquiry based teaching gives very good outcomes, most teachers use the traditional method of teaching. There are several reasons why the modern methods of learning are not frequently used.

1. Curricula require teachers take a large amount of material in a relatively small number of lessons. Therefore they have not enough time for active work with students
2. The teachers are not good paid and therefore most of them have a side jobs or extra lessons.
3. Teacher’s education is based on traditional teachings; they are not adequately prepared for modern learning methods

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Concepts or Context? Hands on Science in Early Learning, its Crucial Role. Understanding from the Pri-Sci-Net Project

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Abstract. *Working on the FP7 project Pri-Sci-Net has shown that experience using cognitive and kinaesthetic skills is essential in learning and understanding science in the observable everyday context. From their earliest years children are hands-on intuitive scientists observing thinking and trying out things and observing the results, hence collecting and evaluation data. Such observations and investigations occur in everyday contexts, often unasked and is verbalise through hidden questions resented an s statements. They are often observed during play, which is divisible into experimental investigative play and narratives, when they are working through a past experience imaginatively or interpreting a story they have heard.*
Hands on activities are essential in the learning of science in the early years the science explanation does not need to be given but the practical experience of the phenomenon inessential to further learning. At this age the foundations for observational and planning skills are laid as well as the process skills of manipulating items, collecting and evaluating such. Later in a child's formal science education such fundamental experiences provide them with an experiential foundation on which go construct the curriculum science required for examinations.

Keywords. Pri-Sci-Net, IBSE, preschool.

1. Introduction

Learning is socially constructed. Today, in the 21st century, there is an emphasis on interactive learning as well as the socio cultural aspects of learning. Dialogic talk (Alexander, 2008)[1] is encouraged rather than what we in England would term a didactic or declarative approach, talking facts at learners. Fleer (1992)[4] reminds us that constructivism places importance on determining the learners existing ideas.
Such pre knowledge, which is personal to each and very learner, is significant in influencing how children respond are able to make sense of what is given, transmitted to them, by teachers of any kind, indeed of non-formal teaching out of school, home, other venues and own observations are even more important. Driver et al. (1985)[3] wrote a seminal book used in many courses on the teaching and learning of science in. This book concerns secondary school children's ideas about a range of natural phenomena and how these ideas change and develop with teaching". Moreover Driver (1983)[2]. Fleer (1992)[4] observed that teaching engages in a 'handover' process and their support of the teacher or facilitator is gradually withdrawn as the learner gains confidence and skill at interpreting their own observations and ideas. Such development of confidence and understanding can be partially achieved by the effective use of questioning, particularly the 'throw back' technique, not telling the learner but asking/challenging their statements to

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encourage them to rethink, a type of cuing process (Chin, 2007)[1].

More recently other researchers have pointed out that children start experiencing science from their earliest years (e.g. Gopnik, 2008)[5]. These researchers have highlighted that the observations such learners make and how they made sense of them for themselves, through what they noticed, are influenced by their ideas and expectations, based on prior knowledge.

One of the issues amongst those working with learners in science is the difference between inference and observation. We need to teach both teachers and learners the critical difference between these two practices. An observation is information that someone gathers about an object or event using one or more of the senses, it can be quantitative or qualitative. Whereas an inference is a conclusion or explanation one makes about an object or event form what you already know and your own prejudices about the topic or situation. It is not evidentially based.

2. What is Scientific Inquiry?

What is Scientific Inquiry? It was defined by the USA National Research Council in 1996[8] as "the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Inquiry also refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world".

This document summarized scientific inquiry for essentially elementary or primary learners as

- Ask a question about objects, organisms, and events in the environment
- Plan and conduct a simple investigation
- Employ simple equipment and tools to gather data and extend senses
- Use data to construct a reasonable explanation
- Communicate investigations and explo-rations

Rather similar to the understanding which many of us in European share. Remembering that inquiry is not just a 'Fair test' (Turner, 2010)[12]. Unfortunately many primary teachers in England have regarded it as such. Where we regard scientific inquiry or Enquiry, as is the correct English when using the word in everyday contexts. However, many of us have adopted the use of the word, " Inquiry " as it is increasingly use d by organizations and funding bodies to indicate this approach to science whereby leaners raise, from observation, often combined with prior relevant knowledge, questions for which they then plan a strategy to answer their question. There are various levels of Inquiry from directed through guided to totally child lead. However, A Framework for K-12 Science Education.

I find it of interest that in the USA the National Academy[9] has produced a new initiative, Next Generation Science Standards' in which they purposely do not employ the term 'inquiry" (http://www7.nationalacademies.org/bose/Standards_Framework_Homepage.html

Indeed in their documents they refer to 3 dimensions, one of which, 'Practices' which merges skills and processes. They use the term "practices" instead of a term such as "skills" to emphasize that engaging in scientific investigation requires not only skill

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but also knowledge that is specific to each practice.
Secondly cross cutting concepts which reiterate many of the unifying concepts and processes that previous documents had emphases. Lastly the third dimension proposed is that of disciplinary core ideas which effectively strive to create through their school education, really scientific literate citizens and practitioners who leave formal school education… *"as science learners, users of scientific knowledge, and perhaps also as producers of such knowledge"*.

3. Hands-on interactive real experiences

Interactive experiences have a value in the consolidation of an individual's learning. Indeed, Inhelder et al (1974)[6] observed that the more activities in which a leaner is involved the more they learn. These researchers, psychologists, identified the transition from one level of cognition to the next. Before learners can involve themselves however in interactive science they need to have mastered practical skills such as manipulation and holding items and the skill of observation. Before phenomena can be investigated through the formulation of a question they need to know how to go about devising such an investigation using items and skill with which they are comfortable and experiences. Children, from their earliest conscious, observe and investigate. They play. In fact they need to play (Moyles, 1989)[7]. Play can be referred to as "messing about, in our case, in science learn to do science (Their and Linn, 1976)[11]. If you observe young children, before they externalise out loud their thoughts, which you can hear as a narrative, which contains, hidden questions. These emergent, intuitive scientists' hidden questions, they are asking them self's questions which guide their subsequent activities when further investigating. The baby in a high chair or push chair drops something out over then side, and observes what happens, they are collecting data including observing and hence learning that most often someone returns the object to them whereupon they can repeat the investigation.

4. Crucial Role of Hands-on

Hands-on is vital to the development of a leaner's real undemanding of science and engineering The United States is emphasising, particularly in its Next Generation Science Standards, museums and science centres, engineering and the hands on approach in such museums as the Thinkery in Austin Texas where children and their accompanying adult, a home, according to their publicity, of the "how" and "why". Other centres emphasise the disassembly of objects so the learner can see how the item works. Other museums stress innovation and the development of workable solutions to issues, and their progress from idea to working realisation, with the drawbacks as well as successes. An example of such is the Museum of History and Industry recently reopened in the Old Armoury building in Seattle.

5. The Experiential learning

Hands-on is a critically important component of learning of science and engineering. It is salutary to recall and to pass the message to our leaners and other teachers with whom

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we work, in the words of Bill Gates[13]. Forgive the Americanism, but the idea is crucial to our learners and us.

"Success is a lousy teacher. It seduces smart people into thinking they can't lose."

He is also quoted as saying

"It's fine to celebrate success but it is more important to heed the lessons of failure."

But, he recognised us too and said:

"Technology is just a tool. In terms of getting the kids working together and motivating them, the teacher is the most important".

Remember that! Good luck.

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An IBSE Approach for Teaching the Concept of Density in Preschool and Primary School

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Abstract. *This paper intends to suggest strategies for planning, development and implementation of simple activities, related to "density", in the classroom, in an Inquiry Based Science Education (IBSE) perspective, i.e. science education based on research/inquiry/experimentation. In this sense, we begin by contextualizing the curricular context on science teaching in pre-school and primary school, and presenting the theoretical context related to the teaching of science based in IBSE. The choice of the suggested activities was based on a set of criteria including their inclusion in preschool and primary school national curriculums, as well as the possibility that it can be addressed with varying degrees of depth, depending on the grade and level of cognitive development of students. The activities are proposed to explore the issue of density that is a subject commonly address in classroom from pre-school to primary school, and was developed to be applied in class with students of those school levels.*

Keywords. Density, physics, IBSE.

1. Introduction

Nowadays, education in science is assumed as an essential component in the education of citizens, as a perspective of individual and social development. There is a comprehensive knowledge of the problems and challenges facing the world, and it is essential that each individual acquire the basic skills that will enable the comprehension and decisions making in a responsible way.

What´s important to foster since the beginning, is the natural curiosity of students and their enthusiasm for science/technology. In particular, for young children, it´s important to explore their day-to-day experiences as a starting point, since it is there they can more easily recognize the contexts and this will possibly increase their motivation [1].

The selection of the theme and the proposed activities take into account the principles set out in the curriculums [2], which constitute the framework for the development of educational practices in the first stage of basic education.

Aware that the practices, at preschool level, should be globalizing, this does not contradict the possibility of children being initiated into procedures and ways of thinking typical of the construction of scientific knowledge [3].

The curriculum of the first level of basic education [4] includes sciences in the curriculum area of environmental studies and its guiding principles to the pedagogical action, recognizing the role of the environment as enhancer of learning and the knowledge that students already have.

There are no explicit references to IBSE strategies in the policy, however, promoting science education based in IBSE seems important from early education, starting at the preschool level.

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2. Science Teaching in Preschool and Primary School

In preschool education, the area of knowledge of the world, root children's natural curiosity and their desire to know and understand why. This curiosity should be encouraged and expanded at preschool, through opportunities to engage children's with new situations, that are both opportunities for discovery and exploration of the world. This area appears as a science awareness, which may be more or less related with the nearby environment, including the extension of basic knowledge necessary for social life, and arising from experiences provided by the context of preschool education [5].

This awareness of the science interests of children must be extended and contextualized by the educator, who encourages the curiosity and the desire to learn. Whatever the issues addressed and their development, it seems essential the relation with the processes of learning, the ability to observe, the desire to experiment and the critical attitude.

The environmental studies at primary school level, should allow the development of themes covering various subject areas, in a cross curricular perspective, having the physical and social environment as a reference.

One of the general objectives of this area relates to the fact that students have the opportunity to *"use some simple processes of knowledge of the surrounding reality (observe, describe, formulate questions and problems, advance possible answers, test and verify), assuming an attitude of permanent research and experimentation"* [4].

It is intended that teachers recreate the program in order to meet the diverse starting points and rates of learning of the students, their interests and needs, and characteristics of the local environment. Thus, it will be through diverse learning situations involving direct contact with the surrounding environment and conducting small researches and experiences that the students will progressively integrate the meaning of the concepts [4].

3. Inquiry Based Science Education (IBSE) in Science Teaching

The rapid changes in our world brings new challenges to education and in particular to science education. Modern society requires schools to provide children with new tools, such as creativity, curiosity and lifelong learning. For this, it is necessary to motivate students to the studies of science, which requires changes in the way science is taught.

It seems necessary to review the teaching of science contents and apply appropriate and modern methods of teaching/learning. Such methods include student-centred approaches in sciences like IBSE, that integrates theory and practice, and the development of problem-solving skills and further the knowledge [6].

The teaching by IBSE refers to the activities of students in which they develop knowledge and the understanding of scientific ideas, as well as, how scientists study the world. It is a multifaceted activity that involves making observations; posing questions; consult books and other sources of information to find out what's already known; planning investigations; review of knowledge based in experimental evidences; use of various tools

to collect, analyse and interpret data; proposing answers, explanations and predictions, and communicate results [7].
It seems logical that the IBSE perspective is specific and dependent on the age of the students to be applied to the teaching of science. However, the use of this teaching perspective involves a large set of activities that constitute the commonly referred hands-on science.
These activities include conducting researches, sharing ideas with colleagues, model definition and development of representations for the observed phenomena [6].
This type of science education involves active learning, and takes advantage of the natural curiosity of children, thereby increasing their understanding of the world by solving problems. However, for students develop the appropriate skills in science, they should have the opportunity to participate in a wide range of activities proposed by the teacher.
This perspective of science education (IBSE) breaks with the traditional teacher-centred didactic, and students, according to this perspective are encouraged to develop the ability to solve problems independently.

4. Proposed Activities for the Classroom

This paper aims to suggest strategies for planning, development and implementation of simple activities in the classroom, based on Inquiry Based Science Education.
Strategies for the development of students' knowledge on these subjects will be presented in an investigative perspective, focused on raising questions, formulation of hypotheses, and the analysis and communication of the findings upon the observations recorded.
The activities will explore the content of density, which is a frequent issue in classrooms from preschool to primary school, and could be applied to students at these levels.
The choice of the suggested activities was based on a set of criteria: inclusion in the national policies [4], [5]; the possibility that can be addressed with varying degrees of depth, depending on the grade and level of cognitive development of students; its frequent observation in family and non-academic contexts; and, to allow the development of creativity and satisfaction of children's natural curiosity.

4.1. Activity 1 – Experiments on Buoyancy

This activity aims to develop the students' understanding of the concepts of mass, volume and buoyancy [8], [9].
It is important that students learn to make predictions and test whether the given objects (coin, pencil, ruler, play dough, rubber, and tree leaf) sink or float in a large water container, and learn to classify the objects, as objects that sink or float, which will depend on two factors: density and buoyancy.
At preschool level, students cannot fully understand these concepts. The most important is that students observe if these objects sink or float. Therefore should be consistent in the way that an object behaves in the water which will allow students to form their own opinions and ideas about the properties of objects and how it will help them sort the objects.

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Guiding questions

- *Which means sink and float?*
- *Can you predict what objects will float? And sink?*
- *The predictions made were different or equal to that was observed?*
- *Describe the characteristics of the objects that sink. Do they have some identical property between them?*
- *Describe the characteristics of the objects that float. Is there some identical property between them? If there are no common characteristics, what do you think has happened?*
- *Is there any surprising result?*

Implementation

The students probably already made some remarks, in a pool or bathtub. Typically, students think that the mass of an object is decisive for determining whether or not a body floats.
Discuss with students the case of boats (huge mass) floating and otherwise very light objects (small mass) sinking. The teacher should clarify the concept of heavy (mass), once in the experience of the students, the boats that use to play are made from plastic/rubber.
Children can develop their activities, games, demonstrations, predictions, results and discussion. If considered necessary, or suggested by any children, measurements of objects mass could be made.
Students should share their interpretations of results and conclusions. All students should have the chance to communicate their main conclusions.
Discuss with students how they can relate the results of this activity to other day-to-day experiences and how they can learn more about this topic.

4.2. Activity 2 – Same Size and Shape

The purpose of this activity is to test the buoyancy of objects made from different materials, with the same shape and size, and develop the ability to understand the different properties of each material that constitutes the objects [8].
In this activity, students should understand that the objects (golf ball, Ping-Pong ball, play dough ball) have two attributes in common: the size and shape.
However the composition of objects is different shows that the material in which an object is made, affects the behaviour that the object will have on the water, or whether it will float or sink.
Students should also be able to understand that the size and shape do not always affect the behaviour of the objects in the water.

Guiding questions

- *What are the different or identical characteristics of the different objects?*
- *Why some objects float in water and others do not? What characteristics have these objects? Describe the objects that float and those that sink.*
- *How objects behave according to the predictions made? The predictions were different or equal to the observations you made?*

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Implementation

Typically students think that the mass of an object is decisive for determining whether or not a body floats.
Questioning students about the volume of the different balls used in the activity and ask them to compare their masses.
Guiding students so they can infer that the weight of the balls are different, but the volumes are (approximately) the same.
Introduce to the students the concept of density in a simple way, as a physical property of matter that is related both to the mass and the volume of a body. The more dense body (ball), has the highest weight for the same volume.
Guide students in order to conclude which of the objects (balls) will have lower and higher density. Help students understand that the objects "have the same volume" and should have different masses (in order to have different densities).
Students should develop a simple research to infer the density of golf, Ping-Pong and play dough balls.
After making their observations, guide students in order to develop a hypothesis on which of the balls has a higher (and lower) density and if it will float or sink.
Children can develop their activities, predictions, observations, discussion of results and possible measurements of the masses of the objects if it proves necessary.
Students should share their findings, interpretations of the results and conclusions.
Students should describe how identical objects are quite different and how it affects its buoyancy. Discuss some of the characteristics that influence the buoyancy of the bodies (mass and composition) and the ones do not (e.g. colour).

4.3. Activity 3 – Same Shapes Different Sizes

This activity aims to investigate whether objects made of the same material with same shape but different sizes, float or sink.
In this activity, students should compare whether each set (pair of cubes) of the same material and shape (wood, Styrofoam, acrylic, aluminium) but different sizes (large and small cubes) float or sink and understand that the objects in question have a common attribute - the shape, and a different attribute – size [10].
Children should also understand the importance of the material as a factor affecting buoyancy, while at the same time, consider size as a possible additional factor.
During the activity, students should also be able to understand that the shape (cube) and size does not affect the behaviour in water, i.e., all objects of the same material, whatever the size, always have the same behaviour, because the material has the same density that does not vary with size.
The teacher should be aware that, generally, the objects less dense than water float and that objects denser than water sink.

Guiding questions

- *All cubes are made from the same material?*
- *What is similar and different between the cubes?*
- *Does the size of the cubes affects its buoyancy?*

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- *Why do you consider some cubes floated?*
- *How objects behave according to the predictions made? The predictions were different or equal to the observations you made?*

Implementation

Is provided a pair of cubes of each materials available, to each group, for example, a pair of wooden cubes (one large and one small) and a pair of Styrofoam (one large and one small).
Question and discuss what are the differences and similarities between the cubes. It may be considered the mass, volume, shape or colour of the cubes.
Students should group the cubes in pairs, according to a chosen criteria. Maybe examples of these criteria, the size (large and small), material (wood or Styrofoam), colour (white or brown), or other criteria chosen by the students. Help students understand that all large cubes have the same size and all the little cubes.
Students should develop a simple research to infer the buoyancy of each cube. After making their observations, guide students in order to develop a hypothesis about which cubes float or sink. Students should share their findings, observations and conclusions. All students should have the chance to communicate their main conclusions.
In large group, at the end, compare the results, and conclude that the activities of the students showed that the type of material that constitutes the cubes is the determining factor for the object to float or to sink. Students should describe the common, different features of the objects used discussing some characteristics that influence the buoyancy of the bodies (the material), and did not influence (size and colour).
Recall the notion of density as a physical property of matter that is related to the mass and volume of a body, and does not depend on the shape or size of objects.

4.4. Activity 4 – The egg

This activity pretends to develop the understanding that an object floats or sinks in a certain liquid depends on the density of the object but also the density of the liquid [11], [12].
This activity aims to demonstrate that the density of water changes when substances are dissolved in it, and that this could affect the buoyancy of an object, in this case one egg. If an object is denser than the liquid, it will sink. If an object is less dense, it will float.
In this activity, the egg sinks in the water because it is denser than water. However, the egg floats in seawater, because the seawater has a higher density than the egg.
This concept can be advanced to the level of preschool level, but it is important that students realize that the change in composition of the water can have an effect on the buoyancy of an object.

Guiding questions

- *What happened to the egg when it was introduced in the glass with water?*
- *What happened to the egg when it was introduced in the glass with salt water?*

- *Why do you think the egg behaved differently in water and in salt water?*
- *Can identify other liquid capable of making eggs float or sink?*
- *What is the relation between the density of water and density of the egg? And between the density of salt water and the egg?*

Implementation

Remind students what they have learned up to this point about density.
Place the egg inside of the glass with water and check if it sinks. Question and discuss with students why egg sink and relate this observation with the previous knowledge they already have about density.
Guide students in order to reflect on the density of the body, but also on the density of the liquid. Discuss with students the egg size and if the amount of water will have influence. Also, discuss the need to control some variables, such as the volume of water and the amount of salt.
Help students understand that salt water is denser than water and realize that we can dissolve salt in water in order to increase the density of water.
Students should develop a simple investigation dissolving in water spoons of salt, watching what happens, until the egg floats.
Students perform their procedures until find the number of spoons of salt needed to dissolve until the egg floats, i.e. until the salt water being denser than the egg.
Students should share their findings, interpretations of results and conclusions. All students should have the chance to communicate their main conclusions, namely the number of spoons of salt used until the egg float.
At the end, compare the results and conclude that the liquid density is another factor that affects the buoyancy of an object.
Students should understand that when salt is added, water gradually became denser.
Students may also discuss suggestions and problems experienced during the activity execution.

4.5. Activity 5 – Different Liquids

This activity aims to analyse, the different densities of liquids, and then compare the density of different objects used with the density of liquids [8], [13].
Initially it is intended that students compare the density of different liquids used (olive oil, honey, water). Later, when they put different objects (marble, metal clip, pieces of cork), it is noted that they occupy different positions in the liquid mixture.
The teacher should note that the concept of miscibility is underlying in this activity, and is the property of two or more liquids mix with each other more or less easily, forming one or more phases. Separated phases when two substances are insoluble when mixed (the best-known example of this is the oil-water mixture). On the other hand, water and alcohol are soluble in any proportions, while other combinations of substances are partially soluble (e.g. salt in water).

Guiding questions

- *If the amount of liquid used was different, there will be changes in the observed layers?*

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- *Why honey is in the lower layer and oil at the surface?*
- *Who will be denser, oil or water?*
- *Why the cork floats while the marbles and the clip sink?*
- *How objects behave according to the predictions made? The predictions made were different or equal to that observed?*

Implementation

Remind students what they learned to the point about density, specifically in previous activities. Present this activity with the aim of investigate different liquids and how objects float or sink in these liquids. Introduce students to the materials available. Begin discussing with students the fact of two liquids mix or not, using simple examples such as water and oil, or oil leaks in the oceans. Discuss with students about if the amount of liquid used, particularly if small/large quantities of oil float or sink in small/large quantities of water.

May be appropriate to students start with simple activities to verify the formation of layers with olive oil and water. Students conclude that regardless of the used amounts of oil and water, always observe two layers, oil on top of water, so the oil is less dense than water.

Lead students to understand that when there is a density difference between the two substances, which do not mix, the less dense substance floats in the other.

Initially present all liquids to the students (honey, oil, water) and introduce them to the problem, by first predict how many layers will observe and how they will be organized, once the liquids do not mix. Discuss with the students, based on how many layers are observed and what is their position in the glass.

At this stage, it may be useful to help students putting the liquid in the glass. The order in which the liquids are poured into the glass is irrelevant, since the liquids are immiscible.

Students should develop a simple research in order to conclude about the density of the liquids involved in the activity. Help students understand that there are three layers of which, honey at the bottom, then water and oil on top. Lead students to conclude that honey is denser, then water and finally the oil.

Show the objects, for instance, clip, marble and piece of cork. Question and discuss with the students what will happen to each of the objects when placed in the glass containing the three liquids. At this stage it is important to listen to students' ideas and what they think about whether certain object floats or sinks. It is possible that students (especially preschool) do not predict that some objects will float in a liquid and be sunk in another (the intermediate layer). Discuss this with students helping them to realize that objects have different densities, such as the liquids used, and they may be denser than a liquid and less dense than the other.

Students of these ages understand in the abstract, the concept of miscibility, as something that does not mix.

Students should share their findings, results and conclusions.

5. Final Considerations

We opted to develop activities under the density thematic, because it is included in preschool and primary school curriculum,

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and also because they are activities that can be used at different levels of depth. In this sense, the proposed activities for the teaching of physics, are based on IBSE and are properly framed in the curriculum.

The set of proposed activities conform an integrated approach to a progression in students' learning enabling the consolidation of knowledge and skills that allow effective progress with understanding progressively more elaborate concepts.

However, in relation this work, seems to be essential its implementation as a way to test them in the context of the classroom, in order to verify that they meet the proposed goals.

This perspective of science education breaks the traditional teacher-centred didactic, and students according to this perspective, are encouraged to develop the ability to solve problems more independently. This type of science education involves active learning, and takes advantage of the natural curiosity of children, thereby increasing their understanding of the world by solving problems. However, for students develop appropriate skills in science they should have the opportunity to participate in a wide range of activities proposed by the teacher.

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Students Perceptions about Artificial Satellites and Circular Motion through Inquiry Based Science Education

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Abstract. *Contemporary trends in teaching and learning science acknowledge inquiry-based science education (IBSE) as a powerful approach for engaging students with meaningful and effective learning experiences that can prepare them to face the demands of a changing society, strongly linked to science and technology. Taking this into account, the present communication aims at describing students' perceptions about the implementation of an inquiry activity that addresses the artificial satellites and uniform circular motion, using the current event of the launching of the Galileo's satellites to engaging students. The research reported is qualitative, adopting an interpretative orientation. Participants were 24 students who attend the 11th grade of a scientific-humanistic course in Science and Technology. The implemented activity was designed in line with the BSCS 5E Instructional Model. The data were collected using two different instruments, namely observation and written documents. According to a naturalist research paradigm, the data were analyzed using a content analysis method that consisted into an interactive process of reading and re-reading data so to uncover patterns, singularities and themes which were associated to the research question. Results show that students perceived the activity popular and relevant, because made learning more enjoyable, helped them to learned the curricular scientific contents and also to made connection between science, technology and everyday life.*

Keywords. Artificial satellites and circular motion, IBSE, *BSCS 5E's Instructional Model.*

Developed inquiry-based science education (IBSE) activities provide an excellent opportunity to foster pupils to use the processes of science. According to Williams, moving students from "performing set experiments to carrying out investigative work can be seen as a move from a positivist approach to science to a more realistic view of science as a process that is largely problem solving" (p. 123) [1]. Actually, IBSE involves students in finding ways for reaching one or more solutions for an initial problem; and in developing multifaceted tasks, such as making observations, questioning, researching in books and other sources of information, planning investigations, reviewing what they known about the experience, using tools to analyze and interpret data, predicting, exploring, and answering to initial questions, and reporting results [2]. IBSE has a key role to build real understanding of ideas that "move from being "small" (just explaining a particular event) to being "bigger", since [students] explain a great number of events" (p. 38) [3]. Alberts proposes that, whether students are involved in an inquiry process they "see them-selves learn and 'recognize that they are capable of tacking harder and harder problems" (p. XIV) [2]. The same author argues, "there can be nothing more

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gratifying, or more important, in science education" (p. XIV) [2].

In the Portuguese context, the secondary science curriculum guidelines point out towards the enhancement of meaningful learning experiences that enable pupils to develop competences, rather than pack a set of scientific concepts, those students must know, without opportunities to connect it to the real world. This document also asserts that learning concepts should be the arrival point, not departure. In considering this, it emphasizes the use of IBSE in an open way and always within the perspective of everyday life experiences. This kind of activities has a valuable contribution, because on the one hand students learn about the contents of science and on the other hand they develop various competences in different fields namely, procedural, conceptual, social, attitudinal and axiological [4].

The aims of this study are to know how an inquiry-based activity that explores the uniform circular motion, using a current event as context, is relevant for students learn scientific knowledge, learn about science inquiry process and enhance their awareness about the connection of science, technology and everyday life. In this communication it will be described one inquiry-based activity related with uniform circular motion and students' perceptions about this activity.

The main idea of the inquiry-based activity, presented in this study, was introduced the topic: artificial satellites and uniform circular motion [5], using the context of the launch of the first and second spacecraft in the Europe's global satellite navigation system, Galileo. The activity was designed in line with the *BSCS* 5 E's (engage, explore, explain, extend and evaluate) *Instructional Model* [6].

The activity was implemented in a 11th grade physics class (15-16 years old). During its implementation, students, working in groups of four or five elements each, were encouraged to formulate and share hypotheses, plan and design experiences, implement experiences, collect and analyze data, formulate explanation from evidence, communicate and justify the conclusions made.

The research reported in this study is qualitative [7], adopting an interpretative orientation [8]. An interpretative research provides us a powerful tool for examining students'. Participants in this study were 24 students; there were 10 females and 14 males, with a mean age of 16 years old, who attend the 11th grade classes of a scientific-humanistic course in Science and Technology. The data were collected through two types of methods: observation and written documents produced by the participants [9]. Consistent with a naturalistic research paradigm, the data analysis consisted of repeatedly examining the data to uncover salient patterns, singularities, and themes associated with study's aims.

The results showed that being involved in this activity provided the opportunity for students developed their own experiments and formulated their explanation from evidences about the effect of the radius on speed, period and frequency, and the relationship of these variables with the centripetal acceleration. Although, they not only learned about scientific contents — that are abstract and difficult to understand — but also made connection between science, technology and everyday life. In fact, at the end of this activity, most pupils developed a

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deeper understanding about uniform circular motion and the capacity to extend this knowledge to other situations, namely the characterization of the motion of artificial satellites. Reflecting upon the work done, most of the students pointed out that by accomplishing this activity they had the opportunity to know more about artificial satellites, about its orbits and tasks. Some students also recognized that before this activity they barely knew about the European satellite navigation system, Galileo. Besides, students found the activity popular, making learning more enjoyable and relevant, because contextualizing the scientific concepts helps them to learn the science contents.

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Botanic Kits "Let´s Sow Science!"

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Abstract. *The Botanic Kits "Let´s Sow Science!" were idealized and developed by the Botanic Garden of the University of Coimbra, Portugal, aiming the involvement with science, particularly botany, among children and their families in non-formal learning settings. The kits are mainly address for children aged 5 to 10, which is an important target group since young children are particularly interested and sensitive to living organisms and their questioning minds are very active. Although children can use the kits autonomously, the interaction with family is encouraged through the collaboration in some activities or in investigations and explorations of additional challenges proposed.*

Keywords. Botanic kits, plant involvement, hands-on activities, science engagement.

1. The decline of interest in Botany

In the last decades Botany has assisted to a decline in its representation in university courses, participants in scientific meetings and also in educational programs [1,2,3]. Several reasons have been used to explain this general decline of interest in the study of plants, such as few experimental and laboratory activities [4], insufficient programmes of nature exploration [5,6] or even the lack of movement by plants [7].

Different researches have shown that many children and adults have restricted views concerning Botany, despite the unique advantages that plants have as science material used for public engagement [8,9]. The inability to see or notice plants in one's environment, to recognize the importance of plants, or to appreciate it's aesthetic and unique biological features was described as being the "plant blindness" phenomenon [10]. To overcome this, it is fundamental to provide people from all ages, opportunities and contexts for contacting and developing creative and emotional links with plants, promoting awareness and understanding of Botany [11].

2. Benefits of involvement with Plants

Several studies have confirmed the lack of knowledge and interest in Botany both among children [2,5,12] and adults [13,14, 15]. Despite that, it was also confirmed that it is possible to invert this situation and change people's attitudes about plants [5,8,11,16]. The promotion of outdoor walks in natural parks or botanic gardens and the development of activities with direct tactile interactions with plants clearly show to be effective in increasing interest in Botany. Even short-term environmental programmes [17,18] improve attitudes towards nature. On the other hand, childhood experiences with gardening and nature positively influence appreciation towards plants as adults [13].

Although the importance of plants is often overlooked, they represent a unique, flexible and complete context for learning and research, particularly with children [9]: plants are large enough to be manipulated by small hands, plants are sufficiently inexpensive to be used by a large number of students, plants are strong enough to be handled by children and plants can be employed in a large number of experiments since they do not require sterile environments as bacteria or ethical regulations as animals.

3. Playing and learning with Plants

From very young age, children show a natural curiosity and a huge desire to learn, associated with the development of capacities to feel, act, talk and reflect [19, 20]. In natural environment, their games are more diverse, with more elaborated patterns, with a higher prevalence of imagination and creativity, which also strengthens their collaboration capacities [19, 20]. Children are particularly interested and sensitive to living organisms and their questioning minds are very active [5,13]. The contact with nature in early ages also promotes observation and amazement, as well as unification with the environment. Playing in nature promotes learning but also physical and emotional well-being.
Although Botany can provide an excellent context of learning, it is common that children (and also adults!) can easily recognize a large number of different animals that they have never seen, but can hardly identify the plants that comes across everyday on the street where they life or in their school garden. Several studies have shown that knowledge about plants is much lower than about animals [5, 7, 12, 14, 22], proving why it is so important to develop plans that promote the interest and discover of the fascinating and unknown world of plants.

4. Botanic kits "Let´s Sow Science!"

The Botanic Kits "Let´s Sow Science!" (Fig.1) were idealized and developed by the Botanic Garden of the University of Coimbra, Portugal, aiming the promotion of science, specially Botany, among children and their families in contexts of non-formal education.

Figure 1. Botanic Kits "Let´s Sow Science!"

Arguments have demonstrated that a great collaboration between formal and informal sectors conduct to a more effective science education [23] and those botanic gardens have a key role in contributing to children's learning and family botany approaches [8].
Although almost activities in the Botanic Kits can be developed indoors, the exploration of surrounding environments and outdoor natural settings is stimulated. Also encouraged are hands-on and minds-on activities through the formulation of questions and learning by doing. The portable format of the "Let´s Sow Science!" Kits contributes to its use in more than one place and can easily be transported from home to the garden, from the garden to school.
Conceived particularly for children from age 5 to 10, younger children can also perform all the activities in the Botanic Kits with the proper help from their family members, and older children can use it too as a starting point for more complex botanic explorations.

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The concept “Lets’ Sow Science!” underlies some principles: i) the development of hands-on and minds-on activities; ii) the forming of – and acting on – questions; iii) the exploration of botany in immediate environments, valuing outdoor and natural settings; iv) learning by doing, integrated with daily routines and linked to the learning of others, in family, shaped by the challenges of the activities, but going abroad.

4.1. The initial project

Initially, the Botanic Kits were created under the partnership established between the Botanic Garden of the University of Coimbra and four Parent Association from different schools of the central region of Portugal. More than 3000 children from age 3 to 15 (Table 1) were involved in the different projects promoted by their Parent Associations and financed by the National Agency for Scientific and Technologic Culture for development of awareness programmes of scientific culture and science and technology education.
All the projects had different thematics such as "Sprouting - Educational project to raise scientific awareness at school as well as in family context", "Herbs that smell and heal", "My first contact with science" or "Children with Science". All the projects had in common the collaboration with the Botanic Garden of the University of Coimbra, which accepted the challenge of developing a product that could be used in different contexts.
Under this states, the Botanic Kits "Let´s Sow Science!" were conceived, in order to encourage observation, stimulation of scientific thinking and experimentation around three main themes relevant for science and botany: Collect, Measure and Grow.

4.2. The themes: Collect, Measure, Grow

The option about the three main themes approached in the Botanic Kits was based on some of the underlying concepts regarding science education in early ages, as key points for getting started in science [24]. Those concepts are related to the nature of science and scientific thought. The Collect Kit is based on organizing and classifying natural materials, in this case from plants. Organization, classification, categorization are activities in which scientists are obviously involved when trying to understand natural phenomena. The Collect Kit suggests the creation of different collections of botanic materials in different settings, for instance, the seeds from fruits and vegetables the family eat or the leaves from the trees in the garden were the family walks. It also involves collecting different kinds of elements allusive to plants considering a diversity of natural environments from mountains to the sea. Sorting objects like leaves, fruits, seeds or petals, according to their characteristics and classifying them according their properties are activities promoted by this kit and that lead children to observe and then compare their own classification schemes to those used by scientists.
Another central concept is to measure. The notion of scales and quantities, both relative and absolute are approached in the activities of the Measure Kit. It encourages the measurement of different objects and botanic materials using different measuring

instruments, from conventional ones such as a ruler, to body measures, like their own feet or hands, and also instruments originally created for the purposes of the activities. The measurement of time is also explored by four calendars representing the different seasons (Fig. 2).

	age 3-5	age 6-10	age 11-12	age 13-15	TOTAL
Águeda	195	900	570	145	1810
Avelar	100	189	93	182	564
Coimbra	_	250	_	_	250
Condeixa	150	390	_	_	540
					3164

Table 1. Number of children for each Parent Association involved in the projects

Full of botanic events and curiosities about plants, all the informations were included in an entertainment way but always having a scientific background. The calendars allow the discover that plants are always around and are part of our daily routines. To understand the time of plants and recognize that there are different seasons for germination, planting, harvesting is also approached in the calendars. Several spaces were left in black as an invitation for the children and family members to fill in with their botanic practices and discoveries.
Cause and effect, associated with predicting and explaining phenomena, are major principles in science. Learning about cause and effect is approached in the kits, mainly on the Grow Kit, where children are invited to observe the effect that light, water or gravity have on seeds and plants, and in their differential growth. The experimentation and manipulation of different variables, considering a diversity of seeds species, as well as the prediction and description of results are the main aims.

Figure 2. Is time to... Spring, Summer, Winter and Fall. The botanic calendars included in the Measure Kit

Transversal to all "Let´s Sow Science!" Kits is the concept of diversity, which is one of the most obvious characteristics of the natural world. Perceiving, understanding and getting fascinated with the diversity of plants and botanic elements is part of the comprehension of its' importance in natural systems. In this sense, the conception of the three Botanic Kits relied heavily on what are consider to be basic characteristics of the nature of science [25]. Science relies heavily on observation, experimental evidence, questioning and the use of rational arguments. The botanic activities suggest the idea that there is not only one way to do science, no universal step-by-step scientific method and the "Let´s Sow Science!" Kits are a starting point for further explorations, for creativity, for promoting questioning an inquiry. Taking notes and recording the observations is also encouraged during the activities, suggesting different registration forms, such as drawing, photographing, writing or making tables.

The Botanic Kits intends to show how science is connected to children' real world, emphasizing learning by doing, in a social manner, within family contexts. Providing opportunities to use their senses, to experiment, to explore curiosity and discovery, is a very real approach to strengthen relationships with science.

4.3. The content materials

Each Botanic Kit contains (almost) all the materials needed for the activities proposed. In fact, only water and two small pieces of adhesive tape were not included!

The need to buy or search for several additional materials after the acquisition of a scientific kit was one of the negative aspects found in the analysis performed to the kits available in the market. After the enthusiasm of having a new kit for developing experiments, disappointment was felt for not having the possibility of doing it right away. For that reason, the inclusion of all the materials needed was considered a fundamental condition and is one of the particularities that make the Botanic Kits "Let´s Sow Science!" unique.

Most of the materials were produced specifically for the Botanic Kits. There was a straight collaboration between the educational and the scientific team project, together with the designer (Fig.3).

Figure 3. Some of the materials developed for the Botanic Kits "Let´s Sow Science!"

For example, a tool for measuring botanic objects was idealized based on the spaghetti measure tool, but shaped as a garden shovel. A ruler-pencil was created to

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be simultaneously used as writing and measuring material. A leaflet was designed with a sequential image illustrating different habitats were plants can be searched and found. For the collection of flower petals with different colours a flower palette was created and for the collection of seeds a box was illustrated with the correspondent fruits and vegetables. A sticker was designed for each Botanic Kit, inviting children to stick it only after accomplishing all the experiments in the Kit, as an earned prize. The list of all the materials inside each Botanic Kit, together with the indication to which activities should be used on, was clearly explained in one of the first pages of the guidebook that accompanied the "Let´s Sow Science!" Kits.

4.5. The guidebook

Another distinctive characteristic of the Botanic Kits is the guidebook. Contrary to the ones that are usually found with the scientific kits available in the market, the "Let´s Sow Science!" guidebooks are thought and prepared to be use independently by children of young ages. It was considered essential the use of clear and synthetic language, although without loosing scientific precision. The aesthetics, illustration and design was carefully planned for the target age children and very valued in the final products.

A mascot was also created, having a figure of a child with leaves instead of hair. Its presence was constant, both in the guidebook where he explained all the activities procedures, and also in all the materials of the Botanic Kits.

Although guiding the children in their discoveries along the activities, the mascot also had doubts, and presented questions without giving the answers, encouraging children to new explorations.

Figure 4. An activity page (A) and an exploration page (B) of the guidebook of the Botanic Kits "Let´s Sow Science!"

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With a total of 20 pages, the guidebooks from the three Botanic Kits include not only the description of all the activities, but also the exploration of key botanic concepts and curiosities that stimulated the children spirit of inquiry and discovery (Fig. 4).
The activity pages are marked with an outline colour and an identification pictogram. The guidelines for the development of the activities are done through elucidative illustrations and short and simple text sentences numbered for each different step. Registration of the evidences collected and the findings from each activity is always encouraged in different and original ways. Exploration pages cover thematics related to the activities of the Kit and end with an open question, encouraging the children to find the possible answers by themselves or together with their family.

4.6. The children and adults feedback

During the development of the project, and in straight collaboration with the Parents Associations, the Botanic Garden offered guidance sessions to the parents and educators. In those sessions, the adults had the opportunity to get to know the Botanic Kits in first hand, to understand the philosophy underlying the "Let´s Sow Science!" Kits, to explore the materials content for each of the kits and to experiment some of the activities proposed. Without the presence of the children, parents and educators spontaneously exposed their doubts and worries of accompanying their kids in performing scientific activities, fearing not to be equipped to provide them answers to the questions that might come up. But they soon realize that the Botanic Kits "Let´s Sow Science!" were prepared to discover science together as a family, and that the appearance of questions was indeed a positive sign. Not knowing all the answers was not negative, but a genuine opportunity to new explorations.
Another topic that was approached with parents and educators was the time of the plants. It was important that the adults who accompany the children in the exploration of the Botany Kits understood that working with plants requires different waiting times and persistence. Contrary to physics or chemistry experiments, that most of the times have immediate results, activities with plants have the constraint, but also the wonders, of taking time. And the time of plants is in fact very different from each other and also very different from our time. In all three kits the time of the plants is explored, but a particular activity was included in the Measure Kit that aimed helping the family realize that is always time for plants, all year round.
The Botanic Garden of the University of Coimbra also promoted visits to the Garden during the weekends, especially for the children and the families involved in the project. The visits occurred in different seasons to give the visitors the opportunity to realize the changes of the garden’s plants during the year. Great excitement was felt, both by the children, their parents and sometimes grandparents, always whiling to participate in the activities proposed and fascinated by discovering Botany.

Parents Associations performed the distribution of the Botanic Kits “Let´s Sow Science” to the children in very enthusiastic sessions, filled with joy and willingness to start performing the activities. The portable format of the Botanic Kits, similar to a briefcase, was reported as a particular characteristic, since it allows its exploration in school, at home or outdoors. The children and families reactions to the Botanic Kits shows that the main goals of the "Let´s Sow Science!" Kits are being achieved: to arouse interest and curiosity for botany by making realize that plants are everywhere, they are part of our everyday life, and they are amazing life beings.

4.7. The new improved kits

In a second phase of the project, the "Let´s Sow Science!" Kits were considered a unique product for science involvement and education by other Parents Associations, Municipalities, School Directions and Science Centres. The increasing interest and the need for developing a larger number of Botanic Kits led the Botanic Garden of the University of Coimbra to search a new partner. Edubox is a company specialized in the production of educational and scientific contents, which together with the Botanic Garden will begin to produce and distribute in the market the new and improved "Let´s Sow Science!" Kits, aspiring to involve even more children and families in the discover of Botany.

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Toys as Change Agent for Children. An Indian Model

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Toys as Change Agent for Children (An Indian Model)

Young people of the world are our future. The future technologies, economics, culture, vision, development, etc. is all dependent on the young people. Educational institutes today have become mark and degree producing factories. In educational context, a child is first asked his marks gained in the examinations rather than what has been learnt. In this scenario it is very important for us to educate the child in a multi dimensional approach. It is not the marks which would build our future, it the understanding in a child's mind which is the real future. Manthan Educational Programme Society, India is an NGO which focuses on non-formal science communication and we try to use several different medias for communicating science to children & students of different cultures and communities. Through this paper, we would like to share some projects where we try to use toys as one of the main medium of science communication.

Learning Science While Playing: A traveling Exhibition on Indian Folk Toys used for Science Education

Toys play a major role in the life of children, be it of clay, wood or plastic. Many of these toys have scientific principles involved in them. While playing with these toys, children knowingly or unknowingly get to learn science. With the change in time, the toys have been transformed from natural materials to manmade materials like plastics. But even today, one can find the local, traditional toys in places like fairs, haats (bazaars) and villages.

In this traveling exhibition "Learning Science while Playing" we tried to use traditional toys to explain different science principles to children in a play way manner. We explained concepts like energy, resonance, motion, gravity, aerodynamic, etc. to children through this exhibition. The concept of the exhibition was more of **"Go ahead, Play, Explore and learn"** rather than just providing scientific information of the toys. In the exhibition we also conducted several workshops where we educated children to make different traditional science toys, so

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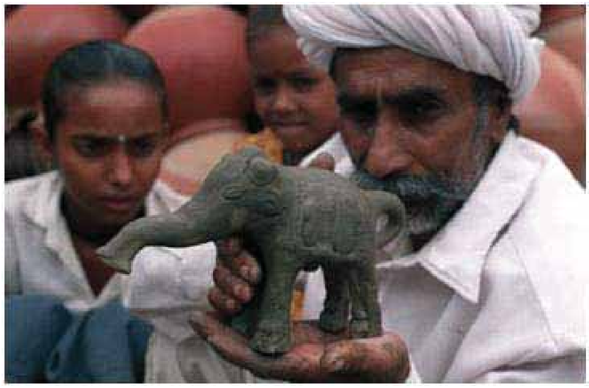
they can act as the communication agents for this concept for their friends and family.
This exhibition was not only showcased in India but has also become a permanent exhibition in Fabrica Science Centre, Aveiro, Portugal where we found out several cultural bridges between two completely distant countries. And there now Fabrica tries to communicate different ideas on Culture and Science through the medium of Toys. Toys are always a part of child's growth and child's learning process and it has a potential to inculcate imaginative thought in a child's mind to build a bright future.

Toy Kits an approach for National Outreach

We at Manthan Educational Programme Society, India have also also developed several Toy Kits which have been produced in millions across the country. The approach of the kit is to develop science activities which are printed in paper format. On folding or assembling the paper activities, a child can make a small toy or a gadget which will give him pleasure an knowledge. These toy kits reach the door steps of child by postal service even in the remotest area of the country. We try to bring an approach of a science museum in a toy kit.
Several such approaches used by our organization has brought a new dimension to educational communication. These activities have been a gateway of several micro and macro level social changes.



Keywords. Outreach, science exhibition, hands-on kits, non formal, toys.

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Hands-on Astronomy for Primary School

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Abstract. *This study presents a research based on implementation of hands-on activities for the contents Sun, Earth and Moon with in-service primary school teachers. A didactic sequence has been established to the learning objectives of the 3rd and 4th years of schooling and put into practice during a 50 hours education training course. A quasi-experimental study was designed and data collected through questionnaire and reflective portfolio analysis show that teachers of the experimental group achieved a significant improvement on scientific knowledge through the practice of hands-on activities.*

Keywords. Hands-on, astronomy.

1. Introduction

Primary School programme for science integrates concepts related to the Sun, Earth, Moon and the Solar System. These topics of Astronomy science arouse interest and curiosity. As a scientific area, Astronomy develops high technology and scientific knowledge, which later are applied in various fields for the benefit of society. Its importance has triggered the increased amount of knowledge at the level of Astronomy education, since the nineties [1]. In 2009 UNESCO and the International Astronomy Union (IAU) promoted the International Year of Astronomy. The success achieved with this event promoted astronomical education through the Office of Astronomy for Development (OAD) and other initiatives allowing access to various resources and innovative activities. All this new knowledge was adapted for the elaboration of the professional development implemented with 21 teachers of 9 school of the north coast of Portugal to the purpose of disseminate hands-on activities of Astronomy.

Research data identifies misconceptions on astronomy both in students [2] and teachers [3], a number of which are due to the fact that the involved phenomena are abstract and difficult to understand both to children and teachers who have gaps in their professional development.

Hands-on activities seem to be the proper way to deal with this problem [4]. The questions to reach the answers we are looking for are: (i) Does this professional development action enable teachers to help their hands-on practice and given them support to do scientific work with students? (ii) Did this professional development action contribute to change prior misconceptions? (iii) What are the main conclusions teachers point after its implementation in class?

2. Methods

A quasi-experimental design was set up with experimental and control groups of 21 teachers which, characterized in Fig.1. All the participants are in-service teachers in 9 public schools of the north coast of Portugal, with lecturing experience between 5 to 35 years and age range of 30 to 57 years old.

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		Experimental group N=21	Control group N=21
Age (years)	30-40	8	9
	41-50	7	6
	51-57	6	6
In-service (years)	05-15	9	10
	16-25	6	5
	26-35	6	6

Figure 1. Characteristics of the participating groups

At the time, none of the teachers had participated in a professional development action about astronomy issues.
To collect data a questionnaire was applied to both participants groups in *pre* and *post* implementation. It consists of 15 questions about Earth, Moon, Sun and Solar System. The reflective portfolio produced by each participant in the experimental group, during application of 4 hands-on activities with the class was analysed.

3. Hands-on Activities

The activities were prepared in an interdisciplinary sequence according to the learning objectives of the primary school program, related to the motion of the Earth, the Moon and the Sun-Earth-Moon System. They are organized as follows: contextualization, specific competencies, learning objectives, conceptual information, scope, materials and resources, scientific processes, security standards concerns, motivating questions, procedure to accomplish the activity, evaluation and extension of the activities. For each activity a poem from the book “Pó de Estrelas” was selected to introduce the topic, motivate and contextualize the students for the work to be carried out.

Activity 1. Learning objectives: (i) The Earth rotates around its imaginary axis for a period of about 24 hours; (ii) The rotation of the Earth causes the day and night cycle.
Reading the poem “Rotação” brought up the following questions: “Where, in the sky, can we find the Sun?”, “What is the path of the Sun in the sky?” and “What causes day and night?”. This fact identified the need to conduct an experiment to construct a model of the sky allowing recording the apparent motion of the Sun, which was made with a transparent salad bowl. After building the model, the 5 elements teachers’ groups, drew their preliminary ideas of the Sun path, with a red marker, in the bowl. Then they registered the effective Sun position in the sky every 15 min, as seen in Fig.2 (black dots on the bowl).

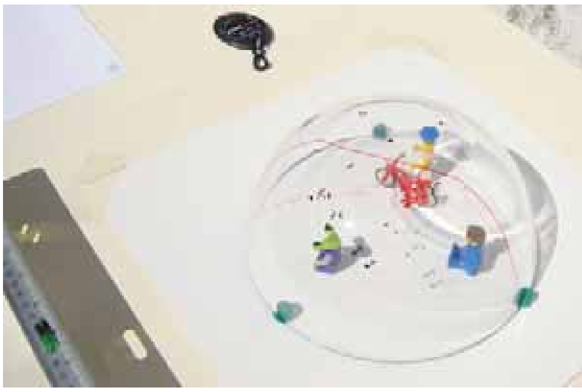

Figure 2. Daily path of the Sun

Complementary, teachers also drew shadows of a little stick and of a standing colleague at different times (Fig. 3), which allowed checking the change in length, direction and shape of both shadows with

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time, and infer that it is due to the Earth's rotation movement.

Figure 3. Shadows registration

Activity 2. Learning objectives: (i) The Moon is a satellite that orbits the Earth; (ii) The moon seems to change shape, showing different stages.
Reading the poem "A Terra" allowed to contextualize activities related with the moon and its phases and put the following issues: "Can we see the Moon during the day?", "Does the Moon always present itself in the same way?" and "Why do we always see the same face of the Moon?"

Figure 4. Observing the Moon phases

On a sunny day, the teachers came to the playground to search for the Moon and were surprised to see it. Afterwards they simulated the Moon phases with a ball stuck on a spike and verified the Sun positions relative to the Earth and the Moon, in its various phases (Fig.4).

4. Data and findings

The analysis of questionnaires (Fig. 5) reveals that teachers had difficulty in understanding the phases of the Moon and the seasons. At pre-test, 85% in the experimental group responded that the Moon cannot be seen during the day, 45% replies the Earth's axis tilts forward and back causing the seasons, and 30% said that the Sun is closer to the Earth than the Moon. In the pos-test a significant gain on the concepts related to the Moon was found.

	Experimental Group				Control Group		
Questions	Pretest (% correct) N=21	Posttest (% correct) N=21	Post-Posttest (% correct) N=20	Gain <g1>	Pretest (% correct) N=21	Posttest (% correct) N=17	Gain <g2>
The Moon rises and sets up every day at the same time. Is it true or false?	20	60	76	0,70	57	76	0,45
The Moon is not visible during the day. Is it true or false?	15	85	79	0,76	57	76	0,45
During the full moon phase the Moon rises around 6 p.m.. Is it true or false?	50	60	85	0,70	57	53	-0,10
Why do we always see the same side of the Moon?	50	65	60	0,20	38	41	0,05
Draw the Sun, Earth and Moon so that the Moon can be seen from Earth in first quarter phase.	20	25	35	0,19	14	24	0,11
Enter the correct sequence (Sun, Moon, Pluto, other stars) with reference to the Earth, extending from closer to the farthest.	25	85	45	0,27	33	24	-0,15
Why is the Earth warmer in summer than in winter?	30	78	40	0,14	38	41	0,08

<g1>= (post-post% -pre%)/(100-pre%) <g2>= (post% -pre%)/(100-pre%)

Figure 5. Results from questionnaire

After the implementation of hands-on activities with students, each teacher

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presented a reflective portfolio where the following statements stand out:

From the student point of view:

"Interestingly the same night happened an eclipse of the Moon, which many students reported." (2nd year)

"It was curious that this aroused interest in students, because some kids continued to observe the moon on its own initiative."(1st year)

"This experimental activity conducted in a simple manner is quite illuminating, leading students to understand why the Moon always shows the same face to Earth." (4th year)

From the teacher's point of view:

"No doubt that the teaching of Astronomy by using the experimental education makes the subject more visible and more easily understood."

"It was very positive and fostered in me an attitude a little safer in relation to science education."

"So this training brought me new experiences, new ways to address and explore the contents."

5.Discussion and conclusions

During practice sessions the teachers felt insecure with the approach and thought that activities outside the room wouldn't have good results with students. The implementation of those activities with students revealed that they provoked interest, attention and motivation to continue conducting these Science activities' in order to achieve an effective learning.

In accordance with some studies [4], [5], [6], hands-on activities seems to help understand unobservable phenomena and develop scientific literacy of future citizens.

This investigation revealed that an educational course for teachers to experience hands-on activities designed for students seems to be a valid option.

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Hands-on Activities as a Support of Re-Education of Students with Specific Learning Disabilities in Science and Mathematics Education

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Abstract. *Specific learning disabilities are the inability to learn to read, write and count. It is important for the re-education of children with learning disabilities to diagnose which functions are impaired or undeveloped, to what extent and in what combinations. We can use hands-on activities for the re-education and development of these functions in science and mathematics education. They should help children to overcome their difficulties in reading, writing and counting that are a prerequisite for successful learning of science and mathematics. The study is presenting examples of special developed hands-on activities for the re-education of visual disorders in physics education.*

Keywords. Hands-on activities, re-education, science and mathematics education, specific learning disabilities.

1. Introduction

Specific learning disabilities (hereinafter SLD) are defined as the inability to learn to read, write and count using conventional teaching and learning methods ([1], [2], [3], [4]). These disorders have their own characteristics both in their etiology (causes of their origin) and also in their symptoms. They are always innate, can develop either because of some damage before birth, at birth or soon after childbirth. Heredity or a combination of heredity and the above-mentioned difficulties play a certain role. It is not a problem based on external causes (that might lead to similar problems) such as neurotisation of the child, wrong educational methods, health problems, absence at school, lower socio-cultural level or different linguistic background of the child. One of the features is that the intellectual abilities of children with these disorders range from average to above average. Their disorder is not caused by decreased intellectual abilities, but by other reasons.

Functions necessary for reading, writing and counting are often impaired with these children. They are perceptive functions when mainly sensory perception (visual, auditory) is damaged; cognitive functions, when e.g. the ability to concentrate, memory, thinking, language, pre-mathematical and mathematical concepts are damaged; motor functions (movement) when fine and gross motor skills of hands are damaged, as well as of eye movements and speech organs. Furthermore, motor coordination disorder, rhythm disorder and disturbance of sensory-motor functions (it is linking cognitive and motor functions), contribute to the emergence of disorders.

It is important for re-education (regeneration, development of impaired or undeveloped functions) of children with SLD, what functions are damaged and undeveloped, to what extent and in what combinations and according to the findings it is possible to define specific disorders. Not all the above mentioned functions are necessarily damaged, sometimes only some of them.

Therefore, symptoms of SLD are so different, diverse and very individual.
To develop these functions, we can use a variety of techniques and resources including simple science and mathematics hands-on activities that are supposed to develop the disturbed functional area and help children with SLD to overcome their difficulties in reading, writing and counting. Speaking of hands-on activities, we include, of course, minds-on activities.

2. Specific learning disabilities (SLD)

Teacher knowledge of the basic nature of SLD is necessary in order to select and modify appropriate hands-on activities for their re-education. The basic types of SLD are:

- **dyslexia** – reading disorder,
- **dysgraphia** – writing disorder, disorder of graphic expression,
- **dysorthographia** – spelling disorder,
- **dyscalculia** – disorder of counting, mathematical abilities.

2.1. Dyslexia

Dyslexia is reflected in reading, when the ability to read is disturbed as such: it is e.g. slow, strenuous with a few errors, or vice versa, fast, precipitous with an increased amount of errors. Dyslexia usually arises on the basis of visual perception disorder when visual perception, very often visual differentiation of e.g. laterally inverted shapes and little details, distinction of figures and background, colour perception, is impaired. Right-left spatial orientation (in the macro and micro space) is often impaired. It is also accompanied by the reduced ability to analyze and synthesize, and not just by sight. Furthermore, visual memory and also micro motor skills of eye movements and motor skills of speech organs are impaired. There is also a relationship with the lateralization of the cerebral hemispheres. Impaired concentration of students participates as well.

2.2. Dysgraphia

Dysgraphia is reflected especially in writing, writing as such is disturbed: the pace of writing is considerably slow, writing is not fluent. In other cases, the pace of writing is fast, but it results in reduced quality of writing. These students have problems with learning and memorizing shapes of letters. The basis of dysgraphia is usually a motor disorder and particularly fine motor skills are impaired, but sometimes in combination with gross motor skills. It is accompanied by motor coordination disorders and sensory-motor disorders. Difficulties also arise in problems with lateralization (with ambiguity of laterality or cross laterality, trained right-handedness or left-handedness).

2.3. Dysortographia

Dysortographia is reflected in grammar, especially when writing dictation and characteristic errors appear. Students miss a feeling for language. Dysortographia usually arises on the basis of auditory perception disorder when auditory perception is impaired, often especially auditory differentiation (distinguishing sounds, tone height, depth and length, individual speech sounds, syllables and words). The ability of auditory analysis and synthesis, auditory

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orientation and auditory memory is often impaired. Impaired concentration participates as well.

2.4. Dyscalculia

Dyscalculia is more reflected in the knowledge of basic mathematical operations than in higher mathematics. Symptoms of dyscalculia include e.g. the inability to match a number with the number of objects, poor differentiation of geometric shapes, poor orientation in arithmetic sequences, difficulties in labelling of operation signs and mathematical operations, inability to read mathematical symbols and write them in dictation or transcription, inability to perform mathematical operations and understand mathematical relationships. The basis of dyscalculia are difficulties in auditory and visual perception; spatial orientation, concentration and memory. Dyscalculia is related to the lateralization and cooperation of cerebral hemispheres and the centres associated with maturation of mathematical functions are often impaired. It is often accompanied by motor disorders and sensory-motor coordination disorders.

Now we will try to establish some influences of SLD on science and mathematics education. We are focusing on physics education of students since it can be assumed by its nature that SLD will affect physics education most.

3. Influence of specific learning disabilities on physics education

Physics education brings problems to students with impaired mathematical ability (dyscalculia) that was discussed above. The described symptoms of dyscalculia show clearly areas of physics with difficulties for students.

Physics education brings troubles to dyslexic students as well. This disorder negatively affects work in all the subjects where students have to read texts and gain information. Perception of the text itself and orientation in the text is strenuous and exhausting. Due to slow reading and difficulties in understanding, dyslexic students need more time to work with the text. When solving learning tasks the performance might be distorted by incorrect reading of the text or improper understanding. Students may have problems with understanding the symbolic notation.

Children with impaired visual perception, right-left and spatial orientation might experience making errors in usual calculations (e.g. by omitting digits, confusing their order in numbers, shifting numbers when recording them under each other, when writing fractions or decimal numbers) or in frequent changes in algorithms.

Students with dysgraphia have difficulty in writing texts and extracting information. Graphic layout of students' records and worksheets makes often impossible for students to learn from their own records. Students with dysgraphia have problems with writing digits in physics (confusion of similar shapes) or numbers (numbers are difficult to read, incorrectly written under each other). These students are not able to write assignments leading to the task solution.

It is obvious that there are many influences of SLD on physics education. Physics teachers should be familiar with these disorders to be able to identify them and

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implement subsequent therapy ([5], [6]). Our study will focus only on therapeutic re-education of visual perception disorders using hands-on activities.

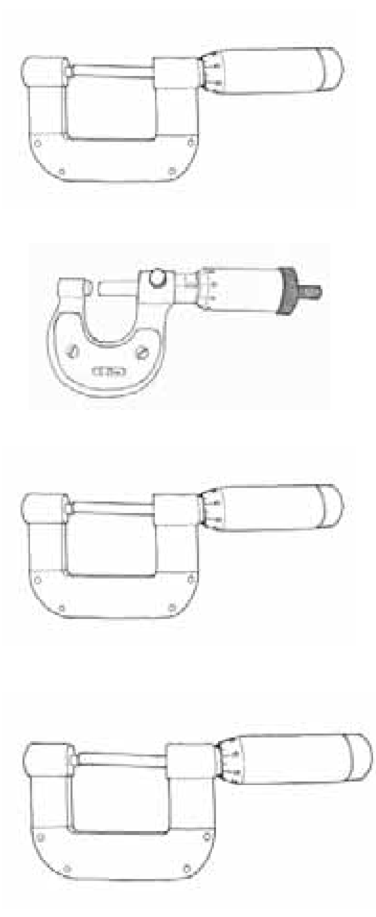

Figure 1. Find one different instrument

Figure 2. Find five differences

4. Hands-on activities for the development of visual perception

Impaired visual perception is one of the main causes of many SLD. Its development is an essential prerequisite for quality re-education. If the re-education of the disorder takes form of entertaining hands-on activities, it is attractive for children and it becomes an important source of motivation, which is desperately needed for the re-education [7].
Out study is presenting a set of hands-on activities for the re-education and the development of visual differentiation, visual analysis and synthesis, and visual memory for students with SLD. Re-education activities and resources have to be implemented in physics lessons [8]. We used hands-on activities with measuring instruments for physical quantities.

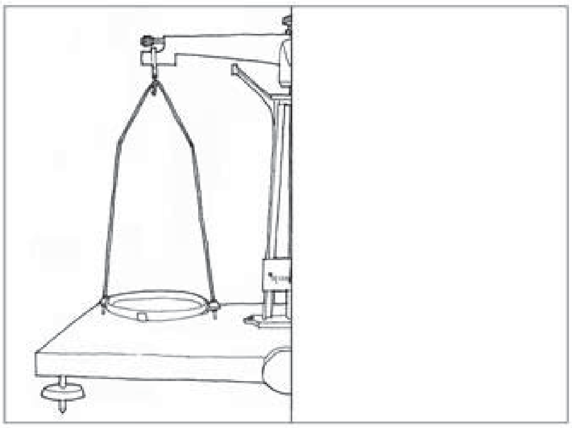

Figure 3. Draw the exact mirror image to complete the picture

4.1. Visual differentiation

We used e.g. these hands-on activities for the development of visual differentiation:

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looking for a different image in the row of images (see Fig. 1); looking for differences in the pair of images (see Fig. 2); completing mirror images (see Fig. 3).

4.2. Visual analysis and synthesis

We use puzzles and their variations to support visual analysis and synthesis (see Fig. 4).

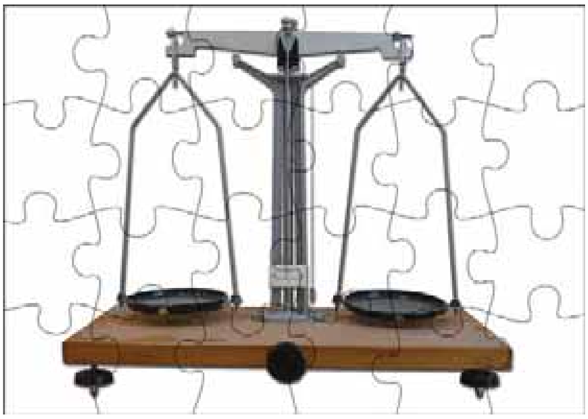

Figure 4. Puzzle

4.3. Visual memory

We can use Concentration games (see Fig. 5) or Kim´s games (see Fig. 6) to support visual memory.

5. Conclusions

Our study focused on the use of hands-on activities for re-education and development of students with SLD. These students have some of the perceptual, cognitive or motor functions impaired or undeveloped.
Our goal was to show that hands-on activities can help students to develop these functions and contribute to the development of reading, writing and counting, which are essential skills in science and mathematics education.

Figure 5. Concentration game

Figure 6. Remember all the objects

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Hands-on Experiments in the Formation of Science Concepts in Primary Education

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Abstract. *Science concepts are formed at an early age of children in non-formal education as preconceptions. The risk is the emergence misconception that later complicate the understanding of concepts. Research shows that primary science significantly affects future understanding of science. Therefore building the foundation for future understanding of natural phenomena, quantities, principles and research methods is important educational goal of primary science. Hands-on experiments play an important role in the formation of concepts. Using design-based research, we implement hands-on experiments in the formation of science concepts. The study presents examples of hands-on experiments, which should develop science concepts in primary science.*

Keywords. Concepts, formation, hands-on experiments, primary science education.

1. Introduction

Many studies confirm that the foundations of science education are significantly shaped since birth. This tendency is probably motivated by natural cognitive needs of humans that actively recognize themselves and the world around them [1]. This gives rise to the first products of informal science learning called preconceptions [2]. The preconceptions fundamentally affect continuous science education, both positively and negatively. In particular, incorrect preconceptions called misconceptions cannot often be removed from the human consciousness at all. Therefore, it is necessary to pay much more attention to pre-primary and primary science, in the form of informal family education [3] and formal education at kinder gardens and primary schools.

Preconceptions most often take form of naive beliefs, own explanations of phenomena and their laws. When creating the preconceptions, experimentation plays a crucial role. It is the scientific experiment, if implemented and interpreted correctly that prevents from misconceptions best. It is clear, however, that a child can neither carry out scientific experiments properly nor interpret them. When experimenting, children should have scientifically correct supervision. The problem is who should be the guide in this period. Natural primary educators of children are parents, siblings and other family members. In the next period, they are teachers at kinder gardens and subsequently teachers at primary schools that are the source of real formal education. Parent involvement in science education of their children might be problematic. Their own earlier education does not often provide a useful source for the education of their offspring. They also very often lack motivation. It is a much better situation if professional education is provided by teachers at kinder gardens and primary schools. But there are still significant gaps and the optimum condition has not been reached yet. Opportunities for teachers

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to educate children in science are equally problematic. The curricula are crowded with other subjects and there is lack of high quality science curriculum materials, textbooks, appropriate methods and aids.

Current major educational factors in informal and formal education of children are information sources - the Internet, television, radio, multimedia programmes, etc. Children's games and toys have an important place as well. They hide a relatively considerable scientific educational potential because these educational materials can be prepared by experts in science education [4].

Hands-on experiments can be applied very well in all these areas. Therefore, we are going to pay close attention to hands-on experiments in primary science.

2. Hands-on experiments in the development of science concepts

Hands-on experiments can play different roles in formation of concepts. Using design-based research, we discovered alternatives of educational methods that involve hands-on experiments. Four roles of the hands-on experiments will be analysed in detail.

2.1. Description of natural phenomena

In order to research a natural phenomenon, a child must be able to observe and describe it. Hands-on experiments demonstrating a certain phenomenon can serve this purpose. Such experiments must also fulfil requirements for simple experiments, such as safety, ease of implementation, cost effectiveness, but especially transparency. An experiment is transparent if it presents a phenomenon in a way easily perceptible by the senses [5]. The criterion of transparency is that the observed phenomenon is not covered by another phenomenon that occurs during the experiment. As an example we present the change of surface tension at the coloured surface (using food dye) of the milk by dipping the cotton (ear) bud with detergent (see Fig. 1):

Figure 1. Surface tension on the coloured milk

2.2. Science quantity

An essential element of science is a quantity. Using the quantities such as length, time, temperature, etc. not only researchers but also children can describe natural phenomena without being aware of this fact. It is obvious that a child is unable to define the quantity precisely, but its definition can develop from the description of its attributes. A precise definition of a quantity occurs at upper secondary school or even at university. Quantities are fixed for so long, that students might develop misconceptions that may block correct definitions of quantities and complicate their

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understanding. Appropriate hands-on experiments can help correct gradual formation and development of science quantities [6]. We chose density as an example. A suitable hands-on experiment that can help the correct development of density is “sugar rainbow” composed of coloured sugar solutions at various densities (concentrations) (see Fig. 2):

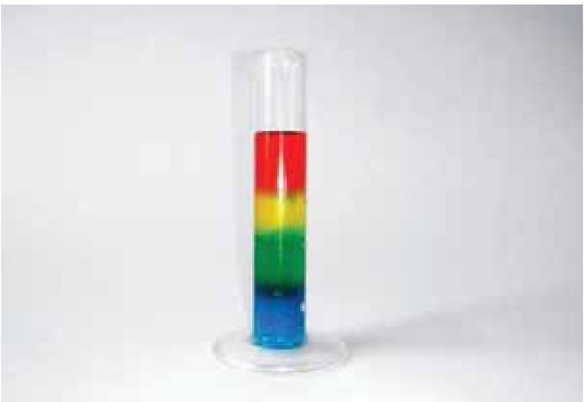

Figure 2. Sugar rainbow

2.3. Science research methods

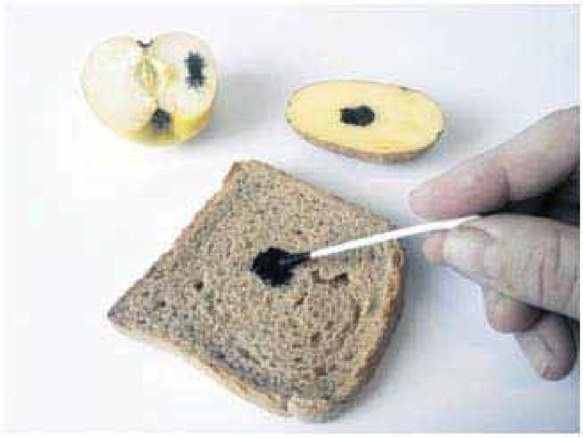

Figure 3. Detecting of starch in food

Significant educational objectives of science education are science research methods. These methods have their specific characteristics and knowledge and skills of students must be develop gradually. Some general and specific science research methods begin to develop at students´ early age. These include analytical observation, description of phenomena, creation of hypotheses, etc. Hands-on experiments may be also beneficial in this area. Our example experiment is method of detecting starch in food using iodine (see Fig. 3).

2.4. Science laws and principles

Figure 4 and 5. Vinegar and baking soda

The highlights of educational objectives of science education are science laws and principles. Laws and principles represent the most difficult teaching/learning tasks for both students and their teachers. There are two basic pedagogical procedures for teaching: derivation of the law (inductive approach) and verification of the law (deductive approach). Hands-on experiments can be greatly beneficial in both cases. As an example we chose the principle of conservation of mass. Total mass of

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substances does not change during the chemical reaction of vinegar and baking soda (see Fig. 4 and 5).

3. Conclusions

The aim of our design-based research is finding different educational methods and the implementation of hands-on experiments in science education. Our study confirms the importance of hands-on experiments in primary science education. We discovered useful hands-on experiments that are effective teaching/learning instruments. The outcomes of our research are transferred into the education of science teachers.

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The Impact of Observational Astronomy in First Grade Students: a Study for Symbolic Representations as a Source of Indicators

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Abstract. *The following study consisted in assessing the changes of the graphical representation of the sun, created by first grade students, after a session of solar observation. Three moments were considered: before the session, afterwards and long after. Two conclusions are derived: the representation of the sun evolved from an intangible object, capable of representing symbolic meanings to an observable one, with characteristics of its own, not inherited from something external. Such feature was persistent but not usurping of the previous imaginative version. Moreover, it combined the observational information from two different contexts: the observational session and the day-to-day experience. The image of the Sun was therefore enriched with new possibilities originated in a scientific observation of nature.*

Keywords. Astronomy, impact evaluation, sun observation, symbolic representation.

1. Introduction

The concern for the public access to scientific and technological knowledge has given rise to discussion, both academic and political, on "scientific culture" and "public understanding of science". Such focus is based on the idea that in a knowledge based society, the average citizen should have a certain scientific literacy and a free and democratic access to information of scientific and technological nature [7].

In this sense, we are witnessing various and diverse initiatives of science communication, whose practices have emerged from two different traditions: the "public understanding of science (PUS)" oriented through science education and promotion of scientific literacy; and the "public engagement in science (PES)" rooted in the ideas of democratic participation [9]. Communication is, however, only accomplished if the message produces an effect. Are “PUS” or “PES” being enhanced? Does it produce changes on the individual’s ability of understanding the world, or the context where he is immersed? Does it provide different judgement on practical day-to-day decisions and promotes a more active citizenship?

One may argue that many of these questions are not in the scope of science communication. Others may disagree. Nevertheless, despite which objectives are pursued, they must be clearly defined in order to draw and implement strategies to evaluate if the communication really existed. Therefore, it is essential to study the impact caused in the individual. Only after that evaluation, can we infer, imagine and apply better communication techniques.

The evaluation of the changes produced in an individual is a very defying task. The single fact that the individual knows that he is being evaluated, affects the result. Nevertheless, its importance on the

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validation of the science communication success should be a driving force to mature it and make it a common practice.
The current study has two purposes: to give new perspective on the Sun and some of its phenomena; and to evaluate if the information was perceived and how it changed, if so, the perspective on the object "Sun". The first goal was aimed by undertaking a session of observation of the Sun using a telescope equipped with a proper filter. The second was targeted by developing a three-moment set of evaluation of the graphical representation of the Sun: before the observation session, afterwards and long after, providing a follow up of the results derived on the second moment. In no moment where the subjects aware that they were being evaluated. The present paper describes how such action was implemented and the reasons why some important choices were made, mainly on the selection of the public and on the impact analysis. It presents a complete analysis of the three-moment set of evaluation and respective comparison. Several conclusions are taken and some suggestions for future work are outlined.
It also intends to make a contribution to promote the discussion of better forms of impact evaluation and set grounds to the development of new, more effective, feedback based, practices in science communication.

2. Scientific Background

2.1. The importance of scientific culture

The conceptualization and definition of scientific culture in itself, is a deep and complex discussion. It is the search of the relationship between science and culture, two terms that are dispersed in meaningfulness. Hence, the approach of this article will start with a clarification about what we allude when we speak of scientific culture. It also aims to provide a better understanding of what we pursue when outlining and implementing any science communication practice.

Scientific culture
Burns et al. [4] define scientific culture as an integrated system of social values that appreciates and promotes the science per se and that considers it important to spread scientific literacy. It is an "atmosphere", something that we breathe, expecting the enrichment of the individual and the community through scientific knowledge.
In most EU countries, it is called scientific culture what is described in the UK as PUS and in the United States as scientific literacy (*ibid*). Therefore, it is necessary to introduce the concepts of scientific literacy and PUS.

Scientific literacy
The definition of this concept has changed over the years due to the complex and dynamic nature of its meaning, having been initially associated with a long list of skills and attitudes towards science.
In 1975, Shen (cit. Burns et al., [4]) proposed to rank scientific literacy in three categories: practical (where scientific knowledge is applied in practical problem solving); civic (which empowers citizens to be more aware of science and related topics, participating more fully in the democratic processes of a society increasingly dominated by S&T); cultural (where science is seen as a great

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achievement of mankind, for many, according to the author, the greatest achievement of our culture).
Later Miller [15] reasoned that civic scientific literacy should take into account three different dimensions: content (knowledge of a basic vocabulary of science on behalf of understanding of news from newspapers and magazines); the process (knowledge to understand the nature of the scientific method); and social factors (recognition of the impact of S&T in individuals and in society). The ideas that have emerged on the subject take into account aspects related to the contexts, skills, ways of thinking and acting towards science, giving a holistic contemporary definition of scientific literacy.
In this scenario, the development of scientific literacy should be the focus of science education in early school years. It should be a priority for citizens, helping them to understand the world around them, to engage in discourse about science, questioning the claims of others about scientific matters, to be able to identify issues, investigate and draw conclusions in order to make informed decisions about the environment, their own health and their own welfare decisions [8]. Such definition, it is worth mentioning because, despite the fact that high levels of universal scientific literacy seems to be an intangible ideal, it is embodied in a major goal for modern society. Scientific literacy is, therefore, the ideal situation in which people are aware of the science, interested, involved, capable of forming opinions and seeking to understand science.

Public Understanding of Science (PUS)
The Bodmer [3] report introduced the idea that, in a knowledge based society, ordinary citizens must have a certain scientific literacy and a free and democratic access to information of a scientific and technological nature [7]. The benefits of PUS also allow a free and enlightened citizenship as indicated in the same report of the Royal Society of London "a better understanding of science by the public can be a decisive factor for promoting national prosperity, to improve the quality of public and private decision and to enrich the life of the individual". In 2000, the "Science in Society" report, noted that this term was an abbreviation for science communication, related to the understanding of scientific issues by non-experts.
As the name implies, PUS, focuses on the understanding of science, its contents, processes and social factors. It should therefore be understood as a social enterprise.
The narrow relationship between terms means that, usually, the scientific culture often appears as a synonym for public understanding of science and scientific literacy. A common misconception is to relate scientific culture to the practice of its promotion. For example, scientists talking to lay audiences about their work, making known their own developments in science. But it's more than that: scientific culture, as Culture itself, is presented as a two-way bridge between science and society, influencing one another. Is not thus exhausted in mere, although essential, disclosure practices and the popularization of science. It will transcend the simple bonding of science to increasingly large groups of society, and proposes to integrate in science the return from this connection.
This introductory systematization presents some issues about scientific culture. If we talk about its importance, we necessarily

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have to ask ourselves to whom is scientific culture important, and what is its purpose.

Why is scientific culture important?
Science appears associated with economic, social and political advantages. Society expects, from what it spends on science and technology, a great return, thus legitimizing its importance, both for the benefits it brings and, even more, by those it projects: one fairer, thriving, more inclusive and therefore more democratic knowledge society.
Science, with its technological arm, gives energy to the ideals of education, to market economies, to increase comfort and longevity, but also to the methods of warfare that characterize modernity [17]. For the individual, it is synonymous with intellect, maturity and prestige (*ibid*).
Scientific discoveries not only shape the way we think and act in society, but above all, how the individual sees himself in the world. An almost prosaic exercise is to remember that since the geocentric theory of Ptolemy, through Copernicus Heliocentric theory, until the Big Bang theory (the theory of the origin of the universe that brings together more consensus among the scientific community), the Earth's position in space and in time and, consequently, of humanity in it, suffered a dizzying shift, which led and continues to produce profound social implications.
The communication becomes fundamental within that interface between science and society, because without communication science cannot develop as Ziman [19] stated "The fundamental principle of academic science is that search results should be made public. [...] The fundamental institution of science, then, is the communication system. "

The constant ramifications in the different scientific areas, increasingly specialized, make communication difficult between scientists from different branches. Moreover, the exponential evolution of science makes it even more a far distant objective than that which human societies can achieve. As a result, the gap between science and the general public deepens.
It is true that advances in science (in bioengineering, molecular biology, understanding of the effects of geological processes, our knowledge about the universe and our place in it) affect our individual and collective existence and will shape our moral choices and law, economics and political control. The informed debate, therefore requires consideration by the layman and requires from scientists, a willingness to communicate, in a lucid and conscious way, about the implications in the social context [17].
It thus becomes extremely important to cultivate the scientific culture, not only for the development of society, but also to the evolution of science itself.

2.2. The impact evaluation

As we have seen we are currently witnessing a trend in the field of science communication that emphasizes the importance of public dialogue and greater engagement between the public, science and technology. This brings new challenges to the area, in particular the impact assessment demands. Chilvers (2013) [5] conducted a study on the networks of public dialogue on S&T in the UK and noticed a waste of the potential of monitoring and evaluating the effectiveness of these processes. It usually neglects the possibility of becoming tools that allow to potentiate alternative forms of democratic participation. What he found was an attempt to promote learning through shared experiences and "best practices" and the creation of monitoring and evaluation systems of the effectiveness of the processes themselves. However, almost all evaluation processes are performed as soon as a process of dialogue ends, losing longitudinal perspectives and possible emerging results in the subsequent time period. Additionally, he noted that some assessment processes are carried out with the aim, often unique, of equipping public dialogue to uphold the credibility and legitimacy of the organizations promoting those same processes. Also concluded that often arises the need to review the urgent preparation of a report with a lack of real concern to take the results of that document into consideration. In reality, what Chilvers found in this field was a "doing more of the same" where assessment processes are instrumental and an end in themselves and not a starting point for reflection, neglecting the possibility of becoming a tool that allows alternative ways to potentiate participation and full exercise of citizenship.

Evaluating aims to verify the effect produced by a given action, taking into account the purpose for which the action was developed [16]. Evaluating determines or explains the success of an action in accordance with the objectives for which it was designed and built. It is complex and involves methodological and epistemological issues that go beyond the scope of this article, however, it is important to discuss this issue even if briefly, calling attention to its relevance in the field of science communication.

In this field, there are many actors involved (scientists, mediators, policy makers, entrepreneurs, students, general public, etc.), each following different objectives and giving different meanings to terms used to formulate those objectives, which means that each actor observes and evaluates the process and the results of different points of view (*ibid*). To resolve even partially the problem of "point of view", it is important to establish some reference parameters as a result of choices and negotiations between those involved. This means that the evaluation produces results that are only valid within a specific context (*ibid*).

Another relevant issue when we talk about the assessment, relates to the choice between quantitative and/or qualitative methods. A multi-method approach (Pidgeon et al., 2005 in [16]) is a good strategy for improving the effectiveness of the assessment.

Thus, evaluating science communication initiatives depends on the context of its implementation, on the definition and negotiation of goals and the type of activity to achieve them, showing that there is a connection between the design and evaluation of an initiative for science communication.

A communication activity of science is developed over time and can be divided into three phases: design (*ex-ante*), implementation (*in itinere*) and completion (*ex-post*). Undertake an assessment makes sense in each of these phases. At the design stage assessment focuses on the adequacy of resources in relation to the objectives. In implementing the assessment establishes what is taking place and whether

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it is necessary to make adjustments. The evaluation at the end of the reporting process to determine and explain the success or failure of a particular action in view of the stated objectives [16].

Although communication is present in our social relations, as well as the individual experience of each person, it is a phenomenon of great complexity whose full definition finds no consensus. However, it is generally accepted that communication happens when you produce some type of change involved in the communication process (*ibid*). This is particularly important if we want to evaluate initiatives of science communication.

If communication produces change, then the purpose of the evaluation is to determine the extent and nature of this change (*ibid*). We can say that these changes take place at three levels: at the knowledge level (which relates to learning); in attitudes (related to how to make value judgments and advisory opinions); and at the level of behaviour (start doing something that was not done before).

The central problem in assessing becomes, therefore, the observation of change. To make this observation, one approach is similar to the experiments conducted in the laboratory experiment, in which a comparison is made of the ex-ante situation with the ex-post situation. With this in mind, a group of people must be involved in the communication process while the other group is not (the control group), assuming that the observed changes are due to the communication process that is being undertaken. It's clear that the design of this experiment fails in certain issues, typical of research in social sciences and humanities, because it is impossible to obtain two identical or sufficiently similar groups in some aspects to be studied, thus violating the principle of experimental investigation. Moreover, if the people involved know before hand that are being investigated, either by completing a questionnaire or be interviewed, activities that by themselves are also a communication process, causing that we can not attribute the change only to the event of science communication they were involved in the study.

Other approaches have been tested in order to find a solution. One has to do with the ex-post observation, where the researcher only examines the features after the completion of the action of science communication, interpreting these characteristics as indicators of change produced by the process. In this case the target audience does a self-evaluation of the initiative of communicating science through questionnaires and in-depth interviews, data which will then be analysed by the researcher.

Another aspect to consider is the time factor. Major changes are expected in learning, behaviour and attitudes of people, even when the duration of action is short. Furthermore, we expect that these changes occur within a short time. To analyse temporal matters, some strategies have been developed that go beyond the analysis of the effects produced in the short term; taking into account the effects generated by successive involvement in science communication activities of the same kind, as well as follow-up questionnaires to determine whether the observed changes in the short term were sufficiently consolidated for the long term observation [16].

These assessment considerations do not intend to define an ideal method, but making conscious the limitations and advantages of

the adopted methods of assessment, calling to attention the fact that the evaluation process should be appropriate to the action. In essence, it is not the effects of communication that matters to isolate on the one hand, and its causes, on the other, but to realize in what ways they combine.
In this regard, assessing the impact of promotion related activities and, in particular, the promotion of science, still has much to grow, presenting itself as a field where we expect contributions from researchers and the various agents acting in the area.

3. Experiment outline

In order to provide some clues for research in the area, we present a study that was carried out on three different occasions and which aimed to realize the influence of an action for science communication in the perception that children in the first cycle of basic education have of the world around them and the phenomena they observe in it.
The mechanism for evaluating the impact of the session focused on the observation of changes in the graphical representation of the Sun on paper.
Children's drawings are instruments for a very rich analysis. They include their own biological, social, cultural and symbolic factors of the environment in which the child is inserted, which are decisive when drawing [11]. In doing so, the child projects a meaning and gives us an interpretation, a creative construction of possible meaning (*ibid*), allowing us to identify, analyse and relate the symbolic elements, it uses to represent an idea and understand the sources that nourish this system of signification.

But why choose children as the target audience? In western societies children are, from an early age, encouraged to produce images. Their illustrations are seen as ways to express themselves, much in part because they have not yet developed other skills to communicate. This activity begins even before entering school. In a spontaneous way, children paint walls, scribble and scratch sheets ... Therefore the drawings appear as learning activities in formal, non-formal or informal contexts, with the aim to acquire, improve or express the knowledge they possess.
At this point it is imperative that a brief clarification of what we mean by formal learning, non-formal or informal. This distinction was established by Bjornavold [2] and can be summarized as follows:

- formal learning is what takes place in a structured and organized context, which is developed in education and training institutions, which usually results in a formal recognition (diploma or certificate);
- non-formal learning occurs through either planned or in environments with educational component activities, but not explicitly oriented for learning (actions are outside the formal systems, such as in the community, in associations, in recreational activities and leisure, etc.);
- informal learning results from broader life situations, and that is often not recognized (individually and socially).

Some authors believe that the difference between non-formal or informal learning is rather vague, so often arises only the term non-formal learning.

We can then say that the activity carried out in a non-formal nature, allowed the children to give evidence of their learning through a drawing. Note that at this stage, six and seven years old, children develop their learning with the use of recreational and leisure activities, being only recently into the formal learning system.

The way children draw is a starting point for their visual literacy, since drawing is an activity that creates meaning, in which the visuals are used to share information, knowledge and ideas [13]. The visual signals are based on iconicity but also create an impression of similarity (Sonesson cit. Hopperstad [10]). However, they can not, at this age, express or convey the complexity of the objects or scenes they represent. Instead, they record invariant features of the world as they perceive it (Gibson cit. in [10]). At this stage of development, children's drawings are not reproductions, but "symbols" of real things [1].

At an age when they easily distinguish one person from another and realize the smallest change in a familiar object, the drawings are still highly undifferentiated. The reasons for this differentiation should be in the nature and function of pictorial representation, in which the image of the object depends on the standards of the designers and the purpose of your drawing (*ibid*). Differences are noted between the perceived and the representation, because the perception is not a "photographic" faithful record, but the seizure of global structural features (*ibid*).

Drawing is a way of communicating that acts as a visual reflection of the mind [11]. Barthes (quoted in [11].) emphasizes that the images represent the cultural significance and not as much the detail or materiality of the object. Furthermore, the individual creates images, perceptions and representations constructed from objective and specific phenomena acknowledged by others [11]. Assessments with children allow to understand the importance of representing concepts, therefore highlighting the difference between recognition and imitation. Perceiving and conceiving proceeds from the general to the specific [1].

Three aspects were key when choosing first grade children (ages six and seven). Being only recently entered into the formal learning system, removed, in some degree, from our analysis the possibility of a pre-existed structured procedure on how to behave when confronted with an observational session.

Also, they share a form of expression that is used both in recreation (non-formal) and scholar (formal) contexts that can be used without suggestion of any kind of assessment: the drawing.

Furthermore, in children, drawing itself is an activity that creates meaning, in which the visuals are used to share information, knowledge and ideas – the perfect method to assess the perception that children have of the world around. The observation of those drawings, produced by children, allowed the creation of some quantitative and measurable indicators in order to help enhance the reading and the understanding of the possible meanings.

3.1. Action Description

The experiment was planned as a three-moment set of evaluation, providing an assessment in each of the three phases: design, implementation and completion. The last moment has also served to infer how the changes, if any, were in the short term, sufficiently consolidated.

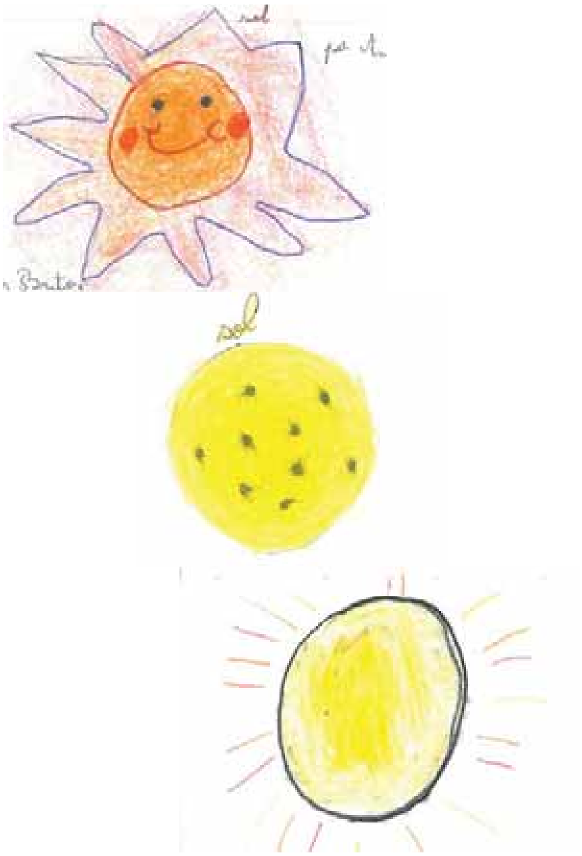

Illustration 1. Sun drawings of a girl. From top to bottom: before observational session, afterwards and long after

In May 2013, in a usual school day, eighteen children in the first year of the first cycle of basic education were invited to do a "free" drawing of the Sun. Unaware of the purpose of this task. In June of the same year they returned to represent it again, but this time after having attended a session observing the Sun through an optical instrument, a fully equipped telescope, accompanied by a brief individual explanation of the phenomenon they were about to observe.

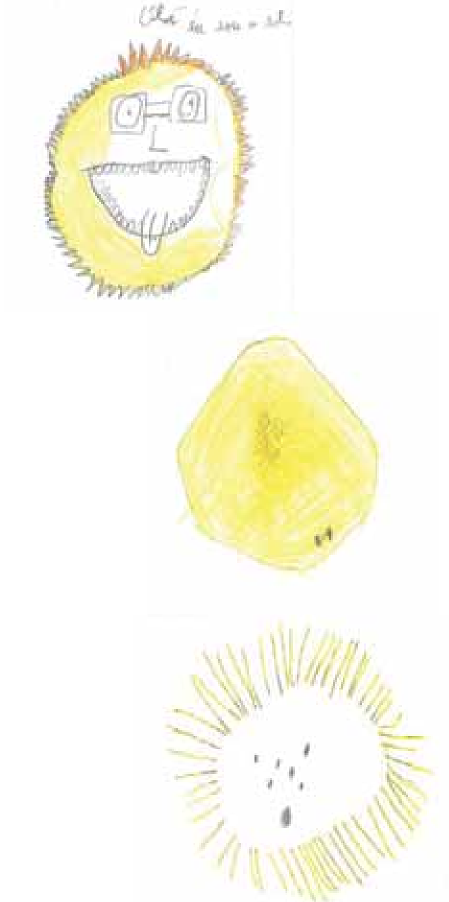

Illustration 2. Sun drawings of a boy. From top to bottom: before observational session, afterwards and long after

In the third stage, which occurred in January 2014, these children, now in the second year of the first cycle of basic education, returned again to draw the sun. There was no suggestion or allusion to the day of solar observation, having been invited to do once again a "free" drawing of the sun. The group of children has remained unchanged throughout the study.

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Indicators			Counting (out of 18) a)	b)	c)
Sheet orientation	*Horizontal*		16	18	18
	Vertical		2	0	0
Background	*Relative position of the Sun*	Big, on the center	15	17	18
		Small, on the center	1	1	0
		Small, in periphery	2	0	0
	Caption "Sol"-Sun	*Yes*	7	5	0
		No	11	13	18
	General information	Name	18	18	18
		Date	2	18	18
		Place	2	18	16
		Curricular year	17	0	0
	Speech or declaration	*Yes*	4	0	1
		No	14	18	17
Sun's Shape	*Almost perfect circle*		18	7	10
	Imperfect oval form		0	11	8
Colour of the Sun	*Only one*		4	14	9
	More than one		14	4	9
Solar rays	*Yes*		18	5	11
	No		0	13	7
Anthropomorphization of the Sun	*Yes*		16	0	0
	No		2	18	18
Presence of solar spots	*Yes*		0	18	11
	No		18	0	7
Number of solar spots	*1 to 5*		x	8	4
	6 to 10		x	3	3
	More than 10		x	7	4
Solar spots location	*Out of the central region*		x	5	2
	On the central region		x	1	0
	All over the Sun		x	12	9
Solar spots distribution	*Dispersed*		x	15	9
	Concentrated in one region		x	3	2
Solar spots size	*Big*		x	5	2
	Small		x	10	8
	Big and small		x	3	1

Table 1

The idea of analysing children's drawings led us to compare the drawings made in these three different times. The objective is clear: to understand how a particular activity of science communication can change the design, namely the visual mode of perceiving the world.
The drawings were placed side by side and a list of measurable indicators was developed, which allowed us to facilitate their comparative reading at different times. As a representative example, we present three pairs of drawings (illustrations 1 and 2 a), b) and c)), made by two children of different gender, respectively before, after observing the sun through the telescope and months later.

3.2. A brief analysis and the choice of indicators

The difference between the drawings in the three moments considered is remarkable. In a first moment it stands out the anthropomorphic characteristics of the Sun, attributing human characteristics such as eyes, mouth, nose and even personality (irreverent, such as the design of Daniel, not his real name, representing the Sun and talking with her tongue out) and in a second moment the Sun is predominantly represented having one colour, yellow, and with the clear presence of sunspots. In the third moment what emerges, similar to what happened the second time, is the absence of anthropomorphic characteristics of the Sun and a significant visual reference to sunspots and solar rays.
In Table 1 we present the indicators and recording of data collected for a total of 18 children. Initially, the selection of the indicators emerged from direct observation.

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Then, as the analysis ocorred, new indicators arose, a consequence of the diversity found in the drawings and from the purpose of the analysis itself. An example of such flexibility in creating indicators, is the awareness of the presence of sunspots in the second and third time. In order to verify the care of their registration by children, where we can possibly signal a scientific look with greater or lesser accuracy, was taken the decision of creating indicators that allowed us to identify details in the record of this phenomenon, such as number of sunspots, its location (right on the edge, in the center or around the Sun), the distribution of sunspots (whether dispersed or concentrated in one place the Sun) and size of sunspots (whether large, small or both). See Table 1 where a list of the indicators considered in the interpretation of drawings of the Sun developed in three stages, for a total of 18 children: a) 1st moment: before observation; b) 2nd moment: after observing; c) 3rd moment: long after the observation.

Considering these indicators, we found noticeable differences between the 1st and the 2nd moments and then the 2nd to the 3rd moments. The indicators where we verify the major changes when comparing the data from the table above are: the shape of the Sun, the colours used to represent it, the presence of sun rays, the presence of sunspots and the anthropomorphic characteristics of the Sun. Also at the first moment, some children introduce speech bubbles, giving the Sun speech ability: "Hello, I am the Sun," "I am the sun and call me Popi!", etc.. In the second and third moments, the drawing is not complemented with any speech. At the last moment we returned to check a wider range of colours, the presence of sun rays, although mostly in a linear-radial form, and a more cared and circular form of the Sun.

A brief reference to the survey made of the drawings made by children of other academic years under the same conditions of the first reference moment. They present the same attributes as those analysed here, in some cases increasing the complexity of the anthropomorphic characteristics of the Sun.

3.3. Data analysis and discussion

The data analysis allowed us to identify differences, seeking their respective meaning processes.

1st moment

The drawings made before the observation session, highlight the following features:

All drawings have the shape of an almost perfect circle; In most drawings we observed the predominance of more than one colour (14 in 18); In all we examined the presence of the representation of sun rays; The design of the Sun has human properties in 16 out of 18 drawings: the Sun talks, smiles, and presents itself as a more masculine or more feminine (which is highlighted by the choice of colours, the shape and length of the solar rays, which are similar, often to the longer or shorter hair, etc.).. We found some drawings where the sun seems to have a personality and even a peculiar name; In none of the drawings was verified the presence of sunspots.

What we find in the overall of the drawings is a representation of the cultural significance of this object rather than its detail or materiality (as Barthes says cit. in [9]). We find ourselves with the reproduction of the concept "Sun", with what it represents (good

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disposition, colour and light). The image was formed from what they see and what they experience, which naturally includes entertainment products and advertising. Furthermore, it is also an expression of the designer himself. Somehow, the representation of the Sun appears in the image and likeness of the author (irreverent, male or female, with or without glasses).
Referring to the historical and cultural significance of the Sun, Durand [6] adds that "the Sun means first of all light and supreme light". Continues by emphasizing that, in the Judeo-Christian tradition, Christ is constantly compared to the Sun, being valued in a positive way by their "luminous rise" (*ibid*). It is in the east that this star is born, making it a "loaded term of beneficent meanings" because the east means the dawn and possesses a sense of origin (*ibid*). Martins [14] reinforces this idea "To the west, the stars became therefore a history of meaning, and even a history of salvation, as the Christian sense is in a star that rises in the east" (p. 131). "At the symbolism of the Sun connects, finally, the solar corona" analogy with the Christian or Buddhist halo [6].
Therefore, the social significance of the Sun takes us to an idea of transcendence, of divinity, of intangibility.

2nd moment
After being the target of an observing session, using an optical instrument (telescope), the following changes are observed in the representations of the Sun: We can see the predominance of an oval shape to draw the contours of the Sun (11 out of 18); In most drawings it has been selected just one colour (yellow) to paint the Sun (14 out of 18); The sun's rays only appear in 5 of the drawings; The Sun loses its anthropomorphic characteristics; Sunspots appear on all drawings, in some cases, abundant and evenly distributed, in other cases, they are scarce and predominantly in a peripheral place in the Sun (the actual position of the spots in that day of the observation).
In the second phase the children rationalize the representation of the Sun, not giving much importance to the creative and cultural representation, to make room for objectivity, and similarity. It is noted the intention of reproducing the model, creating a similarity. When the drawings made in this second moment are compared to each other, we can see greater uniformity: the majority is mostly monochromatic, with a predominance of yellow colour, all present sunspots and human characteristics are not observed. It is the hegemony of the representation of sunspots.
In this case we are dealing with an approach to a representation of a scientific image, as described by Joly [12]. This representation came from viewing a particular phenomenon, the presence of spots on the surface of the Sun, that was complemented with an explanation which allowed for a more concrete observation, attentive to detail, objective and situated.
Scientific images seek to represent phenomena, allowing a questioning observation. The use of the instrumentation, of technoscience (here with the meaning of science that is applied in technology, which in this case has resulted in the use of an optical telescope) aims to observe and then reproduce images. Normally the interpretation of images in science, particularly in the "exact" sciences, requires more than observation, advancing to the explanation.

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3rd moment

At this time the children are in the 2nd year of the first cycle of basic education. Being seven months since the day of the solar observation and without any reference to that day they returned to draw the Sun. We found the following characteristics in the drawings: Predominance of the circular shape (10 out of 18); As for the colour, the Sun appears with more than one in half of the drawings while only one (yellow) is chosen to paint the remaining; Solar rays have a distinct presence (11 out of 18); There is no reference whatsoever, to anthropomorphic characteristics of the Sun in the drawings; Sunspots appear in 11 drawings. The number of spots shown is variable and the spots are located predominantly around the Sun, distributed in a scattered way, usually being reduced in size.

In this third moment the representation of the Sun children do, includes the knowledge they have about it. Although there has been no reference to the day of solar observation, the information obtained in the session appears referenced in most drawings.

When the drawings made at this point are compared with each other, there is a variety of shapes and colours, used with creativity and imagination.

We note that there are two predominant drawing types differentiated by the presence or absence of sunspots. The seven drawings that have no sunspots are very similar to each other: circular shape of the sun, yellow appears as the predominant colour and six of the drawings feature sunrays. But the drawings with the presence of sunspots, if compared among themselves exhibit greater diversity, either by choice of representation, or not, from sun rays, by location and distribution of the spots, as well as the choice of form and colour, despite continuing to predominate the yellow colour.

3.4. Comparative analysis

We understand that during this journey happened very significant changes in the way children represent the Sun and they provide clues that will lead us to a better understanding the impact of the action on understanding the concept of the Sun by children. A comprehensive analysis of the three moments is required.

We consider that the main features of the 1st moment can be summarized by creativity (understood in the sense of diversity), resulting from anthropomorphising and its identification with the individual-designer; the 2nd moment is the representation that is highlighted, very specifically the representation of the phenomenon of sunspots - the only phenomenon really visible; and in the 3rd moment we find a combination, a juxtaposition of the characteristics of previous times.

By doing this analysis some issues arose, such as: why is the first moment more diverse? And why do we find a huge variety of colours? At the 2nd moment the drawings represent the Sun or a specific phenomenon of the Sun (the sunspots)? Why are the sun rays present in the 1st moment, become less representative in the 2nd moment, only to reappear later? Why this change in the circular shape of the Sun throughout the three moments?

The diversity found in the early drawings brings us to the question of iconicity, cited in the previous section. What children represent is the meaning they attribute to the Sun, projected in the drawing they make.

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We are faced with a sign, where the signs are resources that individuals use and adapt to construct meaning. We can conclude that the children built their own, individualized meaning, mirroring in the graphical representation their own ideas and assigning a meaning to the Sun, an expression of the child, his own image, hence the diversity and creativity observed. This process explains the freedom of the use of colour and detail, reflections of the author's expression.

The representativity found in the 2nd moment is the perceived face of the phenomenon found, sunspots, which therefore made the drawing an interpretative picture. Interpretation is always a process between understanding and explanation. The drawing reveals by one hand understanding of the phenomenon but also it integrates the transmission/explanation attempt to others. Thus, the attempt of similarity takes precedence.

On the 3rd moment we find a juxtaposition of some of the features in the images done in previous times.

One of the characteristics that deserves careful analysis relates to the solar rays, very present initially, then disappearing almost entirely and reappearing in the 3rd moment, even if less exuberant. The function assigned to the solar rays varies, the first images appear as "hair" on anthropomorphic figure of the Sun, losing expression in the 2nd moment because they were not observed at all. Come up again in the 3rd moment not as "hair", but as a finding of daily observation of the Sun, whose rays gain visibility by crossing our atmosphere. There is a juxtaposition between the information resulting from the daily observation with the information from the observational session. Some drawings integrate with equal preponderance, both observational informations. The question of form is equally interesting. Initially very circular to represent a face, losing its perfect geometry in the 2nd time, perhaps because the focus is primarily on representing sunspots. An increased expression of circular shape reappears on the 3rd time. At that moment all drawings that have solar rays are circular and all who are not circular have no sunrays. It matters now to question if all that aren't circular, have spots? We seek this relationship between sunrays, shape, spots and found that those who are not circular have spots. That means they are not circular because of the interest of representing sunspots, thus confirming what we have already seen. We can, however, assume (a more detailed study is required to conclude) that the drawings where the integration is done, wherever spots and rays are represented, are performed in a single process where the image of the Sun created includes two phenomena: an inner and another outside. Thus, the border outlining is of particular relevance.

Regarding colour, we observe gradual changes, ranging from a wide variety and then an overpower of the yellow and finally to converge in representations especially dichromatic (two colours, yellow and orange). This development enhances recovery, the 3rd time, of the creative component to complement the representative.

4. Conclusions

Two major conclusions can be drawn from this brief study. The Sun has evolved from an intangible object, from the field of denotation, from creative representation and capable of assigning symbolic meanings to an observable object, with characteristics of its own, not conferred by something outside, in particular the author. This new facet that the Sun acquired in the minds of children aged six and seven years, was perennial and yet not usurping the "creative" previous version, as shown by the recovery of a certain freedom in the use of colour and increasing diversity in the representations.

An integrative imaging using two different sources of observational information, was formed: the data of indirect everyday observation - the sun rays; and direct observation through instruments - sunspots. The image of the Sun was enriched with new possibilities coming from a scientific observation.

Together they radically transformed the process of mental and graphical representation of a given object. The object that needed no observational information starts to require it, and its area of representation becomes to be very close to the everyday life. The Sun becomes a physical object, both in the sense of tangibility and dynamical.

Although the outcome of the session is not the same for each child, the possibility to choose between different forms of representation is in itself a value. Their range of options was enriched. Their future personal experiences will determine whether to extrapolate this experience to an intrinsic way to evaluate the world around them or not.

A first, of many, simple goal must be outlined: to enrich people with new possibilities originated in a scientific point of view of nature. Assessing the impact of a given action in the individual is a very important step to validate and improve the action itself. Although difficult, a feedback based design of the activities of science communication is needed. These three points can and should be applied in activities that are determined to promote scientific culture, on every branch science offers.

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Genetic Transformation of Plants. A One Week Summer Course for High-school Students

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Abstract. *Genetic engineering, the process of manipulating the DNA of an organism often including DNA from a foreign organism, relies on complex molecular techniques. In the program for school students "Universidade Junior", from the University of Porto, we developed a one week-long summer project for 15-17 years old students pertaining the concepts and procedures involved in plant genetic transformation. Students conduct hands-on experiments involving DNA-based Technologies including Agrobacteria-mediated transformation of plants, and observation of fluorescent recombinant proteins by fluorescence microscopy.*
The impact of these technologies is discussed enabling students to resolve these controversial issues and justify their decisions on scientific-based balanced appraisals.

Keywords. Agrobacterium, electroporation, genetic engineering of plants, floral-dipping, GMOs, fluorescence microscopy.

1. Introduction

Biotechnology has an increasing social impact in daily lives requiring citizens to be able to understand its main concepts and make informed decisions regarding its applications. Biotechnology applications are surrounded in controversy and concerns about the public's understanding of their implications [1].Concerns on promoting proper understandings of biotechnology notions and procedures fostered the inclusion of modern molecular biology and biotechnology contents in the Portuguese twelfth-grade biology curriculum with an emphasis on their mobilization into concrete everyday situations. However an extended survey on Portuguese high-school students 'perceptions about biotechnology showed that even the students engaged in this curriculum displayed misconceptions about fundamental concepts and principles, suggesting that adjustments are required to increase its efficiency[1].

The booming field of biotechnology relies heavily on the development of complex molecular techniques, including those related to genetic engineering, as a process of manipulating the DNA of an organism often including DNA from a foreign organism. The subject of genetically modified organisms, or GMOs, has sparked public fear and controversy related with introducing such organisms into our food supply and possibly interfering with genetic diversity.

Most current misconceptions derive from nonscientific views learned by students from sources other than scientific education. Different Eurobarometer surveys have evidenced that misconceptions such as "ordinary tomatoes do not contain genes, while genetically modified tomatoes do" or "by eating a genetically modified fruit, a person's genes could also become modified" derive from a preoccupying level of ignorance [2].

Teaching programs in biotechnology must articulate innovative teaching strategies (such as hand-on-laboratory classes) with the discussion of social and environmental consequences of biotechnology applications. These should enable students to resolve the usually controversial issues and justify their decisions on scientific-based balanced appraisals.

In the framework of the program "Universidade Junior", an initiative launched by the University of Porto to receive school pupils for week long projects [3], we developed a "Summer project" for 15-17 years old students aimed at conveying an understanding of the principles involved in plant cell genetic transformation.

Combine cutting-edge science with simpler activities the students conduct hands-on experiments involving DNA-based Technologies, DNA isolation procedures, nucleic acid electrophoresis, gene cloning, bacterial transformation, plant transient and stable transformation, protoplast extraction and observation of expressed fluorescent recombinant proteins at the fluorescence microscope.

Transformation of plant cells is usually accomplished by means of the bacterium *Agrobacterium tumefaciens* because of its ability to introduce DNA into the plant cell. In nature, Agrobacterium species inject a region of their own DNA (the transfer-, or T-DNA) into the plant cell that is incorporated into the plant genome by homologous recombination. This led to the denomination of Agrobacterium as "Nature's own genetic engineer". In plant genetic engineering, the T-DNA is replaced with a genetic construct containing the gene of interest for the protein to be expressed [4].

Students isolate from existing clones of *E. coli* various constructs coding for fluorescent protein GFP (green fluorescent protein) fused with different intracellular targeting domains, specific for intracellular compartments such as Endoplasmic Reticulum (ER) and Golgi Apparatus GA).These constructs are transformed into *Agrobacterium tumefaciens* cells by electroporation and transformed Agrobacterium cells are further utilized as transformations agents both for transient infiltration of tobacco leaves and for stable transformation of Arabidopsis plants by floral-dipping.

Expression of fluorescent fusion proteins in living plant cells is assayed by fluorescence microscopy [4].Students are welcome in the university for a week-long project under the supervision of a junior tutor, under the coordination of one member of the academic staff. In this case the tutor was a Master student which applied the tools and know-how acquired in her Master project.

Encompassing the laboratory process, students are invited to list and discuss the pros and cons of these technologies and several uses of transgenic plants are demonstrated namely the production of beneficial proteins in agriculture, the production of plant manufactured pharmaceuticals used as therapeutic compounds, and in basic cell and molecular biology research.

Ethical issues of the impact of these technologies are further discussed, namely the possible social and environmental consequences.

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2. Materials and Methods

2.1. Plasmid DNA extraction (mini-prep)

A culture of *E. coli* (DH5-a) was initiated the day before the extraction. 1,5 mL of that culture was transferred to a sterile microtube tube and centrifuged at maximum speed for 30 seconds. The supernatant was discarded and the pellet was ressuspended in 200 µL of Sucrose-Tris-EDTA-Triton (STET) buffer [8% (w/v) sucrose; 0.1% (v/v) Triton X-100; 50 mM EDTA; 50 mM Tris-HCl, pH 8.0] and 5 µL of lysozyme (50 mg/ml). The samples were incubated for 5 minutes at room temperature. The samples were boiled for 45 seconds for inactivation of DNases and lysozyme and centrifuged for 5 minutes at maximum speed. The pellet was removed with a sterile toothpick and 200µL of 2-propanol was added to the tube for DNA precipitation. The samples were homogenized by vortexing, followed by a 10 minutes spin at maximum speed. The supernatant was removed and the pellet was washed with 70% (v/v) ethanol. The pellet was air-dried, at room temperature. The DNA was ressuspended in 20 µL of sterile water with RNase (10 µg/ml) and stored at -20 ºC.

2.2. Transformation of *A. tumefaciens* by Electroporation

Electrocompetent Agrobacterium GV3101 were thawed on ice. 10 µL of pure plasmid DNA were added to the cells and the mixture was carefully transferred to the bottom of the cuvette. The Biorad Micropulser was set to “Agr” mode. The cuvette was placed in the chamber slide. After the pulse, 1mL of LB medium was immediately added to the cuvette. This mixture was incubated for 4h without shaking at 28ºC for recovery of the cells. The cells were centrifuged for 4 minutes at 1300 x g. 900 µL supernatant were discarded and the pellet was ressuspended and plated in LB-agar supplemented with antibiotics. The plates were incubated for 48h at 28ºC.

2.3. Transient transformation of Arabidopsis thaliana

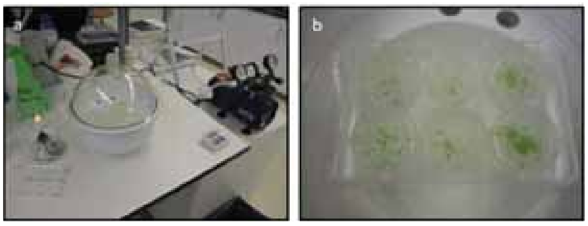

Figure 1. Arabidopsis seedlings infiltration. a. Vacuum infiltration apparatus, b. detail of Arabidopsis in 6-well plate during infiltration process

Arabidopsis thaliana seedlings were transiently transformed by vaccum infiltration based on the work of Marion et al, 2008 [5]. *Agrobacterium tumefaciens* cells transformed with the various constructs were grown overnight in 5 ml pre-culture and used to inoculate a 30 ml culture (LB liquid medium). After overnight growth at 28°C, *A. tumefaciens* cells were centrifuged at 1537 x g and resuspended at the appropriate OD600 in 2 ml of MS liquid medium.. Infiltration was performed by submerging the seedlings in the Agrobacterium solution and by applying vacuum (-70 KPa) twice for 1 min (Fig. 1). The remaining infiltration medium was subsequently removed and the

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plates were transferred to a culture room for 3 days.

2.3. Stable expression of Arabidopsis (Floral-dip method)

Figure 2. Floral dip method proceedings. a. Flowering Arabidopsis plants used for floral dip transformation, b. Arabidopsis flower detail, c. Arabidopsis dipping with gentle agitation and d. covered plants for humidity maintenance after floral dip

Stable transgenic lines of *Arabidopsis thaliana* plants were produced by floral dip method [7]. Agrobacterium culture was centrifuged for 15 minutes at 1537 xg at room temperature. The supernatant was removed and the cells were resuspended in floral dip inoculation medium. The floral dip medium was added to a beaker and the plants were inverted into this suspension (Figure 2.8 c). A minimum of three robust plants without siliques (Fig. 2 a and b) were used per transformation. The plants were submerged two times for 2 minutes each with gentle agitation (Fig. 2c). Plants were removed from the beaker and placed in a plastic tray and covered with a clear-plastic to maintain humidity (Fig. 2d)

2.4. Agrobacterium infiltration of *N. tabacum* Leaves

Figure 3. Tobacco plants and leaf infiltration with a needleless syringe

Agrobacterium-mediated transient transformation of tobacco leaves was performed according to [6]. One mL of a fresh culture of A. tumefaciens transformed with the construct of interest was centrifuged at 16000 xg for 1 minute. The pellet obtained was resuspended in 1 mL of infiltration buffer (10 mM MgCl2 and 10 mM MES) supplemented with 100 mM of acetosyringone, which contributes to increase the virulence of A. tumefaciens. Using a 1 mL capacity syringe, without needle, a tobacco leaf was infiltrated, controlling the pressure applied with the syringe on the lower epidermis (Fig.

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3) until the liquid entered through the stomata and infiltrates in the intercellular spaces.

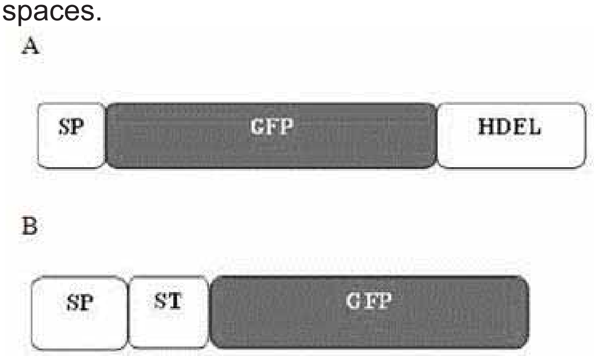

Figure 4. Schematic representation and characteristics of the fluorescent markers/constructs (pre-existent in the laboratory) used for the transformation. A. Endoplasmic reticulum marker. B. Golgi apparatus fluorescent marker. SP, Signal peptide for targeting to the ER; GFP, Green Fluorescent Protein; HDEL, aminoacidic motif in the C-terminal end for ER-retention; ST - Sialyl-transferase, a Golgi-membrane protein

2.5. Constructs for Transient Expre-ssion

Binary vectors containing fluorescent protein fusion constructs were prepared using standard molecular biological techniques. The pVKH18En6 binary vector used in this work is available from John Runions, Oxford Brookes University. Fluorescent fusions pre-existent in the laboratory used were 35s-SP-GFP-HDEL and 35s-SP-ST-GFP (Fig. 4).

2.6. Isolation of protoplasts from Arabidopsis thaliana leaves

Leaves of were placed in Petri dishes with the lower epidermis facing down, floating in digestion medium, containing 1% (w/v) cellulase and 0.25% (w/v) macerozyme. Petri dishes were placed in vacuum for 15 min and incubated in the dark, without shaking for 2-3 h, at 25 ºC followed by incubation with shaking, in the dark for 15 min at room temperature. Subsequently to the digestion, the protoplasts were gently released from the leaf portions with a plastic pipette and recovered into a new Petri dish through a 100 μm nylon mesh (Fig. 5).

Figure 5. Isolation of protoplasts from Arabidopsis thaliana leaves

2.7. Fluorescence microscopy

The monitoring of the cells' transformation was performed through fluorescence microscopy. Small portions (about 1 cm2) of the tobacco leaf infiltrated area were cut and placed in a glass slide with abaxial face upwards. A drop of water and a coverslip were placed on top of the leaf. Three days after infiltration the Arabidopsis cotyledons were excised from the seedlings and placed on the top of a drop of water in a slide with the abaxial face upwards. The fresh material was covered with a cover slide. Cells were imaged using Fluorescence microscope OPTIPHOT-2 (Nikon).

3. Results and Discussion

Students followed a line of reasoning and performed all the procedures even if pre

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prepared material was already available for experiments and subsequent analysis. Tutors provided grown tobacco and Arabidopsis plants as well as already transformed E. coli and Agrobacteria cultures with the appropriate constructs which were also previously obtained in the laboratory and maintained in *E. coli*. All bacterial media were prepared by the students thus being introduced to proper aseptic procedures. Students performed plasmid preparation, bacterial transformation, protoplast preparation, rapid transient and stable transformation techniques and evaluated subcellular localization of fusion protein fluorescence in living tissues by fluorescence microscopy.

During the course, students were immersed in laboratory work, while discussing important concepts pertaining genetic transformation as a molecular and biotechnological tool, cell biology and structure, molecular genetics and biotechnology.

Considering that constructs were available in the laboratory and also bacterial clones, and stably transformed Arabidopsis lines, this course provided simple and inexpensive procedures to teach genetic transformation using plants as model systems. Students contacted with laboratory equipment of the university not generally available in schools, such as electroporator, electrophoresis apparatus and fluorescence microscope.The experiments provided colorful images and conclusive results with of plant genetic transformation.

Students were introduced to the concept of transformation (introduction of foreign DNA into cells) and discussed reasons to transform cells (to introduce new genes and therefore new traits into a cell/organism). Different techniques are used to transform different types of cells and in any type of cell, plasma membranes and/or cell walls must be penetrated without damaging the cell. Some types of plants can be transformed via infection with *Agrobacterium tumefaciens*, a natural tool for plant transformation.

Plant transformation can be transient where there is no incorporation of exogenous DNA into the genome or stable with the incorporation of introduced exogenous DNA into the genome. Steps in plant transformation include, propagate binary vector in *E. coli*, isolate engineered binary vector and introduce into Agrobacterium already containing a modified Ti plasmid and infect plant tissue with engineered Agrobacterium

Transient expression assays in plants can be performed by a procedure called agro-infiltration with *Agrobacterium tumefaciens* that transfers to the plant the T-DNA carrying the sequences in study, which will be expressed in the plant tissue. The technique consists in the infiltration of the abaxial surface of a leaf with an Agrobacterium suspension using a needle-less syringe. Expression of fluorescent fusion proteins in living plant cells was assayed by fluorescence microscopy.

In this work, we usedfluorescent organelle markers specfic subcellular compartments, the endoplasmic reticulum (ER) and the Golgi apparatus (GA), which provided an insight in the organization of the plant secretory pathway and allowed to identify subcellular distribution in living cell. Plants were transformed with a SP-GFP-HDEL construct containing the jellyfish gene encoding for the green fluorescent protein with the ER retention signal, the HDEL

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sequence at the C terminus and with the SP-ST-GFP construct that encodes Sialyl-transferase, a Golgi-membrane protein, fused to GFP.The transformed cells were inspected with a fluorescent microscope. Fluorescent images of SP-GFP-HDEL showed that GFP was localized in the ER while the images of SP-ST-GFP showed that GFP localized to Golgi bodies that appeared as punctate structures (Fig. 6).

During the course, in planta transformation of Arabidopsis was also performed by dip flowering plants into Agrobacterium suspension (Fig. 2). By this simple method transformation of female gametes occurs and subsequently seeds are harvested and transformants selected. Finally, students also performed preparation of protoplasts from Arabidopsis plants (Fig. 7). Protoplasts are plant cells that have had their cell walls enzymatically removed and have been adapted a basic and versatile tool for genetic engineering and biochemical research to study a variety of cellular processes, such as subcellular localization of proteins, isolation of intact organelles and transient gene expression.

The program "Universidade Junior", an initiative of the University of Porto, has brought to the University thousands of school students from various grades. This course configured a research-based "Summer project" targeted for secondary, pre-university students.

Students developed a project in a research laboratory, which provided opportunities to enhance their scientific literacy and envisage future prospective careers in science. Science in society issues were also approached, namely the possible social and environmental consequences of science advancements and the need for citizens to make informed decisions regarding its applications.

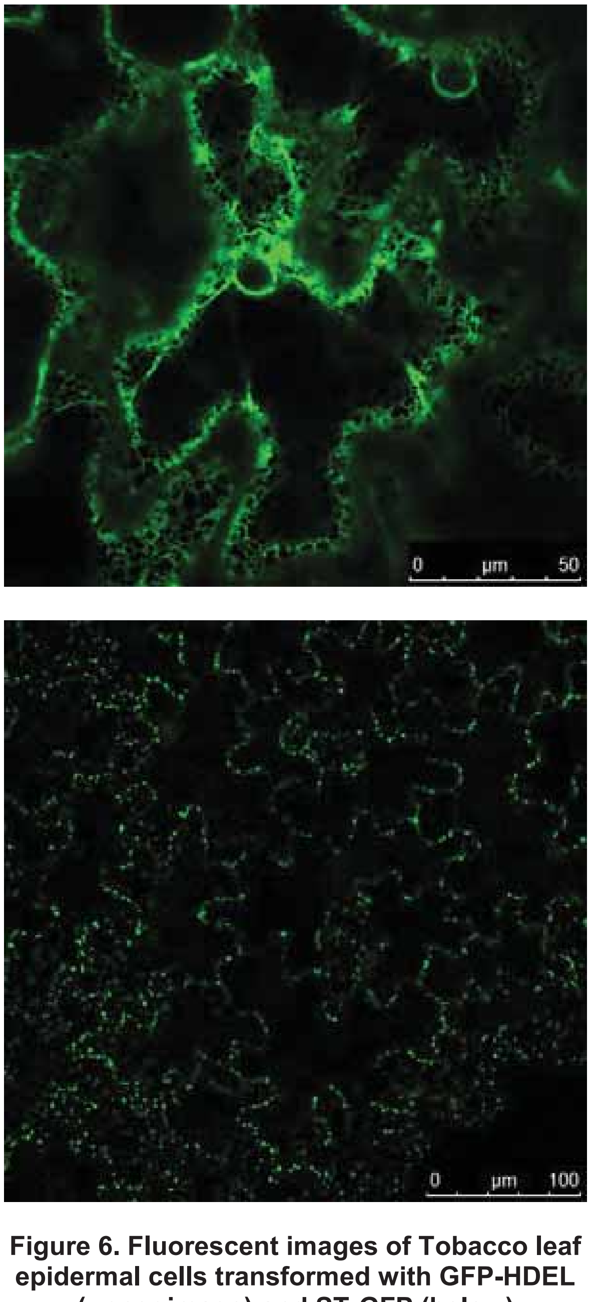

Figure 6. Fluorescent images of Tobacco leaf epidermal cells transformed with GFP-HDEL (upper image) and ST-GFP (below)

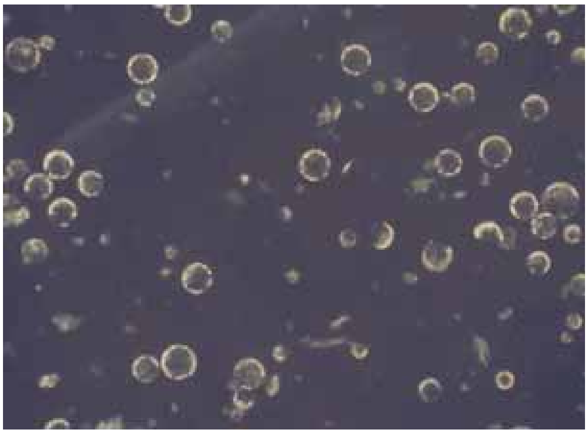

Figure 7. Arabidopsis protoplasts

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Science: 1, 2, 3, Action! How to Teach Science to Primary School Children

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Abstract. *This project is dedicated to students of the Primary Schools of our region. During the primary school, the only contact of children with Science is through a subject named "Estudo do Meio" which presents several problems. Therefore, this project came to cover this gap, with the availability of a set of experimental activities, discussion and debate of ideas. It has been considered interesting and very well received, not only by students but also by teachers, these last ones may eventually be looking at the project as an useful tool of making enthusiasm grow in their students.*

Keywords. Children, education, primary school, science activities.

1. Introduction

Students of Primary School have contact with Science in the "Estudo do Meio" program whose goals are: to identify the basic elements of the Physical environment and use some simple processes of knowledge of the surrounding reality, assuming an attitude of permanent research and experimentation [1].
The principles of this subject enables students to learn the concepts without having to go through the same paths. They are thus expected to become active observers with the ability to discover, investigate, experiment and learn. It is therefore important that teachers provide them the tools and techniques necessary for this learning process [1].
This paper aims to show a project that works on some of the scientific topics covered in this subject with practical, investigative and hand-on activities, that allowing students to challenge some preconceptions. Learning science is not simply the increasing of the knowledge of young people about the phenomena to develop and organize the reasoning of common sense. Learning Science is meant to introduce children and young people to a different way of thinking about the natural world and explain it [2].

2. Methods

2.1. Strategy

All the programs of "Estudo do Meio" are studied sequencing all scientific topics covered in different years and choose the ones that will be explored in the Science sessions. For the choice of subjects, teachers are an active element. They decide what kind of topics they would like to see explored during the year, with their classes.
Each activity begins with a diagnostic assessment, to rate the knowledge's level of students. This diagnosis always ends up in a debate where students expose all their questions and it's possible to individualize the explanation of content, answering all questions. All the activities have a high practical component, with the exception of the subject "Solar System", because in this theme, the students have a lot of questions and misconceptions. So we make a more

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extensive discussion of ideas, reducing the number of experimental activities.
At the end of activities, we ask again some of the initial questions, to understand if students continue, or not, with the same kind of doubts. In addition, students, according to their ages, are asked to text or draw or sum up the activity. The abstracts, drawings or the tests applied, are analysed to understand the impact of the session and which the moments they found most interesting.

2.1. Themes and concepts applied

The topics covered are varied and studied in the program of "Estudo do Meio", but we work also with themes, stipulated by the Ministry of Education. So this school year, the themes worked were:

- Biodiversity Field Trip - Students of kindergarten and 1st cycle of basic education;
- Are microbes all bad? - Students of Kindergarten, 1st and 2nd year;
- Densities - Students of Kindergarten and 1st and 2nd year;
- Physical properties of water - Students of the 1st and 2nd years;
- Air and its gases - Students of the 1st and 2nd years;
- Environmental Education - Students of the 1st and 2nd years;
- Human Body - Students in 3rd and 4th years (2);
- The Solar System - Students of 3rd and 4th years;
- Do plants need water to live? - Students of kindergarten;
- The importance of biodiversity - Students in kindergarten;
- Plants – Students of 3rd year;
- Magnetism – Students of 3rd year;
- The Water Cycle – Students of 4th year;
- Electricity - Students in the 4th year.

2.1. Specific cases

In this article 3 activities were explored using different methodology, different evaluation and different age of audience: Kindergarten, 1st and 2nd years and 3rd and 4th years.

2.1.1. Environmental Education

Figure 1. Student playing the game "Let's separate our garbage"

Audience: Students of 1st and 2nd years
Goals: To sensitize students to the correct way of sorting waste and to the importance of the Environment in our everyday life
Methodology: Exhibition of some typical plants of our region that represent the importance of the environment in our life and debate their importance; Play the game: "Let's separate our garbage"; Listening and comprehension of on the lyrics of the song

"Recycle" by project "O Planeta Limpo do Filipe Pinto" (Fig. 1)
Evaluation: Application of the same questionnaire before and after the activity

2.1.2. Human Body

Figure 2. Students analyzing the organs

Figure 3. Students playing the game: "How's my skeleton?

Audience: Students of 3rd and 4th year
Goals: Exploration of the Human Body: our organs, systems and their location in the human body; What is a muscle and where we have muscles; what types of muscles we can find in our body; Our bones and their functions; The importance of skin and hypodermis.

Methodology: Presentation and handling of pig organs, including: heart, lungs, stomach, trachea and oesophagus (Fig. 2); Play the game: "How's my skeleton?" (Fig. 3); Application of hands-on activities about the importance of the hypodermis (Fig. 4);
Evaluation: Ask for a sum up text and a drawing of the activity, to be done a few days after the session.

2.1.3. Do plants need water to live?

Audience: Students from kindergarten
Goals: Understanding the importance of water for plant growth

Figure 3. Activity about the importance of hypodermis

Methodology: construction of 2 ecosystems (ecosystem 1 - Boys | ecosystem 2 - Girls) with soil collected at school and using two

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bottles of water; Construction of a lake for each ecosystem using a plastic cup (Fig. 5).; planting lettuce in each ecosystem (Fig. 6); Installation of a bag, to close the Ecosystem 2; Setting of ecosystems near window, with direct sunlight.
Evaluation: Fill in a table with what was expected by students, based an daily observations and conclusions.

Figure5. Construction of the lake

Figure 4. Introduction of lettuce in the ecosystem

3. Results

After the activities performed, different forms of evaluation were applied, including questionnaires, observation tables, drawings and sum ups.

3.1.1. Environmental Education

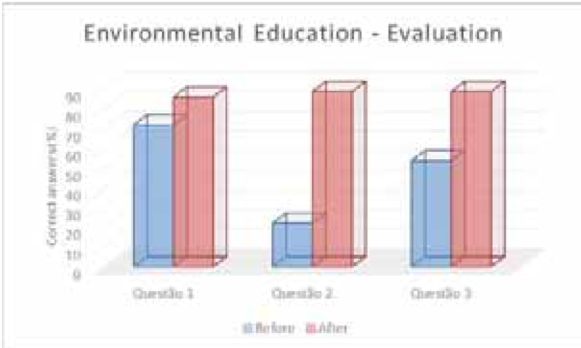

Figure 5. Evaluation of student's knowledge

3.1.2. Human Body

In this activity, the evaluation was based on drawings and sum ups. The students highlighted the handling of organs, including the ability to realize "how they are", "how they work" and "how they fit in our body". The experience was performed to help students to understand the importance of hypodermis.

"... The other part was touching the pig's organs. This was the most impressive part. I liked it a lot. " Tomás Martins, EB1 Cambeses

"... she also lets us ask questions and clarify all our doubts and my question was:" Why do people have heart attacks ". And she

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answered me..." Andreia Filipa, EB1 Cambeses

"... Then we talked about muscles. We have two types of muscles: the ones with voluntary and involuntary contraction. There are two types of muscles of involuntary contraction: smooth, referring to the stomach, trachea, esophagus and intestines and cardiac which is related to the heart ... " André Barros, EB1 Cunha.

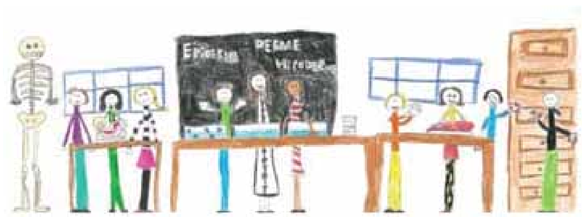

Figure 6. Evaluation drawing

3.1.3. Do pants need water to live?

Table 1. Daily observation of experiment

Before the experiment	
Will the two plants grow?	
Yes	No
3	1
Day 1	
Are the plants different?	
Yes	No
4	0
Day 4	
Which plant is greener?	
Plant 1	Plant 2
1	3
Which plant grew more?	
Plant 1	Plant 2
0	4
Do the two plants still have water?	
Yes	No
4	0
Day 5	
Which plant is greener?	
Plant 1	Plant 2
4	0
Which plant grew more?	
Plant 1	Plant 2
4	0
Do the two plants still have water?	
Yes	No
4	0
Day 6	
Which plant is greener?	
Plant 1	Plant 2
0	4
Which plant grew more?	
Plant 1	Plant 2
1	3
Do the two plants still have water?	
Yes	No
4	0
Day 7	
Which plant is greener?	
Plant 1	Plant 2
0	6
Which plant grew more?	
Plant 1	Plant 2
0	6
Do the two plants still have water?	
Yes	No
6	0
Day 8	
Which plant is greener?	
Plant 1	Plant 2
0	6
Which plant grew more?	

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Plant 1	Plant 2
0	6
Do the two plants still have water?	
Yes	No
0	6

After the experiment	
Are the plants different?	
Yes	No
6	0
Did the two plants grow equally?	
Yes	No
0	6
Which plants grew more?	
Plant 1	Plant 2
0	6
Which plant still have water?	
Plant 1	Plant 2
0	6
Was the water important for the plants?	
Yes	No
6	0

4. Discussion

4.1.1. Environmental Education

In the analysis of the assessments applied it is easy to realize that the implementation of these activities is an asset to increase students' knowledge. So in the three posed questions, they have known better how to separate our residues in ecopoints, with only a few doubts, namely the case of appliances and tissue paper. These problems were dissipated in the end of the session, in the last analysis. This theme is well-known theme by the students, but some of them still don't know how to separate the garbage, showing us the importance of doing these initiatives earlier and more significantly.

Another question made was about 3R's and their correct order. At this point only one student knew the correct order, in the beginning of the session, but at the end of the activity almost everyone knew it. The last question was about the importance of the environment to our daily life. This question shows clearly that students know that the environment is important but they could not explain why. They easily associate the environment to the food, but it was difficult for most of the students to associate the environment, for example, to the production of medicines. At the end of the presentation and discussion of the importance of all the plants, they have realized, recognizing its impact over their own and their families living conditions.

4.1.2. Human Body

The analysis of the collected sum ups and drawings allows us to see that the students improved their knowledge about the composition of the skin and the importance of the hypodermis. They were enthusiastic with working with pig organs. It was quite obvious, during the activities that children have misconceptions about the form and constitution of bodies, getting quite surprised with the constitution of the pig organs, especially in the presentation of the lungs, esophagus and trachea, over which they had a wrong mind-set.

4.1.3. Do plants need water to live?

These activities, which involve daily observation, are quite interesting because they require the students to pay attention to every detail and be critical of their

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expectations. In this experiment, all students were asked to write down their expectations before the activity and compare their initial opinion with the final results. This was surprising for some students. Also surprising was the answer to the first question of the project: "Which plant will grow better?". The answers were completly opposite to what was expected. Girls answered that it would be the ecosystem 1 (made by boys) and boys answered ecosystem 2 (made by girls). At the end of the activity we explored all the results and discussed their expectations. At the end everyone knew why water is important and how the plant "drinks" water.

5. Conclusion

These activities have a curricular interest, they help students to learn and they also help to form socially active and aware citizens. So we want to continue to explore this project. Apart from the above, the students of Primary School demonstrate more ability to respond correctly to the questions, about the tested topics. However it may be interesting to do a more extensive follow-up work trying to understand if, in the next school year, students with remember what we have taught them or, on the contrary, if them maintain the previous idea. It can even happen that they have a mixture of the two ideas and are confused.

6. Acknowledgements

A special acknowledgment to schools and teachers who received the project and one very special, to the enthusiastic students who have always participated in activities showing an excitement and a stimulating spirit.

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The Role of Optics in Engineering Education: First Year Students

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Abstract. *This paper describes and analyzes some specific aspects of our experience in stimulating the interest of the first year students of our Engineering School. They will follow in subsequent years different Engineering Studies, although not Optical Engineering. In general, the first year curriculum doesn't allow a detailed review of the main light properties, least its technical applications. Based on the fact that they have a very basic training in this branch of physics, we have designed a series of experimental demonstrations with the dual purpose of making them understand the basic principles of these technologies, and to know their potential technological applications.*
We assemble these experiments in the final days of each course, and invite the students to pass by the laboratory to get to know them, giving them an explanation in which we focused on the possible range of application of each technique. The students who attended the invitation really showed a great interest for the issue, in spite the fact that the demonstrations were basics and not really spectacular. Here the authors analyze the understanding of the explained principles, as well as the degree of awareness in the importance of the Optics in Engineering and then in their education. Internet technologies make easy for the students to search for information in any scientific field, in particular this of Optics and many questions arise for specific points that awake their interest, leading this to an enrichment of the discussions.

Keywords. Engineering education, optics education.

1. Introduction

The scientific knowledge of the light nature and its handling results nowadays in a multitude of techniques to solve many problems in all engineering fields. From metrology, alignment or non destructive testing to power applications for cutting or welding, there is a wide technological field that can't be absent from the engineer education curricula. Not only the optical engineer student needs an adequate formation in Optics related issues but also those who want acquire competence in the wide field of the modern technology have to be familiarized with the Optic principles and applications [1].
In our case, we teach Physics for different engineer specialties, none of them Optical Engineering. Physics is part of the core curriculum and is taught in the first year. Optics is included in the Physics program, but as it has to be developed in only four hours per week (including laboratory training), little time can be really devoted to an in-depth study or even the basic optical concepts. This, and the fact that the authors' particular research field is in an optical application (Metrology), is the reason that lead us to design an extra-program activity, developed at the end of each year, to encourage students to learn about optics and its technical applications. We designed

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a series of laboratory experiments that cover different aspects of the optical science (geometric optics, interference and diffraction, polarity, laser, etc.), simple enough to be understood by first year's students with very basic optical concepts. When the lectures period is finished, they are invited to visit our laboratory, to attend our explanations and eventually to participate in the performance of these experiences. We try to show both, the basic principles in which each experiment relies and the potential application that it allows.

In this sort of workshop we include a visit to our research laboratory in order to show non-educational experimental arrangements to the students (mainly phase-shifting interferometers for different applications [2-3]) and provide information about the MSc on Photonics and Laser Technologies [4] or the PhD Programme on Laser, Photonics and Vision [5] where the authors are part of the academic team. This allows students to understand the importance of the research activity in the optic and photonic field to innovate in engineering.

Each year, the students answer is very good. They appear clearly excited in the proposal: many of them attend this activity, collaborate in the development of the experiments, ask interesting questions, etc. It is worth to say that nowadays internet technologies make easy for the students to search for information in any scientific field, or simply they discover, when surfing the net, some optic-related point that awakes their curiosity. This gives raise to an enrichment of the discussions, since really students have some previous knowledge and, more important, some concerns about the proposed issues. Amazingly, these concerns may range from the road mirages to the employment of large power lasers in the nuclear fusion. Easily, when visiting, they show in their cells a web page they found, calling their attention, and inquire for details. That is exciting for pupils and for the teacher also!

At the end of the explanations, students are invited to answer a test, with the aim both to know how well the exposed concepts were assimilated, and to evaluate the degree of interest it was attained with the proposal. For this, the test includes scientific questions, like those usual in basic level exams, and questions in which they are inquired directly about the importance of role they think the Optics has in engineering, and also about their disposal to learn more Optics in future years.

The results of this test show that students assimilate quite well the fundamental optical concepts involved in the demonstrations, in spite of the lightness of the explanations (imposed by the short time available).

On respect to their fulfilment with the experience they consider that it was really good, and undoubtedly appreciate the effort of the teachers in the preparation of this extra-curricular activity. It can be said that the goal of awakening their interest, both as currently students of an Engineering Degree and also as future engineering professionals, was clearly attained. Probably the main drawback we find in the development of this experience is the fact that it has to take place in the examination period, when it is obvious the students devote most of their time to prepare their exams and this sure prevents many of them to assist to the activity.

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2. Description of the experiences

As it was explained before, in the design of these experiences we took into account both the necessity to show in a clear way the basic principles and phenomena, and also to suggest their potential applications. Indeed, as we could see, it is the possibility of use of the optical technologies in their future professional fields that really encouraged the students´ interest; but our goal was not only they were able to appreciate the possibilities of practical use of the optics in engineering, we have also tried to make them understand, at least in a basic way, the optical fundamental concepts.

We believe that the University engineering education should highlight its scientific basis and be not limited to training the students as future users of a particular technology. We want students to gain the idea that scientific knowledge, in principle very generic, are always at the root of any technological field.

We noticed that the laser technology has an important appeal for the students, probably because science-fiction movies or because the intrinsic beauty of the well-ordered bright light they emit. For this reason we decided to use the laser light and the configuration and working of the laser apparatus itself as a stimulating element.

Then, we have disposed the experiences surrounding the common theme of the laser: its structure as a light source (active medium, pumping, resonance cavity), the properties of its radiation (power, coherence, polarization), the different kinds of applications (power applications, interaction light-mater, coherent metrological applications, etc).

The basic differences between the laser light, coherent, and that emitted by other light sources has served us also as a thread to our explanation and to the different discussions so originated. According to this, it was covered a wide panoramic view ranging from the elucidation of basic scientific concepts to show some technical applications. This dual approach entails two requirements:

- Simplicity in the experimental set-up. This should highlight the phenomenon or principle which is being illustrating, in a way avoiding to deflect the attention of the student to the technical details of the instrumentation.

- Relationship as closer as possible with some technical application of the illustrated concept. It is desirable even to highlight, if it were the case, some relationship between the experience and the everyday experience of the pupil (interference fringes in a film of oil on water or soap films [6], rainbows [7], moiré effects caused by the interaction of layers of periodic clothes [8], etc.).

We should also highlight that, given the low level of the pupil's knowledge in optics, to whom these experiences are addressed, as noted in the previous section, and the short last of the visit to the laboratory (in an hour at most), we have not tried to deepen in each experience as much as it would be possible. In addition, and for the same reasons, nor do we intend that the student perform himself experiences and measures, thus having the experimental arrangements a demonstrative character.

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2.1. Reflection and refraction

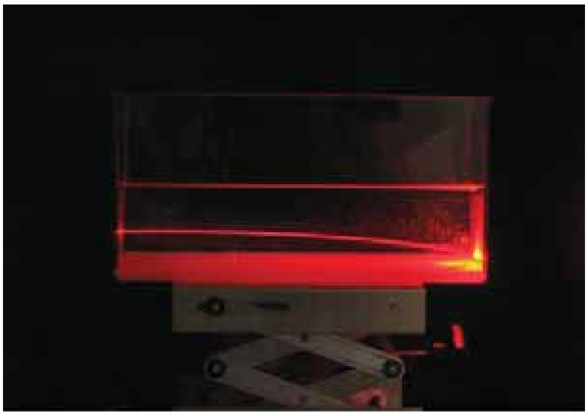

Figure 1

As a starting point, it seems natural to take the refraction and reflection phenomena. This allows to show clearly the basic laws of the light propagation and to introduce also the geometrical optics principles. The experience we implemented consisted in a transparent and elongated methacrylate bucket with a solution of sugar with a gradient of the concentration in the bottom. The laser beam path becomes directly observable by adding a few drops of milk to the solution, which give us the opportunity to explain the scattering phenomenon. In a first approach, the basic laws of reflection and refraction are explained [9], as well as the total reflection phenomenon (Fig. 1). But the most appealing thing in this arrangement for the pupils is to show how the light is bent in passing through a gradient index medium. In this point, it is interesting to explain the formation of some mirages that can be observed easily (for example in a road heated by the sun in summer or on the sea [10]), in the same way some application of gradient index can be mentioned (optical fibers and integrated optics for example).

2.2. Polarization and photoelasticity

Figure 2

The next topic that we show to our students is the polarization. We made the students to see how a transverse wave can have a defined plane of vibration and how a polarizer can filter all the components of the amplitude vector except one (we have restricted to the polarization by absorption). Next, by using two polarizer plates the students can see the light polarization phenomenon. The photoelasticity was observed introducing a transparent plastic (Fig. 2), between the two polarizers, so residual strengths become observable. In the same way, the students themselves can apply a mechanical load to the object and observe the stress distribution on it. In addition, they could probe that the laser light is polarized with the HeNe we use for this experiences.
As practical application, apart from the polarized sunglasses and photography polarizing filters, it was mentioned the study

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of stress distributions in structures by analyzing the photoelastic behaviour of transparent methacrylate models [11].

2.3. HeNe Laser tube

The principle and operation of a laser was explained using a "nude" HeNe laser tube (Fig. 3), where the electric discharge can be observed and also the resonance cavity and its emission. It is powered with a high voltage source. With the aid of several diagrams, we explain the population inversion and the stimulated emission concepts and how they determine the basic properties of the laser light.
This experience also allows describing the different classifications of lasers attending the active medium, the pumping system, kind of emission, etc. Many laser applications are really wide known and this gives the opportunity to make participate the students talking about the practical cases each one can describe [12].

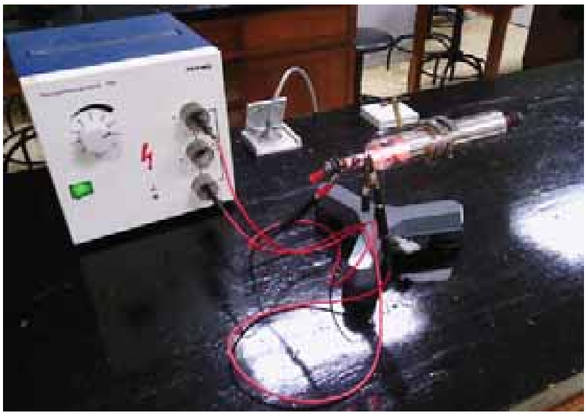

Figure 3

2.4. Diffraction

Using a laser pointer and a transmission diffraction grating (a DVD can be used), we see how the incident beam is split and the diffraction pattern that is formed. We underline, by using different gratings, that the value of the diffraction angle for each order depends on the wavelength of the used light (Fig. 3) and on the number of lines per mm of the grating (i.e., the width of the slits), and suggest the idea that it is possible to measure wire thickness in production lines as a quality control system [13].

Figure 4

2.5. Interference and speckle

To explain the interference phenomenon, the students were drive to the Optical Metrology Laboratory, where we have currently two interferometer arrangements. One of them is a Twyman-Green with two wavelengths in a vertical configuration, and the other is a Mach-Zehnder for fluid flow analysis. With the aid of several draws, the basic concept is exposed, and the resulting fringe pattern is shown (Fig. 5). We highlight

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that the superposition of two beams of coherent light can give rise to areas without light (dark stripes). One of the mirrors is mounted on a translation stage drove by micrometric screws, so that the students themselves can see how a very small displacement of the mirror is magnified in the displacement of the interference pattern, and acquire so an idea of the sensibility of the method. This sensibility can also be demonstrated by asking them to bring a hand close to an arm of the interferometer after being it rub, and observe the distortion of the fringes due to the small air convention produced. The effect of a fluid flow in the Mach-Zehnder, with and without carrier fringes was also shown. Several industrial applications of the interferometers, for example in quality control, were discussed [14].

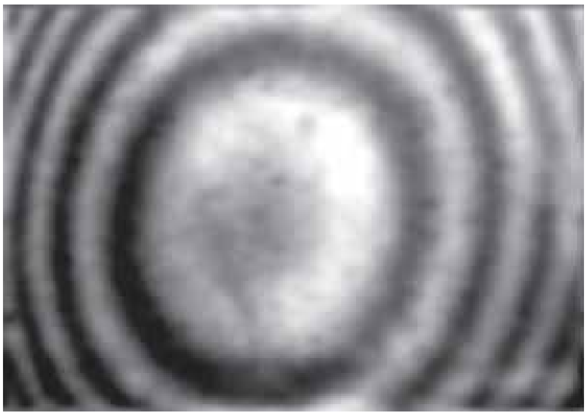

Figure 5

The speckle phenomenon as a consequence of the coherent light emitted by a laser was also shown here. The speckle effect is observed over a rough surface object (or a transmission diffuser) when it is illuminated by a beam of coherent light. It's a pattern of interference due to the overlap in every point in the space of a large number of wave fronts with random phase differences, scattered by a rough surface. Focusing a laser beam on a rough surface or passing through a diffuser this effect is easily observable. The pupils should realize that this phenomenon is three-dimensional, filling a volume around the object [15].

2.6. Holography

We include holography (Fig. 6) in this series of experiences because it is an issue of undoubted importance in modern optics. As expected, it was one of the experiences that most caught the students attention. We show them a transmission hologram reconstructed with He-Ne laser. The reproduced scene consisted of a series of chess pieces placed in different positions, the image was virtual and at certain distance behind the plate. First, did them note that the relative position of the parts change if they move, exactly the same as with real objects. They realized that this does not happen with a photograph, and that a hologram is closer to a framework through which we look at a scene than to a picture.
To the groups of students that showed more curiosity we tried to explain, with the help of some schemes, that what there is in the holographic plate is not an image of the object but a pattern of interference. This pattern is originated by the superposition of the light coming from the object (object wave front) and the reference beam. Once registered this pattern in the photosensitive medium, it constitutes a diffraction grating. When laser light passes through it (generally the reference beam), it is diffracted: one of

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the diffraction orders reconstructs the object wavefront.
Finally, it was discussed that using this technique it is possible to superimpose two wavefronts coming from the same object in two different deformation states (for example, loaded and unloaded). In this way an interference pattern is produced in which the fringe form and spacing is function of the deformation. This is the Holographic Interferometry technique which allows applying the intereference principle to diffusing surfaces. A series of industrial application of it was discussed: automotive industry, aircraft, etc [16].

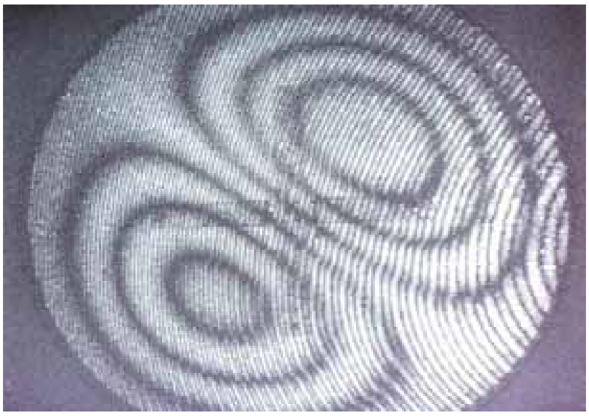

Figure 6

2.7. Optical fiber

The experience of total reflection helps us to introduce the concept of optical fiber. With the help of a scheme we explain how, for a certain cone of incidence of the light in an optical fiber, rays can be confined inside it, and can thus travel all along the fiber (Fig. 7).
As an example, we have used a plastic multimode fiber, launching the laser beam inside it using a converging lens. As in fact all fiber appears illuminated, it was necessary to clarify that this was due to impurities in the material losses, (naturally, the light went out of fiber by the other end with significant intensity). Based on this, we explained briefly the applications of optical fiber in communications, sensors (mechanical stress, temperature, density, pH, etc.) and endoscopes [17].

Figure 7

3. Results and conclusions

The result of this work of motivation of the students towards the applications of optics in engineering can be frankly considered as satisfactory. To analyze their interest towards this proposal, we carried out a survey whose results appeared to us to be very encouraging (was performed both among students who attended the laboratory as well as among those who did not):

- 100% of the students considered interesting to have at least some basic knowledge of optics to apply in their future professional field;

- 86% of the students considered interesting the possibility of studying an optional subject related to the subject;
- 93% of the students saw at least interesting the possibility of doing his thesis on optics applications to engineering.
- 100% of those who did not attend claim not to have done by not have learned of the call to visit the laboratory or have not been able for reasons of time, never due to lack of interest.
- 90% of the students answered correctly to most of the scientific questions (between 7 and 8 of 9), so the basic concepts were well assimilated.

These results reflect that these experiences are able to create amongst the first-year students a climate of concern and interest in light, laser and photonics as a source of many applications in almost all the engineering fields.

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Hands-on Experiments in Development of Gifted Students

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Abstract. *Gifted students have special educational needs. The wide support of students gifted in science is a social necessity. This lecture describes the three main roles of hands-on experiments in the support of gifted students: identification, motivation, and development of giftedness. Crucial areas for the support of gifted students are: education of teachers in identifying and development giftedness, creation of a support system to help teachers and families in the education of gifted students, and setting up of high-quality school facilities for gifted students. Inquiry-based science education is the appropriate educational method for the intrinsic motivation and the development of giftedness.*

Keywords. Development, gifted students, hands-on experiments, motivation, science education.

1. Introduction

A very important group of students with special educational needs is the group of gifted students. The education system devotes time mainly to disabled students, but unfortunately less attention is paid to gifted students [1]. Gifted students are also an important group of students with special educational needs and therefore they need support.

The support of gifted students involves the identification and development of their giftedness. This educational support of gifted students plays an important role in their personal development. School and family [2] have to create suitable conditions for the support of giftedness [3]. According to experts [4] about 2-3 % of students are exceptionally gifted - talented. However, in suitable conditions for the development of giftedness, the rate of students excelling in some areas might increase up to 20-25 % [5]. Therefore, it is necessary to develop appropriate teaching and learning methods for gifted students.

Systematic support of gifted students especially in science is an important part of the educational strategies of developed countries. Current results of research have shown three areas crucial for the support of gifted students:

- Education of teachers to identify and develop giftedness
- Creation of a supporting system to help teachers and parents in the upbringing and education of gifted students
- Setting up high-quality school facilities for gifted students

The creation of suitable conditions for the development of science giftedness is an important task for science teachers [6]. This objective involves the identification and the development of giftedness to the highest possible level.

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2. Naturalist intelligence and science giftedness

Experts include all students gifted in physics, chemistry and biology in the group of students gifted in science. Students gifted in science, of course, may not be gifted in all three science subjects. Usually there is giftedness in some of these subjects, which is combined with a general interest in science and mathematics as a "language" of science.

Psychologist H. Gardner in his multiple intelligence theory argues that giftedness in science relates to naturalist intelligence. "Naturalist intelligence enables human beings to recognize, categorize and draw upon certain features of the environment. It combines a description of core ability with a characterization of the role that many cultures value." ([7], p. 48). R. J. Sternberg [8] combines giftedness and intelligence in his theory of intelligence: (1) analytical intelligence (the ability to analyse a problem and understand its parts), (2) synthetic intelligence (the ability to understand a problem, intuition and creativity), and (3) practical intelligence (application of analytical or synthetic intelligence in practice). R. J. Sternberg [9] has recently included his theory of triarchic intelligence in a renewed model of WICS (W-wisdom; I-intelligence, C-creativity; S-synthesized).

Development of giftedness is an individualised demanding activity because each gifted student has many personal specifics including the type of intelligence. The education of gifted students may be almost as demanding as the education of disabled students because of this variability of specific educational needs [10].

3. Hands-on experiments in identification of science giftedness

We found a set of special behaviours of students gifted in science [10], which are:

- They are not satisfied with passive memorizing
- They ask more questions
- They are curious and have unusual ideas
- They are independent and often prefer working on their own
- They use information to support their ideas
- They draw conclusions and bring new solutions
- They are able to link seemingly unrelated things into a meaningful unit
- They are creative
- They want to know how things work
- The interests of gifted students differ from the interests of their peers.

An important educational objective is the development of diagnostic techniques and tools for identification of giftedness in science [11]. We have developed a special kind of hands-on experiments that can be used when searching for hidden giftedness in young children. We used these hands-on experiments for children (aged 5 to 11) from kindergarten and primary school as a target group for the diagnosis of latent giftedness in science. We implemented these hands-on experiments into simple learning tasks. Gifted children are able to solve these learning tasks successfully with these special hands-on experiments.

As examples we present two hands-on experiments in the learning tasks:

Task 1: *Paul has built three towers of wooden bricks (see Fig. 1). But only one of them is standing, two towers have fallen down. Which tower is standing?*

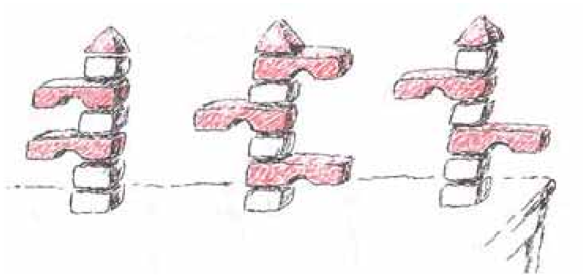

Figure 1. Towers of wooden bricks

Task 2: *There were two new batteries in the torch. The torch was shining brightly. First Johnny put a plastic button, after that a metal coin, and lastly an iron bolt between the batteries (see Fig. 2). In one case the torch stopped shining. When?*

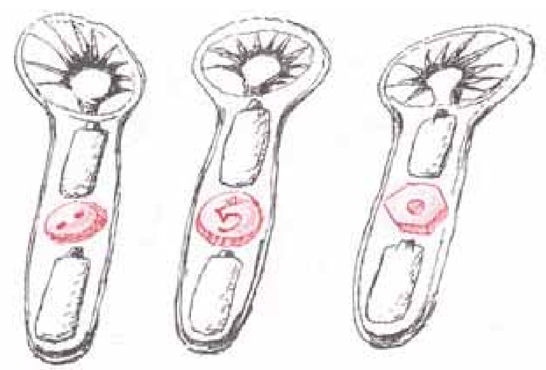

Figure 2. Objects in torch

4. Hands-on experiments in the motivation of gifted students in science

Important factors affecting the development of gifted students in science include intrinsic motivation (interest). Renzulli [3], Mönks and Ypenburg [4] argue that motivation plays a decisive role in the development of students' giftedness. J. S. Renzulli [3], created a three-ring model of determining factors for the development of giftedness: creativity + ability + motivation (called task commitment). J. F. Mönks & F. J. Ypenburg [4] modified Renzulli´s model and replaced the expression "task commitment" with the general term "motivation". They stated that the development of giftedness depends largely on a supportive environment. If we consider the family and the school environment, we find many problems and complicating factors. If the support of gifted students is to become significantly stronger, these complicating limiting factors need to be reduced [12].

Experiments (including hands-on experiments) have a significant motivational potential. They can therefore be used as a source of intrinsic motivation for gifted students. We conducted research into the interest of gifted students in experimentation [6]. In the year 2011, we distributed a questionnaire with a representative sample of 15 students aged 15-18 from upper secondary schools who are gifted in science [12]. Their giftedness was verified by a specialist pedagogical-psychological board and by the declaration of their teachers. We present (see Tab. 1) a part of the questionnaire results: a list of specific educational needs of gifted students indicated by more than 50 % of them.

The results of our research shows that gifted students consider experiments, including hands-on ones significant for their education.

As an example we present a learning task with a hands-on experiment for gifted *students (age 14-15) in physics and chemistry: "Density of liquids". This hands-on experiment can help the correct understanding of density as an important quantity in science. Gifted students solved the learning task: how to demonstrate and verify behaviour of different densities of liquids. They worked on this task with the use of the set of coloured sugar solutions at various densities (concentrations) (see Fig. 3, 4).*

Which activities would you like to do in classes; which activities interest and attract you?	*Gifted students N =15*
Experimentation	100 %
Measurement	93 %
Identifying the fundamental processes in nature	93 %
Observation	93 %
Analysing phenomena	87 %
Expressing an opinion and defending it	87 %
Solving projects	80 %
Substantiation of solutions	80 %
Formulating conclusions	73 %
Describing phenomena	73 %
Verification of hypotheses	67 %
Data processing	67 %
Creating hypotheses	60 %
Evaluation	53 %

Table 1. Specific educational needs of students gifted in science

We verified the effectiveness of hands-on experiments as an incentive to gifted students through action research in 2014. The motivation of students in these hands-on experiments was greatly enhanced by the combination of satisfying their cognitive needs: experimentation, problem solving, measurement, observation, etc. These hands-on experiments have a strong emotional efficiency also due to the beauty of the coloured solutions.

Figure 3. Coloured sugar solutions at various densities (concentrations)

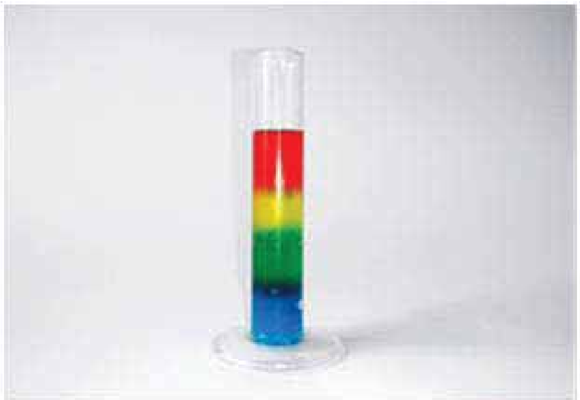

Figure 4. Combination of coloured sugar solutions at different densities

5. Hands-on experiments in the development of gifted students in science

Hands-on experiments lead gifted students also towards the development of their giftedness. These experiments allow for the

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creation of alternative variants of an experiment and open venues for the creation of new or alternative experiments. Use of hands-on experiments in education therefore supports the development of students' skills in experimentation and develops their creativity. This method leads to the development of their giftedness. As an example, we present one hands-on experiment demonstrated by a teacher during a lesson and alternative hands-on experiments made subsequently by gifted students:

Hands-on experiment 1: *A glass tube with water is closed at both ends. There is an air bubble in the water (see Fig.5). If the tube is inclined appropriately, the bubble begins to move upwards with uniform motion (constant velocity).*

Figure 5. Uniform motion - teacher's hands-on experiment

Hands-on experiment 2: *A glass test tube with water in it is closed. There is a glass ball in the water (see Fig. 6). If the tube is inclined appropriately, the ball begins to move down with uniform motion (constant velocity).*

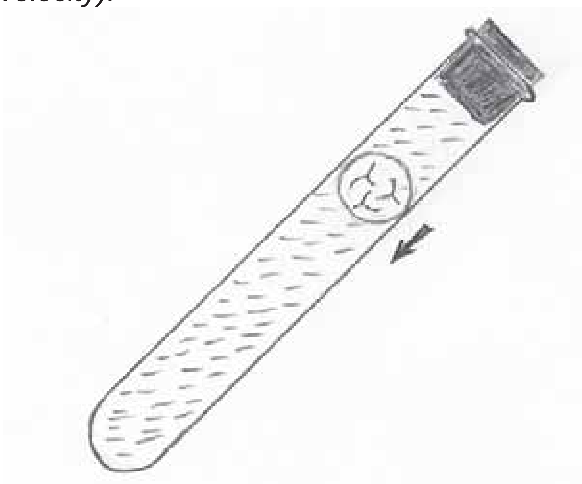

Figure 6. Uniform motion – gifted students' alternative hands-on experiments I

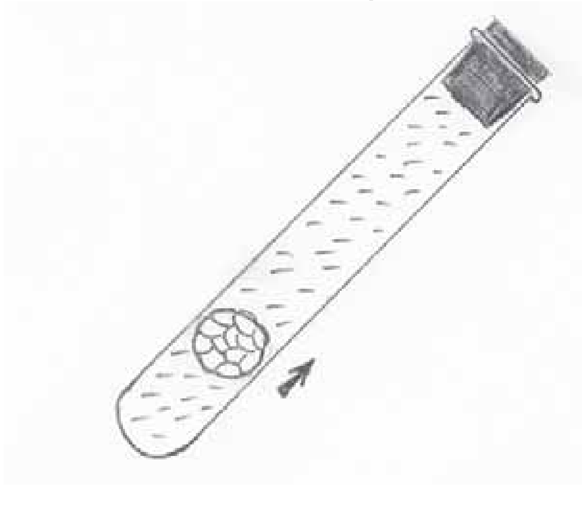

Figure 7. Uniform motion – gifted students' alternative hands-on experiments II

Hands-on experiment 3: *A glass test tube*

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with water in it is closed. There is a polystyrene ball with a diameter close to the interior diameter of the test tube (see Fig. 7). If the test tube is inclined appropriately, the ball begins to move upwards by with uniform motion (constant velocity).

Hands-on experiment 4: *A glass test tube with air in it is closed. There is a polystyrene ball with a diameter close to the interior diameter of the test tube (see Fig. 8). If the test tube is inclined appropriately, the ball begins to move down with uniform motion (constant velocity).*

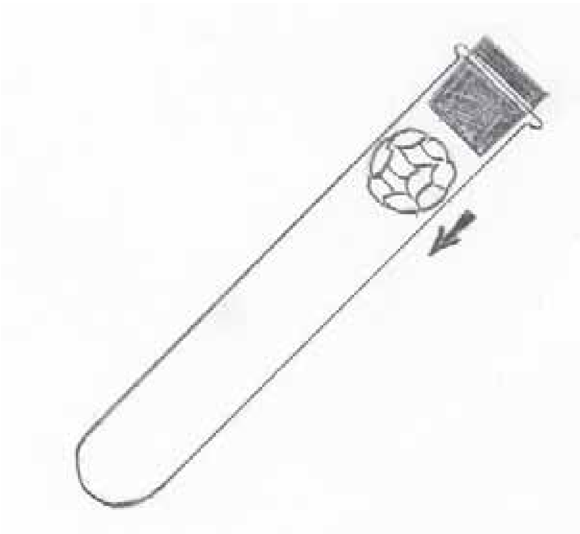

Figure 8. Uniform motion – gifted students' alternative hands-on experiments III

6. Inquiry-based science education and giftedness

Teachers need special educational methods and tools for the development of gifted students. Our research addresses a new topic: hands-on experiments in inquiry-based science education (hereinafter IBSE) and giftedness. This pilot research suggested the importance of IBSE as a motivational and developmental method for gifted students in science. IBSE, including hands-on experiments, should be implemented into pre-service and in-service science teacher education.

IBSE supports a deep understanding of the process of science learning [13]. The core principles of IBSE are student involvement in discovering natural laws, linking information into a meaningful context, developing critical thinking, and promoting positive attitudes towards science ([14], [15]). In terms of teachers' and students' involvement, there are four levels of IBSE: confirmation, structured, guided, and open as defined by H. Banchi & R. Bell [16]**.** These levels are different according to the rate of the teacher's assistance (helping in the process, asking questions and formulation of expected results).

Hands-on experiments can be widely used in all four levels of IBSE. The proof of the great importance of experiments, including hands-on experiments, is our comparison [6] of the specific educational needs of gifted students and core IBSE components (see Table 2 for detailed comparison of educational needs and IBSE components).

The IBSE components (including hands-on experiments) for gifted students in science education must be selected and modified according to their educational needs. It is obvious that hands-on experiments are IBSE components which correspond to the educational needs of gifted students. We have created specially adapted hands-on experiments suitable for IBSE modules within the project PROFILES [17].

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Table 2

Educational needs of gifted students	***IBSE components***
Observation; experimentation	Inquiry: observation, experimentation, building apparatus, measurement, collection and evaluation of data; finding and checking and the importance of information (with the help of inquiry); development of conception; evaluation of preconceptions; the use of ICT
Measurement; data processing	
Analysing phenomena; identifying the fundamental processes in nature; describing phenomena	
Creating hypotheses; verification of hypotheses; evaluation	Logical thinking, interconnection of facts, drawing conclusions (not only to memorize facts); implementation of own innovative solutions (not only to follow instructions blindly), argumentation, communication.
Formulating conclusions; expressing opinions and defending them; substantiation of solutions	
Solving projects	Suitable contents from everyday life; interdisciplinary nature of problems; using evidence gained from a range of information sources; understanding of science concepts through the students' own activity and reasoning.
	Student = active researcher
	Teacher = adviser and guide.
	Working in groups, cooperation, and discussion.

7. Conclusions and discussion

Because of the effective development of giftedness, information about the use of the special roles of hands-on experiments for gifted students in science should be included into science teacher education. Science teacher has to obtain detailed information about hands-on experiments and about their role in the education of gifted students. Creation of these professional competences for teachers is acquired though the experience of the teacher which is why acquiring these competences is not possible only during pre-service teacher education at university. For this reason, there is a need to prepare quality courses of hands-on experimentation and insert these into in-service professional education. The current use of ICT allows the creation of e-learning courses and databases on the Web.

Our research has shown that it is necessary to identify, motivate and develop gifted students in science. A latent giftedness cannot be developed without identification and motivation. The school environment is the main factor in the realization of this support of giftedness. Thus the role of the teacher is totally irreplaceable. It is, therefore, necessary to include the specific educational methods regarding how to use hands-on experiments for the support of giftedness in pre-service and in-service teacher education. Since the education of gifted students is realized in very variable conditions and situations, it is necessary for the teacher to be creative. Our significant research finding is the need for a high level of creativity of teachers, especially in experimentation. The development of creativity and teacher mastery of specific

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methods for gifted students must be a part of the continual professional development of science teachers.

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Project Salt Science II: Getting Students Closer to Science through the Study of Sodium Chloride

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Abstract. *In this talk we present some activities (centred in fieldtrips) conducted during the project SaltScience II, which is an interdisciplinary study-research network around sodium chloride, commonly known as Salt. The project involves secondary school students and teachers from five Portuguese public schools, the Portuguese Chemical Society and a team of researchers, and other specialists, from the University of Aveiro and the Mãe d'Água.*

Keywords. Field trips, secondary schools, science, salt.

1. Introduction

Sodium Chloride, commonly known as salt (NaCl), is one of the most important chemical compounds to the history of humans and life in general. In fact, the value of salt is timeless. It was crucial in the development of past civilizations because of its use in food preservation. It has applications at present day, not only in the domestic activity, but also in industry. There are also investigations that consider the salt and its derivatives in electronics and high-performance materials, among others. In the past, salt was an expensive resource since it was difficult to obtain. Presently, this compound is much cheaper, but not less important. Therefore it constitutes an excellent study object to introduce high school students to science in the context of several disciplines such as: Biology, Geology, Physics, Chemistry and Mathematics. These are the basic reason why the project SaltScience was born.

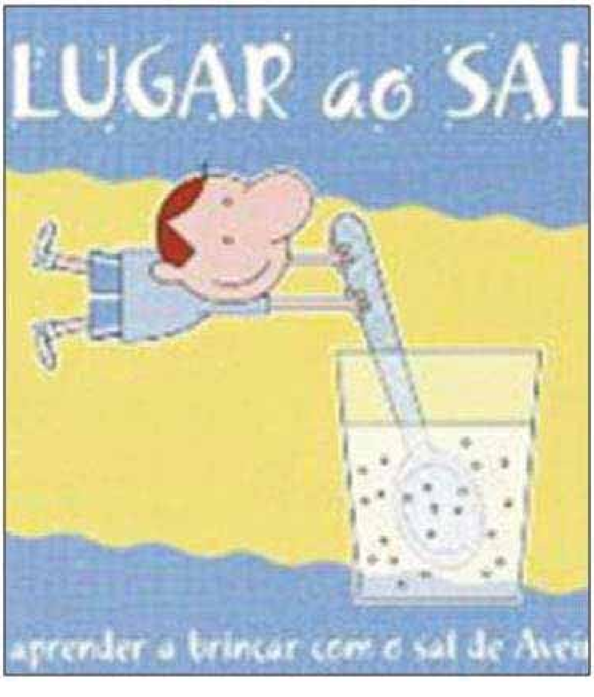

Figure 1. "Interactive CD-rom" – a place in the salt

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2. Previous chapter of this 'story': Projet SaltScience I

Project SaltScience II is not the beginning of the story. Actually the first project SaltScience was developed in 2006 and 2007 involving the Aveiro city council through the Aveiro City Museum, and three secondary schools, besides the University of Aveiro. This first project was centred in the development of laboratory activities around the sodium chloride. The final product of this first project was the creation of the interactive CD-rom called "Lugar ao sal – A place in the Salt" that is available from the site http://sal.spq.pt/.

3. Projet SaltScience II: main aims

SaltScience II is a project that aims to create a network around the study of salt, seawater and brine, using knowledge from different scientific areas.
The ultimate goal is that students understand that in Science any question can be observed by many different angles, and that each perspective is a partial approximation towards understanding the whole phenomena, which is always more complex than the sum of its parts.
Considering the above, the project has the following specific aims:

- Develop experimental activities in the classroom and in the field, involving seawater and brines, as well as other materials containing salt, and which are related to the curriculum guidelines for secondary education of Chemistry, Biology, Physics and Geology;
- Promote visits to salt evaporation ponds, e.g. sea salt in Aveiro (Troncalhada and Santiago), or rocksalt in Rio Maior, as well as Portuguese industries using sodium chloride as raw material;
- Promote conferences and workshops around the use of sodium chloride and its substitutes in food;
- Publicize the activities and the materials, created during the making of the project to the educational community.

Figure 2. The logo of SaltScience II[a]

4. Project SaltScience II: main activities conducted until now

So far, the following activities were undertaken:

- 'Thinking, making and living science' (Secondary School Dra. Maria Cândida, Mira);
- Salt Day celebrated at the 9th May 2014 (Secondary Schools of José Estêvão,

Aveiro and Soares de Basto, Oliveira de Azeméis);

- Workshops (Secondary Schools of Estarreja, Estarreja, José Estêvão, Aveiro and Soares de Basto, Oliveira de Azeméis);
- Field trips to the Troncalhada salt evaporation pond in Aveiro and the rocksalt in Rio Maior (Secondary Schools of José Estêvão, Aveiro, Soares de Basto, Oliveira de Azeméis and António Damásio, Lisboa).

Testimonies and photographs of all events will be available at the web page: http://sal.spq.pt/.

5. "The world can be your classroom"[2]: getting closer to science through 'salty' field trips

Science field trips are one of the most popular hands-on-science activities, since they entail many learning benefits [1]. They foster curiosity, promote active learning and student interaction. Indeed, if adequately planned and sustained by field trip guides, this type of science education strategy may get students closer to research work. After all, field trips are one of the most common data gathering methods in several scientific areas.
Considering the above it was only natural to include in the Project SaltscienceII field trips, for instance in the context of mini-research projects or assisted by specific field trip guides.
The main activities included:

- Collection of salt (Chemistry and Mathematics) for further study of weight variation with temperature and drying time (constant weight). The obtained material was used for the analytical determination of the composition of the salt (use of atomic absorption at the university). The same crystals are used in studies of crystal structure and properties of ionic solids. Besides working with microscopes in schools far-visits to the electron microscope at the University of Aveiro were realized.
- Collection of saltwater and some examples of local vegetation to study the salt tolerance of different plant species involving macroscopic and microscopic observations of plants from plant cells (see, as an example the field trip guide "Visit to Troncalhada" replicated further on this section);
- Photographic record of the fauna and flora associated with saline and collecting feathers for biodiversity studies (Biology) and study of the influence of salt in the physiology of those living beings.

Field trip guides, Testimonies and photographs will be available at the web page: http://sal.spq.pt/.
In this talk we will focus on two specific field trips, namely to the salt evaporation pond "Troncalhada" in Aveiro (5.1.) and the Rock salt in Rio Maior (5.2.).

5.1. A visit to the to the salt evaporation pond Troncalhada (Aveiro, Portugal)

Troncalhada, is a recovered salt evaporation pond that was constituted in the 90 as an outside-eco-museum where salt production

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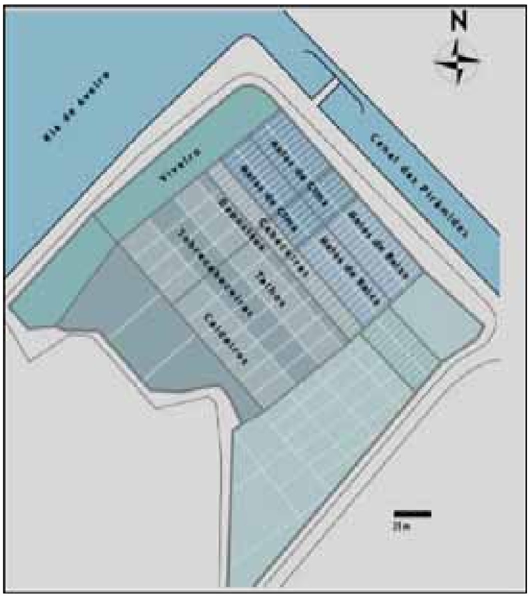
is undertaken according to artisanal methods [2].
Considering the importance of field guide trips we replicate here one of the possibilities:

Guião de Visita (Troncalhada sea salt evaporation pond visit guide)

		
Gramata branca	Junco	Salicórnia



1- Marca no mapa, com o número respectivo, dois locais onde: encontraste cada uma das plantas das figuras.

2- Descreve um dos locais, Em que compartimentos existem plantas?

____

3- Como se chamam os compartimentos de onde se retira o sal?

____

4- Indica no mapa, junto da rosa dos ventos, a direção e o sentido do vento.

5- Vê nos cartazes informativos as salinidades dos diferentes compartimentos da salina e regista:

Viveiros: ___________________

Algibés: ____________________

Caldeiros: ___________________

Sobrecabeceiras: _____________

Meios de baixo: ______________

Meios de cima: _______________

6- Como é constituído o fundo dos compartimentos da salina

____

7- Investiga e indica porque é que a água não drena.

____

8- Como se chamam os instrumentos da figura e para que servem?

____

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9- Assinala as aves que encontraste na salina:

Andorinha do mar anã ____________

Borrelho de coleira interrompida ________

Corvo marinho ____________

Flamingo comum ________

Gaivina _______________

Gaivota de asa negra ________

Guincho ___________

Perna longa _________

Pilrito _____________

Outros, Quais ____________________

10- Que fatores influenciam a produção de sal?

5.2. Field Trip to the salt rock in Rio Maior (Portugal)

Near to the Portuguese location, Rio Maior, and approximately 30 km away of the sea, exists a salt rock which has been exploited since pre-historic times(c).

The salt rock deposit was formed million years ago as a consequence of the sea´s retreat which once occupied the region. The calcareous nature of the geological substrate allows the infiltration of rainwater which is then extracted seven times more salty than seawater.

6.4. Concluding Remarks

All activities of SaltScience II can be considered successful combination of formal and non-formal science education, since the topics of study were all embedded in the current Portuguese curriculum proposals for secondary science education (Chemistry, Physics and Biology). Therefore it is expected that the project raises awareness of the importance of Science to every day live.

7. Acknowledgements

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Hands-on Science
Science Education with and for Society
 ISBN 978-989-98032-5-1

Lisbon Cycling Cultures

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Abstract. *The city is no longer possible without the car, the city is no longer possible with the car [1]. This emblematic sentence pictures the relationship between the city and the automobile as a dead end, a stalemate, a circular predicament with no solution. Alongside with this almost symbiotic relationship between the car and city, a controversial topic emerges, regarding the consumption of natural resources and the pollution generated by all the mobility rituals of motorized technology. In this research we use the motility capital concept to compare institutional policies towards cycling (top-down narratives) with the actions and proposals of MUBI cycle activists (bottom-up narratives). Following Kaufmann definition, motility "encompasses interdependent elements relating to access to different forms and degrees of mobility, competence to recognize and make use of access, and appropriation of a particular choice, including the option of non-action". Semi-structured interviews were applied to policy makers and pioneers of MUBI association, and participant observation during last year in Mubi mailing list and Voca project (the Volunteers of Cycling Academy project has been funded with support from the European Commission under the Lifelong Learning Programme - Grundtvig Learning Partnership). We intend to demonstrate differences between both narratives, discerning the main obstacles to prosecute a sustainable mobility in the city and, at same time, demonstrate the value of scientific social sciences knowledge, namely the storyteller method, to understand our reality and to solve social and environmental heath problems.*

Keywords. Mobility, motility capital.

1. Introduction

In this research we use the motility capital concept to compare institutional policies towards cycling (top-down narratives) with the actions and proposals of MUBI – Association of bicycle mobility – (bottom-up narratives). Following Kaufmann definition [2], motility "encompasses interdependent elements relating to access to different forms and degrees of mobility, competence to recognize and make use of access, and appropriation of a particular choice, including the option of non-action". Semi-structured interviews were applied to policy makers and pioneers of MUBI association, and participant observation during last year in Mubi mailing list and Voca project - Volunteers of Cycling Academy – is a partnership network whose goal is to strengthen adult activists and volunteers of cycling advocacy organizations. We intend demonstrate differences between both narratives and discern the main conflicts in the three dimensions of Kaufmann approach.

2. Cycle Paths: distance / proximity of problems

Access refers to the range of possible mobilities according to place, time and other contextual constraints, may be influenced by networks and dynamics within territories and is constrained by options and conditions Access is constrained by options and conditions. The options refer to the entire range of means of transportation and communication available, and the entire range of services and equipment accessible at a given time. The conditions refer to the accessibility of the options in terms of

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location-specific cost, logistics and other constraints [2].

Figure 1. Lisbon cycle path

The municipality of Lisbon has been constructing a cycle path network since 2007 following the concept of Greenways, and cycle paths connect different green areas of the city. Therefore, the system is totally segregated – two-way buffered path – either by constructing the cycle path through the city parks, on the sidewalk, or on the roadway, but with a significant curb separating it from the cars. Nevertheless, the network is not coherent, and several interruptions are found whenever the cycle path crosses a street or when the sidewalk narrows due to the location of a bus stop for instance. Moreover, the network is very difficult to use, as pedestrians tend to use the paths to stroll, especially because the cycle pavement is far more comfortable to walk than the typical Lisbon stone sidewalk. This separation however, brings the notion of safety to inexperienced cyclists, but once they get more experienced, they tend to use the roadway instead of the cycle path.

MUBI was founded in 2009 but “took off” only in the beginning of 2011 and its work “aims to achieve the social and legislative recognition of bicycle as an integral part of traffic, as well as the promotion and protection of measures that reestablish the natural competitiveness of the bicycle for travels in an urban setting.” The Association main claims about bicycle strategy is focused on three different, but interconnected, measures in order to reduce the travelling speeds of cars instead the segregation of different kinds of vehicles: a) implement a group of “zone 30” across the city; b) to enlarge the BUS corridors of the city and allow bicycles to travel in them; c) bicycles parks.

3. Urban Mobility Strategy: idealized / experienced proposals

Competence includes skills and abilities that may directly or indirectly relate to access and appropriation. Three aspects are central to the competence component of motility: physical ability, e.g. the ability to transfer an entity from one place to another within given constraints; acquired skills relating to rules and regulations of movement, e.g. licenses, permits, specific knowledge of the terrain or codes; and organizational skills, e.g. planning and synchronizing activities

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including the acquisition of information, abilities and skills [2].

Figure 2. Signal of “zone 30”

Besides the cycle paths, the municipality of Lisbon is trying to implement some changes in the mobility of the city, following a multi-modality and inter-modality perspectives. This concerns all transport modes and its integration has left the bicycle in a secondary position, included in what the city designates as non-motorized modes. It should be noticed that there are several problems in the walking accessibilities in Lisbon (the majority of curbs are raised in the crosswalks for instance), which makes the bicycle, to some extent, compete with pedestrians when both are included in the same category.

CARRIS (Bus Operator of Lisbon) – BikeBus started its operation in September 2007 by Carris, the bus operator of Lisbon. It consists of 6 bus lines, with buses modified in order to carry up to 4 bicycles per bus. The service is mainly oriented towards leisure cycling. The total utilization is 82 bicycles per month, or 14 bicycles per month per line (only 1 bicycle every 2 days on average).

Figure 3. Cycle paths map

Bina - Park and Bike is a bike-renting scheme created in September 2010 by EMEL, the municipal parking company of Lisbon. The service works only from 9h to 19h on weekdays and it costs €2,00 for half-day and €3,50 for the entire day. It is possible to rent the bike for the entire weekend for €8,00. The service can be considered expensive and barely anyone knows it exists. Moreover, despite the service being located at car parks and

focused on car drivers, there is no discount for car drivers or for drivers of parked cars.
In MUBi its majority of afiliates use bicycle as a vehicle (commuting travels, shopping travels, etc. Looking at the first hundreds of members, the profile of a member is as follows: age between 17 and 66 years (the average is 34): 17% are women; the majority is living in the Lisbon urban area; 87% are interested in actively collaborating in the association, by joining the working groups and projects, or by collaborating in isolated initiatives; 69% use bicycle for al times per week; 44% use bicycle for leisure several times per month. and defines it self as “a grassroots civic association formed by cyclists that promotes the use of bicycle as a means of transport, both in vehicular and recreational levels.
One of the themes of fracture is helmet use. Among the less experienced and more experienced another polemic theme is the passing red signals. Passing the red signal is itself an indicator of increased ability of cycling culture.
The Byke Buddy is a project in which volunteers sign up to help inexperienced in their first bicycle travels to work or to school.

4. Distrusts and conflicts

Appropriation refers to how agents (including individuals, groups, networks, or institutions) interpret and act upon perceived or real access and skills. Appropriation is shaped by needs, plans, aspirations and understandings of agents, and it relates to strategies, motives, values and habits. Appropriation describes how agents consider, deem appropriate, and select specific options. It is also the means by which skills and decisions are evaluated. All three elements of motility are fundamentally linked to social, cultural, economic and political processes and structures within which mobility is embedded and enacted [2].
On the part of activists there is an awareness of the limitations of action and, also, a distrust of political power agencies because they assume that each political party has its own agenda with regard to mobility and have limitations of understanding problems of proximity and neighborhood.

Figure 4. Bike Buddy project to help new urban cycle users

The agencies of political power have limitations in understanding the organizational logic of the DIY movement activists. This logic of the Do It Yourself interlocutors vary widely because the organization maintains a horizontality in the form of acting, based on compromise solutions, that means much exchange of emails within affiliates. They don't have defined hierarchies and leadership is ephemeral, linked to proposals or projects that are carried out. The decision time is

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therefore slower, contradicting the rhythm and the intensity that characterizes decision making in most part of hierarchic organization.

Figure 5. Rodas de Mudança means Wheels of Change and is a campaign to encourage bicycle use

In terms of policies agency, it now emerges a new practices approach like participatory budgeting in which citizens are asked to submit proposals and discuss needs of the city in terms of mobility. MUBI is, at same time, a greater indicator of the grows of civic movements related with particular life problems but without relation with any political party.
MUBI is the cycling DIY voluntary association with more affiliate members and within its pioneers are the ones that starts the Lisbon Critical Mass in 2004, they turn the bicycle a political tool to discuss the quality of urban Lisbon life through sustainable mobility. In its mailing list affiliates discuss and debate the daily practices, the problems faced and presents proposals to try to solve them. They share experiences, at international level, though projects as VOCA and, at local level, they create campaigns as Rodas de Mudança.
Volunteers of Cycling Academy (VOCA) is a partnership network whose goal is to strengthen adult activists and volunteers of cycling advocacy organisations
Rodas de Mudança means Wheels of Change and is a campaign to encourage bicycle use. Through portraits of ordinary people who simply chose this mobility option, proof that one need not be a superhero to use the bike on a day-to-day.

5. Conclusion

The lack of coordination between public policy and the needs of users means that the bike lanes are the result of a political agenda blurred more localized problems. The logic of these to-down narratives is to develop leisure facilities. The competencies enable the ground to make the experience a good source of proximity synthesis regulation is broader as the highway code.
Projects of activists do not stop at borders of their neighborhood, their city, and they have high cultural capital, can master information technologies and seek international networks that share the same interests at the bicycle as a means of affirmation and option to more sustainable mobility instead leisure.

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Hands-on Science
Science Education with and for Society
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Staining Techniques Can Help to Learn about Bacteria: A Hands-on Activity

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Abstract. *Laboratory work, in particular the use of staining techniques and optical microscopy to teach about bacterial cell structure, can be successfully implemented by teachers with various levels of expertise to engage students in simple, but informative procedures, feasible even in school settings with limited resources. In this work we propose and discuss the potential of staining and optical microscopy methods as hands-on activities to advance high school students' (15-16 years old) understanding of bacterial cell biology.*

Keywords. Bacteria, laboratory work, microscopy, staining techniques.

1. Introduction

Nowadays, in what has been referred to as the "knowledge society", education plays a pivotal role [1]. In what concerns biology education, teachers can help their students develop their scientific literacy and promote their procedural skills by implementing laboratory work. Indeed, laboratory activities can improve conceptual knowledge, laboratory competencies and scientific methodology, which contributes to the development of scientific reasoning and attitudinal competencies [2]. Consistently, the use of laboratory work is recommended in science curricula worldwide.

In this work we propose an activity aimed at high school students *(15-16 years old),* which includes a set of bacterial cell staining techniques and optical microscopy purposely selected to study bacterial cell structure.

2. Staining Techniques: From the lab to the school

Staining techniques are important approaches to study the biology of bacteria (e.g. their morphology) and for identification and diagnostics. The resources required to perform these techniques are easily available and relatively inexpensive. Furthermore, the procedures involved are simple and accessible even for inexperienced students and teachers.

Thus, using staining techniques to study bacteria can be a way to teach students about prokaryotic cell biology and structure, and to develop lab skills. In this activity, we propose to use structural staining procedures to identify bacterial cell structures (such as the nucleoid, the capsule and lipid droplets), and a differential staining technique: Gram staining.

2.1. Learning Objectives

With this laboratory activity students will be able to:

- *Recognize the importance of following biosafety and basic laboratory rules;*
- *Perform basic microscopy procedures and techniques;*

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- *Recognize the importance of staining techniques for the study of bacteria;*
- *Interpret and discuss experimental results based on qualitative observations;*
- *Develop creativity skills and motivation towards experimental activities;*
- *Develop procedural competencies.*

2.2. Bacteria Cultures, Growth Conditions and Safety Concerns

For this activity we used the following bacteria strains: *Klebsiella pneumonia* LMG 2095, *Bacillus subtilis* 168 BGSC 1A1, *Bacillus licheniformis* BGSC 5A1 and *Bacillus sp.*
The culture media can be obtained from a commercial supplier, or prepared from a meat broth, as described by Fonseca & Tavares [3].
Every laboratory rule must be met and students have to be carefully instructed in this regard. Furthermore, all bacterial cultures should be sterilized before disposal following the procedures described in Fonseca & Tavares [3].

2.3. Staining Procedures

The staining procedures followed the ones described in Brown [4].

Figure 1. Negative staining of bacterial cell capsule. The cell is stained blue and the white halo corresponds to the capsule

2.3.1. Capsule Staining

A structural negative staining (Fig.1), to identify the capsule, which is a well known cell structure present in several pathogenic bacteria such as *Klebsiella pneumonia* and frequently associated with their virulence.

2.3.2. Gram Staining

A differential staining technique widely used for diagnostics and able to distinguish between the two main organizations of the eubacterial cell walls: the Gram negative (Gram -) cell wall (*Klebsiella pneumonia*) and the Gram positive (Gram +) cell wall (*Bacillus subtilis)* (Fig.2).

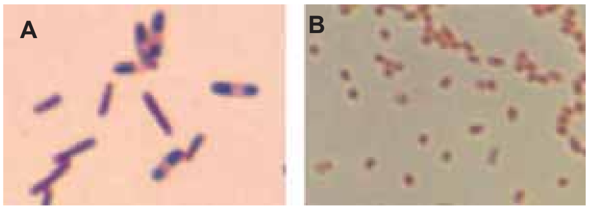

Figure 2. Gram staining of bacteria cells. Example of a Gram-positive bacteria, *B. subtilis* (A); example of Gram-negative bacteria, *K. pneumoniae* (B)

2.3.3. Nucleoid Staining

A structural staining to observe the nucleoid in cells of *Bacillus licheniformis* (Fig.3).

2.3.4. Lipid Droplets Staining

A structural staining to observe cell lipid reserves in bacterial cells. Specific strains have to be used to stain the lipid droplets of the bacterial cell (Fig.4). For this exercise, a isolate of *Bacillus sp*. was used.

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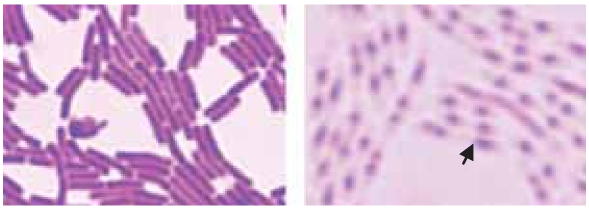

A B

Figure 3. Staining of the nucleoid. Control (A); The nucleoid is stained purple by basic fuchsine (B)

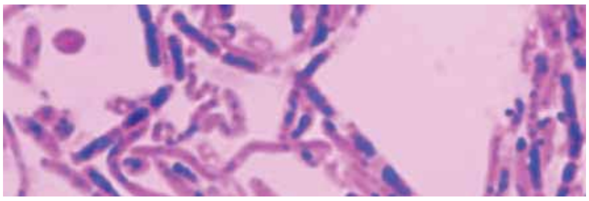

Figure 4. Structural staining of lipid droplets. Lipid droplets are stained purple by Sudan Black and the cell is stained pink by safranin

3. Discussion Topics

With this activity, aimed at promoting the acknowledgement of the importance of microscopy techniques routinely used for bacteria identification and characterization, students have the chance to contact with microscopy procedures, specifically with differential and structural staining techniques.

With careful observations, students identify different cellular components, witnessing the lack of individual organelles, unlike what happens in eukaryotic cells.

Specifically in this activity students observe: the capsule, recognizing that it is not present in all bacterial cells; lipid droplets; and the organization of chromatin, which differs from eukaryotic cells. In addition, they interpret the differential behaviour of bacterial cells to Gram staining.

Students may relate the cellular components present in different bacteria with their biology. By observing the lipid droplets, they can be led to discuss their storage function, an essential feature when bacteria are in unfavourable environments. Gram staining also proves important, as students recognize that the different colouring observed is due to a specific structural organization of the bacterial cellular wall, a key feature for diagnostics. Witnessing the presence or absence of the bacteria's capsule, students are asked to relate this character with bacteria pathogenicity. As for the observation of the nucleoid, it allows students to understand how genetic material is organized in prokaryotic cells.

Taken as a whole, the rationale for this hands-on activity, besides improving students' procedural skills, is to strengthen their understanding of the bacterial cell, overcoming some of the common misconceptions associated with these microorganisms, as for instance the idea that all bacteria are pathogenic [5].

4. Curricular Framing

This activity is framed within the Portuguese biology curriculum for grades 10 and 11. The contents addressed are covered in the initial unit - "Biosphere diversity", which includes a topic focusing on "The cell". In this section, it is stated that the cell should be addressed as a structural and functional unit and that students should get acquainted with its basic constituents [6]. The activity presented promotes students' ability to conceptualize these topics, but also to plan and perform

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experiments, and to develop scientific reasoning.
The National Science Curriculum foresees carrying out practical work, including laboratory observations of cells using the Compound Optical Microscope (MOC), and by subsequently interpreting pictures and diagrams [6]. We believe that all these objectives can be fully met by this hands-on activity.

5. Acknowledgements

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Astronomy with Hands-on Data

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Abstract. *A starry night is the astronomer's favourite lab. The sky is mankind's heritage and is available to all, for free. This immense lab poses challenges and brings mysteries even to the most skilled and inquiring minds. Ground based telescopes are now at a distance of a click and freely available provided we have internet access and a device capable of handling data. So the next natural questions are: "Can we use this richness of tools and resources for science teaching"? "Are there new strategies to sparkle students interest for science using such possibilities in classroom"? During this talk we will share some examples on how the scientific method is being integrated in school curricula in several countries in Europe, in the framework of projects that are cutting edge solutions to e-learning, community building and online/remote labs.*

Keywords. Astronomy, citizen science, data mining, community building, inquiry.

1. Introduction

Technology is opening a world of opportunities to educators. Cutting edge tools and resources for science education are now freely available at a distance of a click and students have the possibility to reproduce inspiring experiments or be involved in real research activities. This is true for many fields of science but even more in astronomy. The astronomer's lab is the sky and images acquired by professional and amateur telescopes are, in many instances, available on the web. This is, in many cases, an unexplored treasure that is now available to educators. So the mission at hand is how to empower teachers to effectively use this wealth of resources to enrich their teaching practices.

2. Cutting edge science tools for education: Remote and Virtual Labs

Figure 1. M63, the Sunflower Galaxy taken by schools using the robotic Faulkes Telescope

The integration of technology in learning contexts is changing the way students interact with knowledge and how they can acquire new skills. Experiences that were only registered in text books are nowadays at a distance of a click. From voyages to the core of matter at CERN to a nursery of stars and far away galaxies with robotic telescope, all is now freely available online.

Cutting edge projects, targeting science education, are now offering to students the possibility to reproduce important experiments that shaped our current knowledge about the Universe we live in and also to explore yet unknown territories. In the field of astronomy, in particular, students can give important contributions to research activities. These experiences can range from simple measurements of craters on the Moon, to help scientists map the geological features of our companion satellite, to finding new planets around other stars.

There are very sophisticated tools for science education and some research projects in science education make use of such tools. Examples of such powerful tools are for instance Planetaria Software (Stellarium, Celestia, World Wide Telescope, etc), Image processing software (Salsa J for instance), and other applications that simulate real life experiences, all freely available on the web. These tools can be integrated in learning pathways were students learn curriculum concepts while reproducing experiments or performing new experiences designed by them to test their own hypothesis. Examples of such approach are European funded projects Go-lab [1] and Inspiring Science Education [2]. Go-lab stands for "Global Online Science Labs for Inquiry Learning at School" and is offering teachers the opportunity to use pre-designed material or to design their own, where virtual and/or remote labs are integrated in the learning scenarios. The platform is offering an environment to build Inquiry Based Science Education (IBSE) scenarios that can range from fully guided to open experiences. "Inspiring Science Education" (ISE) is going one step further by being integrated in a large repository of tools and resources (Open Discovery Space [3]) and by having embedded in the whole process the possibility to assess the progression of the students step by step following the PISA approach.

In these platforms students can build their own hypotheses, design their experiments, acquire and analyse the data, compare the results with their initial hypothesis and restart the process or finalize it by concluding and evaluating the results and the process. Teachers can prepare the learning spaces with introductory material that will set the direction for the student's research, state the problem/sparkle the curiosity and specify the minimum criteria to be met by the student journey. In ISE teachers can go one step further and evaluate the problem solving skills of the students by using the assessment tools available for this purpose.

3. Inquiry Learning Spaces and the Big Ideas of Science

The above described tools can be indeed very powerful tools but they won't help the teachers if they are not connected to the curricula. In spite of the fact that these are very fancy possibilities, if they are not integrated in a structured format for the classroom environment, teacher will not use it.

The adoption of the inquiry learning methodology is being advocated by the European Policy Guidelines for their member countries but, in spite of the huge investment in this direction, many countries are still resisting this change. For educators this can be translated as a big obstacle since they don't have the necessary time allocation to explore the use of the powerful

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tools being designed with the purpose to facilitate such integration. Thus, the creation of spaces where the tools are already integrated, lessons that are connected to the curricula, and examples that are not time consuming, is crucial in order to create a graceful solution for educators eager to explore this route. The tools to create these so called Inquiry Learning Spaces are being used by Go-lab and ISE and teachers will find many activities on the sites of these projects.

Figure 2. This is the designing of an inquiry learning space from ISE

4. The Big Ideas of Science

The activities proposed by the mentioned projects are created around the Big Ideas of Science as proposed by Harlen [4]. These are based on a document assembled by experts in the field of science education during a seminar aimed at identifying the key ideas necessary to the students during their science education in school. The main outcome listed a set of ideas of science and about science. Go-lab and Inspiring Science Education are built around this vision that all natural phenomena can be related to at least one of such ideas.

Example scenarios are being built using tools and resources that allow students to explore these set of ideas from different points of view, working with different disciplines. This approach allows for a more contextualized pedagogical approach and flexibility to interdisciplinary projects development in schools.

5. Training teachers, reaching out to all corners of the world. From face-to-face events to the use of MOOCs

Teachers have now to prepare students for a world that will certainly involve the use of more advanced technology than we can foresee at the moment. So the task is to prepare students with the skills to be able to be autonomous learners. Besides this very

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challenging mission they have to develop their own knowledge related to the use of modern tools and the possibilities they bring. This is not an easy task and in order to embrace the opportunities being presented by modern trends for science education they need support. Support to find the relevant tools and resources, support to adapt them to their national curricula and local requirements, support to the use of the technological solution being presented, support to the use of the methodologies suggested and support to the use of specific tools.

This is the mission of the Galileo Teacher Training Program (GTTP) [1], empowering teachers to the use of modern tools and resources for science teaching, in particular astronomy. The task is achieved by using several different strategies: face-to-face training, demo activities in schools, online training, thematic hangouts and we are now initiating the construction of MOOCs.

Reaching out the necessary numbers to make a visible difference requires specific strategies. We have adopted the model of training the trainers. We train engaged teachers, which after mastering the use of specific tools and resources start training other teachers, becoming what we call Galileo Ambassadors. This model is proving to be very strong and sustainable.

6. Building communities and sharing resources

An important concern when training teachers on the use of modern tools and resources is how to support the effective selection of the ones that are well adapted to their needs. Different solutions can lead to different results in different environments. So localization of ideas is a key step. Teachers sharing their experiences with other teachers, communities discussing the use of specific tools, adequacy to specific grade level or subject area, can be a powerful ally. Different teaching and learning methodologies are being continuously tested and teachers might be interested in adopting/adapting some of them to their daily practices. All these ideas are being explored by ODS, a project that aims to be a one stop shop to tools and resources for all areas of knowledge. The portal is built around the existence of thematic communities that share the use of specific solutions tailored and/or repurposed to the interest of the members of the group. The platform provides training academies for educators, trainers and parents. This solution is being implemented and will certainly represent a nice hub for sharing good practices.

7. Global Citizenship Awareness

Sparkling the interest of students towards science, creating science literacy, preparing young generations to the world of work. These are all challenges that have different flavours across the globe. Different challenges are posed to educators in different countries considering the different facilities they have at school, the different education systems, and the different social and cultural environment. This means that solutions are locally tailored but the international aspects must be present.

Our organization aims to provide support to our partners around the globe in order to help finding the solutions that better adapt to their specific needs. We also hope that all the opportunities presented here and many more are equally offered to all GTTP partners ensuring the same opportunities to students no matter in which corner of this pale blue dot they live in.

Figure 3. A map showing the distribution of GTTP around the globe

The aim of our organization is to ensure that cooperation between countries emerges and that awareness about innovative visions and solutions are shared equally among all. Sharing the best opportunities and building a global support community is our mission. The success stories our reward. They are already many and more will come. Join our efforts and share your achievements.

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Playing for Science and Mathematics Education: An Experience for Pre-Service Kindergarten Teacher Training

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Abstract. *For small children, there is no difference between learning, playing and working. Playing is the most important way how they learn. Even for older children, games promote high levels of attention and concentration that may be applied to learning. This work reports on the experimental approach to a subject matter for university training of pre-service kindergarten teachers, newly developed with the aim of applying the use of games and ludic resources for children's education in science and mathematics. Although the full evaluation of this subject matter must await more data, the present work introduces its methodology and provides results of its implementation.*

Keywords. Kindergarten, learning by playing, pre-service teacher training, science and mathematics education.

1. Introduction

For small children, there is no actual difference between learning, playing, and working. Playing is the most important way in which they learn. Even for older children and teenagers, games promote high levels of attention and concentration that may be applied to learning since, if well designed, games enhance motivation, which is the key element in learning [1, 2].

It is widely known that mathematics and science are among the subjects that present the most learning difficulties for students. There is a consensus about how mathematics and science education can be improved but this is not yet widely reflected in the way teaching is conducted in the schools [3]. First of all, it is never too soon to start. From their earliest years, children are developing their own notions about how the world works. All students come to their first science classes with surprisingly naïve theories to explain real world events. There is reason to believe that naïve theories will not take hold so firmly if scientific theories become available to students early. Furthermore, it is becoming clear that it takes a long time, and many different examples, for learners to develop understanding. It is thus not reasonable to postpone the beginning of this process to a higher school. On the other hand, teaching needs to focus on the qualitative aspects of scientific and mathematical problem situations. Too quick an advance to formulas and computational procedures will not help children acquire the kinds of analytical and representational skills they need. Extensive qualitative analysis is not common in science or mathematics teaching since it takes classroom time and many teachers are perhaps inexperienced in these ways of thinking. A focus on qualitative analysis and understanding of situations means not only treating computational procedures and formulas as matters that take on meaning but also involving children in the task of making sense of them. Otherwise, these formulas and computational procedures are unlikely to be used in any situation other than the exact ones in which they were taught.

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In this sense, the use of games and ludic resources allows an earlier introduction of science and math instruction and also a more significant approach. Moreover, it becomes an invaluable tool for kindergarten teacher training in science and mathematics.
The purpose of this work is to report the experience of a newly developed subject matter for pre-service kindergarten teachers training at the University of Granada, Granada (Spain). The aim of this subject is to apply the use of games and ludic resources for children's education in science and mathematics. The general idea is to take advantage of the beneficial aspects of playing for the learning process, in order to improve this education from the early childhood.

2. Methodology

As stated above, children learn while playing and, by playing the right games, they can learn a great deal. It is therefore obvious that games should be used to attract children to science and mathematics [4] and, moreover, the analysis, projection, design, and evaluation of ludic resources and games are interesting tools for teacher training in science and mathematics.
With this idea, devoted not only to formal but also to non-formal educational contexts, a subject matter was introduced in the last year of the Bachelor's Degree in Early Childhood Education at the University of Granada.
In this university subject, we presented diverse games and ludic resources for children in preschool and elementary school. Traditional games of different cultures and commercial learning games on the market were analyzed by 10 pre-service teacher teams using a systematic procedure. In addition to general aspects, the procedure was especially attentive to science and mathematics teaching and learning.
Afterwards, each work team projected, designed, made, and analysed a game or a ludic resource, dedicated primarily to educate children in science and mathematics (Figure 1).
Using the free wiki host-providing community Wikispaces, we developed a wiki in which the pre-service teacher teams were joined (Figure 2). A wiki is a web 2.0 application which allows people to add, modify, or delete content in collaboration with others [5, 6]. As teaching tools, wikis can be used to enhance the learning process by engaging students in learning with others within a cooperative environment [7, 8].
Each work team incorporated in the wiki the games and ludic resources analysed, including the one of its own design. The wiki pages prepared by each team for presenting and analysing their own games were subjected to three modes of evaluation: self-assessment, peer assessment, and assessment by teachers.
A well-supported finding is that the use of a combination of different assessment forms encourages students to become more responsible and reflective, improving their metacognitive skills, as require lifelong learners and reflective practitioners [9]. Moreover, it boosts the evaluation skills, which is such an important issue for teacher training.
All the evaluations were conducted using the same tool: a rubric specifically designed and agreed upon among students and teachers. The rubric was selected as the evaluation tool for being a set of clear criteria in which the expectations are descriptive, so it helps

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teachers and students to develop a common understanding of what is valued in a performance [10].

Figure 1. Pre-service teachers designing and making their own games and ludic resources

3. Results

Figure 3 presents the results of the three modes of evaluation attained for each work team. When the resulting marks were compared with those corresponding to the assessment by teachers, the average absolute difference was 0.7 points in the peer assessment and 1.6 points in the self-assessment (with standard deviations of 0.4 and 0.5, respectively). The minimum and maximum absolute differences were 0.3 and 1.5 for peer assessment, and 2.5 and 0.8 for self-assessment. As can be seen, marks resulting from peer assessment are more similar to those of the assessment by teachers than the marks provided by the self-assessment.

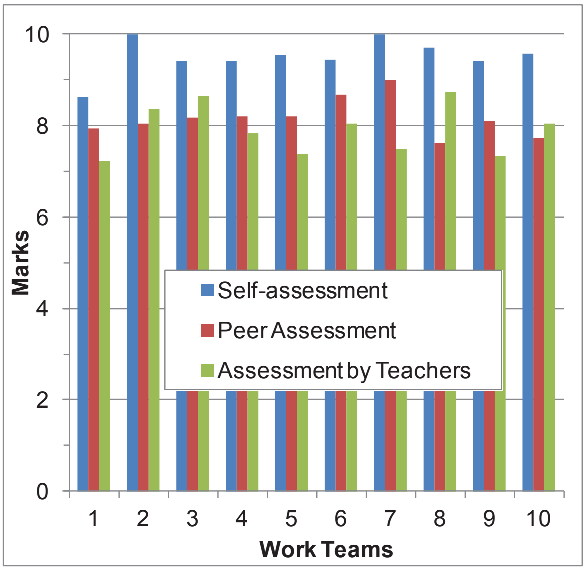

Figure 2. Results of the three modes of evaluation attained for each work team

4. Conclusions

Comparing the resulting marks, we find that the results of peer assessment greatly resemble those of the evaluation by teachers, enabling a positive assessment of the students' engagement. Moreover, the high marks and motivation attained revealed the educational payoffs of using games and ludic resources for kindergarten teacher training in science and mathematics.

5. Acknowledgements

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Autonomous Robot Programed on Arduino to Teach Science in Schools

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Abstract. The idea of this paper is to show school professors how good robots can be to teach students. Many other papers are written by university Professors, but this one's written by a student who learned *from a* robot and in the future would like other students to have the same opportunity to learn with the help of a robot as I have.

Keywords. Robot, programming, school.

1. Introduction

1.1. Importance of Robot

The mobile robots are considered a way to teach several areas, so it was a multidisciplinary tool [1 and 2].
Students like lessons with robots but as said by Ribeiro (2009) "Many excuses are heard from some teachers NOT to start such challenge. *This is not my field of knowledge* (…) *There is no budget for such a project* (…)". In my opinion the idea that it is not their field is wrong, their field is to teach us as well as possible and in enthusiastic and different ways. Nowadays there is financial support for Lifelong Learning programs to teach teachers to apply this technology. Concerns about the budget is a reality as Portugal is in a crisis, but the problem is that teachers don´t ask students if some of them want to contribute to buy a robot or try to arrange sponsorships. Since secondary school I have been involved with robots but I have never been directly supported by my school teachers.
A lot of teachers complain that students are easily distracted in the classroom, so maybe it is a correct time to change the way of teaching and create lessons more attractive and less boring.

1.2. Different Robots for schools

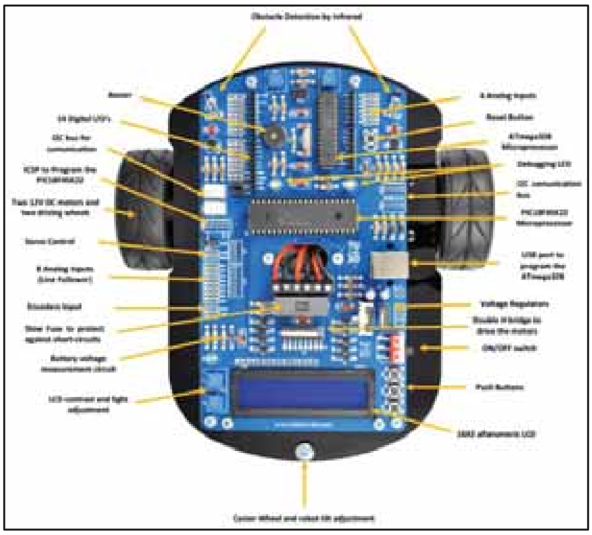

Figure 1. Bot'n Roll ONE A [Source: http://botnroll.com/product.php?id_product=811]

The Lego has a robot but the fact that you can construct and deconstruct it is not very good for schools, because it's very easy and common to lose pieces that will make the robot impossible to use.
The robot that is in my opinion is the best to teach in schools is the **Bot'n Roll ONE A.**

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This robot is easy to construct and programed in Arduíno compatible which is an Open Source didatic product.
This robot was created by the Portuguese company called SAR - Soluções de Automação e Robótica. For more information check this site:
http://botnroll.com/onea/

Figure 2 - Construction of Robot in RoboParty 2014

I constructed my robot in RoboParty 2014 (Fig. 2). This event is well described by Ribeiro (2008) where the concept teachers and students are learning together [3].

This robot has also the advantage of been robust. It is amazing what we can learn from this little robot. It has many different subjects that I'll talk about and explain what students of all levels can learn in each subject, mechanics, physics and informatics.

2. How to teach to primary school

In primary school it's possible to teach some basic concepts. The students can understand better what a robot is, because at that age the majority of the children when thinking of a robot they see a humanoid that acts like a human. But what they don't know is that a robot is everything that does a certain job automatically or preprogramed. It's even possible to program them a little, for example, program them to make the robot go straight ahead, turn right, turn left and reversing. With this they can certainly understand, by experience, that robots can be made a certain way and are us that programme and "tell" the robot to do what we want.

3. How to teach to secondary school

We can study mechanics, more specifically movement if we put the robot in movement at a certain velocity and ask students to measure the time that the robot spends to do a certain distance.
After this it is possible to ask them to calculate the velocity of the robot.
Another case is to get students to put in programme a certain velocity and determine the distance that the robot will do. After asking them to determine the time, they should then put the robot in movement and check if the time is the same as they calculated. With higher distance and floors with some resistance it is also possible to explain that friction is also a velocity affect.
We can start showing a bit of programming and explain why we put a certain word or number and the consequent effect in the behaviour of the robot, and in the other way, if we change a certain variable what the effect will be.

4. How to teach to high school

In high school it is possible to use this robot to teach different subjects, but essentially physics and informatics.

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4.1. Physics

In this area of physics it's possible to study a lot of things using the robot. We can study the movement of the robot, making accounts to see how much power and time the engine needs to go from a point A to point B (with a certain distance) in different environments with different slopes. This will make the students understand the practical use of the theory they've learned.
We can give robots a certain acceleration and ask students to calculate the distance.
It's also possible to study the power and
It's possible to study the efficiency of robot engines and to see how much power we need to put in each engine. It's even possible to teach some basic concepts of electronics like resistances and condensates.

4.2. Informatics

There are authors that have mentioned that robots are very good to teach informatics [4]. This area using the robot is very interesting because high school students aren't used to use the programming for something physic like a robot that moves. They usually make programs to run in the computers such as …. So programme for robots will show them a completely new world where programming can be more enthusiastic because they saw the effect of programme in movement of robots. They will learn many things by themselves, like if I changed a variable or the value of the variable, the robot would have a certain behavior. They will also see that there isn't only one correct way of programming that robot, but many possible ways. You can programme in Arduino using the basis students had from different programing languages for example Pascal. You can use C language. In my case learning Pascal has helped me to understand easier the Arduino programming that are based in C. The bases of programming are the same, what changes is the language you use.
Learning another programming language can be very useful for them in the future.
In Portugal there is a unit in the last year of school called "Informatics Applications" where some teachers already used this robot and considered the work done by students to the evaluation of the unit.

5. Conclusions

In conclusion the teachers will have a big advantage of using robots to teach, and students would like this more than traditional lessons that exist in almost all schools. Using robots is a fantastic way to teach physics and informatics. I know the Portuguese programs of these subjects and dealing with robotics and programing has helped me a lot in understanding the different related subjects.

6. Acknowledgements

To Julie McCann for English revision. To RoboParty teams that helped me in editions, where I always went without a school teacher.

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Entrepreneurship in "Sciences": Mini-Entrepreneurs

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Abstract. *The learning of natural sciences requires an active and committed intervention by students in conducting experimental activities. Experiments are inherently of investigative nature. To assume, accepting or even creating their own, new challenges and responsibilities is very important to growth of our students and should be promoted as earlier in age as possible. Entrepreneurship and specially when directly related to science and technology can be a valid way of achieving this. In this communication we report the implementation of a science entrepreneur-ship project, "Mini Entrepre-neurs Project", promoted in Portugal by Science4you, in the primary school of Gualtar in Braga, Portugal. Our project was aimed to prepare a draft of toy that has both scientific and educational nature. The project challenged the children to work actively and present their ideas on scientific toys or projecting a toy based on their scientific knowledge. In a dynamic and appealing atmosphere this activity sought to encourage entrepreneurship among our youngsters while contributing to the learning and discovery of science by hands-on investigative experimentation. The relevance of this activity is the application of entrepreneurship in the study of the natural sciences, as facilitator of acquiring new skills, through the need to transfer and mobilize the knowledge acquired at school. It was therefore important to establish a clear relationship between entrepreneurship and classroom learning. Children start having contact with entrepreneurship in sciences and technologies early in school. Entrepreneurship appears here as a promoter of science learning by creating a toy based in the application of scientific knowledge.*

Keywords. Entrepreneurship, toys, natural sciences.

1. Introduction

The "Mini-entrepreneurs" project was addressed to students of the 1st, 2nd and third cycles of basic education, in public and private schools, aged up to 13 years old, in the entire continental Portugal and the autonomous regions of Madeira and Azores. The teaching approach of the project is aimed to stimulate the entrepreneurship and the use of its knowledge, in two classes of the 6th grade. The entrepreneurial culture in the classroom emerged as a differentiated education whose final proposal is to strengthen the student's personality and build their initiative capabilities, creativity, planning and insertion in the competitive market. Creative skills development in school can be used from entrepreneurship, encouraging confidence in finding solutions to the challenges that were presented to the students. Decision-making is a key to factor that may become dominant in an increasingly demanding market/society. This educational process starts from issues, problems and phenomena that become objects of reflection and experimental investigation. The experimental situations generate several ideas that raise the

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communication discussion and argumentation among students. These can again make use of the experimental method for assessing the conformity of ideas with evidence, allowing the best choice of ideas and answers to the problems raised. The whole process is mediated by intentional action of the teacher which promotes a stimulating atmosphere of thought and creativity, based on principles of mutual respect, freedom of communication and expression of affection [1].
It is at school that our young student socialize while learning the construction of knowledge inherent to entrepreneurship. The school is essential for stimulating entrepreneurial skills that should be durable and are essential to the future professional and personal development.
During this activity science teaching in an experimental reflexive and deductive approach were explored.

2. Mini-entrepreneurs

This project was presented to the students and teachers of the Primary School of Gualtar, asking if they used the learning and knowledge of science, seeking to encourage new entrepreneurs. After contact in the classroom environment and through blogs and websites, we challenged children/students to present captivating ideas for the development of a toy that linked to the experimental sciences, but obeying the rigor of a structured project and respecting a schedule.
After checking the interest in participating in this project, we made the data transmission and the registration of the tutor, which had to be a schoolteacher, which would be responsible for the coordination and promotion of activities and the registration of students who showed interest. Teams of three elements were created. The elements of each team sought to work collaboratively in order to develop and optimize their design scientific educational toy. The tutor or their helpers supervised all phases of the study. For this purpose, the tutor appointed team helpers, which could be other teachers or employees of the participating organization. After the formation of teams of students to develop the work, an assistant teacher was chosen for each team. It was explained that in addition to work, should be written or produced a portfolio prepared by the students, with support if needed. This feature should rely on the following items:

i. Name, ages and classes of team members;
ii. Name of the school entity to which they belong to;
iii. User design toy;
iv. Materials used in the production of the toy;
v. Relevance of design toy for science and education;
vi. Budget used in its construction;
vii. The document should not exceed two A4 pages.

In addition to the portfolio, photographs of the toy should be provided, and should be created a small video explaining the functioning of the toy.
At the stage of collecting ideas, inspirational materials were available to students. Resorting to experiences of Hands-on Science Network (www.hsci.info), and

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experiences of the European Project FP7, Pri-Sci-Net (www.prisci.net) the students had contact with similar experiences and thus, could implement the concepts for an object with the characteristics requested for this purpose. Were also proposed various websites, with a special attention to "la Boîte à Bidouilles" (www.laboiteabidouilles.com). At this time, the students could have a moment of reflection to subsequently communicate the proposed toy. During this period, students were invited to talk with the teachers, so that the works were directed and thereby obey the imposed rules.

After the choices of the type of toy to accomplish, their suitability for the promotion of science, began with the development of the first schemes and first tests. Existing and necessary scientific processes for the operation of the prototypes were also scrutinized. Whenever possible the evolution of the prototypes was shared in order to improve them. Jointly were elaborated rules for the use of toys, making them more complete in its playful and fun functions. This reflexive process was important for the students who were unaware of the applicability of the ideas and the respect of the rules. There were simple rules that promoted safety for the user, so it was necessary to perform some corrections. The tutors, together with the Forest Club, claimed that the toys were mainly the result of the reuse of objects/materials, to promote environmental sustainability.

The tutor had the responsibility of organizing a Science Fair that targets the demonstration and dissemination of the various projects created by the teams, and later also had to provide photographic records of the respective shows of Science. In that, Science Fair was settled a jury composed by teachers of 3-5 elements, who should undertake an assessment of the various works and select the top three, but in this case only reached the finals three jobs. After collecting the three best toy projects, were prepared portfolios that should be corrected. Moreover, some photographic records were made in order to illustrate the operation of each toy, as well as making videos in which each student exemplified the potential of each toy.

3. Developed toys

A - Air Launcher Toy

This toy was constructed in a very simply way. For its design, we needed a piece of PVC pipe, a membrane of plastic and all should be clustered with tape. On one of the openings was placed an elastic membrane, recovered from a balloon, fixed by tape. At the other end, the tube remains open.

Figure 1. Air Launcher

We start from simple principles: the study of gas pressure and its interaction in launching projectiles and pressure exerted on objects; relationship between the gas pressure and the force exerted on a surface quantified by

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the ratio between the force (F) and the area (A) where the force is applied, thereby verifying the transformation of elastic potential energy in kinetic energy.
For a more playful use, two possible applications were created:

- With fixed target

Putting a projectile in the opening (e.g., paper soaked in water), indent the membrane horizontally and drop looking to hit the target, with the goal of trying to hit the centre of the target and thus get the highest score possible. It is a game in pairs or team whose goal is to get the highest number of points.

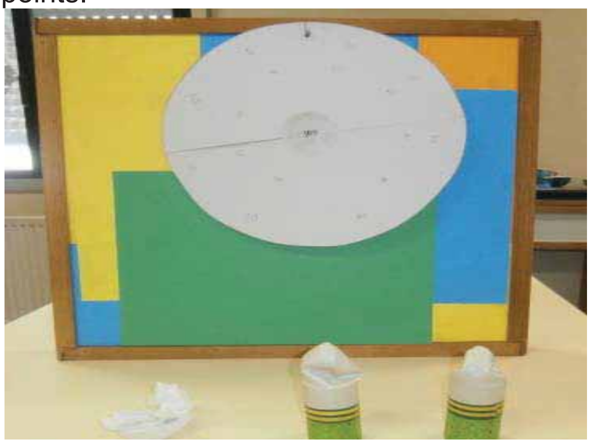

Figure 2. Air Launcher with target game

- With cups

Using the Air Launcher with a small cup opening and embedded in a plastic container (cup). This activity is performed with two teams of two elements, where each partner stands in front of the other with the plastic container, and the partner with the Air Launcher, aimed to catch up with the projectile launched by the colleague.

Figure 3. Air Launcher with a cup

B - Wind Slider

The Wind Slider is composed of very simple materials of easy access. Just stick a cap from a PET bottle with a small hole next to the hole of a CD. Wrap the container through the stopper and in the other side there is a hole that allows passing a straw, which will allow the balloon to fill with air.
The action of Wind Slider is based on the principle of jet propulsion air, combined with the ability of an object to rise in an air layer and move. The action allows the study of the dynamic balance in the internal pressure with the external pressure as well as the study of friction forces in different types of surfaces. These phenomena were analysed in a reflexive perspective.
The applicability of the toy was associated with a card game that tests the knowledge in science and math and encourages the appreciation of scientific knowledge. Initially, fill the balloon of the Wind Slider with the help of the stuck straw and keep the balloon with your fingers. Then, land the Wind Slider on the board and just let you press the air intake and let the air out of the balloon. Two players must take small touches in the Wind

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Slider with a straw, one at a time, until all the air has gone out and it has stopped.

Figure 4. Pieces of Win Slider

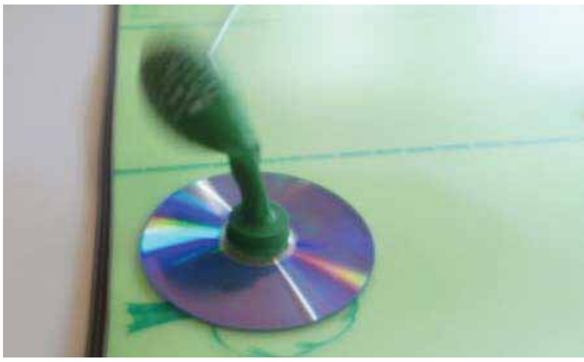

Figure 5. Playing with Win Slider

The player who placed the Wind Slider in game should answer a question corresponding to the location on the board where the Wind Slider stopped. If answered correctly he will receive a point. In case of error, must put the letter aside a lot.

C – Final Surgery

The game Final Surgery is composed of a board of plywood, a wire mesh for construction of the lungs and metal accessories to hold the lungs to the wooden board. As attachments, surgical instruments like clamps and plastic box with eight "cigarettes" of paper will be required. To the electrical part is needed a lamp with stand, electric buzzer, electric cables with crocodiles and battery.

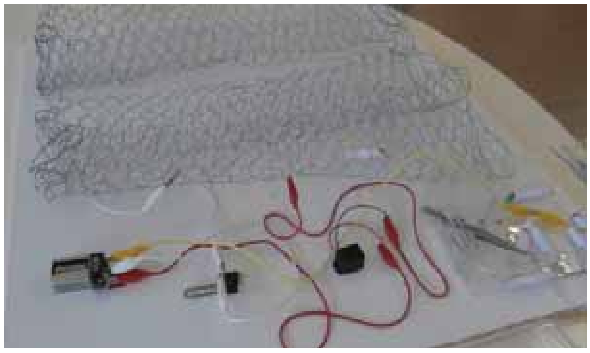

Figure 6. Final Surgery

This game covers two areas of science: medicine and electricity. In the case of medicine, the player simulates the work of the surgeon. There is also an awareness component related to public health, which deals with the diseases associated with smoking. The player also learns important concepts of electric circuit and realizes that electricity can produce different effects, such as light or sound, and can explore the conductivity of the materials.
The eight "Cigarettes" are placed randomly within the lungs. The player must remove the surgical instruments without touching the metal structure that represents both lungs. The game has 4 surgical instruments that the player can change as his will. In the case of touching anywhere in the lungs, the electric circuit is closed, triggering a light signal and an audible signal. After 3 rings the player gives turn to another player.

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When no more cigarettes are available, wins the player who has taken more cigarettes.

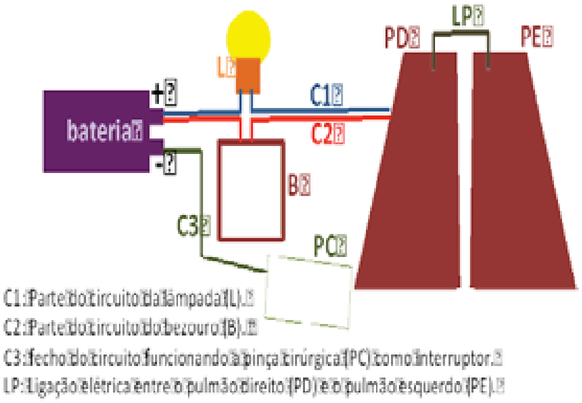

Figure 7. Scheme Toy

4. Project results

The strategic planning for the development of cultural and social changes involved in the free environment and not constrained by rigid programmatic contents or programs, make these initiatives a single tool to promote autonomy. With this encouragement of collective creativity and largely stimulated by national and local initiatives, such as the mini-entrepreneurs project, teachers can have the freedom to choose the activities for promoting reflexive teaching of science and its applicability to a society that expects innovation and entrepreneurship.

In this project, the entrepreneur or entrepreneurial spirit was introduced in order to be combined with the knowledge acquired at school. Students were faced with the need to manage a project budgeting and presents it in an official way before the scrutiny of the school community. Students were faced with the need to respect the guidelines, teamwork and respect a schedule. The notion of cost of the project represents a significant impact on the viability of the same, promoting the reflection on the entrepreneurial part, once there will be another variable: the financial sustainability of what´s developed. In this project, the concept of science fair was introduced, supported with the works created, designed and developed by the students themselves, who will personally represent and enhance their own work in front of the school and a jury.

According to [2] "learning becomes a metacognitive experience when students are encouraged to develop a clear intentionality in their actions, becoming reflexive in planning activities, in implementation and evaluation". The effect of "hands-on" during the whole process brings a greater meaning of the concepts addressed, as well as a clear representation of them. This learning experience had a significant training benefit to the understanding of science from the experimentation, design and the internalization of all processes. The self-reflexive nature was stimulating, and promoted the critical and reflexive skills necessary for providing a motivating and facilitator thought of the dynamics of knowledge construction.

Another aspect is that we can actually notice when a student participates in the formative process, even if initially he was wrong. It is clearly an entry in the process of understanding from observation. There is a degree of self-esteem that allows them to begin to develop assumptions and seek support by promoting the construction of knowledge and skills in a transversal way,

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sustained in students' observations, soon understood and supported.

5. Conclusions

The ability to innovate and to create is certainly not written in a part of the DNA genome of human beings. It is recognized however, these days, that innovation and creativity are critical factors of development that rely heavily on the attitude and behaviour of each individual in a logic that those who can innovate and who are able to create, are those that reach the highest standards of personal achievement and, in parallel, contribute most to the development of societies in which they live, both in the economy as in the areas of culture, politics or the arts. [3]
In this sense, science at school, taking into account the curriculums, may develop a set of knowledges, skills, attitudes and values that allow students to interpret, understand and act scientifically informed about physical and social reality that surrounds them. There was a significant involvement and mobilization of students to investigate, think and create something scientific and functional. I found that the collaborative construction is linked with other areas of knowledge. The mental structuring and verbalization are processes that trigger valid metacognitive processes. The discussion allowed the development of capabilities through exposing ideas, defence and argumentation. The most appropriate strategies for performing a specific task are relevant to the construction of a logical and scientific reasoning. I feel that these activities have contributed greatly to the intellectual development of students. I identify clearly the processes of logical and scientific reasoning. I noticed that the dynamics of verbal interactions allows students to establish mental connections of great consistency. The validation of knowledge by the students showed me clearly, that this factor benefited the success in the task of teaching and learning.
The manipulation and construction of an object (toy) based on scientific processes, confers skills that are arguably positive, but the use of science and technology to create something, is certainly more enhancer of mental connections. When a student is confronted with demonstrated scientific processes, he admits they occur, but in this particular case, students gave a step in knowledge, starting from the employment of the concepts to a practical and entrepreneurial situation. The knowledge or identification of scientific phenomena, not necessarily endows the student with a concrete ability to create or innovate, maximizing all that society gave him.

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Fungi Ubiquity. Arousing Curiosity, Astonishment and Scientific Knowledge

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Abstract. *Following the training course entitled "The Microbial World around us", promoted by the Ordem dos Biólogos and attended at the Biology Department of the University of Minho, it was proposed to 11th grade students of secondary education the planning and achievement of an experimental research activity related to the presence of fungi in everyday materials and the evaluation of the disinfectant capacity of various substances for common use.*
The students accepted the challenge enthusiastically, which allowed them to question reality, training tasks in an investigative context and revealing the results in various communications among school colleagues, other members of the educational community and in scientific meetings for peers.
The initiative was a success, having increased in the students directly involved in the project, their active and critical involvement in other intervention activities in the school community. On the other hand, it allowed stimulating the scientific curiosity of many students from 5th to 12th grades, as well as parents and even other teachers.
This communication aims to show how stimulating activities can promote an education in science and the development of the citizens' critical minds, starting with easily accessible materials (even in a school that does not have well-equipped laboratories). They can also involve the whole community because they aren't restricted to the teaching practice of a subject.

Keywords. Biology, Fungi, hands-on/ minds-on project, scientific literacy.

1. Introduction

One of the basis of the educational project of *Centro de Estudos de Fátima* intends to "educate citizens capable of evaluating and critically transforming the social environment in which they live" [1]. Therefore, the associated educational teams seek to stimulate and to create environments that could allow students to develop their scientific literacy, exploring their learning in real situations, even if they are not formally included in the study curriculum of the subjects.
In this context, it was suggested to 11th grade students of secondary education the planning and accomplishment of an experimental research activity related to fungi, in a perspective that is not approached in a formal way in any subject programme.
Therefore, it would allow a freer exploration, perfectly adapted to the skills and interests of each student.
Despite its clear ubiquity, fungi are living beings not very well-known by society in general. They are almost exclusively associated with the deterioration of food, and for the common sense simply prevails the image, often considered repulsive, displayed by the molds found in our daily lives.

2. Engage

Based on the observation of images (Fig. 1) of an experience carried out at the training course entitled "The Microbial World around us", promoted by *Ordem dos Biólogos* and attended at the Biology Department of the University of Minho, in July 2012 [2], we awoke the students' curiosity to this fungi topic, focused on two axes: fungi are everywhere, even if they are not visible in the majority of situations; it is possible to put in evidence this ubiquity using everyday materials (being additionally possible to perform such experiment at home).

Figure 1. Results of an experiment held in the training course "The Microbial World around us", concerning microbial deterioration and food preservation, which aroused curiosity among students

The students were very interested in learning more about these living beings, to search for fungi presence in various locations (like a game), and suggested to add an additional topic of research concerning the disinfectant capacity of several everyday products against these microorganisms.

3. Explore

Divided in groups of 5-8 elements, the students (n=23) developed their own research plans, feeling the need to look for additional information on the topic. They planned different experiences based on the use of slices of bread which could function as a culture medium for microbial growth and development. The experiments were designed in order to (i) rubber the slices of bread on various surfaces or on water from different sources, and to (ii) use the slices of bread to test the action of different substances, such as disinfectants. Such activities allowed to test students´ initial questions: on one hand, queries like "is the floor of the corridor "dirtier" than the table in the canteen after lunch?" or "what about the seats of the school buses?; on the other hand, a big question concerning "what type of products have higher disinfectant power?". Each group chose different experimental situations to answer the two types of inquiries. During this process, the students worked independently under a discrete supervision of the teacher, who had a role essentially associated to the clarification of concepts and the search for better solutions to the problems faced. The various workgroups were encouraged to share their questions and doubts systematically, so that the entire investigative process was followed by the other colleagues.
The students were very interested in learning more about these living beings, to search for fungi presence in various

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locations (like a game), and suggested to add an additional topic of research concerning the disinfectant capacity of several everyday products against these microorganisms.

4. Explain

Figure 2. Poster prepared by the students to report and present the research project developed

The presentation of the collected evidence took place in the classroom, and it allowed to share and discuss the results observed as well as the conclusions. Then, each group was asked to organise the results in the form of a scientific poster (Fig. 2), and this was the first time that high school students have had contact with this form of scientific presentation.

Figure 3. Group of students presenting their research project at the "VIII National Congress *Scientists in Action*", in Estremoz, Portugal

Figure 4. Group of students showing their experimental project in the "VIII National Congress *Scientists in Action*", in Estremoz, Portugal

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Members of the whole class were then invited to participate in the “VIII National Congress *Scientists in Action*", in Estremoz, Portugal [3], where they presented all the work done to a committee of scientists' guests and to students from other schools across the country (Figs. 3 and 4).
Other students presented the same project work to several classes at their school, from different levels of education, in scientific communication sessions.
All these actions were reported in the school media (newspaper and television programme), as well as in the local media (Fig.5) [4].

5. Extend


Alunas do CEF participam em congresso nacional

Figure 5. An article published in the local newspaper “Notícias de Fátima” about students' participation at the “VIII National Congress *Scientists in Action*”

Throughout the final discussion of the results and conclusions, topics have come up for future research. The lack of time made it impossible to accomplish new projects; however, the students involved were able, in their oral and poster communications, to highlight the ecological importance of this group of living beings and to draw important conclusions, with effects on their daily lives, in particular with personal care and space cleanliness.

6. Evaluate

A formal assessment of the students was not the purpose of this activity; the evaluation was held mainly in the form of surveys of global fulfilment. The transcription of some opinions allows us to understand the impact that this activity has had in the development of the students and in the perception of various members of the educational community.
Quoting some students and teachers testimonies:
“This experience with fungi was something that has allowed us to move away from the topics of the programme, and do something that is not too much developed until University: being a researcher, having a project on which we have to keep a "diary".
"Since we have done this experience I pay more attention to fungi that I sometimes find in the food at home or even outside."
"I think there should be many more projects like this one, because we do not know what the true science is. We should be more prepared for the science of the real world, full of mistakes and problems."
"I think it was a really interesting experience because it allowed us to elaborate a real scientific project, which, in my opinion, is very important, considering that in a couple of years we'll be at the University. This way, we already know what to expect and what to do in the future."
“When I recall the presentation on fungi given by a friendly group of students, I

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always think of their enthusiasm and how they have succeeded to attract the attention of the youngest students from the 9th grade. It was a great job and it was an exceptional way to show how they studied and made known the presence of fungi in the different school locations."

Therefore, suggesting to secondary school students the accomplishment of research projects on this topic is a great challenge that causes them some awkwardness, but also a lot of curiosity and expectation.

7. Acknowledgements

To Centro de Estudos de Fátima school board for the possibility and motivation to undertake these projects. To the students of the 11th grade, class A, of the school year 2012/ 2013, for the enthusiasm with which they have embraced this idea since the very beginning.

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Instructive Fun with Water

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Abstract. *A selection of involving hands-on experiments with water is presented, covering a wide range of physical principles and laws. Their possible applications extend from lecture demonstrations and measuring labworks to creative students' research projects and summer camp fun activities. Experiments on 'violated' Archimedes Law, measuring of atmospheric pressure with water containers, water jets used to set in motion toy cars and to measure time intervals, are all about how to develop entertaining demonstrations into instructive accurate measurements. Reflection of surface waves off the walls of water tanks is studied experimentally as well as with computer models designed by the students. Reviewed surface tension phenomena include buoyancy of the bodies denser than water and 'liquid marbles', the amazing powdered drops. Exploration of the three-bend self-starting siphon is an example of a step by step students' inquiry.*

Keywords. Hands-on experiments, Archimedes law, measuring of atmospheric pressure, water clock, surface tension, elliptical mirror.

1. Introduction

Celebrating the 100th anniversary of Martin Gardner (1914-2010), whose books and papers on popular science always were our inspiration, we present a series of creative activities with water, many of which directly originate from the Gardner's legacy.

2. Modelling water boiling at low pressure

The 'Boiling without Heat' demo in the famous Gardner's book ([1], p.107) could be interpreted as modelling of water boiling at lower pressure, e.g. in the mountains. Straightening the handkerchief that tightly covers the inverted glass of water by pulling its ends up or by pushing the glass down, one increases the volume of air captured in the upper part of the glass, Fig.1.

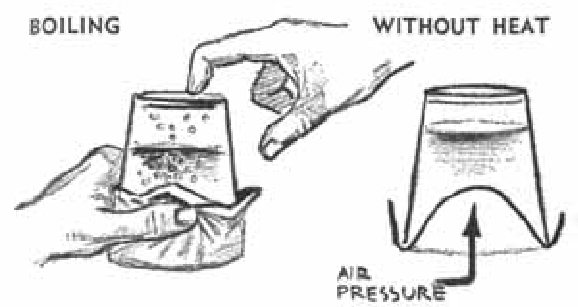

Figure 1. Modelling the boiling of water at low pressure (from [1])

This must reduce the pressure of the captured air. With the non-penetrable membrane for the cover, a real decrease of the pressure in the glass would be the case. At low enough pressure boiling at room temperature could be observed. Since the

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handkerchief's cloth is penetrable to the surrounding atmospheric air, it is pushed inside the glass by the difference of pressures. Resulting air bubbles perfectly simulate boiling. This funny spectacular demonstration is especially convincing when practiced at higher elevations.

3. Inverted glass of water: from amusing demonstration to measuring of atmospheric pressure

The above entertaining experiment and its variations are perfect for development into a series of instructive accurate measurements.

3.1. Bottle&Ping-Pong ball barometer

When the air-penetrable cloth covering the inverted glass of water is substituted by a piece of cardboard or plastic, a no less impressive demonstration is possible. Unsupported from below, the cover supports itself and the column of water in the glass. Inquiry-based approach suggests variation of the water level inside the glass. Pretty intriguingly for the observer, this experiment fails with partially filled glasses ([2], p.79; [3], p.102). More quantitative experiments and explanation are presented in [4]. To prevent spilling, vacuum produced by slipping of the water column down the glass should be big enough to counter-act the gravity force of the water. For partially filled containers this displacement reaches several millimetres, too big the distance for the cover to stay attached to the brim. Slowly releasing 'extra' water from the container, one provides for the balance between the action of gravity force and difference of internal and atmospheric pressures. To control dropping of water from the container without leaking of atmospheric air inside, a spherical cover was suggested instead of the traditional flat one. Ping-Pong balls are light enough to serve for this purpose and perfectly fit the neck of a milk or soft drink glass bottle, see Fig.2.

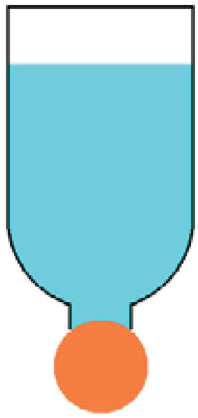

Figure 2. Water bottle and Ping-Pong-ball barometer

The technique to measure atmospheric pressure with that sort of an apparatus is described in detail in [5] and discussed at this workshop.

3.2. Improved Alexander's bell

A creative idea to determine atmospheric pressure from the difference of water levels inside and outside the long straight tube immersed into the water-filled container [6] was developed to achieve better accuracy with more practical apparatus [7]. Fig. 3 presents the principal scheme. Experimental details and students' feedback are discussed at the workshop. Should be noticed that the most convenient version of the apparatus utilizes a long thick-walled plastic hose, Fig. 4

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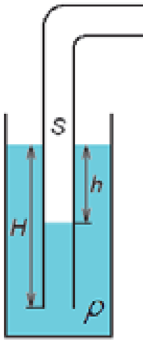

$$P_{atm} = \frac{\rho g h V}{S(H-h)}$$

Figure 3. Scheme of measuring atmospheric pressure by improved Alexander's bell method

Figure 4. Single-tube apparatus to measure atmospheric pressure

4. 'Violated' Archimedes Law

Authors owe interest in the experiments seemingly violating Archimedes law of buoyancy to the presentations of *The Stray Cats Group*, Japan and to the paper of Leoš Dvořák [8].

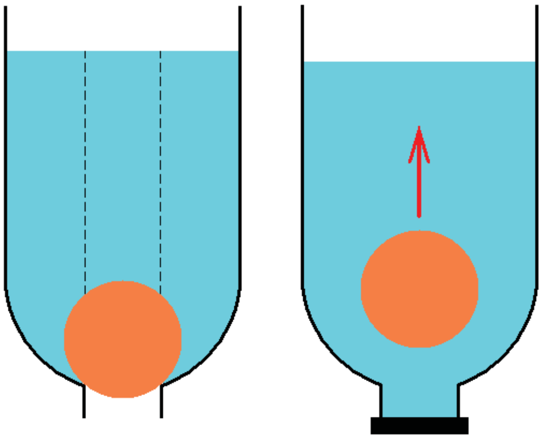

Figure 5. Ping-Pong ball stuck at the bottom of the uncorked bottle of water (left). Closing of the bottle makes the ball buoyant (right)

Figure 6. Combination of Fig. 4 and Fig. 5 schemes initiated a creative project

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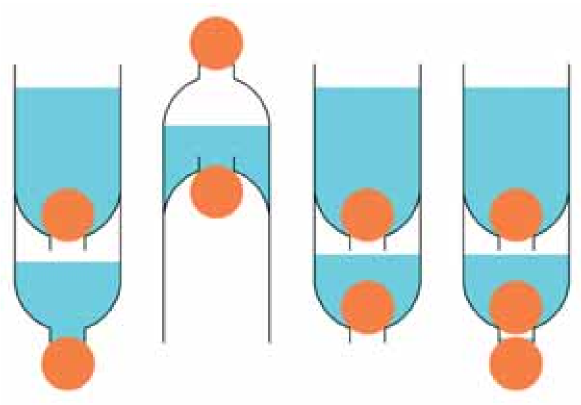

Figure 7. Some developments of Vlad Sidorenko's inspiring idea

Scheme of an initial experiment is given in Fig.5. Strange behaviour of the ball is explained by its being pressed down by the weight of the central column of water marked by dashed lines. No water from below this column means no Archimedes force acting on the ball.

Figure 8. Buoyancy and pressure exploration at Heureka Workshops Conference

A creative brain-storm suggestion of the then university freshman student Vladislav Sidorenko, Fig. 6, initiated a series of hand-on experiments on pressure and buoyance. Figures 7 and 8 picture some of the possible schemes to build multi-stage 'Archimedes-violating' apparatus.

Much practiced with students and colleagues, the 'violated Archimedes' experiments nevertheless look no way the completed project and are open for the further development.
These perfectly hands-on&minds-on activities are presented at the workshop.

5. Linearized *clepsydras*

One of the oldest measuring devices, a water clock or a *clepsydra* ordinarily measures an inflow or an outflow of water into/from a container. To use a marked transparent container (like a plastic soft drink bottle) with an opening at the bottom seems to be a good option. Essential complication here is due to the changing of the speed at which water flows out of the container. That affects the speed of the decrease of water level in the bottle, making the 'dial' of that sort of a *clepsydra* non-linear.
A good solution to produce liner water clock could be Mariotte's bottle which may be further modified for a variety of creative hands-on activities [10].
We also suggested to use a horizontal *clepsydra's* dial measuring distance L achieved by the outflowing jet of water at fixed level [11]. All during the flow the value of L linearly depends on the time which makes this clock much more convenient.

6. Water-jet driven cars

Another successful hands-on project with water jets exploits propulsion of the outflowing water. A water jet-driven toy car in Fig. 9 was assembled and studied by Columbian students, while their Ukrainian contemporaries came up with a (joke) project of real-size jet driven city buses.

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Figure 9. Water-jet driven toy car

However joky was the students' observation, it gave an idea of scaling the results of jet-driven toy car experiments to the standard size vehicles.

7. Waves in elliptical and circular water tanks

Elliptical water tanks (a variety of modern containers is available for this purpose) are ideal to demonstrate focal properties of an ellipse. Dropping water into one of the foci produces spherical surface waves that reflect off the tanks' walls and meet in another focus. Will be a surprise for the students to observe very similar scenario in the circular tank. Waves originating from some point on the surface meet after reflection in a confined area symmetrical to the 'starting' point. Although further reflections deteriorate the picture, strong dissipation of surface waves diminishes degradation of the pattern.
Computer simulation (Fig. 10) performed by the students strongly supports these hands-on activities. It also reveals that when dissipation is low, waves in elliptical tanks travel between the foci as an intense isolated pulse rather than the expanding&contracting circular fronts.

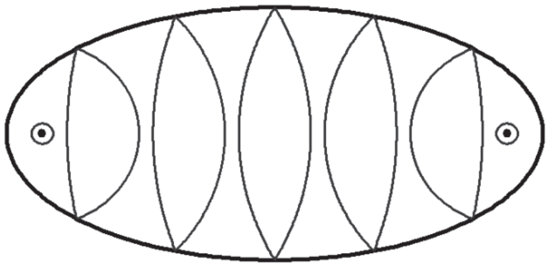

Figure 10. Surface waves in elliptical water tank, computer simulation

8. Amazing surface phenomena

To demonstrate how liquid surfaces support denser bodies is a common and didactically efficient practice. Here we are focused on the less known creative experiments with surface phenomena.

8.1. Floating of bodies denser than water on curved surfaces

Again, Martin Gardner's book was an inspiration of another exciting students' inquiry. In a '*Center the Cork*' activity ([1], p.117) convex surface of water makes an object less dense than water climb to the topmost area of the filled glass. Meanwhile, denser objects, e.g. steel paper clips or aluminium coins, tend to slide down the convex water surface towards a brim, and even fall out of the glass. In a partially filled glass with the concave surface everything is on the opposite. Adding more water to the glass, one 'switches' the positions of the

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'light' (Ping-Pong ball) and 'heavy' (coin) objects floating on the surface.

Axial rotation of the water-filled container pushes the denser objects on the surface towards the periphery, leaving lighter ones in the center. Should be noticed that buoyance caused by surface tension is incredibly stable, making aluminium coins float at high revolutions and at improbably big inclination angles.

8.2. Liquid marbles

Durable covered water drops, the so called 'liquid marbles', are produced by rolling droplets of liquid in a highly hydrophobic powder. Learning the amazing properties of thus isolated water bodies [12, 13] leaves no participating student uninvolved.

9. Three-bend self-starting siphon

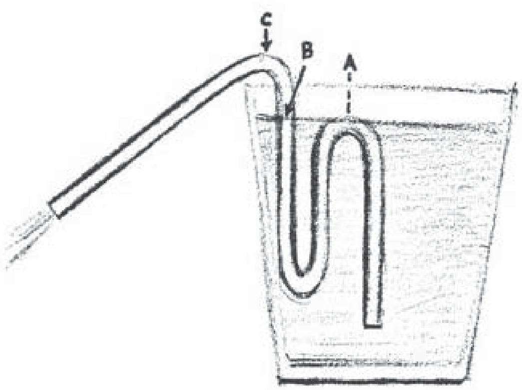

Figure 11. Self-starting siphon (from [1])

The last activity of the series originates from another masterpiece demo presented in Martin Gardner's book [1], p.112, scheme shown in Fig. 11.

Step by step experimentation with 0-bend (straight tube), 1-bend, and 2-bend siphons allows students to explain how the self-starting siphon operates. Other interesting properties of siphons are also explored during the project.

10. Acknowledgements

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Hands-on Science
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Understanding Growth and Thermal Inactivation of Foodborne Bacteria Using the Pathogen Modelling Program (PMP)

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Abstract. *According to the biology curriculum guidelines for the last year of high upper secondary studies, Portuguese students (16 to 18 years old), should be prepared to rationally mobilize and apply knowledge in the analysis of issues that impact society. Amongst the various contents addressed, students are expected to become more knowledgeable about key concepts related to the topic "Food Preservation". In this instructional level, and following current curriculum recommendations, practical work should be regarded an integral and crucial component of the teaching-learning process.*
In this work, we present an activity aimed at promoting high school students' understanding about microbial growth on foodstuff, and food preservation methods by engaging them in the use of a bioinformatics tool, the Pathogen Modeling Program (PMP).

Keywords. Growth of microorganisms bioinformatics, food preservation.

1. Introduction

Following a socio-constructivist perspective of learning, students are expected to develop meaningful understanding about key socio-scientific issues, which they can mobilize to answer challenges encountered in their every-day lives, preferably by engaging instudent-centred active learning activities. According to this perspective, practical activities can provide fruitful ways to build conceptual knowledge and develop procedural skills [1].
Amongst its variants, laboratory work has been given a privileged role in science education, with most educators and researchers acknowledging its potential to foster learning about scientific concepts and methods, in ways that appeal and motivate students [2].
Having this in mind, we propose a hands-on activity for pre-university students (12th grade biology students) to address microbial growth and its implications for food presservation using the Pathogen Modeling Program.

2. Pathogen Modeling Program and the Portuguese Biology Curriculum

In Portugal, science teaching guidelines for high school levels are based on a socio-constructivist perspective [1, 3] in which students are encouraged to take on an active role in planning and performing practical activities. Concerning the conceptual content "Conservation, improvement and production of novel foods", addressed in 12th grade biology, students should be able to perform laboratory activities that encourage them to understand the underlying biological phenomena methods of food

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preservation, by emphasizing the interdependence of conceptual and procedural dimensions in laboratory / experimental activities [3]. The integration of theory and practice in tasks in which the students are required to interpret natural phenomena, is expected to scaffold meaningful learning and improved scientific understanding [2].

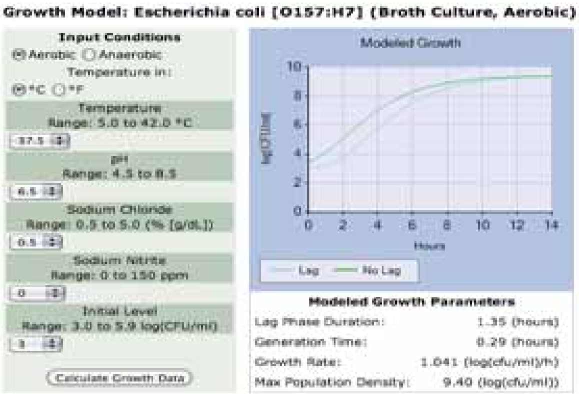

Figure 1. The user-friendly layout of a PMP growth model for a pathogenic E. coli, highlighting the independent variables (factors), the graphic output of the growth kinetics and the modelled growth parameters

Nowadays, bioinformatics tools can be explored as educational resources that offer effective opportunities to meet this goal [4].
The Pathogen Modeling Program (PMP) allows predicting the growth or inactivation of food-borne bacteria in diverse conditions. In fact, the PMP offers simulations of microbial growth or decline, based on data obtained by comprehensive laboratory experiments, but providing reliable predictions of bacterial growth and inactivation parameters in response to different intrinsic and extrinsic factors, such as pH, water activity, temperature, sodium chloride, food additives, etc. (Fig. 1) [5].

All these factors can be easily manipulated by the students, allowing them to perceive the importance of setting control variables in experimental work, but most importantly, to increase their understanding of the effects that these factors have and how they can be manipulated through food preservation methods, in order to control microbial growth on foodstuff [3].

3. Learning Objectives

By engaging in this activity, students are expected to:

- Identify the main intrinsic and extrinsic factors and their values that better limit microbial growth and avoid food contamination and/or spoilage;
- Understand that different microorganisms are prone to colonize different foods;
- Interpret and discuss experimental data produced by the online platform;
- Develop problem solving skills.

4. Predicting the Growth and Thermal Inactivation of Foodborne Bacteria

In this activity, students are challenged to put themselves in the place of a microbiologist contacted by a food processing company interested in optimizing their food preservation processes aiming to prevent foodborne illness by the pathogenic *Escherichia coli* O157:H7.
Students are then instructed to use the PMP, available at:
http://pmp.errc.ars.usda.gov/PMPOnline.aspx
and to manipulate a set of factors that influence the growth of microorganisms in food, namely the presence or absence of

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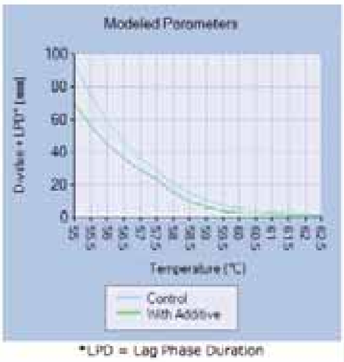
atmospheric O_2; temperature; pH and sodium chloride. The initial inocula (log 3 = 1000 CFU-Colony Forming Units/ml) and sodium nitrite are other independent variables that might be controlled. The most commonly used food preservation techniques are centred on the control of the abovementioned factors, namely refrigeration, pasteurization, modified atmosphere packaging, smoking, drying or adding salt or sugar to reduce water activity, are subsequently discussed.
Along the activity, students are presented with the following problems:

- Can anaerobic conditions be used to control the growth of *Escherichia coli*?
- Having in mind that refrigeration conditions are costly, and frequently unfeasible for long-term storage of some foodstuffs, using the PMP and assuming the need for storage at room temperature (20º C), propose values for other factors that would ensure the same effect on *E. coli* as storage at 10ºC. Your task is to propose different heat inactivation temperatures and compatible exposure times, in order to obtain a 10 fold thermal destruction of *E. coli.*

4.1. Bacterial Growth

The first two problems are related with predictive growth models, i.e. models that predict bacterial growth changes in response to different factors. Therefore the students have to access the growth models for *E. coli* available in the PMP, which lead them to the display highlighted in Fig. 1. Then, they must change the independent variables, i.e. the factors displayed as Input Conditions (Fig. 1), to obtain the growth parameters, i.e. generation time and/or growth rate that would allow them to assertively answer both questions. Regarding the first problem, the students should conclude that, although anaerobic conditions may delay the growth of *E. coli*, this bacterium is a facultative anaerobe and therefore able to grow without oxygen, suggesting that modified atmosphere packaging is not a safe food preservation technique.



Modeled Parameters

Temperature (°C)	Control D-Value + LPD (min)	Additive D-Value + LPD (min)
55.0	94.31	69.89
55.5	74.46	56.31
56.0	58.79	45.36
56.5	46.42	36.55
57.0	36.65	29.44
57.5	28.94	23.72
58.0	20.90	15.57
58.5	15.09	10.22
59.0	10.89	6.71
59.5	7.87	4.40
60.0	5.68	2.89
60.5	4.65	2.51
61.0	3.81	2.19
61.5	3.12	1.90
62.0	2.55	1.66
62.5	2.09	1.44

Figure 2. A PMP model of thermal inactivation for a pathogenic *E. coli*; emphasizing the graphic output of the inactivation kinetics and the modelled inactivation parameters

For the second problem, students have to manipulate factors such as salt concentration (sodium chloride) and pH, under aerobic and anaerobic conditions at a constant temperature of 20ºC, to find which are the conditions that ensure the lowest and longest values of growth rate and generation time,, respectively. This has to be done in comparison with the values of these parameters observed for temperatures of 10° C, and keeping the other factors constant. This knowledge should provide the

information needed to discuss the most suitable food preservation options at 20ºC.
In addition, students should acknowledge that the control of these factors does not completely destroy the contaminant, contributing to change long-standing ideas regarding food preservation, such as: i) refrigeration temperatures kill or inhibit bacterial growth; ii) basic pH values favour bacterial growth; iii) bacteria grow better in oxygen-rich environments.

4.2. Thermal Inactivation of Bacterial

The third problem, correspond to thermal inactivation models, i.e. predictions about the length of time during which foodstuff should be submitted to different lethal temperatures to ensure the thermal destruction of contaminant bacteria (Fig. 2). In the PMP platform, students have to choose the model: Thermal Destruction of *Escherichia coli* O157:H7, which will provide the details shown in Fig. 2, in the form of a graph and a table comprising the Thermal reduction times, i.e. the D-values, for different inactivation temperatures. This exercise contributes to the understanding of the basics of pasteurization, by allowing to witness that identical destruction of a bacteria population may be obtained at different lethal temperatures with different time exposure periods.

5. Acknowledgements

The authors are grateful to teachers Armandina Esteves and Natália Ferreira, and to Rio Tinto Secondary School for the opportunity to implement this activity.

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Preschool Chemistry: A Soluble Story

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Abstract. *Will be Chemistry important and understandable in preschool children's development? This question was the inspiration of this activity, where we took in children's curiosity and willingness to try, a story and chemistry, all mixed together. We used safe and familiar children's material and we followed the course of the activity observing the difficulties and conceptions of them, using the inquiry focused on what was happening with each one and trying connections with their predictions. All the children observed and understood that the colour in the water came from the previous M&M's® exterior colour.*

Keywords. Chemistry, colours, solubility, preschool.

1. Preschool chemistry

The Portuguese curriculum for preschool education includes a variety of objectives, such as awaken curiosity and critical thinking, and stimulate the overall development of each child [1].
The preschool education offers a formal development place where children can interact with situations and experiences of their daily lives, facilitators of learning in science [2]. The aim of chemistry is the knowledge of properties and transformations of matter and therefore the Chemistry could help to develop curiosity and critical thinking [3].
Children have developed their own ideas of the world and how it works, including about chemistry, even before entering school. By listening to these ideas seriously, educators can assemble on what children already know and can do. The initial ideas may be more or less consistent and sometimes may be incorrect with the advantage of building up significant knowledge [4].
The science education should start, as early as possible, awakening curiosity of the children to his surroundings and highlighting its importance. It's essential that science education start in a qualitative way to take advantage of children's natural curiosity and their activity with objects, introducing general ideas and terminology [3, 5].
The solubility exploitation is relevant and appropriate to the proposed objectives even though this theme does not appear explicitly in the Portuguese preschool program.

2. Solubility

The solubility concept is probably a new word for this children's age. They use mixture, disappearance, dissolution, etc. The concept involved is the same but synonym of those words.
The Hutchinson Pocket Dictionary of Chemistry described solubility as the "measure of the amount of solute (usually a solid or gas) that will dissolve in a given amount of solvent (usually a liquid) at a particular temperature" [6].
Solubility involves making a solution (an homogenous mixture) with, at least, one solute and one solvent. For the formation of solution the solute particles must scatter throughout the solvent. One way of thinking

is that the process requires initially the separation of the solute and the solvent mixed in the end. Another interpretation is the initial separation of the solute particles from each other being dispersed throughout the solvent. The solvent particles must be separated to allow room for the solute particles occupy the free space [7-9].

3. Hands-on activity

In this activity we used material safe to handle, because children have no sense of danger, may taste without asking and especially for being one of the first experimental activities in chemistry to them [10].

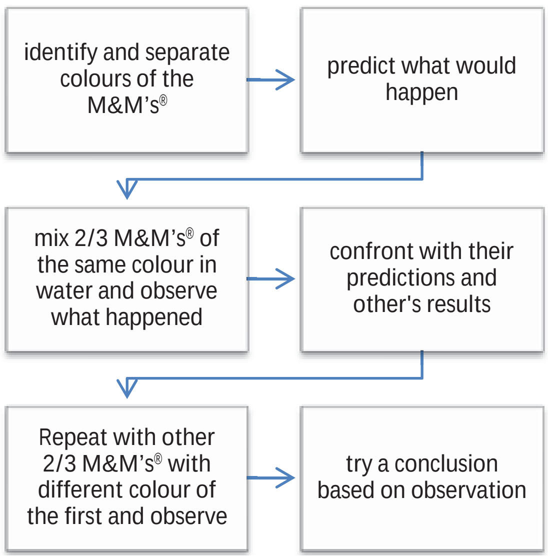

Figure 1. Objectives scheme

The main objective of this activity was to strength the idea of solubility/dissolution in water. The following objectives are showed in the figure 1.
The activity was introduced with an emphasized story suitable for their ages with characters they know ending with one problem.
The story was based on the need of M&M’s® to cross one bridge over water. The problem was that they were afraid of what might happen if they fall to the water.
The materials were introduced sequentially to help student focus on the process and not directly in the result [10]. It was presented first the M&M’s® milk chocolates, then the cup with water, the spoon and the stirring process.

3.1. Conceptions

The educator collected children’s individual predictions about what would happen to the M&M’s® fall in water. The children’s ideas were that the M&M’s® will:

- lose colour;
- melt;
- sink and change colour;
- be dirtying the water;
- stay with the colours of the rainbow.

3.2. Mixtures

We had six available M&M’s® colours: blue, orange, yellow, green, red and brown.
In the first mixture the children added to the water two or three M&M’s® of the same colour chosen freely and saw what occurred.
In the second mixture they added other two or three M&M’s® with the same colour but different of the first two or three M&M’s® added.
Between the first and the second mixture they observed what happened to the water and to the M&M’s®.

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3.3. Assessment

The children observed continuously the changes occurred in their cup and mentioned the M&M's® colour loss to the water. In this activity it was only possible to collect this verbal opinion in group. In addiction we collected some children's drawings of this activity like Fig. 2. They liked very much this activity because was hands-on, consider the best so far by some children.

Figure 2. Drawing of the activity

3.4. Further developments

The children's activity had an exploratory nature and it's possible in the future to do a more systematic study with a larger sample, interviews, drawings and analysis of content produced by children. This activity could explore the mixtures of colours, the more or less solute solubility, the reaction time, the influence of temperature, the size and the concentration of solutes.

4. Conclusions

In this activity all the children observed and reported that the exterior colour of the M&M's® had "moved" to the water and the M&M's® remained brown because they were made of chocolate. We motivated the children to think why this happened, but they can't explain why. However that explanation was not an objective for this activity.
With this activity was possible to stimulate curiosity and critical thinking during the process and helped them to develop the motor and intellectual skills.
We believe that the chemical hands-on activities in early years would be a great help to enhance knowledge and dissemination in chemistry.

5. Acknowledgements

We have to thank to Centro Escolar de Fão, especially to the educator Dina Zão for availability, consent and participation on this study.

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SAFE: Secagem de Alimentos e Fruta em Estufa. ECO-FOOD: SOD (Solar Oven Dehydration) of Food and Fruit

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Abstract: *SAFE is a project that was made by the 12th grade students of Agrupamento de Escolas de Caldas de Vizela, which the objective is introduce the consume of fruit in school community, it means, increase the consumption of fruit among the school community with the access of fruit with an improved texture and flavour, while maintaining all the nutritional value.*
This project consists in the construction of a greenhouse/ solar oven for the dehydration of all types of fruit or other kind of food. All of our school community has a part on our project. The greenhouse is completely "green" because the only source of energy is the sun. We intend to built prototypes for drying food and fruit with more technology.
These prototypes where build based on papers and research from another country's that use sun energy for this task [1].
Portugal is a producer of fruit and vegetables of high quality so we intended to make a project that promotes small food and surplus valorisation. On the other hand, there is enough solar energy to dehydrate foods without recourse to other energy sources in part of the year.
This type of food is very unusual in our country and few people will be using this method or cook with these foods. So, we'll create a recipe book to promote the use of this type of fruit.
Concluding, SAFE combines the ecology with health.

Keywords. Fruit dehydration, food dehydration, natural resources, food preparation, solar power, solar drying oven.

1. Introduction

This project consists in fruit and other food dehydration. For the concretization of SAFE, we had many moments: the first one was the development of the greenhouse / solar oven [2], [3]; the second one was dehydrate fruit in the greenhouse and study what happens in it. We also tested some ways of preparing these foods. In sum constructing and testing.

2. Activities developed

Figure 1. 3D model

First of all, with SAFE, we wanted to promote fruit consumption and value natural resources. After that, we establish that a part

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of our work would be based on some investigation. And for that, we needed to read some papers talking about how to build a greenhouse/ solar oven for food dehydration [1], [2], [3]. We also needed to choose the best materials to use in the construction of a greenhouse. Then we studied what kind of food, such as fruit, is more available and has origin in Portugal.

Before greenhouse construction we made some prototypes: we made a virtual model in 3D, as we can see on Fig. 1, and a mock-up with paper (Fig. 2), and other material, until we get functional prototypes (Fig. 3).

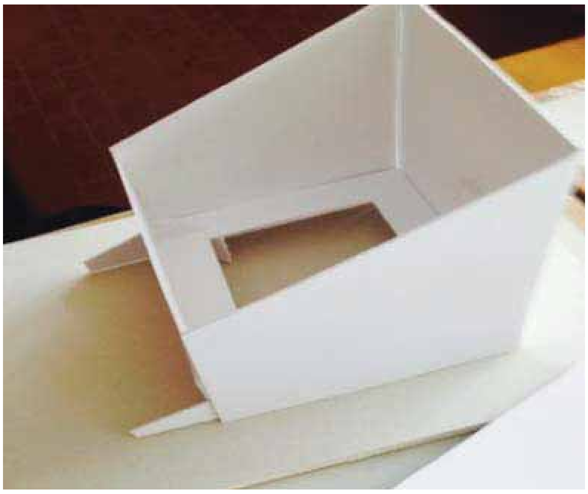

Figure 2. Paper model

During the evolution of the project we made some adjustments because of problems that were appearing. Our group work has also built humidity and temperature sensors, adjusted to needful measurements, using informatics and robotics principles. Using the open hardware Arduino and humidity and temperature sensors platform we developed a prototype of measuring this quantities.

We also investigated equipment to regulate the dehydration conditions and to have the best conditions to use the sun energy (calorific and photovoltaics), such as best place to put the greenhouse, best inclination, etc.

Figure 3. Functional greenhouse prototype

For us was also important the communication with public, it means that we wanted to show the world what we are doing. And for that, we created a blog, a logo (Fig. 4), bags with dry fruit and flyers and other materials.

Figure 4. Blog of the project – www.safevizela.blogspot.com

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After the construction, we focused in other objective that is promoting fruit consumption. For that, we created a recipe book whereupon fruit is the main ingredient. And why creating a book? Dry fruit is not common in Portugal so recipe books don't include them on the recipes. That way, with creative and delicious recipes we can also make people healthier (just because fruit is included on their meals).

3. Construction and greenhouse materials

The greenhouse was constructed with materials resistant to environmental changes.
The outer part of the phenolic panel, a wood does not degrade. This surface presents a black to facilitate absorption of sun radiation to the upper part of the greenhouse heat. Thus, creates a greenhouse capable of natural dehydration of the fruit.
The upper part is inclined and has a resilient plastic to permit the transmission of energy into the interior.
Inside, the oven has two shelves to put the fruit to dehydrate. These shelves can be opened and closed easily. It is noteworthy that the stove is coated with a very fine mesh that keeps out insects.
All materials are articulated in order to maximize the efficiency of the dehydration process.

4. Technological component

The full operation of the stove requires the use of technology and efficient energy sources.
The use of photovoltaic panel is essential. This has the functionality to convert solar energy into electrical energy to power the fans on the move. The two fans which are arranged inside the greenhouse to allow air circulation. The air must be constantly renewed to dehydrate fruits.
In addition to these, the greenhouse has implemented a temperature sensor and humidity developed by us. This sensor uses a hardware (Arduino) and record the temperature and humidity inside and outside the greenhouse.
With these measurements we record the values that optimize the drying of fruits.

5. Areas involved

In this project, there are many disciplines involved at different stages of education. The 8th grade contributes to the project in terms of Natural Sciences (exploitation of integrated enhancement of natural resources), and on Geography (viewing examples of exploitation of natural resources and the integration of the study of climate and its impact on human activities). The 9th year works with the natural sciences to explain the importance of eating fruit, complementing the study of nutrition and healthy diet. The 10th and 11th grade cooperate with Physics, practical exploration of different sources of energy and the photovoltaic panel, and Mathematics of 10th year for the use of spreadsheets and statistical tools. Finally, the 12th year helps to understand the importance of the chemical quality of the fruit (heavy metals, presence of toxic), different biological molecules, weighing procedures and understanding of variation in the concentration of sugars and other substances, the chemical stability of different molecules (oxidation), also lets help to

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understand the importance of biological and bacteriological quality of the fruit, the identification of organisms contaminants (mold, bacteria, ...) and helps to explain the advantages of organic farming production and quality testing for dehydration. Thus, summarizing, the knowledge areas that assist in this project are: Physics (solar energy, materials and properties, convection currents, saturation point, relative humidity, ...), Chemistry (food properties, oxidation of different compounds, different constituents of food (organic molecules), water content of the food), Biology (nutrition, biological resources, classification of living things, identification of decomposers,...), Geography (orientation to the sun, use of natural. resources), Computing (sensors and Arduino programming, spreadsheets, ...), Mathematics (statistics), Robotics (using relays), Cuisine (food recipes), the Portuguese Language (book building) and Marketing (promoting the consumption of fruit, building layouts of books.).

6. Cookbook

We also elaborated a cookbook that was published. This book covers various cooked whose key ingredient is dried fruit. Was recently published and is being sold to the whole community. The monetary amount raised will be used to support the costs of this project.
It is important to note that revenues were prepared by chefs.

7. Partnerships

Involved in this project are several entities that assist us in managing the greenhouse.
We have partnered with two supermarkets Vizela region that provide us with fruits and food for their dehydration.
We also have the help of marketing students from our school and cooking. The chefs who executed publish recipes ideas for the SAFE project is a success.

8. Conclusions

We accomplished the major objectives of the project, and we can show that Portugal may use solar energy for fruit and food dehydration.
This project as many possibilities of expanding: testing other fruit and food, improving uses of dehydrated food, new recipes,…
There is a big potential of applying this projet on another schools, even with another level of students. We believe it´s pedagogical value is proved and it can showcase a new way of promoting healthy habits, but also reducing ecological footprint.

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Didactic Experiments on Science

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Abstract. *In our daily life we are constantly in contact with chemical substances. All of them intrinsically possess a number of properties which can be used to our advantage, as a society and as teachers. These properties are classified in two general groups: chemical or physical properties. Chemical properties are oxidative or reductive powers, acidity or basicity, etc. whereas states (solid, liquid and gas), shapes, density, and so on are physical properties. When variations take place in the chemical or physical properties of a compound, this compound shows a chemical or physical change, respectively.*
A physical change maintains the molecular integrity of the substance, for example the state of matter or the density of fluids changes. A chemical change, however, implies the transformation of a substance into another, with a different molecular constitution. For example, when iron oxidizes or the combustion reactions with oxygen which take place in our cells. In this work, we are introducing some didactic experiments related to both physical (density, water-oil-metal and plastic) and chemical (acidity-basicity, red cabbage extract obtained will use to identify acids and bases) properties. In addition, experiments prepared to do at home are also discussed in this work - because of their importance for students and the possibility of using them to increase the student's, their families' and finally the whole society's interest in science.

Keywords. Didactic experiments, chemical properties, physical properties, at-home science.

1. Introduction

Children and teenagers are constantly in contact with chemical substances independently if they live in a city or in the countryside. Each chemical substance intrinsically possesses a number of properties that we could use for our benefices. These properties are classified in two main groups: chemical or physical properties. Chemical properties are oxidative or reductive powers, acidity or basicity, etc. while states (solid, liquid and gas), shapes, density, and so on are physical properties. In this work, we describe some didactic experiments that could be do at home because of being completely safety for students and their families and, a part of that, they are related to both physical (density, water-oil-metal and plastic) and chemical (acidity-basicity, red cabbage extract obtained will use to identify acids and bases) properties.
Because of science is all around us, our backyard, our kitchen, and other areas around our home provide natural "laboratories" for children. It is well known that primary school children (ages 6-12) are curious and intuitive scientists [1]. They observe, find patterns, hypothesize and try out ideas [2].
For that reason, exploring with science can be lots of fun while also teaching them a

great deal about themselves and their world [3]. When children's families are involved with science at home, two important issues for children are present: education and safety. While science projects can be fun, they should be based on solid educational standards that provide them with knowledge and skills that are age-appropriate and, wherever possible, related to their school science curriculum [4, 5]. However, at-home activities should be designed by professionals with the child's safety and success in mind [6, 7].
The experiments described in this work were developed by Catalan primary school students at their homes with the help and the guidance of parents. All the pictures presented here which illustrate their at home results of experiments were given to us by themselves.
It is important to point out that even the simplest activities with the most basic of materials can be harmful or dangerous, so either parental or tutorial supervision and guidance are critical at all times.

2. Procedures, results and discussion

All substances have properties that we can use to identify them. For example we can identify a person by their face, their voice, height, finger prints, DNA etc. If we can identify more of these properties we will know more about that person. In a similar way matter has properties - and there are many of them. There are two basic types of properties that we can associate with matter. These properties are called: physical properties and chemical properties.
Physical properties are those properties that do not change the chemical nature of matter. Some examples of them are: colour, smell, freezing point, boiling point, melting point, infra-red spectrum, attraction (paramagnetic) or repulsion (diamagnetic) to magnets, opacity, viscosity and density. It is important to mention that measuring each of these properties will not alter the basic nature of the substance.
On the other hand, chemical properties are those properties that do change the chemical nature of matter, for example: heat of combustion, flammability, oxidation states, reactivity with water, pH and electromotive force. This property measures the potential for undergoing a chemical change.
The more properties we can identify for a substance, the better we know the nature of that substance. These properties can then help us model the substance and thus understand how this substance will behave under various conditions.
We describe in this work some didactic experiments related to a physical propriety: the density. Furthermore, we also explain other experiments related to a chemical propriety: the acidity or basicity grade.

2.1. Physical properties

The density, or more precisely, the volumetric mass density, of a substance is its mass per unit volume. In chemistry, a substance is a form of matter that has constant chemical composition and characteristic properties. It cannot be separated into components without breaking chemical bonds. Usually, the matter could be presented in solid, liquid and gas state. The reason is because matter is compacted in each substance in a different way. While, solids have the highest grade of compaction, liquids present a middle compaction grade and finally gases possess the lowest one.

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Scientists use the concept of density to describe the grade of compaction of a concrete substance. Density is defined as the relation between the mass of a substance and the volume that occupies.

Thought the following didactic experiment, students could compare the density between two liquids, two solids and, obviously, between liquids and solids.

The materials that are needed are a large glass, oil, water, a plastic (polypropylene) cap and a copper coin. The density values of oil, water, plastic and copper are quite different (Table 1).

Substance	Density (g/cm^3)
Plastic (polypropylene)	0.900
Oil	0.918
Water	0.999
Copper	8.933

Table 1. Density values of plastic (polypropylene), oil, water and copper

Firstly, students fill partially a glass with oil (Figure 1A). Then, they could add water slowly to oil and observe how drops of oil come up through the water to the upper part of the glass because its density is lower than the water density (Figure 1B). After some time in rest, all the oil will be to the upper part of the glass and water to the bottom part. Student could also throw a copper coin in the glass and it falls to the bottom of the glass because its density is 9-fold higher than both oil and water density (Figure 1C). Finally, students could carefully throw a plastic (polypropylene) cap and observe that it floats on the surface of oil due to the Archimedes' Law (Figure 1D) [8].

Archimedes' Law or Archimedes' principle is the fundamental natural law of buoyancy, first identified by the Greek mathematician and inventor Archimedes in the 3rd century B.C. It states that any object floating upon or submerged in a fluid, is buoyed upward by a force equal to the weight of the displaced fluid. This buoyant force is caused by the weight of the fluid, which causes the fluid pressure to increase steadily with increasing depth from the surface. Any submerged object is subject to a greater pressure force on its lower surface than on its upper surface, creating a tendency for the object to rise. This tendency is counteracted by the weight of the object, which will sink if it is heavier than the surrounding fluid and will rise if it is lighter. If the object weighs the same as an equivalent volume of the fluid, it will be in equilibrium and remain motionless. Buoyancy may be thought of as the density of a fluid relative to the densities of objects submerged in it.

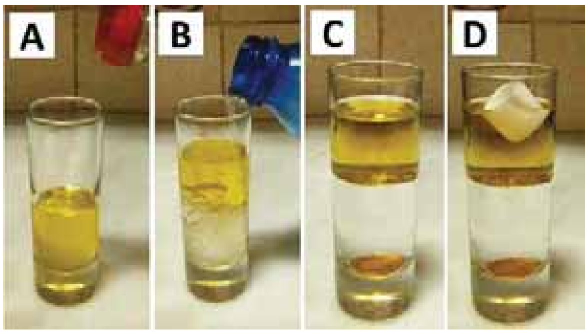

Figure 1. (A) A large glass is partially filled with oil. (B) Then, some water is added on the glass. (C) A cooper coin is thrown in the glass. (D) Finally, a plastic (polypropylene) cap is carefully thrown in the glass

Through these experiments students could learn the types of state matter (solid, liquid

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and gas), grade of material compaction, density and buoyancy.

2.2. Chemical properties

One of the most important chemical properties of substances is their acidity or basicity, so they could be classified into acid, neutral and basic substances depending of their pH values.
The pH is a scale that scientists use for measuring if a substance is more acid than others [9]. Some chemical products such as household cleaners and laundry products that we normally use in our daily lives possess a strong acidity or basicity grade that is dangerous for our bodies, especially for our skin and mucosa. However, some foods, hygienic products and chemist products have also an acidity or basicity grade but not so strong to damage our skin and mucosa. Therefore, they can be used for students to measure their pH values at home in a safety way with the guidance of their parents or tutors.
We introduce an at-home experiment that consists to obtain a pH indicator from red cabbage [10]. Some vegetables such as strawberry, cherry, red cabbage and red onion have a substance, called anthocyanin that is very sensitive to pH changes [11]. Just red cabbage has cyaniding, which is an excellent natural indicator [10].
In this experiment at-home, the red cabbage extract will be used to measure the acidity or basicity grade of 3 substances: vinegar, antacid table (bicarbonate) and egg white.
Firstly, children could not do any part of this experiment without the help and supervision of their family or tutors. Darker leaves of cabbage are cut, added in a glass with a small amount of boiled water and crashed with a spoon for a few minutes (Figure 2A). Later, the extract is allowed to cool and then is transferred to another glass reserving the liquid and discarding the leaves that have discoloured (Figure 2B).

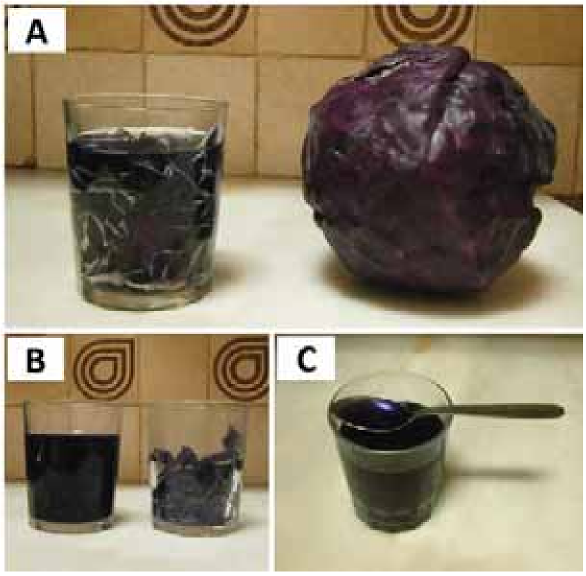

Figure 2. (A) A glass is filled by red cabbage dark leaves and hot water. (B) After leaving cooling down the aqueous extract, it could be transferred into another glass. (C) The red cabbage extract is purple

The aqueous red cabbage extract is purple (Figure 2C) and is a natural pH indicator because its colour changes depending on the environment [12]: acquires red colour in acidic medium [vinegar (Figure 3A)], bluish-purple colour in neutral medium [water (Figure 2B-2C)], and greenish-blue colour in basic medium [antacid tablet (bicarbonate) (Figure 3B) and egg white (Figure 4B-4D)].
Another fun experiment for students is to cook a fried green egg using extract of red cabbage (Figure 4E). Firstly, it is important to separate the white from the yolk of the

egg. The egg white is mixed with a few spoons of red cabbage extract (Figure 4F). When the white is frying, the yolk is quickly added without forgetting a pinch of salt. The alkalinity of the egg white turns the purple juice of red cabbage into greenish-blue colour (Figure 4F). This fried green egg can be eaten in peace without any fear (Figure 4G).

Figure 3. Students could use red cabbage extract to check the pH of the following substance: (A) vinegar and (B) and antacid tablet (bicarbonate). At the top-right corner of each picture there is a glass filled with one of the three tested substances and at the bottom-right corner these substances after adding some drops of red cabbage extract

Students doing these experiments could discover that food and chemist products could be classified as acid, basic or neutral substances and also learn the properties of an indicator.

Science teacher schools could encourage students to do these didactic experiments at home and later discuss the results obtained with them to teach the chemical definition of acid and base (proton and hydroxide ion), pH concept, neutralization and ion exchange, acid-base indicator and acid-base valoration [13].

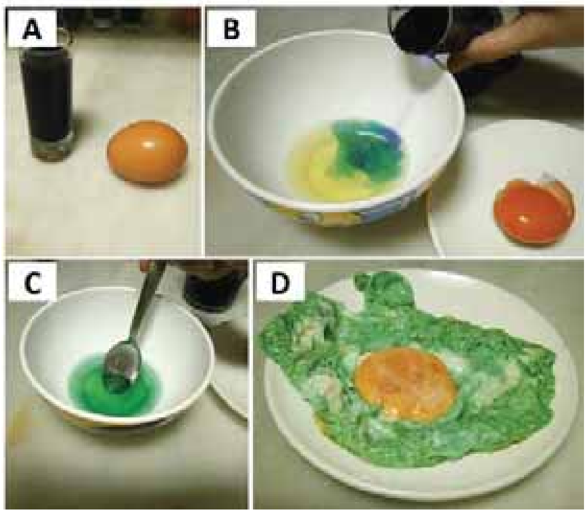

Figure 4. (A) Aqueous red cabbage extract and egg are the only two ingredients to cook a fried green egg. (B) After separating the white from the yolk of the egg, few amount of red cabbage extract is mixing with the egg white. (C) The alkalinity of the egg white turns the purple juice of red cabbage into greenish-blue colour. (D) A fried green egg which can be perfectly eaten

3. Conclusion

The most traditional arena for exploration and experimentation is school's science laboratory [14, 15]. However, we have been taking advantage of another setting: the home. For some time now, we have strongly encouraged our students to do science experiments with family and friends at home using simple materials [16]. The benefits of at-home science activities are many. Firstly, they increase the time that students are both thinking about and doing science [17]. Secondly, since many of these didactic experiments are focused on counterintuitive phenomena, students delight in sharing unexpected outcomes with others [18]. Finally, parents love seeing what their children are doing in school.

Quite often the materials needed to investigate both physical and chemical phenomena at home may be found in the kitchen or workshop [16]. On the other hand, when more specialized equipment is needed, we create a "Laboratory Bag" by packing required materials in either plastic bag or box. Using the “Laboratory Bag” approach, students take home simple materials from school’s science laboratory relating to a concrete didactic experiment.

These at-home experiments, which we introduced in this work, are intended to be engaging, thought provoking, and enjoyable. The principle goal of these activities is to allow students, and their families, to experience science in a less-structured and more playful manner. All these experiments are designed to be straightforward and materials are chosen with safety in mind. The low-cost nature of the simple materials used in these experiments do them more accessible to perform. We hope and, at the same time, encourage teachers to share these didactic experiments with students and the student’s families. We strongly believe with the possibility of using these experiments to increase the student's, their families' and even the whole society's interest in science [19, 20].

4. Acknowledgments

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EasyPET. A Didactic PET System

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Abstract. *The Positron Emission Tomography (PET) scanner is one of the most advanced imaging systems for medical diagnosis. The easyPET project envisages promoting the knowledge of this technology within the younger student community (high-school and undergraduate), by exploring PET physical and technological principles. For this purpose, a small-scale prototype, easyPET, was built using the same basic technology as medical human PET scanners.*
The easyPET system comprehends only two small detector cells, using a simple electronic system for signal amplification and coincidence detection, and two stepper motors to simulate the whole detection ring. During the rotation, real-time image reconstruction is performed. In this work, the PET principles and the operation principle of the easyPET prototype are presented. Also, a description of the activities enabled by our system is described.

Keywords: Didactic experiment, nuclear radiation, scintillation detectors, positron emission tomography, PET.

1. Introduction

The PET scanner is the state-of-the art imaging system for functional medical diagnosis. Using a molecule labelled with a positron-emitting radioisotope, high resolution functional 3D images of the internal organs and structures of the human body can be obtained, showing the related physiological processes. The conventional PET system is assumed as a powerful tool for medical diagnosis but at the same time enormously complex with respect to both its technology and construction, being a very high cost device. [1]
The easyPET project [2] aims to develop a simple educational system, with a minimal amount of components that will allow showing the physical and technological principles of this medical imaging technique.

1.1. Principles of PET imaging

A PET system allows obtaining images of the distribution of β^+ decay process in the human body / object.
A pharmaceutical labelled with a radioactive isotope is injected in the patient and will associate to molecules involved in physiological process. The radioisotope used is a positron (β^+) emitter, which will interact with surrounding matter, losing its kinetic energy. Every time a positron interacts with an electron of the human body, annihilation occurs. The mass of the positron and electron is converted into two photons with 511 keV, emitted in opposite directions. [1]
The two photons are detected by a ring of scintillator crystals, which allows a pair of crystals to detect two opposing photons in any direction. The scintillator crystals are

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made of a high density and atomic number (Z) material, with a particular characteristic: they are able to convert the absorbed gamma photons into optical photons (typically thousands per MeV), which are then converted to a measurable electric signal, by appropriate photodetectors.
The detection of the two gamma photons within a coincidence time window, allows defining a line that connects two detector units, the coincidence line or line of response (LOR). Therefore, the annihilation occurred somewhere along the line. This kind of detection is named annihilation coincidence detection. [1]
Since the radioisotope emits positrons from a specific point in the field-of-view (and annihilation photons are emitted in isotropic directions), the coincidence lines will cross and the emission position is determined, resulting in an image of the radioisotope distribution in the body.

2.2. The easyPET project

The main goal of the easyPET project is to promote the knowledge of PET technology within the younger student community, both high-school and undergraduate students, by exploring the physical and technological principles of PET with a user friendly, low-cost, portable didactic system, using the same technology as conventional human PET scanners.
A web page [2] was also developed to support this project, including easyPET project highlights, support materials and activity logs.
This project counts with the participation of the students, who contribute actively for the project development. In this way, it is possible to promote scientific knowledge through research experiences and contributing to educate and demystify the nuclear energy common sense, reinforcing the benefits of its application in Health Care, Medical Physics and Biophysics.
All the activities were designed and developed applying the best procedures, relating the radiological protection and the safety of all members involved, taking into account the Portuguese and European law directives [3].

2.1. easyPET Concept

The easyPET system requires only two scintillator crystals and a mechanical system to simulate the entire PET ring (Fig. 1).
The two small detector cells, each composed of a small LYSO scintillator crystal coupled to a silicon photomultiplier (SiPM), are oppositely aligned in order to detect back-to-back gamma photons originated in the β^+ annihilation process.

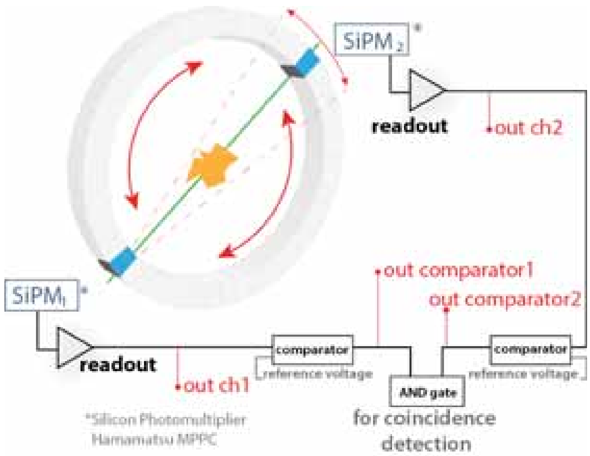

Figure 1. Schematics of easyPET operation principle

A fast and simple electronic system,

developed for this particular application, allows detecting coincident events resulting from the same β^+ decay process and amplifies the signal.

The electronic system includes two comparators and an AND gate. The signal from each SiPM is compared to a reference signal by the respective comparator. If both signal amplitudes are higher than the reference, within a given time validation window, the AND gate verifies the existence of a coincidence (Fig. 2).

Figure 2. Energy spectra (top) and coincident signals (bottom) from the two easyPET LYSO-SiPM detector cells

A single printed circuit board (PCB) supports the two LYSO scintillators, the photodetectors and all the electronics, including power supply for the SiPMs. The PCB is attached to two stepper motors that perform rotation and scanning movements allowing the simulation of the entire detection ring, covering the whole field of view (Fig. 3). For each scanning position, the number of coincidences is counted and an image of the accumulated scans is reconstructed in real-time.

The mechanical system (stepper motors) and PCB electronics are controlled through a microcontroller-based module, Arduino Uno, equipped with a Motor Shield (Adafruit) and connected to a computer through Universal Serial Bus (USB). In the computer, a graphical user interface (GUI) allows setting the acquisition parameters, such as SiPM bias voltage, acquisition time in each scanning position, the step or each motor, the range of the top motor scan, number of complete circles, among others. During acquisition, the coincidence count at each position is sent back to the computer and the image reconstruction can be visualized in real time.

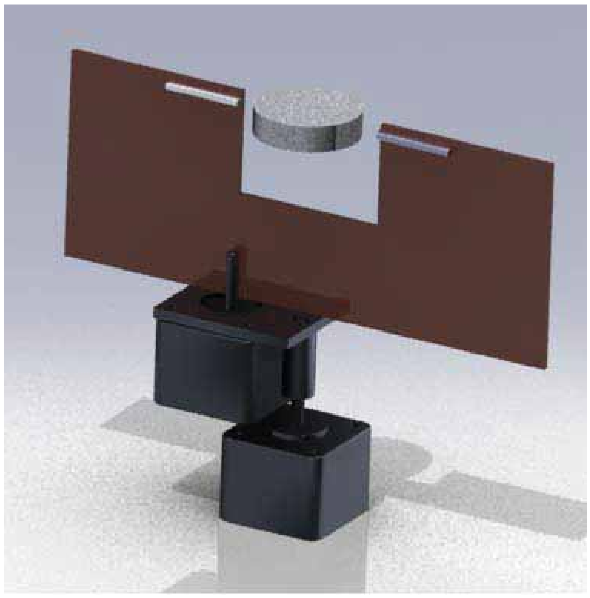

Figure 3. easyPET sketch, showing the mechanical system, Printed Circuit Board (PCB) with coupled crystals and a radioactive source

2.2. Didactic activities with easyPET

As explained, the easyPET system allows visualizing the distribution of the β^+ decay

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process in the object. For that, a Na-22 β^+ emitter is used, following all radiological protection and safety procedures. In addition, other activities are possible, such as gamma spectroscopy, the determination of the total detection efficiency, the annihilation efficiency and the spatial resolution of the PET system.

2.2.1. Gamma spectroscopy

Using the signal produced in one cell by gamma interaction, the energy spectrum can be obtained. With this functionality, gamma spectroscopy studies can be performed using different radioactive gamma sources (like Na-22, Cs-137 and Co-60, standard in many high-school and universities).

2.2.2. Total Detection Efficiency

The total detection efficiency ε_T, depends on the electronics and crystal efficiencies:

$$\varepsilon_T = \varepsilon_T \text{ x } \varepsilon_{crystal} \qquad (1)$$

Experimentally, it can be determined from the number of measured photons $N_{photons}$, the source activity, , and the solid angle, Ω , using eq. 2:

$$\varepsilon_T = N_{photons} \text{ x } [\text{A x } \Omega]^{-1} \qquad (2)$$

The number of photons is determined by summing all the photons acquired during a measurement. The source activity can be estimated by knowing its initial activity, the decay constant and the time passed since the initial time.

2.2.3. Annihilation Efficiency

Annihilation efficiency is another parameter that can be determined with the easyPET. The total annihilation efficiency, ε_{Tan}, varies with the crystal efficiency, $\varepsilon_{crystal}$, and with a parameter that depends on the electronics efficiency and coincidence time validation window. eq. 3 allows calculating a value for the annihilation efficiency:

$$\varepsilon_{Tan} = k \ \varepsilon_{crystal}{}^2 \qquad (3)$$

The scintillator crystal efficiency is a known value that can be obtained from the manufacturer [4]. The electronics efficiency can be calculated using eq. 1, after determining the total detection efficiency.
Since parameter k depends also on the coincidence time window, which is defined in the system by the user, the annihilation efficiency can be easily calculated. An interesting study made possible by our system is the analysis of the annihilation efficiency as a function of the coincidence time window.

2.2.4. Spatial Resolution

A characterization of the system spatial resolution can be performed. Successive acquisitions can be made, varying the radioactive source position linearly in one direction, measuring the respective response. This will allow constructing the response function for that line of response (LOR) which consists on the number of counts (coincidence rate) versus the radioactive source position and whose Full Width at Half Maximum (FWHM) represents the position resolution of the system. [5-6]

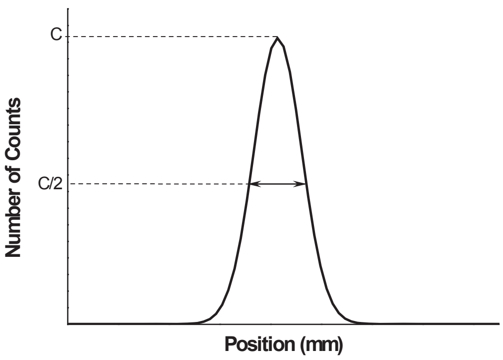

Figure 7. Example of Gaussian function showing how to measure its FWHM

3. Conclusions

The developed easyPET system demonstrates, in a very simple system compared with the human PET, the operation principle and technology associated with this medical imaging modality.

The students can interact actively with the system, namely in the definition of the acquisition parameters. The image is reconstructed in real-time and other activities can be developed with this system, such as gamma spectroscopy, the determination of total detection efficiency, annihilation efficiency and position resolution.

The promotion of knowledge of PET technology within the younger student community, both high-school and undergraduate students, has been achieved through collaboration with secondary schools, university, science fairs and science museums. The webpage supports this project, having an important role in the development of the activities and sharing of experiences between all the participants.

4. Acknowledgements

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Atreve-te!: Dare Yourself to the World of Engineering

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Abstract. *The Engineering plays a fundamental role in our society. Since it's defined as the science which aims to apply scientific knowledge and techniques in order to solve problems found in a society or to improve solutions already proposed to the same problems, it's important spreading among the students what is really the Engineers' role and where we can find Engineering.*

Keywords. Electronics, engineering, high school, additional training.

1. Introduction

The world without engineers would be some kind of mess, but not always we can recognize both the value and effort of these professionals. The technology evolved so quickly that now the evolution is given as granted, appearing to be quite normal to have, for example, at each year more advanced cell phones, able of giving response to the most demanding services and, if something goes wrong, people seem to be unable to recognize the work which is behind of that technology. If this is true for the people in general, this is even truer when we talk about young students, who want to watch films, to listen music and surf through the social networks, anywhere, anytime.

For these reasons, the project *Atrave-te!* aims to bring among the high school students the engineering as a challenge field of studies, which should be capable of give response to the problems of a society and the engineers' role as both professionals and people of the society.

2. The *Atreve-te!*

2.1. The Team

The project is as a partnership between the Aveiro's pole of the Instituto de Telecomunicações and the Department of Electronics, Telecommunications and Informatics of the University of Aveiro. The project is coordinated by the authors of this paper and concretized on the field by the same team together with other colleagues who have interest in spreading knowledge among young people, for instance Gil Fernandes and Tiago Varum.

2.2. The Project

Inserted into one of the main goals of the Instituto de Telecomunicações, transferring knowledge to the society, the *Atreve-te!* aims to clarify among young students what is the engineering, what the engineer as professional do and both the social and economic impact of the engineering around all of us.

Following these main goals, participated already more than one thousand and hundred students of Vilar Formoso, Mira, Guarda, Fornos de Algodres, Nelas, Vila Nova de Gaia, Sever do Vouga, Oliveira de Azeméis, Castro Daire, Porto, Albergaria-a-

Velha, Tondela, Gafanha da Nazaré, Vouzela, Oliveira de Frades, S. João da Madeira, Cantanhede, Arouca and Marques de Castilho.

Figure 1. Stand at one of the interventions

The implementation on the field occurs through a talk between an engineer and the students and, for one hour, topics related to the engineering are discussed.
The definition of Engineering is presented first as being talent and contrivance. The necessity of solving problems found in the society is stressed then. For solving those problems the engineer should be armed with several important qualities such as communicational and team work skills, logical thinking, practical and objective approach to the problems found, so how the engineers think, are aspects open to the discussion.
The world without engineers is discussed and the importance of the mechanical, electrical, telecommunications, electronics, informatics, civil and acoustic engineering is presented.
Meanwhile, since the engineer should propose solutions to several kinds of problems, the complete chain, since the problem identification, to the solution's proposal is discussed. Aspects such as creativity to have an idea, research in order to establish a procedure to be implemented during the development process in laboratory, manufacture or present the final solution and, finally commercial aspects are exhaustively discussed in order to get an insight into what is behind the development of any novel product, service, process, technique or even model.
In order to allow the students to concretize the true engineer's role, several projects in electrical, electronics and telecommunications engineering are presented. The first one aims to improve the public illumination with LED technology, which should reduce the power consumptions by adjusting the illumination in function of the ambient and turned on when's necessary. Economic and environmental aspects are stressed here. The second one is related to the development of an intelligent device, capable of be a radio, TV or even a cell phone, and the third aims to improve the mobile network for the fifth generation. Thanks to this project we can stress the needs to have more bandwidth and be capable of give response to the most demand services which the clients want, clients like ourselves and the students. The remote control, free of batteries, is a project presented next, and here environmental aspects are stressed again, together with the fact of all of us are just right now exposed to several kind of radiation, which could be used to charge batteries or even to put devices to work without these batteries. The fiber technology is also presented as an important field of studies capable of give us greater TV and internet quality. Another

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project presented is a social network to vehicles, which aims to help drivers to get a safer driving experience, since if a car gets broken a repair shop is automatically informed, together with the other drivers in the neighbourhoods. Also, if a car has an accident, both the authorities and the drivers in the neighbourhoods are notified, assisting immediately the passengers and preventing accidents, specialty if reduced visual conditions occur. The necessity of modelling the Earth-Satellite communications channel in order to improve the satellite communications system, leading to the services cost reduction is discussed and following this project, another one regarding the implementation of electronic devices for space applications is presented. Since the experiment, which is now aboard of the Alphasat satellite, aims to test in real scenario the behaviour of a new transistors' design and its immunity to the background cosmic radiation, a project in radio astronomy is presented together with the importance of this field of studies.

At the end of the discussion, the students are warned to their own role in the society as being the future researchers and engineers responsible of get answers to the world around us, so they should prepare their selves to the future challenges.

A practical demonstration of an ongoing project is presented and the students are invited to ask whatever question they want to be clarified.

2.3. Practical Demonstrations

Two practical demonstrations are presented. One of them is a project that involves a quadcopter. Some technical details regarding the project are given to the students while the quadcopter is just flying, always guaranteeing the security of everyone in the room. The software that is being developed combining hardware will receive a GPS signal and a predefined route should be followed. This route will be a GPX file that will be created on Google Earth or other similar software, allowing the marking of way points and saving them in GPS data files. When receiving the GPS coordinates, the software should convert them in control commands recognized by the drone, performing the autonomous flight. This know-how are transmitted to the students for a better understanding about how it becomes a solution and then a product, like many of the other projects already discussed. Finally, some examples about civil applications are specified to the students. Also, practical issues and constraints found during the development are presented from the engineer's point of view and the approaches taken face to those problems are discussed.

Figure 2. Practical demonstration

Another one is an educational kit used to explain the fiber technology. Aspects such as light propagation on a fiber, reflection,

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refraction, and impairments found on the propagation medium and how to overpass these last ones using for instance amplification are some aspects explored using this kit.

Figure 3. Promotional kits

2.4. Promotional Kits

To each student is given a promotional kit, this one composed by a project flyer, a DETI-UA flyer, and a Summer Academy flyer, since the students could find on this summer courses an opportunity of carrying out practical activities on engineering, everything package in a DETI-UA case. To the teachers is offered the same material, the UA magazine, a pencil and a bookmark.
The project was disseminated through the internet, via facebook and UA Online Journal.

3. Feedback

The feedback is truly good. Both the students and the professors got interested in this and other similar initiatives, since it helps the students to get an insight into what is this concept of engineering, as disclosed as yet so poorly explained, and also into what is being done now at the laboratories.

We realize that the students got committed with this project, since they actively participate and ask interesting questions regarding their possible future careers in engineering. In spite of our main example be the telecommunications engineering, since it's the field which we feel more comfortable with, we should stress that the engineering in general is discussed.

4. Conclusions

The *Atreve-te!* gave the opportunity to more than one thousand and hundred of young students get insight into the engineers' world by actively discussing several aspects regarding this challenging professional activity. Practical aspects are also explored and discussed and the feedback obtained is encouraging since both the students and professors got committed with this initiative.

5. Acknowledgements

The team would like to acknowledge the Instituto de Telecomunicações and the Dep. of Electronics, Telecommunications and Informatics of the University of Aveiro for their helpfulness, which was fundamental in order to reach the complete success of this project. Also, and specially the team would like to acknowledge the engineer João Pedro Madaleno Pereira for his commitment with this project, giving us his testimonial as engineering professional.

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Scientifc Readings in EIDH

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Abstract. *The application of new methodologies in the teaching of experimental sciences can be a facilitator process of acquiring skills in the interpretation of scientific texts and experimental results, which are referred by teachers as gaps presented by the students. In this communication, we present a project developed with students of various levels of education, which aimed at combining playful reading activities with practical activities that sought to materialize the "story" told in readings.*
By being aware of the limitations of the impact assessment of the project that we implemented, we intend to continue it, exploring, more fully, its real potential.

Keywords. Children, education, school, science activities, reading, hands-on activities, non-formal education.

1. Introduction

The didactic communication, both in science education or in other subjects, is quite complex. The dialogue in the classroom is seductive, allows the active participation of students, but has some problems. What the teacher says is rarely fully understood by the students and what the teacher perceives often leads to the supposition that he was understood, although this could be a mere result of the student's adaptation to situations, thanks to the resources of students and learning habits [1].
The teaching of experimental sciences enjoys of a secure reputation in colleagues, parents, students and society in general, because it presents itself as a place of formation of the scientific spirit. Experimental sciences are very attractive to students. But the way they spontaneously conceive and perform it is far from scientific requirements because, in general, this practice does not allow them to comment on the effect of a variable. It's more a "to see" experiment rather than a "to prove" experiment. The former are a good starting point for the later, if being treated as an object of a didactic work. Thus, the use of experimentation is an important resource for school success. This type of science education activities require flexibility qualities, being more difficult to organize, but more exciting. [1]
As teachers of science, we realize that younger students are quite resilient when it comes to acquisition of lecture and interpretation habits, scientific texts in particular, what is of great importance to a good academic performance in this area. However, they are very curious and receptive to carry out experimental activities, although not often interested in their interpretation.
Our school is part of the Rede de Bibliotecas Escolares (RBE), a national project promoted by the Ministry of Education and Culture, which pretends to develop libraries in public schools at all levels of education, providing users the resources they needed to read, easy access, use and production of information in analog, electronic and digital media.
The project "Newton enjoyed reading" [2], supported by RBE, brings together two conceptions which are not always related:

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- scientific knowledge is crucial to the advancement of civilization;
- the school library ensures conditions to emanate science.

We apply this project in our school to improve the scientific literacy of our students. We encouraged students, of 2nd and 3rd cycles of basic education, to read one book suggested by the project "As Mais Belas Coisas do Mundo" by Valter Hugo Mãe. Then, we organized an activity in which we used extract of rose petals to detect the pH of various solutions.
Encouraged by the success of this initiative we organized a new series of activities for students of 1st cycle, 2nd cycle and 3rd cycle.

2. Methods

Several books in our library were selected; some experimental activities were developed based on the selected books, which had a content that could be interpreted by the students; the activities were conducted in the laboratory, the organic garden and schools of the 1st cycle.

2.1. Books selection / Practical active-ties

1st activity
Book - "O Planeta Limpo do Filipe Pinto", by Filipe Pinto.
Audience - 3rd cycle students.
Goal - understanding the role of earthworms in the fertilizer.
Practical activity - describe the external morphology of the worms with a binocular loupe (Fig.1 and Fig.2); observe the behavior of earthworms in relation to abiotic factors (light and humidity); build a composter with a wooden box, containing soil micro-organisms that serve as food for earthworms and *Eisenia phoetida* (California red worm).

Figure 1. Reading the book "O Planeta Limpo do Filipe Pinto"

Figure 2. Observing the morphology of the earthworms

2nd activity
Book - "Três Histórias do Futuro - Que grande furo", by Luísa Ducla Soares.
Audience - 3rd cycle students.
Goal - understanding the ecological impact of oil and the importance of alternative energy sources.
Practical activities - install solar ovens in biological garden of the school (Fig.3); place

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in oven pizzas and apples and the story during cooking; eat the food while it analyzes the moral of the story (Fig. 4).

Figure 3. Reading the book “Três histórias do futuro”

Figure 4. Cooking the apples in the solar ovens

3rd activity
Book - "A Princesa Inês e o Sapo Lineu", by Lília Cunha (not edited).
Audience - 1st cycle students.
Goal - understanding the importance of amphibians and the impact of Humans in their life cycle.Practical activities - on Valentine's Day, it was explored in a primary school and was complemented with a session of observation of amphibians in order to demonstrate their form of reproduction and copulating rituals (Fig. 5 and Fig.6).

Figure 5. Amphians collected

4th activity
Book - "Ao lado dos bichos-da-seda", by Maria Alberta Menéres.
Audience - 2nd and 3rd cycle students.
Goal - studied the life cycle of the silkworm (*Bombyx mori*)
Practical activities - collect silkworm eggs; expect their development and feed the larvae (with mulberry’s leaves - *Morus alba*); observe the development and hatching of cocoons of butterflies; take a reading of the poem from the book; observe the different stages of development of being with the binocular loupe; discuss the different aspects of their development.
For the realization of this activity the Câmara Municipal de Braga offered the school a specimen of mulberry (*Morus alba*) and silkworm eggs (*Bombyx mori*).
The activity was also explored with the children of the 1st cycle who visited EIDH while they observed pictures and real

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images of the metamorphosis undergone by *Bombyx mori.*

Figure 6. Demonstration of amphibian's life cycle

3. Analysis

The feedback obtained during the evaluation of the activities, obtained through the application of surveys, allowed us to conclude that students understand the importance of earthworms in soil enrichment by compound without requiring a prolonged development about the theme of composting, which would make the activity more uninteresting, causing some dispersion of attention regarding the purpose of the activity; the importance of alternative energy sources to fossil fuels, its value in terms of the economy and also the role of politicians in the development of environmental awareness; analyzed the role of the silkworm in obtaining silk, understanding the stages of their life cycle and realizing how a biological resource can be produced.

4. Final considerations

Thus we think we have achieved, by reading and interpreting the stories, a significant development of students' interpretation of data and results skills. We hope that these students reveal these skills in the future and that these confer them a greater ability in solving problems related to everyday life.
To understand the real impact this project has on improving the scientific literacy and culture of the students, we intend to continue to develop these activities, by enhancing the methodology for realizing that we print changes in students as a direct result of the project.

5. Acknowledgements

We thank our school library for the receptivity and interest demonstrated in the implementation of this project, to the Câmara Municipal de Braga, Museum of D. Diogo de Sousa and Quercus Environmental Association, for providing resources for the implementation of some activities. Our colleagues Ana Fangueiro, José Alberto Pereira, Luís Silva, Madalena Mourão and, especially, to Rui Leite, who did one excellent presentation of the book "Ao lado dos Bichos da Seda".

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Hands-on Science
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An Exploring in-Service Teachers' Professional Development Activities for Enhancing Students' Scientific Thinking

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Abstract. *This study aims to investigate the junior high and elementary school in-service teachers engaged in the design of hand-on science learning activities and to enhance students' scientific thinking and learning attitudes. 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. There were 30 teachers participated in the workshop. The hands-on science learning activities were not only for fun but emphasizes to promote the students' scientific thinking ability. Then teachers finished the preparation of material and provided for a total about 1,200 students from junior high and elementary school participated in this activity. With the simple random sampling, there were 136 students (junior high: 87, elementary:49) filled out the "hands-on science" learning survey questionnaire. The research discussion include: there were 10 set learning units produced by the cooperative teacher, the study generalized the design criteria for hand-on science activities form the workshop instructor's sharing experiences and in-service teachers' viewpoint. The results of analysis show that the hand-on science learning activity can enhance students' learning effectiveness in scientific thinking and attitudes.*

Keywords. In-service teacher, science fair, scientific attitudes, scientific thinking.

1. Introduction

From the viewpoint of informal science curriculum, science fair is an effective method to enhance the scientific literacy. Have developed motivate students to think about learning unit for in-service teacher education in non-scientific, such ability is very important. Science fair activities not only learn science, knowledge, but the scientific way of thinking and attitudes to help students in the future to deal with complex social problems.

For the importance of models and modeling in science education, scholars [1] have pointed out: the hands-on science should provide opportunities for students to create, express and test their models. Moreover, in the process of science inquiry, when students conduct the predicting phase of experiments, if they did not think, the experimental work is often only a trial and error, and do not know what variables are feasible.

1.1. Motivation

Education authorities advocate for students with portable competency, is an important goal of education nowadays. A science fair sponsored by the Department of Education activities in Pingtung County, Taiwan. It

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requires in-service teachers' assistance and participation. The teachers have the ability of design for carrying out an inquiry-based science game is very important. In order to improve the quality of teachers' questions, and to explore the contents of the teacher's questions, the way in order to promote students' thinking, which also showed the importance of scientific thinking.
Many teachers in the Science fair targeted at simple game, the dialogue almost nothing to do with education-related meaning. If the teacher does not mention any problems to the students to think, just a simple play, a departure from the purpose of education. As long as teachers can be a little hard to design the questions, the students can be guided by the teacher's questions, and promote scientific thinking, and even solve the problem.
The hands-on science learning activities were not only for fun but emphasizes to promote the students' scientific thinking ability.

1.2. Research purposes

This study aims to investigate the junior high and elementary school in-service teachers engaged in the design of hand-on science learning activities and to enhance students' scientific thinking and learning attitudes. The research question including:

- To understand teachers' opinion on what rules we should have about the activities suit hands on science?
- Which are to promote student thinking the teachers' questioning approaches?
- What are the results of analysis of students' scientific thinking?

2. Overview of science fair and scientific thinking

In junior high school and elementary school classroom, the formal science curriculum is limited to course content and progress of choreography. Since most unified and natural science courses follow a fixed order, emphasizing the acquisition of scientific knowledge, only a few opportunities to let students learn integration issues, carefully thinking to solve problems. Students at the science fair through the informal curriculum activities can be carried out scientific thinking exercises.

2.1. Science fair and inquiry

If science teaching wants to achieve the maximum effect, the teaching of science must be careful planning. Looking for teaching methods, teaching strategies, as well as the opportunity to import the proper teaching to help students improve their learning. In the choice of teaching subject, it should be emphasized that the life as the core, to guide students to conduct the scientific inquiry and problem solving.
In the classroom formal science teaching and the Science fair is usually different purposes. Science fair can activate students' interests, and then achieve the science concept learning goal. The hands-on science learning activities were not only for fun but emphasizes to promote the students' scientific thinking ability.

Inquiry teaching has five common stages:

- To enable students to contact problems, events and phenomena, in order to cause conflicts;

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- To through the process of forming a hypothesis and test hypotheses, and to investigate the proposed interpretation reasonableness;
- Analysis and interpretation of experimental data, a comprehensive idea of the parts, build the model;
- To apply their knowledge to the new situation;
- To Review and evaluate what and how they learn acquisition.

2.2. Scientific thinking

Comprehensive analysis of the literature from the perspective of the scientific process: the ability to advocate scientific inquiry is a collection of science process skills as well as from the use of scientific inquiry into scientific thinking strategies: ability to advocate scientific inquiry is a scientific thinking skill. Cognitive psychologists Kuhn (2005) considered an important goal of education is to promote students' thinking. Science education should not be visible purely cognitive science knowledge, but should focus more on exploring methods and processes, particularly in the thinking process during the inquiry.

2.3. Questionings strategies

Teachers may be questioning techniques to guide the inquiry. During the inquiry, the teacher using the open question dialogue with the students, which will help students to think, including inference, creativity, critical, causality, more variable, forecasts, formulating hypotheses, designing ... open question.

The rule of question of science fair:

- The meanings of question.
  - To have interest on problems and have motivations to keep doing study.
  - Problems are related to daily lives and culture.
  - We cannot do harm to lives and environment on the process of resolving problem
- The range of problems.
  - The range of questions cannot be too wide or too narrow. (we can finish it in time)Suggestion: make a little question and make the range of question widely.
  - The answer of the question cannot be too simple.
- The value of question.
  - Students can use the science conceptions they have learned on the process of exploration.
  - The answer can apply on different situation.
  - The exploration can bring a better science model or theory.
- The Feasibility of problems.
  - We can make a hypothesis which can be tested according to problems.
  - Problems can be answer by science research.
  - The materials and resource must be acquirable.

3. Research method

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.

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3.1. Sampling

There were 30 teachers participated in the workshop. Then teachers finished the preparation of material and provided for a total about 1,200 students from junior high and elementary school participated in this activity. With the simple random sampling, there were 136 students (junior high: 87, elementary: 49) filled out the "hands-on science" learning survey questionnaire.
An instructor of in-service teachers' professional development activity who is an Elementary School science teacher and has taught more than 30 years. By the way, he has a doctorate in science education and has published two papers on journal about models and modeling.

3.2. Design of Activity

In order to enhance students' scientific thinking, the study held a design science inquiry activities in-service teacher professional development seminar and a science fair for 1200 student.

3.2.1. Activity of professional development

In the in-service teacher professional development seminar, the instructor prepares some demonstration about inquiry material. A week later, each group needs to pay out the design documents for review by three experts to check the content.
Based on previous experience of in-service teachers design science fair activities to integrate the seminar as fallowing [2]:

- professional development learning time 3 hours
- design the inquiry units developed one week
- material prepared 1 week

Figure 1. Activity of professional development

3.2.1. Activity of science fair

Figure 2. Science fair activity

One day science fair activities, students from the county can hold checkpoints cards, explore each station. There were 10 units, including the type of mathematics, physics and chemistry activities for students to explore.

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4. Research result and discussion

Based on the goal of enhancing students' scientific thinking, first of all, we hold a teacher professional development workshop, followed by promoting the science fair activities, after analysis, the results were as follows:

4.1. Rule of Development of learning units

To understand teachers' opinion on "What rules we should have about the activities suit hands on science?”
The research discussion include: there were 10 set learning units produced by the cooperative teacher.

- The rule of chosen of Subject.
  - Students' interest on doing science research can be stimulated by Subjects.
  - We can train high school and elementary school students have creavity and ability of doing research.
  - Students can be facilitated to find some problems on daily lives or phenomena of society by Subjects.
  - Subjects must be on the basis of students' interest.
- The rules of operating
  - Students have to do the things have practicality.
  - Students have to make funny things.
  - The design of operation must be on basis of students' ability.

- Put the emphasis on the standard of thinking
  - It can let students think individually and find answers.
  - It suffer students enough information to make them find the answers by thinking or inference.
  - Students can observe the same and the difference of phenomena easily.
  - It can facilitate students to think deeply.

4.2. Good questions strategies

Figure 3. Promote student thinking the teachers’ questioning

Which are to promote student thinking the teachers’ questioning approaches? Good question can trigger students' thinking, but how to guide students to think about it? Scientific phenomenon of friction, the following is an example. Teachers make a big cue cards, display problems above, ask students to think:

- That straw stuck on different angles, whether affecting crabs climb?
- Take different materials string, whether affecting crabs climb?

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4.3. Analysis of students' scientific thinking

Based on hands-on science scientific inquiry and scientific thinking activities relatively questionnaire, the junior high school data statistical analysis as shown in Table 1, including mean, standard deviation. The table also shown the t-test to compare students' exploration activities with before and after the concept of scientific inquiry had significant differences. On the table the BI: Before activity students' concept of Inquiry; AI: After activity students' concept of Inquiry; BT: Before activity students' scientific Thinking; AT: After activity students' scientific Thinking.

	m	SD	d	t	Sig.
BI	45.38	6.963	86	46.083	***
AI	48.52	7.149	86	47.989	***
BT	45.92	6.533	86	49.698	***
AT	48.74	6.336	86	54.387	***

*** p<.001

Table 1. Summery of t test of BI & AI in junior high school

	m	SD	d	t	Sig.
BI	45.38	6.963	48	46.083	***
AI	48.52	7.149	48	47.989	***
BT	45.92	6.533	48	49.698	***
AT	48.74	6.336	48	54.387	***

*** p<.001

Table 2. Summery of t test of BI, AI, BT and AT in primary school

The primary school data statistical analysis as shown in Table 2. The table was shown the t-test to compare students' inquiry activities with before and after, the concept of scientific inquiry had significant differences.

4.4. Research discussion

Learning science is learning: how scientists think and explore problems, which scientific concepts are in the process of thinking has been to construct. In other words, scientific formulas and Laws, however is the result of thinking. When we learn, to understand the whole process of thinking, the formula and the Laws can help us sum up the final results. However, if without thinking, scientific concept is not really being constructed in the mind.
The study generalized the design criteria for hand-on science activities form the workshop instructor's sharing experiences and in-service teachers' viewpoint.

5. Conclusions and recommendations

This study aims to explore the in-service teachers' professional development activities for enhancing students' scientific thinking. According to the above findings, conclusions and recommendations are as follows:

5.1. Conclusions

The results of analysis show that the hand-on science learning activity can enhance students' learning effectiveness in scientific ability of inquiry and thinking scientific thinking. Choose a good science fair topic, effective in attracting the attention of

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students, and skillful questioning strategies that can guide students to scientific thinking. When held science fair, except for fun and playful design, teachers should focus on enhancing students' scientific thinking. Teachers in the use of questioning techniques, so that students have the opportunity to think, they can further understand the operation of the mechanism behind natural phenomena.

5.2. Recommendations

Recommended in primary and junior high schools through the instructor, organize in-service teacher professional development workshops, promoting hands-on science activities.

6. Acknowledgements

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O Continhas. Mathematical Activities for Children from 5 to 10 Years Old

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Abstract. *We present an extra-curricular mathematical project for children in the first years of school.*

Keywords. Cognitive stimulation, contextual learning, creativity, mathematics.

1. Introduction

Thinking and creating are exclusively human actions and the development of thought and logical reasoning is essential to our life and integration into society. Mathematics develops those mental abilities and these are essential to the development of Science.
Several studies about the brain nature, how it works and its development emphasize the importance of starting very early to do activities that include learning languages, learn music and the development of logical abstract thinking, ([3] and other references in [2]).
We are convinced that, in pre-school and first years of school, it is necessary to stimulate logical abstract thinking using mathematical algorithms and concepts through play – one of the highest achievements of the human species and related with intellectual achievement and emotional well-being [4].
On the other hand, in the first years of school, children have not yet learned to dislike math, so learning and motivating them should be done as soon as possible.

2. "O Continhas"

With the purpose of motivating children for mathematics and develop mathematical abilities, Adelaide Carreira from Lisbon University, M. Teresa Malheiro and Estelita Vaz from University of Minho created an extracurricular project for children aged between 5 and 10 years, "O Continhas ". This project has the aim to change attitudes, prejudices and increase motivation for learning mathematics, motivating for mathematical thinking using procedures directed towards the acquisition of conceptual and formal mathematical knowledge, as well as the awakening of oral communication, abstract thinking and calculation skills [2]. Outside formal classes, children can work and play with activities which present mathematical concepts in a different and day life environment.
"O Continhas" consists of a set of activities – learning objects - that children do in extracurricular environment. The learning objects are mathematical activities, set in different themes, Numbers and Operations, Geometry, Discrete Mathematics (Logic, Combinatory), Mathematical History, Classification and Organization of Data and Games.
In the beginning of its implementation, the project was influenced by the Singapura Mathematics teaching methods, but along the years has built its own content and methodology.

2.1. The learning objects

The activities guide the participants to

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construct by themselves, ideas, concepts and mathematical methods, trying to encourage them to create logical and abstract thinking, and, in parallel, interest them and bring them to a discipline that so often causes resistance and rejection.
Each activity consists of twofold: one worksheet to the children, with the procedures and another to the teacher, identifying objectives, materials and suggesting a methodology for guiding the activity.
The learning objects may be comprised of just one activity worked in one hour session or several activities worked in several sessions.
The structure of the activities is very important to the learning process and to the development of capacities and mathematical abilities and at the same time capture the child's interest. The activities are contextualized with stories, games, exploratory activities, manual works. This is important as we consider play as a valuable way of learning and development. Hence the majority of the activities have three important parts:

1- They start with a story, allowing the child to make a mental representation of the character as it unfolds throughout the story and its environments. This allows the creation of images and ideas representation and, most important, the development of creativity.
2- In the context of the story there is a problem or a challenge that the child must solve.
3- The child is asked to build a similar activity, a new situation with the same problem. This part enables the child to develop its creativity and to look to the problem in a different context – this is a fundamental part of the activity.

Activities such as finding out what is wrong in a picture, discover the differences or similarities, connecting related figures develop attention, sense of observation and interpretation of images and help the child to know or recognize numbers and letters. In some activities the child learns to select the given information and organize it. In others activities, the child uses the same geometric shapes to build different stories, developing the ability to use the same elements in different applications - a first step toward abstraction, start looking these elements off the context where they are applied, and recognize their own identity.
Many activities are games that have analogies with mathematical problem solving: it is necessary to understand the rules and complying with them, find strategies to win the game or to solve the problem.

2.1.1. An Example

Let us see an example of a learning object for 5 years old children. The teacher tells a story and shows an object using plane geometric figures.
Then, the teacher asks them to identify each geometric figure, count and draw them using different colors, under given instructions (or gives them the figures already drawn, depending on the children abilities). After this, the figures are cut out.
The teacher tells now a different story and introduces a new object using the same geometric figures.

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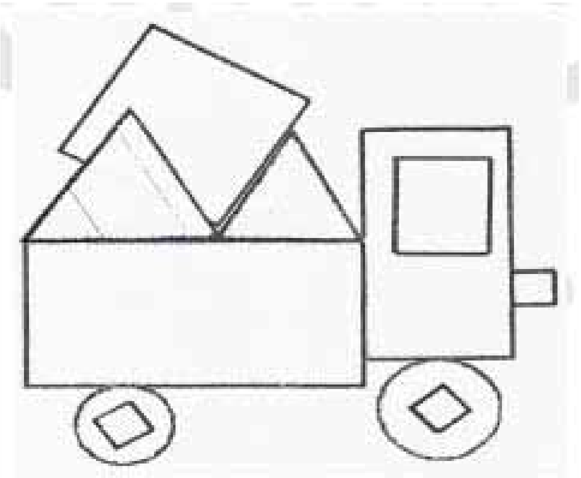

Figure 1. An example of an object made with plane geometric figures

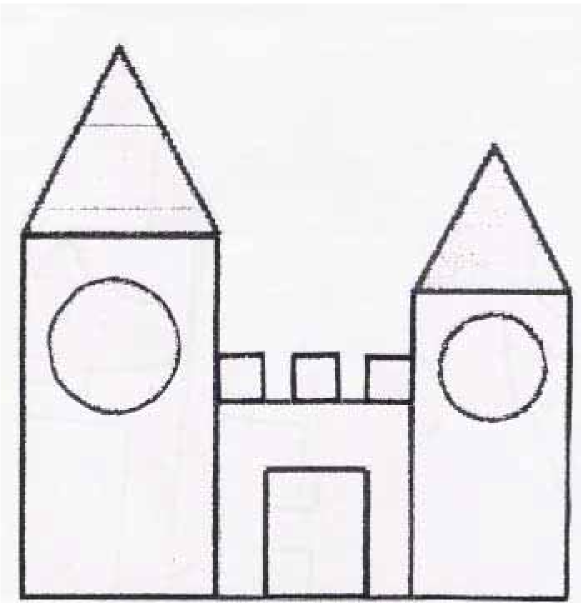

Figure 2. Other object with the same plane geometric figures

The children must built this new object using the geometric figures.
After this, the children are asked to create and build a third different object with the same geometric figures and to create a story with this new object.

2.2. The teacher role

The role of the teacher is very important to achieve the goals of the project. The teacher must give the initial instructions and be present along the session, identifying difficulties and guiding the children, if necessary. Also he should ask the child to present his reasoning or justify his answer; to create similar situations and formalize them. It is important that the teacher does not give an answer to the problem. He should help the child to construct his answer. These features distinguish "O Continhas" of an ordinary collection of mathematical activities.
Hence, a regular monitoring of the teachers work is important with action trainings, where they can solve difficulties and insecurities about their mathematical knowledge, guiding them in some procedures and receiving from them feedback about the work done with children.
This project was implemented in some schools, public and private preschools of Braga, Guimarães and Lisbon with an initial monitoring. But "O Continhas " is promoted independently as an intervention project and partnership between the School of Sciences of University of Minho and schools that receive it.

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About Science Fairs: Revisiting Alan Ward

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Abstract. *Twenty years ago, ten years of experience and some movies watched were meet to an Alan Ward article, "Planning, organizing and staging a school science fair", … and a new life begin for my students and for me and several mates in our school.*
Twenty years after, each with (almost) one science fair celebrated, and with experiences in other events-like, several papers and conferences, a wiki about science fairs and after have helped to begin other science fairs-like events, it's time to remember the Alan's article and comment it from my experience, to try of make an improvement of their function as guide to begin and to do a Science fair.
Development will show comments about the article but also new questions (and answers) related to science fairs in our schools today.

Keywords. Science Fairs, guide, didactics.

1. Introduction

After a wide relation with events like Science Fairs (SF), I still find it exciting. And, too, I completely agree with the Rocard Report [1] views and I wish I would be able to help to that change of approach when states: "While most of the science education community agrees on the fact that pedagogical practices based on inquiry-based methods are more effective, the reality of classroom practice is that in most European countries, actual science teaching does not follow this approach."
After helping to organize a first SF, made it possible thanks to the Alan Ward's article "Planning, organizing and staging a school science fair" [2], I felt the need to tell about. And years ago, I began to write a wiki on Science Fairs through Galicia [3]. One of the first pages in that wiki (writing first in Galician language) was about Alan Ward's (AW) advices what I profited [4], an interpretation that summarized the most important tips, ideas, clues (sometimes, extended) I'd taken from the article "Planning, organizing and staging a school science fair". I made just a summary, not a discussion, though I did not completely agree with it. To specify this idea, I only leaved written in this page that the SF referred in that article may be enough restrictive or illustrative in its development, level or goals. This summary will be my reference here, what I will use to guide this new review.

1.1. A short biographical note and an effect

Even in a short work as this, it is convenient as foundation to understand and to analyze a core of the ideas of AW. Because of this, I leave some short references, published in the same year and the same review that "Planning...": [5], [6], [7], [8], [9], a reference to a book [10] (among several that AW wrote).
And a short biographical note: born in 1947, the article analyzed was published with 47 years and for this, a long experience that could serve to build other events like SF. We can read as biographic note in an article by

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AW published in 1988 [11]: “Now freelancing as a consultant on elementary science education, Alan Ward was senior lecturer in science education at the College of Saint Paul and Saint Mary, Cheltenham, England. He is a frequent contributor to Science Activities.”
So, after this little amount of data on his biography, for instance, we must interpret his “Planning...” in clue of SF for children more than for students of secondary or university levels. Naturally, leaving clear that SFs are not reduced to these levels.

1.2. This (and 'the other') article

A last note to introduce the reader: The article “Planning...” in the School Science Review occupied 7 pages, but only about two are generalistic ones, while near five are samples of typical SF projects. The analysis below is about the first part of the article, the organizational one. I will use the second part only to make a final reflection. I do not reproduce it, but it is easily available in internet.

2. A double note about what a Science fair is

In his article, AW, first thing that reflects is a warning: the ideas and suggestions are based in the own author's experience.
So, it’s clear that other person, from other experience, or from different students, could have different seeing, too. Most: the validity of suggestions is reduced to a precise experience an idea about that a SF is.
Because of that, next paragraph written for AW define that a SF is (for he!), in what have relation to the article: “an activity introduced by students in the school, where other pupils and adults come to see, learn and comment a spectrum of expositions and activities about science and technology. The main aims of a SF should be “to put over the ideas that science can be fun and full of wonder, and an exciting way to find interest and meaning in all the various happenings of life.”
The definition, for me, is inclusive, but not exclusive. It centers the focus in the communication, forgetting for instance other aspects need to prepare that could be exposed. Anyway, the definition permit analyze a wide range of activities, and was the one that I used in my wiki, what has permitted me hosting several manifestations like SFs, although they differed in my main idea about, more restrictive and with different orientation.
Some additional restriction came of the aim that suggests some as that 'fair' implies 'smile', and smile implies interest in science. After years, it seems me that if an experience produces a smile has a better impact, but the need is the interest, not the smile. And some smile can be negative to scientific consideration of a project of a student, and for the student that projects.

3. Presentations, exhibitions... differ-rences through age, level, ...

After a general seeing, the article centers what could do a single exhibition. And that claim for a question about what include the words presentation or exhibition. Are only included exhibitions or shows, or also results of research or constructions of models? I think that we need displace, through the different ages of the students, the focus from simple exhibitions to research, something that AW leaves unclear because his implicit

focus on children: to little children, research could be to prepare a exhibition, but when the student grow, he need to deepen and make his own little contributions, to have a wide understanding that science is and of his possible contribute.
And what explain AW that could do an exhibition? Several things are possible:

- show of information (sample: how an ant is born?)
- a model showing a technical or scientific idea (sample: how a rocket works?)
- an experience (sample: Does the skin of an apple protect the fruit?)

… More grateful things are the preferred to the first editions of an event in a school, but like 'not only of bread lives the man', trend I think that must be towards research, not only experience, but finding new results on simple things. Amusement, as explicated by AW, is conveyable to improve the experience and link the visitor to science, but isn't enough up to a limit of age: a sample presented in the article, a bottle that pours water on your face, could produce a wide smile as curiosity, one step more, result interesting accompanied of a explanation on his behavior, but definitively is improved in performance if some variation is tried, analyzed, measured, … These different possibilities are too marks to identify different phases of development of a school SF and of the students in science.
Each exhibition must offer to the visitor something interesting to do, like to handle the models, to fill a test or to enjoy an amusement, say AW. And I agree that trend must be that. But difficulties are bigger when we afford more research work. In this situation, I would change the 'to do' for 'to capture the interest of the brain of the visitor', assuming that once interest is captured, the cerebral circuits will be move with the ideas in a similar way to a handle practice with stuff, facilitating the integral interest of people.

4. Suggested issues

AW put several examples of suggested issues as titles. This implies one question: should the teachers suggest, give the title, leave free way... to the matters of the projects?
My experience say me that one of the learning that the students do in a SF or any comprehensive learning is to have own ideas about what study. In fact, in Spain, at the begin of middle school (about 12 years old), students have lost their open minded views, and they need to reconstruct, to be learn, a free mind to research a project. A project for a SF represents at this level, a challenge from the first moment, the election of an issue.
And, from a thing to another, answer that teacher give to these options results one or another kind of SF: the imposition of a title or issue should implies (for the teacher) a detailed guidance (and orders!), while the 'do it yourself' to the issue will implies more a supervision or soft mentoring that a total implication of the teacher in the making of the project.
So, it is need to return to the definition of what a SF is. For you and therefore, for your students.

5. Weaving connections to real life

Connection with real life isn't a possibility: is

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a necessity that AW recognizes.
In the economical aspects, low cost of the projects and of the whole SF (more in a crisis position) is desirable, recycling than possible as a first step. Other steps can begin to use simple materials (generally, easier to find and also cheaper and enhancing the imagination of students and feasibility of the projects.
Related to understanding, communication or fun, it needs an effort to facilitate all that: make easy seeing displays or easier shows, hardy panels and models engaging sets, …
No more to add to Alan's words, if not to explain more intensively some part: simpler is more beautiful! (and powerful!)

6. A plan should consider...

AW presents a list of points to check before end the planning:
First (and before the list), he points that is needed the help of adults/tutors/parents …
To have helped could be need, but even before that need, help is convenient to build a project (the way on what we must interpret 'help' here). 'Need' assumes that without help the students couldn't go. I'm not agreeing in need -it could be to students of primary education-, but results without help are very much poorer not only in presentation, but too in improvement of learning. Participation of parents is a measure of their educational commitment, and links with his educational participation out of the SF project. And help could be also a form of to teach for imitation or by linking the students with aims nearer to their possibilities (thus exploiting the 'zone of proximal development', ZPD [12]).
The quoted list itself begins with the recommendation of to choose titles for the projects. 'Practical' is a magic word that AW use, and I'm agree, but 'practical' is also a word that includes all possibilities on engage, lovely or … put here that you wish! Thereby, a precision: here, 'practical' should be minded as good to understand, and good to advice, to engage, to suggest, ... too.
Second, he says that is to choose if students will work alone or in a group. For me, this is a mistake: teachers can influence considering student to student one or another option, but impose to go alone as the only way implies and impose a lack of collaborative work, individualism and closed intellectual space. And too, impose a workgroup could derive in inconvenient groups, unbalanced and so on.
Third, to ensure a variety of projects is need to present a fair and not a close space without interest. Do you remember the old fairs in your village? Could you imagine in a fair only a product as protagonist? (A note: I nor refer to the new fairs to exalt a product)
Fourth, trend to have handily resources. Is that, try for it. But impose that and... results would be a SF on reproduction of experiments and models, etc. Newly, differences based on age must be possible
Fifth thing that AW proposes is to realize a little timetable to the SF. So, dispose to have a time to put up and take down displays. Or (and this was not the idea of this point of AW), to mounting the exposition and leaving the space free, what represents a lot of time, although could seemed a short lapse need. Time should be disposed to the cleaning of space, too, as I could note in my last 'first edition' of a SF in a school this June.
Sixth. Today, social networks are developed in the internet and should be employed, but other faces of internet (as blogs), the net versions of traditional media (newspapers,

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radios, TV) and wallpapers and leaflets are a basis of the success of the SF face to the mental image of the students. And too, to the impact that the activity could cause in our students, in their social environment or in the number of visitors and their influence.
Related with the publicity, participation of students to realize a logo and to choose a slogan is welcome: it is not only publicity, but enhancement to our students!
Seventh point is 'practicing what children will say to the visitors'. Yes, it’s true. It´s needed. But the students should be aware of their property of the fair. So, practice should not repeat typical schemas of a recitation of something memorized and imposed by a teacher, as is easy to note in the preparation of many SFs.
Eight. Getting together raw materials, books and apparatus. Of course, teachers' job implies that: to guide. From counseling to approving, the practical realization can vary with the level and age of the students or the focus of the SF in the amazing science or in research. But a project to a SF not is something that is born, grows and dies freely, neither something encapsulated that students must take.
Nineth. Raising money. Well, to have money isn't a bad idea... but I think that most important that money itself is to answer two questions:
-What counterparts will have each contribution?
-It´s possible attach contribution and visibility, or public enhancement or more didactical performance?
Literally yesterday (June 5, 2014), in a new SF (1st edition of SF in a public school) I have two informal talks about. First, pointed that this new fair has not sponsors, I (and visitors, almost, no one talk about!) don't have noted differences because that. Second, talking about other SF, what a passed edition had a lot of money extra (about 10 000 € several years ago), all people coincided that the didactical profit was small: simply, people was not prepared!
Tenth. Finding the best place to hold the fair. School or community hall? This is a decision to consider quietly. Space in the school could be scarce or poor to have a SF. And search for space out the school need an infrastructure and organizational disturbance that could affect negatively to fair. I could tell that related questions are linked to a low-profile result in the SF of my school last two years. But we could not generalize to one solution, because the wide range of possibilities and problems associated.
Out of numeration, points AW that 'Almost six months before', an 'enthusiastic person must be encouraged to assume the role of Event Leader'. I think that for a first edition, someone like an event leader is who puts the idea and encourage the other to go. So, it will exist a 'natural event leader'. Addressing to the future, a SF could make a distribution of roles if possible: it is possible that the first 'natural event leader' could leader successive editions because it's not capable to build a team to distribute tasks, but the best is option that school could structure a team with different roles: this facilitate work, improve results, enhance a good relationship in the school, permits a continuity in knowhow,...
Other things that AW touches quickly in this paragraph of the article are:
-The tasks of this event leader (after I said, I think, best title is 'coordinator'): the coordination (for me, the main subject of this person), to help teachers not specialists (generally, he/she would be very limited to

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help to teachers in other subjects), to help new collaborator in the SF team, to try that teachers organizing their students...
-Also, he/she will trace a timeline ('the' timeline, that we have mentioned before, in 5th point that AW states). I think that could cooperate, but main timeline (not for each project, that depends on each tutor, although depends of the main timeline) must be agreed among school header, coordinator and team of teachers. Day-to-day reality in each could strong vary this initial plan.
-Timeline must reveal time to develop projects, and also if time for projects will be subtracted of class sessions, etc. In this point, I think that solution could be different to different teachers, levels and/or groups. Could be difficult of organize in only a SF? Yes, but only if the school hasn't flexibility to leave teachers have their own methods. And, if they have only a way, they don't have this problem!
-It is important to have parental support. Of course! The parental participation must be centered: for the projects, helping students, but not substituting they could have a big effects of collaborative work and precedent of the parents. For main organization, helping teachers but not substituting they could create a good climate to improve educational results.
And, a thing more on parental help: please, watch over that this help do not cause differences in valorization of work of students! (Differences of educational impact are unavoidable and profitable)

7. Organizing and mounting

After being encouraged and helped to choose a topic, students must choose a clear and simple title. After, they need to make observations, to carry out fair test, seek information and clues in books, contact people for personal opinions and advices,... All ok. Today, the fountains of information vary to the internet, but foundations are the same. Maybe could be established some ad:

- choosing of topics could be limited by different factors, included the orientation that will drive the project (from teacher's point of view, student background and possibilities, ...)
- likes of students frequently do not agree with likes of teachers: 'help' is not only help, but advice.
- search on the internet need more contrast that search through books, because persistence of mistakes and visibility in the net of minority opinions.
- science is equal, topics to a SF could be similar, but contact relevant people to an experience are very different in a student of a family of an engineer in Silicon Valley of that a farmer in Thailand...

AW stand out those details of these investigations “will be concisely written to final presentation with the exhibits”. I consider that must be written, but not exactly for a final presentation (they need a space in the presentation, but must be to main relevant data and process). After SF, the students must do a report on their researches, for them (to enhance and organize their ideas) and for teachers, to evaluate the work, to bring their advices over all the process, to can improve next projects, etc. This report is too a remembering that projects through time the improvement of learning. I reserve the detail to this final

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report.
AW advice aim for displays that are explicit, yet uncomplicated. Art or science? Leave students go, after counseling a minimum size of letters and a maximum of wide of texts, the priority of graphics and pictures over text and having an order in wallpapers. Legibility should be the result: visitors don't read! And, logically, a SF organization needs a lot of walls, tables and/or different types of displays: a mosaic that could transmit science!
Of course, the main actors are the students that presenting projects, and therefore, the main part of the presentation correspond to the explanation of these actors on their own work and results. So, should be not only “opportunities of rehearse brief expositions” (AW says), but compulsory ones, plus prepare answers to the questions that could be posed to they. A good idea could be to show and comment some videos with performances of previous years, as sample to illustrate the students that will build his first SF presentation.

8. Happy reminders, congratulations and awards

AW talks about those participants can receive small certificates.I think that the main recognition must be the feedback received in the expositions about their exhibits, but could be a good idea to give colorful certificates, particularly to the small people (the target of AW).
Too, is very convenient to have sticky badges. Today, this could be improved by cheap t-shirts with the logo of the SF (sponsored by local trades and industries?)

8.1. A fair is a gallery

Before paragraphs are minded to students. But a SF has an independent life to consider. So, visitors must have a catalogue of exhibits and exhibitors (today, a webpage with info, too). Named the exhibitors and not only the exhibits enhance the work of students and themselves. The design could be realized by one or several students with artistic talents. AW not distinguish among list of projects (back) and front face in a catalog, but the front could be widening presented in wallpaper, too, and list could be diffused by local newspapers. Diffusion, as we have seen, is a basic part or organization.
All this needs money. To help raising funds, “perhaps there will be a charge for admission”, AW says. We have experienced some year with a little charge, but most of years were free entrance. Problems of regulation of functioning in public institutions could interfere and condition the charge.
But not only must consider legal dispositions. What in favor of charges of admission? Maybe a better consideration of the visitors, valorized the SF by the payment?. Against? A mercantilist vision of science? Or the possible decrease of the number of visitors? These are some points to consider.

8.2. Criteria for awarding points

To have awards and distinctions, AW recommends the appointment of a committee to judge the exhibitions, and some basis to judge: enthusiasm showed attractive presentation, easy understanding of the project, cheap materials or how much thought went in the project.
I should admit that I like awards, but in the

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practice, results of judges could enhance a relatively bad project with a good presentation, or a subject 'á la mode', and to be a bad influence in a student with hard work in a subject with no fashion that could see that the award is to the project build with much less work and poorer results

But about awards, we must consider an ethical question: we encourage our students to compete or to collaborate? Really, we could/should/must search some intermediate solution?

Prizes in the big SFs, with a lot of the centers and students participating, are common, and this is a sample about as is managed the whole world. Should be just like that in education, too?

9. Others (and reflections)

AW shows typical projects to a SF: the smoker (namely 'Madam Nikk', for nicotine), how to give the 'kiss of live', observations of air pollution, switch craft galore! and shocking fun with an electric bell transformer. The development in the article "Planning..." is high illustrative and used names, too.

I think that, before the development of these samples, AW could have advised some sentence as 'Ideally, students must be encouraged to develop their own ideas as projects'. And this, even more when its last words are (previous to an offer of answer any question) "I have intended the contents of this article to be inspirational and therefore to stimulate individual initiatives'. Without the note about the own ideas of students, the words of AW try of stimulate only teachers, not students. But, for me, in passing of ideas about SF, teachers are only intermediate persons that facilitate things... even knowing that are the leaders to an event-like SF.

All this leave us also with the main idea over SF that I have show below: You consider a SF on research or on fun? Yes, I know that ideally best is both, but...

10. End notes

1. From a short article, I've drawn here some comments. The work of AW about SF has been analyzed. I'm preparing a more extensive work as you can see in the wiki [3]. So, please, consider these words not isolated, but as a part of a more extensive contribution.
2. Please, before work considering these ideas as starting point, you should consider too that the world is changing and different circumstances are possible; so, different way of approximation are recommended. For SF, too. Apply these ideas and comments having in mind your particular situation: thinking by yourself and sharing with your fellows is the best method in science and to realize a SF.

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Audiovisual Animations for Teaching the Theory of Special Relativity Based on the Geometric Formulation of Minkowski

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Abstract. *We present a proposal to make available the contents of the Special Theory of Relativity (STR), explained through video animations. The ability to advance the teaching of the main relativistic phenomena to previous courses (1 high school and even earlier) was the subject of an investigation conducted as a doctoral thesis.*

The inherently visual characteristics of the didactic proposal, based on the geometric formulation of Minkowski, can incorporate all the physical aspects of the STR in spatiotemporal diagrams.

As a result, we propose to participate in the realization of educational animations based on these diagrams to those who may be interested.

A provisional website and a DVD are presented as examples.

Keywords. Animation, Minkowski, relativity, spacetime.

1. Introduction

The theory of Special Relativity (SR) is part of the course content for Physics 2nd baccalaureate (sophomore), being a subject whose teaching is under permanent investigation because of its counterintuitive characteristics as well as its relevance and permanent topicality.

There are two basic approaches to the didactic application of Special Relativity in pre-university courses: one is based on the phenomenological and operational description of SR, according to the way it was originally presented by Albert Einstein, and the other one uses a formal geometric approach based on the tensorial formulation established by Hermann Minkowski. This tensorial (and therefore geometric) formulation of SR was initially rejected by Einstein, but later, as he himself acknowledged, formed the conceptual basis for his development of general relativity.

The didactic proposals based on the first formulation are more or less based on the text of Resnick [9], while a fundamental reference for the second formulation is the text of Taylor & Wheeler [11] and the posterior by Callaghan [1]. Although the latter two are based on the same geometric formulation, the second has much more presence of bi-dimensional spacetime diagrams to justify and present results.

Spacetime diagrams have an intrinsic property that makes clear the possibility of creating animations with them: the fact that one of the coordinates is time, which is an essential component of any graphic animation. Based on this, we performed a series of animations of the diagrams of a didactic proposal for SR in anticipated levels (1st High School and earlier), in which the theory was presented only visually. This does not mean it is less rigorous than any algebraic approaches, since the display is based on the geometric essence of the theory, as we have seen, and geometry does not imply only visualization but also rigor and accuracy, as Euclid very clearly

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established.

2. Audio-visual animation

We present a web site [13] dedicated to the visual presentation of the theory of relativity (TR), with a series of videos in eleven chapters in which the TR is built from the most fundamental concepts of space and time, which are united from the beginning in a new entity : spacetime.
The structure of each chapter is as follows: an introduction video as a presentation, which recapitulates what has been seen in previous chapters, and which also presents the problems that will be addressed, in the form of questions. This is followed by a FLASH animation (with captions in English) lasting several minutes, in which the theory is constructed sequentially in a logical and visual way, based on a geometric interpretation of physical quantities, established almost from the Greek era (Aristotle, Archimedes etc..) and formulated in a novel way as a theatrical performance in a frame or scenario that is none other than the spacetime with its transformation properties. Finally, there is a kind of "recipe", which briefly summarizes what has been seen in the chapter on static graphs that summarize and list the key issues that have been developed.
In all these videos we disregard completely mathematical formulas without losing exactness.

2.1. Chapters

Several animations which are available at a provisional website [12] are presented in the following set of 11 chapters:

1- Physical quantities in spacetime
2- Classical transformation: Galileo
3- Classical Physics
4- Waves in spacetime
5- Discrepancies: GPS, Michelson
6- New transformation: Lorentz
7- New Physics: Relativistic phenomena
8- Time dilation
9- Space contraction
10- Speed limit
11- Equivalence of mass and energy

2.1.1. Physical quantities in spacetime

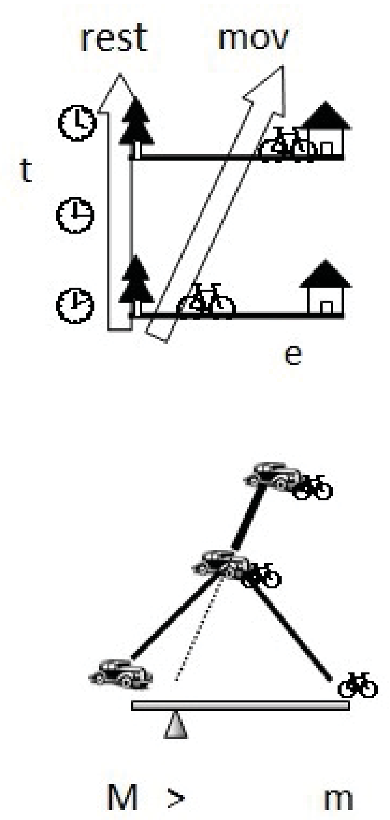

Figure 1. Spacetime: rest, movement and masses

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This set of chapters constitutes a progressive introduction to the main relativistic concepts based on a geometric formulation of essential and intuitive physical quantities like space, time and speed, but also mass and energy (Fig. 1). The series begins accordingly with the presentation of these quantities using ideas that were established since the time of Hellenistic science, in Chapter 1.

2.1.2. Galileo and classical physics

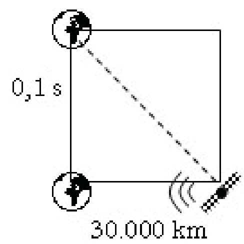
The dispute between geocentrism and heliocentrism is presented visually in the second chapter, followed by the solution provided by Galileo as a spacetime transformation which turns both rest and movement (speed) as relative magnitudes while keeping unchanged the remaining figures, what makes it imposible to detect moving reference system based on "internal" measurements. Classical physics is based on the transformation of Galilean relativity, and Chapter 3 presents a view of it.

2.1.3. Classical waves

In Chapter 4, a new player is introduced in this scenario: the waves and their behavior in the transformation of the reference system, observing that now appears an opportunity for an absolute statement about rest or movement (speed), always under concepts of classical physics.

2.1.4. Experimental conflict: electro-magnetic waves

Having established the essential visual elements necessary to understand the relationship between the transformation of the reference system and the behavior of physical quantities (in particular how we can detect the absolute motion of the reference system from measurements on waves), we present in Chapter 5 the experimental evidence that led to the need to radically change all this interrelated set of transformations: the behavior of electromagnetic waves.



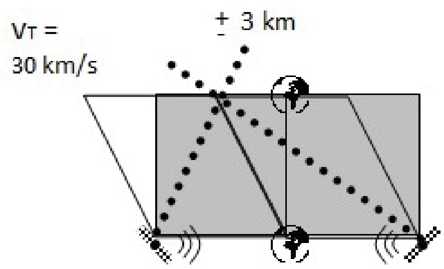


Figure 2. GPS satellite (left) and expected error in position

We present simplified views of two experiences: the one made by Michelson with negative results and the daily operation of the GPS global positioning satellite (Fig. 2), which according to classical relativity should submit an intrinsic error of 3 kilometers inland due to translational movement [5].
Here me make a provocative reflection to the reader: do you think, in view of this

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evidence, that we should abandon the concept of a moving Earth (because placing the Earth, as Aristotle and Ptolemy did, in an absolute “at rest” reference frame would explain both experiences perfectly), or will it be necessary to find a way to reconcile these experimental results with the Earth´s movement by a reformulation of the geometric transformation of spacetime? From this moment (provided that the reader agrees with the second statement), we will enter fully into a new physics, so it's time to stimulate discussion, reflection, attempts to modify the transformation by ourselves, etc.

2.1.5. Accommodation: Lorentz transformation

Chapter 6 is dedicated mainly to deduct, in a purely visual and totally intuitive way, how should be the shape of this new transformation, which is none other than the well-known Lorentz rhombus. (Fig. 3).

2.1.6. Consequences on physical magnitudes

In Chapter 7 we proceed systematically to exploit a fundamental property of geometric diagrams: the fact that any property of the transformation affects in an inescapable and predictable manner its entirety. As an analogy, if we take a photograph and rotate it, all characters will be affected in the same way by this transformation, something that is obvious that it seems trivial. But it is precisely this property of the geometric transformation (which for photographs, with characteristics of Euclidean space, is called "rotation", while for the relativistic spacetime is called "Lorentz transformation, or boost", with properties that are different from the Euclidean rotation but not least stringent) which will allow us to build the main relativistic phenomena as mere consequences of the transformation (Fig. 4).

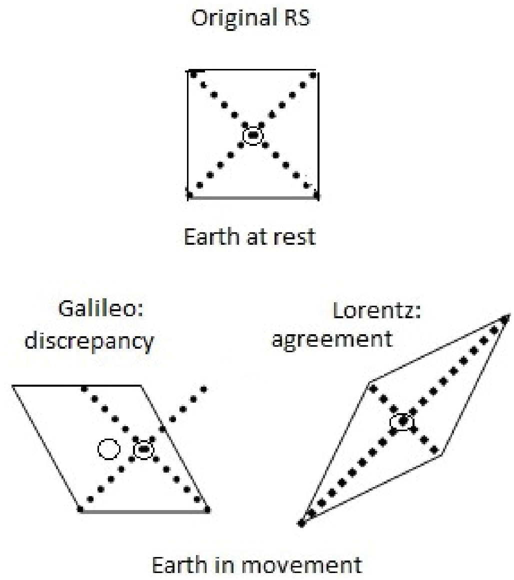

Figure 3. Breaking with Galileo and recomposition: Lorentz

2.1.7. Relativistic physics

The next four chapters are devoted to an exploitation of the implications of the simple phenomena that previously established mainly by geometric reasonning. This possibility, of great interest and educational potential, is based on the correspondence established in Chapter 1 between the physical variables and spacetime, ie, on ideas that date back to the Greek era, which also allows us to incorporate an interesting reflection on the historical evolution of physical ideas and their consequences.

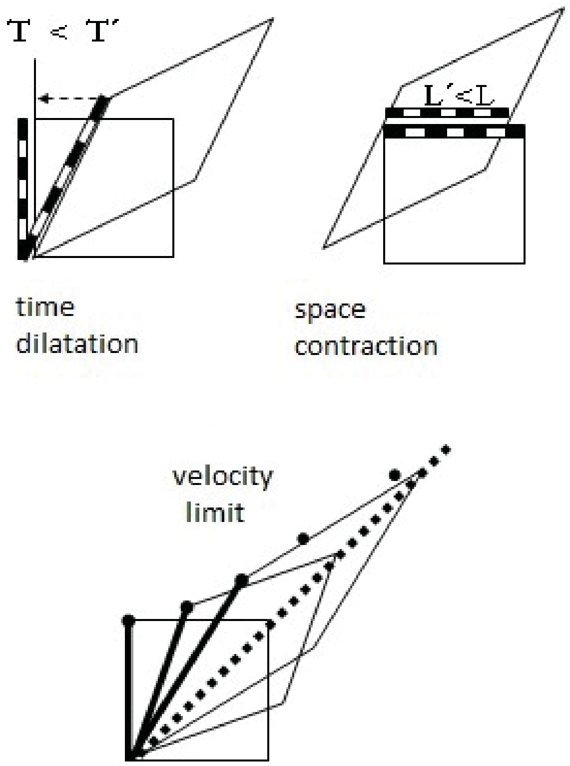

Figure 4. Geometric vision of relativistic phenomena

In Fig. 5 we present the visualization of the mass/energy equivalence for a symmetric collision (upper diagram), which is derived from the fact that both variables are added to make the Lorentz transformation, which can be seen in the shift of the mass center towards the moving mass in the lower diagram, an effect which does not happen at all if we apply the Galilean transformation instead.
It can be demonstrated geometrically that this effect corresponds exactly with Einstein's famous formula $E = mc^2$ (in these figures we use natural units, where c=1, and the previous formula becomes E = m)

3. Project background: visual didactic proposal for the theory of special relativity

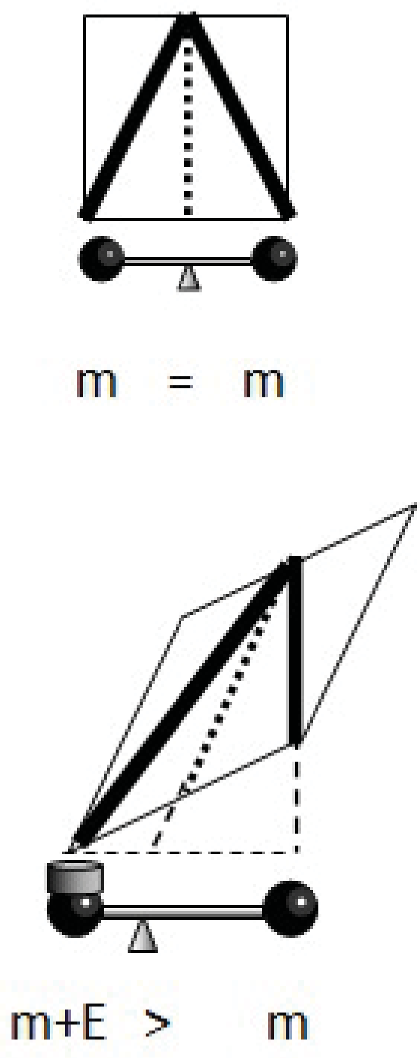

Figure 5. Equivalence between mass and energy in spacetime

The audiovisual materials presented are

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based on a research paper submitted as a doctoral thesis by the first author under the direction of the second [8], in which the subject was a teaching proposal radically visual and geometric for the introduction of SR formulated in courses prior to high school 2nd. Intention of this proposal is to ease further education by creating a visual intuition (which, being geometric, is also rigorous) of relativistic phenomena, allowing further analysis of them without the interference of their counterintuitive aspects.
It is important to highlight a key aspect of this proposal, which is also present in the audiovisual materials derived from it: first, we proceed to construct a classical relativistic intuition, a learning process which is not without difficulties [6] and then we produce a break with this formulation, leading to the introduction of an alternative intuition, this one being fully relativistic. The apparent "didactic spin" on it is not so if we consider that the constructed thoughts are not of an essentialist, logical-deductive kind, but appear directly incorporated geometrically in a backdrop that "drags" them in its own behavior, like visual consequences. Therefore, in this process of "build-breakdown-reconstruction" underlies a permanent visual and geometric conceptual unit.
For the formulation of the proposal we took into account teaching proposals like the one by Mermin [4] and others, in which certain aspects of SR are explored using an essentially visual formulation. Following the presentation of the thesis appeared didactic proposals in line with its ideas, like the one by Takeuchi [10] in which a purely visual introduction of SR is performed. After establishing and justifying the visual theoretical formulation for the teaching of SR, we proceeded to establish an instruct-tional sequence based on constructivist ideas [3]. This teaching sequence was investigated in the classroom with students in 1st High School and 4th ESO, and for its testing and validation we resorted to explicit the students´ conceptual schemes and observe their evolution throughout the phases of instruction [2]. The results [7] allowed to state a high degree of learning of relativistic concepts involved and a significant retention after a period of six months without further instruction, both for 4th ESO and 1st High School.

4. Possible applications of the audio-visual formulation

This proposal is a culmination of previous research, as a way of enhancing the effectiveness of explanatory diagrams that were presented as simple (ie. static) graphs, However, the potential scope of these materials is not confined to the area explored in our research (secondary school students), but may be useful as promotional teaching materials in other areas: university students whose study plans do not yet include SR, adults with an interest in understanding the scientific advances, etc.
The manner in which we created the animations, using a a non-specific program for geometric graphics such as FLASH, and by persons with no specific preparation for it, allows us to foresee better results for similar products made with better means and conditions.
Similarly, the proposal supports more ambitious formulations in relation to content, since any of the built physical elements is susceptible of a visual treatment that becomes much more "real, intuitive" without

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losing the essentially geometric characteristics with which they are shown in the produced videos.

4.1. Other materials available online

We are currently developing the website in order to add new materials and sections. The structure, as for july 2014, is the following:

Horizontal bar:
- -Spacetime
- -Special relativity
- -General relativity
- -Fields
  - Electromagnetism
  - Quantum fields
- -Geometries
  - Relativistic formulas
  - Geometric algebra

Vertical column:
- -Didactics
- -Links
- -Experiments
- -Histroy
- -Presentations
- -Publications
- -Video series

These are provisory sections, and they are subject to changes in the future.
The great majority of the materials which can be currently available in this site are in Galician language, and one of the aims of the project is to present improved materials in English as well as in other languages.
This presents therefore the need for collaboration in several directions: The addition of new visualizations for the proposed areas and subjects, as well as improving the quality of the animations and videos, taking into account the need of making translations which offer both strict physical meaning and clear explanations.

5. Proposal for collaboration

Given the above, we consider this proposal as a starting point for the development of audiovisual materials for the teaching and divulgation of the Theory of Relativity (both Special and General) as well as of other physical phenomena contained in spacetime and explainable by its transformation: electromagnetism, waves, classical and relativistic quantum physics, etc..
The authors express their willingness to collaborate in the development of materials with these characteristics, in order to arrive at an interdisciplinary networking group that allows to develop a consistent set of audiovisual materials for the teaching of physics based primarily on the geometry of spacetime.

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Scientific Literacy and Laboratory Activities in Physical-Chemical Sciences

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Abstract. *According to the* curriculum guidelines*, given by the Ministry of Education, teaching Science Education implies learning based on Science-Technology-Society (STS) activities, looking forward to the development of competences related to the promotion of scientific literacy. Thus, the teaching of science should create conditions that allow students to develop thinking skills, leading to the (re)construction of scientific knowledge and the promotion of autonomy, through the use of active learning strategies. In this perspective, laboratory activities, as a teaching resource, are likely to contribute to an integrated development of students´ skills and competencies.*

Keywords. Science-Technology-Society (STS), education, scientific literacy, laboratory work, social scientific interference.

1. Introduction

Nowadays, scientific knowledge is accessible to most citizens. This requires a solid scientific background for all, as well as learning skills that last throughout life. Thus, in recent decades, the slogan Science-Technology-Society (STS) has gathered efforts of many educators, around the goal of changing the *status quo* of Science Education. The new curriculum should focus on the development of knowledge, skills and attitudes, useful in the daily lives of students, reinforcing social responsibility in collective processes of decision-making, on issues related to Science and Technology [9].

Therefore, it is undeniable the importance of studying Sciences, at compulsory education, to develop scientific literacy, in the younger generations, in order to make future citizens, scientifically educated [8; 10].

So, it is important to provide students with activities that allow them to observe, compare, experiment, select and organize data. Moreover, teachers should discuss and evaluate curriculum guidelines, for the teaching of Physical and Natural Sciences [2], which recommend and value learning and knowledge, joining conceptual and procedural levels [5; 10].

Mass access to education has brought new challenges to school, which forced the development of methodologies, for innovative teaching-learning, able to overcome the effect of social class [6]. Therefore, although many researchers in didactics recognize the "superior effectiveness of teaching practices, based on methods that lead student to investigate for himself" [11, p.2], this practice is not implemented, in most European countries.

Literature review show that teachers, in the field of experimental sciences, recognize significant gains in learning physics and chemistry, based on laboratory work [7]. However, there are voices that call into question the effectiveness of laboratory tasks [4]. As arguments, they point out the complexity of the tasks, which are not restricted to observation and experimentation, but also involve theoretical concepttions, debates and confrontation of

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ideas, in group work [7].
Despite these constraints, the researchers maintain that teaching and learning scientific procedures are incomplete without laboratory activities [3; 10]. On the one hand, the importance of laboratory work is well-recognized; on the other hand, its effectiveness depends on the objectives, strategies and activities implemented.

2. Methodology of Research

This study is an educational research with a socio-scientific intervention. The research focuses laboratory activities, and learning strategies, concerning Physics and Chemistry. Thus, this study aims to investigate how basic education students, attending 8th grade, at a public Secondary school, view the implementation of laboratory activities, in the teaching-learning process of Physical and Chemical Sciences, regarding STS features. We selected this school year, because it is an intermediate level, when many students begin practical activities. The research took place in the natural settings of classroom activities, in the context of a public school.
In this case study it was applied a mixed methodology, both qualitative and quantitative, combining perspectives and meanings, attributed by the participants, with quantitative results. The procedures involved application, analysis and systematization, which were the basis of the methodological strategy we selected. Therefore, it was possible the collection and subsequent analysis of data, obtained through a questionnaire survey, applied to students. Additionally, students´ written reports of laboratory activities were analysed, and an interview survey was applied to teachers.
The choice of those data collection methods was intended to gather varied information and to compare the results obtained. In order to achieve the triangulation of data, i.e., "observed from different points of view" [1, p.172], we analysed the structure and scientific language of the laboratory activities reports, written by students, to confirm the progression of learning, at an intermediate level of education.

3. Conclusion

The study has found that the pedagogical practices, that foster laboratory activity, can promote Science Education. Such practices, properly reflected and sustained, are fundamental to improve the quality of education, in general, and for the exercise of citizenship, in particular, proving that laboratory work is a tool to engage students, developing not only cognitive capabilities, but also attitudinal, i.e., abilities and skills.
In this sense, it is undeniable the importance of renewing the study of Science, in order to develop young people scientific literacy. It is an important step to achieve a Science Education, more humanistic, comprehensive and less fragmented. This way, schools may prepare students to think more critically, and develop complex and sustainable views, on social and environmental issues.
However, this change, towards a more innovative curriculum, and new teaching strategies, can only be achieved by means of continuous teaching training, which can break with institutionalized practices, concerning the use of laboratory activities. Finally, students are well aware that active teaching methods can lead to better school results, and they show a new conscience of Science, using scientific knowledge in

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everyday activities.

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School´s Robotics: Improve Teacher Praxis to Promote Science and Technology

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Abstract. *Recently the authors, teachers at different school' levels and Portuguese regions, attended, on a lifelong learning program, a training course on 'School' Robotics', organised by the Hands-on Science Network. They were able to learn from the know-how of trainers in Educational Robotics and to exchange experience with trainees of other nationalities. From this acquaintance the authors created a partnership among them since they aim to improve the quality of their teaching practice and to promote science and technology in schools. In this communication we will report on the acquired knowledge and on three practical cases which intend to engage pupils in learning, create robotics clubs, make pupils participate in national robotics competitions and disseminate knowledge among other teachers and schools. We conclude by pointing out the significance of such training for the improvement of our praxis and the holistic view brought to it.*

Keywords. Lifelong learning, education, school' robotics, motivation.

1. Introduction

We are living and learning in a technology-rich world. It is widely recognized in literature that 21st century learners need to be technologically fluent to develop essential skills to operate in the learning environments of today [1], [2]. Engaging pupils in an inquiry-based approach where they are encouraged to collaborate and be creative in solving open ended robotics challenges offers a unique platform to address many areas of 21st century learning.

Robotics provides teachers with an opportunity to reimagine what learning could be like. It provides a context for inquiry and discovery, leading pupils to become active problem solvers and to engage in their own learning. If pupils are given the time, space and purpose to operate with robots and solve open ended problems, this will allow for thought and action to come together and will create opportunities for them to construct knowledge and build theories in individual and collaborative settings. These are critical practices for learning and discovery that have application across all curriculum areas and perhaps may give rise to greater human potential in creativity, participation and effort.

Being aware of this reality three teachers resorted to a lifelong learning program - Comenius, which aims to improve and strengthen the European dimension of education, from pre-school to secondary levels and received a training scholarship to attend the 'School' Robotics', coordinated by the network 'Hands-on Science. Firstly, in this course teachers could enjoy the wide experience of the trainers in Educational Robotics, and secondly, they had the chance to exchange their work experience with other learners, not only from Portugal, but also from other nationalities.

From this experience, a partnership was born among the authors of this article. They

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teach in different parts of continental Portugal, two in public schools and one in a private school at different courses and levels of education; however, they pursue the same educational goals, namely improving the quality of their teaching by motivating their pupils and promoting science and technology in schools.
United, these teachers intend to develop actions that may allow their pupils to develop together with national and international partners, their academic and social skills, as European and world citizens.

2. Training / knowledge acquired in training course

The way the course 'School´ Robotics' was taught provided an overview of the most adequate teaching methods to introduce robots in education, establishing an asset for future praxis.
The content focused mainly on the issue of application of robotics in education. The central question was 'How can robotics be used to improve the quality of teaching and learning in various subjects, from basic education to vocational and secondary levels?' Several trainers from different European universities shared their views on the topic based on the testimony of their experiences, according to the learning theories they advocate. Another advantage of the training was the methodology adopted, specifically, The Hands-on Workshop, an exploratory and investigative approach (Inquiry Based Science Education (IBSE). Trainees were acquainted with many international competitions as well. A laptop with the necessary software and a full kit of a LEGO robot was available to each group of trainees who had the opportunity to succeed, to fail, to investigate their failure and to draw conclusions, constructing their own knowledge. The various work teams also had the chance to present and compete with their robots. Participants with different backgrounds in very diverse schools frequently shared experiences and knowledge during the sessions.
The training course took place in Paris, France, which allowed teachers to develop their language skills in French and English. Socializing and working with different nationality colleagues provided a very rich cultural exchange.

3. Intended Pedagogical / educational goals

The introduction of computational robotics in the teaching practice of the three schools aims to motivate pupils to programming languages, mathematics and physics through practical experimentation, i.e., the hands-on practice [3], [4], [5], on a inquiry-based learning perspective, where scientific process skills and science attitudes are trained [6]. It also intends to develop pupils attitudinal skills related to self-confidence, security, mutual aid, teamwork, personal and collective responsibility, autonomy and respect for difference. Moreover it plans to involve parents, guardians and the whole community in the activities carried out in schools, leading to a more active school participation.

4. Activities have / to develop

In 2013/2014 a Physics and an ICT teacher created a Robotics Club together with a group of 8 pupils from the Scientific Science and Technology course and the Professional

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Computer Management course, at the Externato Cooperativo Benedita. These teachers felt relevant to create groups of pupils from both areas, ones for their knowledge on physics and others on programming languages. The club has had the support of teachers from the Technology and Management School from Leiria Polytechnic Institute, who have organized workshops on robot programming and electronic components welding. They also participated in this year's 'Roboparty' [7] event with two teams of three pupils and one teacher each. The registration for the event gave the school two Bot'n Roll One A robots. These experiences led the school board to consider a new professional course of Electronics, Automation and Command Technician in the next school year. To motivate 9th grade pupils to enroll in this course, and to show what pupils could learn, 'Roboparty' robots were used in demonstrations.

In the future the robotics club will be stimulated and will develop programming competences of participating pupils, preparing them to the robotics national contest (Robô Bombeiro [8], First League Lego [9]), conducting promotional and motivational activities and making the use of robots useful in the pupils' learning process.

The club will also keep its university partnerships with teachers with other experience and resources and possibly start new ones.

In the Briteiros school group the programming unit of the ICT subject in the 2013/2014 school year integrated robots from LEGO. Previously this unit was only taught using Scratch. In addition to applying the acquired skills in the course to the classroom context, the teacher intended to develop internal teacher training and to show both teachers and pupils how to use these materials. So, one week after completing the lifelong training, the teacher prepared a presentation with the collaboration of pupils who were previously exploring pedagogical resources related to this topic.

Several particularly interesting examples already applied to educational context will be presented to teachers of the department of science and technology. The teacher proposed the creation of a robotics club in the next school year and 50 pupils have already enrolled in it. The coordinator of the Hand's on Science organisation in Portugal, Professor Manuel Costa teaching at the Universidade do Minho, loaned the school a robot similar to the one that the school had acquired at the beginning of the school year and was willing to lend some more after the club had started. In the future, pupils are meant to participate in national competitions, with multidisciplinary teams and to make presentations at other schools in their country or abroad. The Briteiros school foresees the accomplishment of these objectives through the exchange with other countries in the candidature to the Erasmus project.

The results obtained in the ICT subject confirm that robots may become an ideal resource for cross curriculum activities when used properly in schools. Thus, next year this experience can be used to teach other subjects as: Mathematics; (spatial concepts and geometry); scientific principles and computer programming as an extra activity curriculum.

Finally, within the curriculum of the Programming Language subject, in Cidadela school's group, it is foreseen the

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development of a computer management application using Lego robot [10], [11] EV3 version provided by Professor Manuel Costa. One group of pupils will programm the robot on computer management for subject assessment. They are also expected to demonstrate the robot potential to their primary school and 8th grade colleagues, who started studying programmimg languages in ICT.
A Lego workshop by Professor Paulo Torcato and his pupils from the 'O Robôt Ajuda' (Robot Helps) project is scheduled, where the Lego robots version NXT will be assembled and programmed.
Still aiming to motivate pupils for programming, another workshop is planned this time on a creative programming language, Snap, by Professor Manuel Sequeira, the CoderDojo Lx facilitator from European University, providing pupils with different perspectives and opportunities in the project development.
Furthermore it is intended that this introduction to computational robotics in the teaching practice is complemented by a municipal project, where several Cascais school groups participate in several activities related to this knowledge area, sponsored by several entities. The activities carried out together as complementary activities in each school group are robotics local council meetings, with emphasis on the parents and community involvement; participation in national and possibly in international events; workshops and demonstrations in schools, having pupils as major actors as participants, organizers, trainers and demonstrators. Stronger pupils will spread it to other colleagues.
In achieving these goals we hope to have more pupils engaged in academic practices, focused on their school as a formal/informal learning environment, enhancing the programming languages potential at school and later at work, supported by educators at school and at home, in perfect harmony.
After implementing the initial phase it is intended to further expand the computational robotics potential to other knowledge areas such as physics, as a complement to NIAC – Cidadela's Astronomy Research Unit [12], maths and multimedia as a complement to Multimedia Technician Professional Course [13] and nucleus ROC – Onda Cidadela (Television and Radio) [14], using the already existing resources of Cidadela's school group.
The remaining school groups that participate in the municipal project will extend objectives to other subjects' areas.

4. What we want to do in the future

The three teachers intend to continue the partnership started in 'School' Robotics' through workshops targeting teachers and pupils, interschool's encounters, friendly competitions, fostering a network between pupils and teachers of experience and knowledge exchange.
In order to implement the project activities they count on Professor Manuel Costa cooperation, who always showed his support and to whom they thank all the collaboration.

5. Conclusions

We conclude that the experience of this training was essential to improve our praxis, giving us a holistic perspective of Portuguese teachers, but mostly of European teachers. Within the paradigm of IBSE and robotics in schools, pupils cease

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to be passive targets of teaching methods and become active learning subjects and faster learners, showing initiative and independence [15], [16].

Pupils usually work in small groups of 2 to 4 pupils per robot. This encourages the development of basic communication and inter-personal skills. The ability to collaborate and to convey complex ideas to fellow pupils or colleagues is an important skill that is seen as essential by modern employers.

The use of robots in the classroom subconsciously introduces pupils to possible career paths they may well have never considered. Engineering principles, such as electrical, mechanical, and chemical, as well as IT skills are required to successfully complete a robotics based project. This is important as it may make pupils want to pursue a career related to engineering, a field where a lack of skilled workers has been proven.

Robotics is a perfect way to show pupils that engineering and IT can be fun.

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Development and Construction of Educational Materials in Physics and Geosciences for High School Teachers Training in the State of Rio de Janeiro

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Abstract. *The contents of Geosciences, namely the Geology, begin to be worked in basic education, especially in the sixth year of the second upper elementary school, especially by Geography and Science disciplines teachers, addressing issues related to the internal structure of the Earth, tectonic plates, volcanic activity, earthquakes, rocks and minerals cycles. However, these educators, in many instances, are challenged in transferring these matters to their students. This is a quite complex understanding, as the students need a greater awareness and maturity, because they refer to matters of endogenous activity on Earth. The purpose of this work is to develop and apply skills, techniques and appropriate teaching-learning processes and elements of the geosphere resources, thereby supporting the improvement of the teaching of Earth Sciences/Geology headquartered in public schools in the state of Rio de Janeiro. Research has also approaches aiming at observing and inferring the links between Geosciences/Environmental Education and tentatively with other school subjects, such as Mathematics, Portuguese and Arts with regional realities, which depend on the integration of teachers these disciplines in the process. More specifically we foresee the creation of a Sciences lab at the Municipal School JúlioRabelloGuimarães. The location of this school is of particular importance because it lies next to the Municipal Natural Park of Nova Iguaçú (RJ), which keeps in its area geological and geomorphological features that betray the event of preterit volcanic activity, such as: magmatic cameras, syenitic rocks, pits, dams, breccias and volcanic pumps, which makes this an important heritage Park. The area contains extensive technical and academic production related to aspects of local volcanology. Furthermore, we propose the creation of a Laboratory for Geosciences practice mineralogical study of rocks in the schools, through the acquisition of collections of minerals, laboratory installations for studies and practices. Concomitantly, manuals for students and teachers to research and study minerals and rocks will be developed.*

Keywords. Geology learning, minerals, physics learning, rocks.

1. Introduction

1.1. The difficulty of teaching Geology

The contents of geosciences, namely the Geology teaching, begin to be worked in basic education, especially in the sixth year of the second upper elementary school, especially by teachers of Geography and Sciences disciplines, addressing issues related to the internal structure of the Earth, tectonic plates, volcanic activity,

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earthquakes, rocks and minerals, among other cycle. However, these educators, in many instances, have the challenge to present this contentto their students, since it is a complex matter, as they need a greater awareness of the students, as long as it refers to matters of endogenous activity on Earth [1].

To improve teaching, it is necessary appeal to fieldwork [2], experimentation in laboratories and playful work. They bring students closer to reality and promote the motivation to learn. Therefore, the use of skills, techniques, and resources is necessary to geosciences learning.

However, there is a lack of resources and professional training in basic education, particularly in geoscience matters, present in many schools, particularly at public schools [3]. This as prevents the development of more effective practices and attractive learning, and that can lead to discouragement of both student and teacher. Therefore, it hampers the processesof teaching and learning and not only of indirectly related geosciences disciplines, but also to other scientific and empirical knowledge [4].

1.2. Justification: Bringing science students and citizens

The project is justified by the observed deficiencies in the teaching of Basic Education in Geosciences. These deficiencies at both the material resources and professional training for teaching content often difficult to be worked in class room and traditional techniques, which is necessary to create favorable environments and materials for implementation of best practices.

This reality can still contribute to a society lacking adequate geological scientific knowledge on the social, economic and environmental importance of the knowledge of good and services departing from the geological diversity.

This shortcoming, seconds Piranha & Carneiro [5], reflects in a deficiency of geological and scientific concepts in population, constituting a barrier to the empowerment of the individual to opine, decide, choose and influence in a number of decisions adopted by part of society. Support for the improvement of teaching in the school of Geosciences thus aims to achieve educational practices that can lead to significant learning and consequent development of citizenship and, broadly, planetary consciousness.

Therefore, it is necessary beyond building resources and more appropriate techniques for teaching geology at school, the training of educators to know to work with such proposals. In this sense, the object of study of Geosciences is the planet Earth [8], in form of complex and dynamic system, involving the interconnection between the spheres (hydrosphere, lithosphere). This field of study works from a historical, interpretive perspective and interdisciplinary way, from the moment that infers about the past and build a more complex reasoning starting from effect to cause, utilizing many disciplinary knowledge (e.g. physics, chemistry and biology) [6]. Space and time in longer intervals, confer a significant role in this thinking, as well as local/global relationship appears as the key point geological scientific thought [7].

Many authors, such as Frodeman [8], for instance, argue the need of Geosciences in Brazilian elementary school, with the

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intention of assisting in the formation of more informed this planetary dynamics, in order to realize as part of her people, and part of their historical transformations [9].

1.3. The Teaching of Geosciences and Environment

Geosciences, understood as Earth System Science, among others, by Piranha and Carneiro [5], Carneiro et al. [10], seek cover and understand the relationship between rock spheres, atmosphere, hydrosphere, biosphere and technosphere, where forms of energy cause changes as they are exchanged. Interdisciplinary approaches and insights of studies in each area of knowledge are needed to relate different concepts of geology (Earth System) and geography (world system). Thus, teaching Geosciences is more than imparting knowledge on Geology, Geography, Biology, Chemistry and Physics. It is action that goes beyond organized activities to meet, identify, classify, recognize agents, actors, facts, places and events that describe the Earth in all its structural, physical, chemical, biological and human. Teaching Geosciences involves development of reasoning processes of establishing relations, evaluation and analysis of phenomena that are in constant interaction on the planet, from its formation to today. These processes are interrelated due to permanent and complex relationships between matter and energy [10, 11].

With the systemic approach of Earth System Science, Geosciences discipline in the basic education curriculum articulates the understanding of natural processes with human activities and allows analyzing the origins, causes and consequences of environmental degradation. It also discusses the conditions necessary to achieve or lose, planetary sustainability. The insertion of Geosciences in basic education helps develop a critical awareness of environmental issues, because it takes the contemporary citizen to understand the values involved in the discussion on the dynamics of natural processes and their implications for the existence and maintenance of life.

The teaching of Geosciences should help form an idea of the complexity and dynamics of natural processes and therefore can contribute decisively to form "informed, participatory and committed to the responsible management of the planet and its resources citizens" [12]. In addition, it is desirable gradual integration in basic education, according to the students' cognitive stage.

1.4. Target School: Development of innovative teaching techniques

The institution of education in public schools selected for the realization of this project is the Julio Rabello Guimarães municipal school, located in the municipality of Nova Iguaçu, state of Rio de Janeiro/Brazil, due to deficiencies in their teaching resources for geosciences, such as absence of sciences laboratory, didactic activities and booklets for using by the students and teachers and, last but no least, its location next to the Municipal Natural Park of *Nova Iguaçú* – PNMNI (RJ).

The PNMNI is a conservation unit located in the *Gleba Modesto Leal*, between the municipalities of Mesquita and Nova Iguaçu, in the state of Rio de Janeiro (RJ); More specifically, in the *Iguaçuana* slope of the

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Serra de Madureira, GericinóMassif, in an area of environmental protectioncalled Gericinó-Mendanha. With an area of 1,100 ha, PNMNI presents altitudes ranging from 150 meters at the entrance of the unit and 956 meters in the southwest mark, near the Gericinó peak. Inside that thereare held in custody geological and geomorphological features that betray the event of preterit volcanic activities, e.g. magma chamber, syenitic rocks, pits, dikes, *breccias* and volcanic bombs, which makes that an important geological patrimony park. The area contains extensive technical and academic production related to aspects of local volcanology. In this sense, the *Geological Paths* project, developed by the National Department of Mineral Resources of Brazil, for the dissemination and preservation of naturaland geological heritage of the State of Rio de Janeiro is an important contribution. In the regional context, this conservation area is surrounded by large urban areas, roads and railways, for shopping, for industries and other establishments. This comes under a lot of degradation, mainly caused by unplanned growth of the city, common problems in this region are excess runoff (lack of soil sealing, generating floods), lack of green areas, accumulation of garbage and water contamination, and therefore chose this bowl for the present study.

2. Methodology

2.1. General Purposes

The project's overall objective is to build and apply skills, techniques and appropriate teaching-learning processes and elements of the geosphere resources, thereby supporting the improvement of the teaching of Earth Sciences / Geology headquartered in public schools in the state of Rio de Janeiro. Research has also approaches aiming at observing and inferring the links between Geosciences / Environmental Education and tentatively with other school subjects, such as mathematics, the Portuguese, and the Arts with regional realities, which depend on the integration teachers of these disciplines in design.

Briefly, the objective is the training and continuing education of practicing teachers of elementary school for the teaching of Geosciences and Environmental Education with the integrated use of practices in science and field work for the study of environmental laboratory.

To achieve these goals we are developing books for the teaching of geoscience materials at high school levels.

In order to implement this project we started a science lab at a municipal school. The practical activities in mineralogical rocks at schoolwill start with collections of minerals and elaborating securitynotes for studies/practices in the laboratory.

An important supporting material is the elaboration of workmanuals on minerals and rocksfor students and teachers. For such texts that allow optimization studies of samples of minerals and rocks in PNMNI both listed as from collections will be developed.

The field work will consist in the preparation of didactic itineraries for fieldwork in PNMNItextbooks for field work with students of basic education in PNMNI roadmaps will be constructed. These scripts are easy to understand with information about the geology and environment in the Park. As a

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methodological approach, it is intended that the work results in easy view of socio-environmental problems at the site.

2.2. Practical and field activities

Teaching activities in a living-class will be essentially expository and supported by illustrative material from various sources, mainly from investigative experiences of teachers involved. The aim basically is to present aspects of geological processes and their materials.
Practical lessons: are supervised or very close teacher monitoring activities being conducted in classrooms, in laboratories or in the field. They aim to provide students with the opportunity to manipulate various geological materials, enabling the acquisition of a practice in the identification of minerals and rocks and recognizing the structural and morphological characteristics that allow interpretation of geological phenomena recorded in each material and its characteristic environments.
The teaching activities in the laboratory will center in training with the equipment that allow to obtain detailed information of minerals in their geological and chemical constituent materials information will be used, and information resources for the treatment of geological information. At this point will be stressed the connection with another branches of sciences as physics and chemistry.
The teaching activities in field will include observation and interpretation of the evolution and meaning of landscapes and diverse exhibition of materials and geological conditions, besides the preparation of teaching collections and graphic material (drawings, photographs, maps, profiles) to permit the reconstitution of the aspects studied in field. In particular, are exploited to the maximum exposures of rocks or geological situations of interest (parks, mining, records imbalances of the medium as landslides and other civilian buildings associated with the occupation and use of natural materials, etc..), Particularly those located in around New Delhi, complemented by other areas, in order to include all the geological diversity.

2.3. Introducing some experiments in Physics through their application to Geology

Some experiments were selected in order to start interest and knowledge transference between Physics and Geology.
The first experiments are: Measuring density of a rock sample by using Archimedes' Law; Measurement of gravity acceleration, using a simple pendulum; Resistivity measurements of rocks and soils.
The chosen ones are quite easy to be build up with little resources. At that place and public this is also very important because it also transmits know how against a overwhelming sensation of incapacity of doing experiments without the ultimate equipment.

3. Expected results and conclusions

It is intended that the implementation of the contents of Geosciences in high school can stimulate the exercise of specific skills of interpreting reality through inductive thinking, which focuses on the formulation of multiple causal hypotheses and allows students to consider different points of view. However,

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for the didactic transposition occurs, it is necessary a good academic training of teachers whose will be able to act as producers of knowledge and stimulating the teaching-learning process.

To teach Geosciences, under the tripod of interdisciplinarity, it is necessary to change the ways to work with the information. Information is the instrument of the student's knowledge, a tool for understanding and developing the world. Thus, the development of skills through education must overcome that of pedagogy centered only in the transmission of content, requiring from education professionals a new approach, namely, the appropriation of methodologies that foster meaningful learning. For this, the teacher should articulate the contents with the historical reality of the student, allowing it to parse and transform reality.

The teacher, acting as coordinator of the teaching-learning process, should no longer be "[...] the mere transmitter of knowledge but assume the role of stimulator and facilitator of learning, respecting individual characteristics, avoiding anxieties and taking into account the context. Only thus one can achieve intellectual autonomy and the construction of cognitive structures of the student" [13].

Thus, at the end of the learning process, it is expected that teachers involved would be able to organize field activities for their future students, at all levels, as well as preparing scientific collections with didactic purposes and still recognize and show in practice, human interventions in the natural dynamics that bring undesirable impacts on different levels, and to discuss possible actions towards remediation of problems.

Special attention is given at field works with the students, which aims to promote, through questions and directions of interpretations, the increased interest in learning through the process of discovery, as suggested by Perkins [14].

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Triggering Male and Female Student Questioning through Device Experiments

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Abstract. *Device experiments (DE) were short science demonstrations implemented to foster student questioning and to identify gender differences in questioning. The demonstrations were applied to three groups of science, technology and engineering undergraduates, each respectively composed of four female students, four male students, and two male and two female students. Male students in the single sex group posed many more questions than female students in the single sex group, and many more questions than male students in the mixed gender group. However, in the mixed gender group the number of questions posed by female students was significantly higher than that of questions posed by male students in the same group.*

Keywords. Gender differences, student questioning, undergraduate students.

1. Introduction

A 21st century education requires the development of higher-order thinking skills and conceptual understanding [1]. The students' questioning competency is considered to be the most significant indicator of students most critical and highest order thinking [2,3,4]. Besides, the development of students' questioning skill has the potential to enhance other higher cognitive level capacities, as critical analysis, problem solving and creative thinking [5].

Educators should therefore reinvent their practices to promote student questioning. However, they should be aware that the ability to pose a question might also depend on the student's gender. As several authors hold, students' conceptual understanding, academic performance and success are gender-dependent [6,7,8].

As nowadays girls participate equally or more than males at all education levels, including HE [9], educators have the duty to adapt their strategies and practices to meet both their male and female students' needs.

Under such rationale this study would like to contribute to the understanding of the more or less pronounced gender differences in student questioning. This paper attempts to describe a strategy implemented with higher education students to foster their questioning, and to analyze and compare male and female questioning through the experiments and discuss the observed evidences of gender differences.

2. Student questioning

As students progress in their studies they tend to raise fewer questions. Avoiding posing questions in the long term may compromise students' academic success, as they fail to promptly clarify every doubt they have. Not being able to understand a certain concept or fact may hinder the understanding of further concepts or facts.

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Encouraging a true questioning spirit of students from the first year on can improve the quality of teaching and, hence, learning in higher education [5,10,11].

3. Device experiments

Device Experiments (DE) were one of the strategies to foster student questioning that were implemented for twelve students enrolled in Science, Technology and Engineering degrees, during one semester, at the University of Aveiro (Portugal). Student questioning during the DE was analyzed in pursuit of gender differences.

DE were small science demonstrations carried out in the lab by a lab technician to three groups of four students each. Participation in DE was voluntary, but students were previously selected and invited to participate according to their grades. Students with better grades were preferred. Gender balance was taken into consideration. One group was formed with only-male students; another with only-female students and another was mixed-gender, being two male and two female.

After the demonstration students were asked to develop their individual opinion about what had happened, confront their different opinions, discuss among their group what was the group's interpretation of what had just happened, and together formulate the questions they would need to pose to provide an explanation for the challenging situation presented.

Students were informed that they could ask the technician to repeat the whole DE, to repeat just a particular step of it, or to do it in an alternative way. As the DE were conducted in the lab, students could take advantage of the lab facilities to deepen their understanding of the DE. There was no time limit for each group's DE and respective discussion. The length of the overall experience would depend on the groups' involvement in the discussion and the students were informed that they could decide when to finish the discussion.

The demonstrations and following discussions were audio and video recorded, and later transcribed. Participation and performance in DE wouldn't affect the students' course assessment.

4. Results

Gender representation of the group	Number of questions posed
Only female group	26
Only male group	262
Mixed gender group	67 (26 male, 41 female)

Table 1. Questions posed by students during the DE

Gender representation of the group	Approximate time taken (minutes)
Only female group	19
Only male group	68
Mixed gender group	34

Table 2. Time taken by each group to observe and discuss the DE

During the DE session carried with a group of only-female students there were a total of 26 questions posed by students. In the session of the only-male group there were 262 questions posed. And during the session of the mixed-gender group, there were a total of 67 questions posed, having been 26 posed by male students and 41 asked by female students. Table 1 is presented to more clearly systematize this

information.
As the decision to finish the DE and following discussion was made by the students in each group, we also listed the time that each group took until they decided to finish (Table 2).
As we can see, the time that each group took until they decided to leave the lab was very wide-ranging.

5. Findings

As shown in Table 1, there was an enormous gap between the number of questions posed in the only-female group (26) and the number of questions posed in the only-male group (262).
It was obvious that the only male group was the one wherein students showed more motivation to discover what was happening in the experiment. The male students in this group were much more active and persistent, asked the technician to repeat the experiment with other reactants, asked if they could take some notes, stood up and wrote schemes on the board, had deeper constructive discussions among the group, checked the periodic table hanging on the wall of the laboratory and tried to find the solution for the DE for over 1 hour, as can be seen in Table 2.
On their turn, the only-female group wasn't as enthusiastic as their male colleagues were, were always sitting through the demonstration and discussion, seemed to be less willing to find what was going on and didn't try so hard to solve the science behind the DE, as they left the room within less than 20 minutes after the beginning of the demonstration, as highlighted in Table 2.
The mixed-gender group took nearly 35 minutes until they decided that they wanted to finish the DE and respective discussion. In this group, there were many more questions posed by female students (41), than by male students (26).
Comparing the number of questions posed by the 4 female students in the only-female group of DE (26) and those posed by the 2 girls that integrated the mixed-gender group (41), we verify that female students pose more questions in mixed-gender groups than in only-female groups. This result is in line with the findings of Conti, Collins and Picariello [12] and Moely, Skarin and Weil [13], who during an investigation of the performance of men and women, or boys and girls in various competitive environments observed that girls perform better when competing with boys than when competing with girls.
This result, as well as ours, suggests that the gender composition of a group of students, for instance a class, rather than the gender of a student *per se*, affects the students will to pose questions.
Besides, despite the fact that any of the groups managed to fully understand the scientific explanation for the device experiment, the only-male group has been far more successful than the other two groups, as the discussion among the four male-students that composed that group reached a higher level of understanding and explanation of the experiment.
Upon the analysis of the transcriptions the lecturer even noticed that the only-male group was just about to solve the DE, when they decided to finish it. If we tried to establish a hierarchy of understanding of the experiment, the mixed-gender group would follow the only-male group and in the third place there would be the only-female group.

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6. Conclusions and limitations

The male students who participated in this study have asked many more questions and have been much more persistent to understand the scientific explanation for the DE, than their female counterparts.

It is possible that this differentiated behavior and will of male and female students to continue trying to solve the DE and finish the task is due to women's lower self-efficacy towards science and technology than males [14,15,16,17,18,19]. As emphasized by Bandura [20], "people who regard themselves as highly efficacious act, think, and feel differently from those who perceive themselves as inefficacious" (231). The more proactive posture of male-students could be an evidence of male's higher perceived self-effectiveness towards science.

However, these results must be considered with caution. Despite that we selected the best students, we recognize that they weren't equally cognitively capable and individual differences may have affected the groups' dynamics.

Another aspect that we would like to underline is that whether each student perceives the audience as friendly or uncomfortable may affect the students will to pose questions, regardless of the student's gender. Besides, as students already knew each other, factors such as peer pressure, social norms or loyalty among the group members may have affected their questioning behavior among the group.

It would be interesting to repeat this study with more groups of students, with the same gender compositions of our study and with varied compositions, to better understand gender differences and to generalize our results.

Similarly, other experiments should be conducted with less successful students (in terms of evaluation), to understand how students individual assessment affected their questioning behavior among differently composed groups of students.

Besides, as a caveat of the current stage of this study we highlight that it was only considered the number of questions posed, regardless of their quality. If the quality of the questions was taken into consideration different conclusions could emerge. In further stages of the analysis the quality of the questions will also be taken into consideration.

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IRRESISTIBLE Project - Portuguese Community of Learners: Teachers' Perceptions

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Abstract. *The European Union has developed a framework for Responsible Research and Innovation (RRI) to address the growing need to bridge the gap between scientific community and the rest of society. The EU funded IRRESISTIBLE project aims to engage teachers, teacher students and school students in RRI. As part of the project, each of the ten partner countries will establish a Community of Learners (CoL) for the professional development of in service teachers. The portuguese CoL comprises five science teacher educators, four research scientists, one science museum member, and fifty-two science teachers. Results of the impact of CoL on teachers' perceptions regarding the main project domains and on their professional skills will be presented.*

Keywords. Community of learners IRRE-SISTIBLE project.

The European Commission (2012) in a framework to improve on strategies to make a better connection between science and European citizens stressed the importance for Responsible Research and Innovation (RRI) in order to foster the fully engagement of all societal actors in the co-construction of innovative solutions, products and services. Responsible Research and Innovation means that societal actors work together during the whole research and innovation process in order to better align both the process and its outcomes, with the values, needs and expectations of European society. RRI is an ambitious challenge for the creation of a Research and Innovation policy driven by the needs of society and engaging all societal actors via inclusive participatory approaches [1].

In the light of this the EU funded project IRRESISTIBLE — Including Responsible Research and innovation in cutting-edge Science and Inquiry-based Science education to improve Teacher's Ability of Bridging Learning Environment — which aims to engage teachers, teacher students and school students in the process of RRI. The main focus of the IRRESISTIBLE Project is to develop educational modules of activities that foster the involvement of students and the public in the process of RRI. To raise the awareness on RRI the project aims to foster the development of knowledge about research by bringing relevant and controversial cutting edge scientific issues, and their discussion through a RRI perspective and by using formal (school) and informal (science center, science museum) teaching to familiarize school children with science.

Ten countries are involved in the project — Finland, Germany, Greece, Israel, Italy, Netherlands, Poland, Portugal, Romania and Turkey — and each participant will develop educational modules of activities, involving the planning and design of exhibitions. After use, and test by teacher at their own schools, the modules will be exhibit at a science center or science museum in their own country. The exhibit should engage the audience in the

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relationship between research and society. As Hodson argues "legitimating and establishing education for sociopolitical action necessitates extensive community involvement" (p. 204) [2]. Pupils devising and presenting an exhibition is a means of transforming science from product to process [3] which is considered a major aspect of scientific literacy [4]

The development of the educational modules of activities privileges an approach of Inquiry Based Science Education (IBSE) in line with Roger Bybee's 5Es Teaching Model (Engage, Explore, Explain, Elaborate and Evaluate) [5]. The IRRESISTIBLE Project has extended this model witha sixth additional step: Exchange; and the Portuguese team introduced a seventh one: Empowerment. This two steps have the intent to support the planning and development of interactive exhibits design by the students. The process of exhibits' construction and presentation allows students to move beyond analysis, communication and discussion (Exchange), creating an opportunity for them to participate in (and even to instigate) community action on socio-scientific controversial issues (Empowerment).

The IRRESISTIBLE Project involves the development of Communities of Learners (CoL) with the participation of science teachers, teacher educators, scientists developing research on elected topics and non-formal educators (from science centers and museums). Within these CoL it is intended that each group plays a distinct and relevant role: teachers hold the experience in the classroom, teacher educators have a broad theoretical background on science education; science centers and museums hold valuable experience in non-formal science education, and scientists are experts in the areas of current and controversial research. All the process of develop the educational modules of activities is supported by these CoLs, formed in each one of the ten countries involved in the project. Indeed a broad literature have stressed that for meaningful and lasting changes occur, including the use of innovative learning strategies, teachers have to be involved from the beginning of the process and a culture of collaboration should be valued [6][7][8]. It is known that CoLs, through the interaction [2] and collaboration of a group that shares practices, beliefs and knowledge [9], can provide a vehicle for teacher consider and implement new practices [10].

The Portuguese CoL consists of five science teacher educators, four research scientists, one science museum member, and fifty-two science teachers (biology, geology, physics and chemistry): eleven from primary school 1st cycle (1st grade to 4th grade - ages 6 to 10); nine from 2nd cycle (5th grade to 6th grade - ages 10 to 12) and twenty-two from 3rd cycle plus secondary (7th grade to 9th grade - ages 12 to 15; 10th grade to 12th grade - ages 15 to 18).

The main goal of the Portuguese CoL is to develop a RRI integrated module on the four cutting-edge scientific topics chosen: (a) The extension of Portugal's Continental Shelf; (b) Polar Science; (c) Biotechnology and Bioethics; and (d) Energy and Radiation.

The first portuguese CoL meeting was held in March 2014. Since then, the CoL meets every week, and a total of **18** meetings will have been held until the end of June 2014 - these face-to-face meetings are also supported by Moodle platform. During CoL meetings, teachers will have the opportunity to: (a) discuss with scientists regarding the cutting edge scientific issues chosen by the Portuguese group; (b) analyze and discuss supporting texts; (c) collaboratively explore and designactivity modules according to IBSE and the 7E Model, using web2.0 tools and regarding RRI aspects of the chosen scientific issues; (d) analyze, reflect and share experiences lived in their classrooms.

To evaluate the effect of the CoL in teachers' perceptions regarding the main project dimensions (IBSE and the 7E method; cutting edge cientific topics and IIR; the process of planning and building scientific exhibitions using web2.0 apps and students' empowerment), and also to evaluate the effect of the CoL in teachers' professional development we will use several methods, one of which questionnaires. In order to evaluate the effect of the CoL in teachers' perceptions regarding the main project dimensions it will be applied a pre-post-questionnaire (closed-endend questions); in order to evaluate the effect of the CoL in teachers' professional development, it wil be apllied a questionnaire comprising open-ended questions.

The pre-test questionnaire was applied at the first CoL meeting; the post one, as well as the open-endend questionnaire, will be applied at the final CoL meeting, in June 2014. The present communication will present findings regarding these two different questionnaires, although some preliminary ones can already be mentioned, namely: (a) teachers perceive some aspects relating to the characteristics of IBSE as relevant for students; (b) teachers perceive scientific exhibition planning and design as a means of empowering students; (c) teachers are improving their knowledge regarding the scientific cutting-edge topics of the project; (d) teachers are reinforcing their knowledge on IBSE and improving their knowledge on the extended 5E model, using web2.0 tools.

Teachers are improving their skills on planning and building classroom activities on cutting-edge cientific topics regarding IIR, using an IBSE approach and an extendend 5E model having in mind web2.0 tools.

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Non-Formal Science Education: the Role of Outreach Programs, Science Centers and Science Museums

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Science Education with and for Society
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Audiovisual Participatory Content for Science Communication

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Abstract. *The need science centres and museums feel to renew their languages and means of communication opens opportunities to the development of new interaction and media solutions.*
In this paper, participatory contents in science centres and museums and a practical use case, developed in a Ciência Viva science centre in Portugal, are discussed. The guidelines of the research were focused on the cooperation on knowledge communication among visitors and their engagement in the production of audiovisual (AV) content. The goal of this project was to present a participation model where collaborative science videos can be produced with the contribution of the visitors. With the aim of identifying different levels of participation and participatory models that could be adopted, this work started with the analysis of some use cases with similar goals. It was followed by the development of different prototypes that propose different levels of participation.
The study was designed taking in consideration, the main interests of users and their enthusiasm towards AV content. Therefore, a "Participatory Design" approach using bidirectional techniques was adopted: visitors were invited to watch and produce their own scientific explanations in video. Four stages of observation were implemented to evaluate the categories of preference of the audience (children). Each stage was structured into sessions targeted at various classes from different schools for two months. The prototypes included the presentation of concepts/questions about science complemented with options that allowed to evaluate the target preferences for: an active role (answering), a passive role (viewing answers from other children or scientists (male or female) or making questions. These prototypes were presented on a computer. The analysis and adjustments on the prototypes were made between sessions. The set of participations has shown that children tend to prefer by this order: answer, hear the explanations of scientists (male) and finally to make their own questions. The preference was always towards video content.
It was concluded that there was collaboration and mutual support among peers. Children showed total willingness to participate, specially to answer, being however curious to hear the other presented options. Based on the analysis of the results a proposal for a participatory model was developed, involving visitors in providing and receiving audiovisual contributions to help clarify science concepts. The proposal also offers some relevant indicators for a potential implementation in a Ciência Viva science center.

Keywords. Audiovisual contents, science exhibitions, knowledge communication, collaborative production, participation.

1. Introduction

Science exhibitions are dynamic information

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spaces for knowledge building [1]. The creation of participatory applications related to audiovisual contents may become interesting as a new solution to engage visitors to knowledge communication at science museums. Considering several studies as well as a few examples of current media applications we expect to offer opportunities to support visitor-to-visitor knowledge communication.

Children collaborated with peer during seven sessions, on different classes, helping to design and improve a participatory model, using AV contents.

The conceptual model described in this paper is based on the results obtained during the observation and the application development — between sessions enhancements on the application, conceptualized and implemented using a computer, with navigation based on Microsoft PowerPoint, were discussed. The application allows the users to answer some questions about science contents i.e. robotics concepts, recording them on video through a webcam, on science related sessions.

2. Forms of Participation

The purpose of the study was to design an installation with AV content that trough video recording stimulates participation.

However, it was necessary to understand whether or not there would be public interest in participating, whether participation was more effective towards the videos or the participants. Also wanted to know if the videos of scientists would be more valued than those of children.

For a better understanding of what could be the model to use for this application some examples of participatory museums that already used participatory techniques and strategies were studied. From this analysis it was possible to identify two main kinds of "Participation" characterized by: active [2] and/or collaborative.

Collaborative participation distinguishes itself by allowing in-group construction of knowledge [1].

Collaborative activities not only help to improve the understanding of the participant's perspectives, but also facilitate student's creation of new insights and new ideas. This is because during the collaboration process students will bring different ideas and with each other will try to create a shared understanding [3].

Raise and answer questions on a exhibition room can be a resource [4] and can become a challenge to drive the visitors conversations [5].

Media applications, which offer a broad range of open-ended questions, might be effective in guiding visitors joint exploration and communication on an exhibit, too. it maybe be also appropriate to focus multi touch large format systems that allow simultaneous interactions for groups with several users [6].

3. Development though Participatory Design

This study was structured as an experiment to investigate a participatory AV model, considering the collaboration among peers, to the explanation and learning of science concepts. It was designed based on the main interests of participants and their preferences concerning AV contents.

Collaborative situations often take place in a co-narration form [7] in which participants

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communicate and exchange ideas verbally. As students go through the answers development process, they are provided with opportunities for interaction and self expression [7]. Therefore, a "Participatory Design" [8] approach using bidirectional techniques was adopted: visitors were invited to watch and record their own scientific explanations in video. Four stages of observation were implemented to evaluate the categories of preferences of the audience (children). Each stage was structured into sessions [9] targeted at seven classes from different schools for two months.

3.1. Participants and procedures

A robotics activity designed to children between 6 and 10 years old was selected and adapted. 154 students from 5 elementary schools of Aveiro region, in Portugal, were included but only a part was in contact with the application. Most students were only observed during the sessions to select the contents that generated significant participation.
The robotics activity took one hour, including, in the first part, the explanation of a few scientific concepts about robots. Then the prototype was shown during the next 15 minutes and the participants were invited to make their choices and their reactions were recorded for future analysis.
Groups of 6 students came to a room where the researcher, who was moderating, was seated in front of a computer equipped with a version of the prototype and a microphone for voice recording. This recording and observation was important since the student's behaviors and perception in this activity can help us understand the influence of a scientist or peer to peer to the knowledge communication.
Twenty-two students became in contact with the researcher and with the different versions of the prototype. During the sessions, students were introduced to the purpose of the study and the prototype, as shown on Figure 1.

Figure 1. Prototype presentation to students

During the activity, student's onscreen behaviors were captured by a screen capture application for further analysis. Some questions were made during the activity, by the researcher, to improve the understanding of student's preferences and options.
The prototypes included the presentation of concepts/questions (Figure 2: A) about science complemented with interaction options that allowed to evaluate the target preferences for: an active role (answering) (Figure 2 B), a passive role (viewing answers from other children or scientists (male or female) (Figure 2: C) or making new questions [10]. These prototypes were presented on a computer.
During the sessions sequences of screens like the one on Figure 2 were shown to the participants.
The choices and new questions aroused by

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users were then registered and the sessions were followed by data analysis that leads to some adjustments on the prototypes before the following session.

Figure 2. Prototype navigation screens

4. Results

The results indicated that, during sessions, there was interest around the questions presented in the prototype. Except for the first group, all children wanted to discuss the possible answers as a team before recording the final answer.

The set of participations has shown that children tend to prefer, by this order: 1) to answer; 2) to hear the explanations of scientists (male) and, finally 3) to make their own questions. Their preferences were always towards video content instead of textual content.

Users revealed curiosity for more information and presented eleven new questions to be introduced into an improved version.

5. Proposal for a Participatory Model

The purpose of our model is to implement arrangements to provide one installation based on AV contents for more equitable, co-located collaboration by enabling easier control switching between group members at a science center [6].

5.1. Main features

During the stages of observation a prototype was used to identify the user preferences. Based on these results is proposed the following model based on AV contents.

The installation should be supported by a computer, displayed on touch screen technology, integrating a video camera (webcam) and microphone. For management and control of the contents left/recorded by users, a database and a content backofficės required. In the studied prototype it was possible to obtain, adapt and include questions and suggestions provided by users about robots.

Figure 3. First screen presented

The first screen identifies content. Other content may be adapted to other different activities about robots. On this proposal

questions suggested during the study were included and the option to record new questions was added (it can be seen in the last line of Figure 4).
After the user selects one question, on the next screen it is possible to record, in video, the user's answers or to watch videos of scientists and children (previously produced) as shown on Figure 5.
For questions that still do not have answers, it is only possible to record one and wait for the curator approval. An invitation to come back later and see the answer (after its acceptance by the moderator) is made. However, contents could be presented randomly if there is a lot to publish.

Figure 4. Questions screen

6. Conclusions

The goal, inherent to this application, of inviting the visitors to create their own content was successful. The system enables collaboration and visitor-to-visitor knowledge communication. The application proved to be a good tool to encouraged participation and the engagement of users.

Participants showed total motivation to contribute with their own explanations about the concepts, being however curious to listen the answers of scientists and to hear the answers of other children.

Figure 5. Record and watching options

The results provide strong indications that users would want to see such devices on a science center.
Nevertheless, more real context data would be needed for an analysis about how participants engage in museum exhibits and science centres. Further tests, namely in a setup without the presence of the researcher are needed. The study showed that the audio is not always distinctive in the recorded answers. This implies some technical adjustments because of the importance of recording the answers.

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How a Sustainable Way of Collecting Bivalves Becomes Unsustainable: Case Study in Ria de Aveiro

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Abstract. Ria de Aveiro *is a popular place where professionals and the population who lives nearby go to collect bivalves (the population does that as an economic complement). The species collected are: cockle (Cerastoderma edule), grooved razor shell (Solen marginatus), pullet carpet shell (Venerupis senegalensis) and grooved carpet shell (Ruditapes decussata).*
This work study is based on the observation which has been carried out for the last 10 years in the area and concludes that:
The legislation applied to this activity was and is thought in order to keep the sustainability of Ria de Aveiro. In this context, the majority of the capture of these bivalves is being performed by hand or with small tools, according to the law. Although the impact is thought to be almost none (both in the environment and with the species), compared to some other capture techniques, the reality shows that these bivalves are being collected far below the legal size by adulterating the tools used in the process. Also, some legal tools are not the best to use in the collection of bivalves because they cause damage to the intertidal bottom of Ria de Aveiro. Both situations endanger the sustainability of the biodiversity of bivalves in the area.

Keywords. Collection cockle, bivalves, clam.

1. The study area

1.1. Ria de Aveiro

Ria de Aveiro is a barrier-lagoon system, located along the Portuguese northwest Atlantic coast. It could be considered an estuarine complex which receives water from the rivers Vouga (more than 50% of the freshwater input), Antuã, Caster, Boco and a series of drainage channels although all the hydrology in this area is dominated by the tides [1].

1.2. Mira Channel

Our work here was developed taking into consideration the Mira channel which gets more influence from the drainage channels and this is showed in Fig. 1.
A study conducted by Freitas *et al.* (2014) reported that in the Mira channel the grain size is 1.86 ± 0.15; the percentage of total organic matter content is 4.46 ± 3.15; salinity is 31.00 ± 4.76 g/L. Concerning heavy metals the values are: Cd - 0.04 ± 0.02 µg/g, Pb - 3.69 ± 1.24 µg/g, Hg 0.01 ± 0.01µg/g [2].
The majority of people that collect bivalves in the area do that on foot and not by boat so, in this work, we are focusing essentially on this kind of collection which is also performed in the intertidal zone which is composed by mud and some mixed kinds of sand. (Fig. 2)

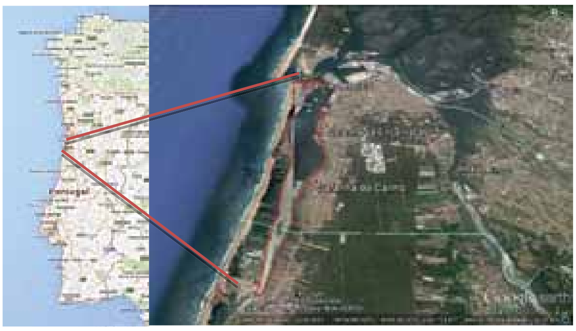

Figure 1. Localization of the study area. (Source: Google Maps)

The collection [11] of bivalve mollusks in the Mira channel (Ria de Aveiro), on foot, begins when the intertidal zone allows people to walk on it and also when specific holes, typical from this kind of mollusks, can be found in the bottom (allowing people to explore them in order to find out what kind of mollusk is in it). All of this occurs before the low-tide peak and can finish [13] some time after that peak, when the water level rises and the tide does not allow anymore the collection of the bivalve mollusks on foot.

Figure 2. One of the intertidal zones where some samples of bivalves were collected for this study

1.3. Classification and legislation

The classification given to the Mira channel by IPMA (Instituto Português do Mar e da Atmosfera – the Portuguese Institute for the Sea and the Atmosphere), namely Class B zone [7], allows that the bivalve mollusks can be collected but they can only be put on the market for direct human consumption [8], after depuration or transposition, because in these areas the quantity of the *E.coli* by 100 grams of meat and intravalvar liquid exceeds 230 and is less than or equal to 4600, in at least 90% of the samples tested [9].
The last classification of the bivalve mollusks production areas, which is currently in force, was established by the Despacho n.º 14515/2010 of INRB (National Institute of Biological Resources), IP and published in the Decreto-Regulamentar n.º 182, II série of September, 17th, based on the data collected during the last two/three years. [7].
Depuration is one process to which the bivalve mollusks are subjected in order to reduce the microbiological contamination levels to legally accepted ones (the quantity of *E.coli* by 100 grams of meat and intravalvar liquid of the bivalve mollusks cannot exceed 230) with the goal of cleaning them, using their own natural filtering ability.
Depuration can be natural in transpositional areas, which are not defined/established in our country, or it can be performed in depuration centers, accredited for this purpose [6].
In the depuration centers, the bivalve mollusks are put inside tanks which are filled with clean sea water, or water that was cleansed through appropriate methods during the amount of time needed to reduce the contaminants.

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The transposition process consists in transferring the bivalve mollusks to marine areas (estuarines or lagoons) during the time needed to reduce the contaminants.

This is a natural depuration process which can only be performed in approved areas for this purpose, where the bivalves ought to be in for a minimum of two months and according to the policy "all in, all out", this way avoiding the mixture of different lots.

2. Bivalves' collection in Mira channel

The species collected in here are mainly four. The cockle (*Cerastoderma edule*), locally called as "*berbigão",* is one of the most common species in the intertidal zone.

The grooved razor shell (*Solen marginatus*) locally called as "longueirão" is also very common, even today.

The grooved carpet shell (*Ruditapes decussata*) locally called as "*amêijoa rainha"* is the most valued species collected in this area. In the past this species was collected very often on foot and nowadays it became very rare to find. During the last 10 years it has been verified that people on foot and by boat collect these four species below the legal size. The first author of this study had the experience of working in a bivalves' wholesale warehouse in the area, and many times they had to sift the bivalve mollusks in order to guarantee that those that were sent to the depuration center had the minimum legal size approved. It was very common place for these bivalves to be below the legal standard. So whenever the entire collection of one fisherman in a specific day was below the legal size, the entire lot would be sent back and then, instead of being returned to the water, it would be consumed by the fisherman, himself, and it would never return to the water again. So nowadays, for example, the grooved carpet shell is very rare, mainly in areas with access only on foot.

The pullet carpet shell (*Venerupis senegalensis*), is a native species that is locally called as "*amêijoa macha",* it used to be abundant in the area but it started to have the same problems mentioned above becoming rarer and rarer to find.

3. The collection tools used

The fishing arts/methods authorized and the characteristics of the handicraft tools used to the collection of bivalves, on foot or by boat, is defined by the Fishing Regulation in Ria de Aveiro [12] (Portaria n.º 563/90 of July, 19th, changed by the Portaria n.º 575/2006 of June, 19th), complemented by the Portaria 1102-B/2000 of Novembrer, 22nd, which approves the Regulation of the Collection for commercial purposes, changed by the Portaria n.º 477/2001 of May, 10th, re-published by the Portaria n.º 144/2006 of February, 20th, which establishes the Judicial Regime of the collection of marine animals in oceanic waters, interior maritime waters and the ones that are not maritime but are under the jurisdiction of the coast guards/port authorities, and changed by the Portaria n.º 1228/2010 of December, 6th.

The fishing arts/methods mentioned in the bibliography [3], [4] and [5] do not match with what has been observed in the field for the last 10 years, in the Mira channel.

The handicraft tools that are used the most when collecting bivalves on foot are the rakes and the "nassas" (kind of a net fishing bag), the "berbigoeiras", salt bottles and sometimes they use the sticks.

When collecting cockle and clams by boat it is a common illegal error to use the "ganchorra de arrasto" (a big rake with a net bag attatched to it that is released until it reaches the bottom of the sea and then is trailed and finally pulled back at the end).
The rake used when collecting specially cockle and clam on foot consists of a pole (of wood or metal) with a metal or wooden toothed crossbar at the end which is used to stir the soil in order to find the buried bivalves in the intertidal area. (Fig. 3)
Regularly, the people who collect bivalves on foot use not only the rake but also a "nassa", independent of the rake, which is used exclusively for the transportation of what is collected. (Fig. 4)

Figure 3. Hand rake

The "berbigoeira" (Fig. 5) consists of a long metal pole with a toothed crossbar at the end and it is connected to a bow-shaped net bag. In this tool all the dimensions of each part is established in the legislation in force concerning the fishing in Ria de Aveiro. [12]
The "berbigoeira" is defined in the Fishing Regulation in Ria de Aveiro [12] and it can be used from a boat (with longer poles) or on foot (with shorter poles).

Figure 4. Hand rake and net bag

The way it is used is very similar to the rake (being its main function to stir the intertidal area to collect cockle and clam) but the size of this tool is bigger than the rake and it has a net bag attached to its metal structure, they are not independent from each other. It is very common for the coast guards to apprehend illegal "berbigoeiras" because the dimensions of each part is normally adulterated, the number of teeth in the crossbar and the space between them is also adulterated and the size of the net bag or the kind of net used can be also adulterated. In all these situations the legislation in force is not being respected. [12].

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The "ganchorra" is a fishing art that is not laid down in the authorized arts of the Fishing Regulation of Ria de Aveiro [12], being very similar to the "berbigoeira", the main difference is that it is trailed by a cord and not by a metal or wooden pole.

Figure 5. Berbigoeira

Concerning the collecting tool "adriça", locally called "vareta" in Ria de Aveiro, although is it not laid down in the Fishing Regulation of Ria de Aveiro, it is laid down in the collecting Regulation for commercial or professional purposes. (Fig. 6)

Figure 6. Stick

The stick is a collecting tool used when collecting on foot only which consists on a long metal rod with one sharp end.

In cases of lack of financial or material resources to manufacture this tool, the fishermen use the central rod of an umbrella removing everything else and then they use this just like a collecting stick.

The way the stick works is very simple, the men stick it in the holes which show the presence of the bivalve mollusks buried in the intertidal bottom, in this case the grooved razor shell (*Solen marginatus*) and they pull it out as soon as the stick touches the bivalve valves because these close immediately when touched. So the stick touches the bivalve, it immediately closes around the stick and they easily pull it out to collect it. This technique has become more and more obsolete because it hurts the bivalve mollusks and so they do not survive much longer from the moment they are collected and there is only a short period of time since that moment until they are presented in the markets to be sold with enough quality. [10]

Besides, there is another problem for the gastronomic consumption of this bivalve when collected using this technique. The stick makes the bivalve close when it is hurt and the soil grains stay inside the shells getting all over the meat. Even though the meat is washed many times, it is not enough to remove totally the grains and the restaurant customers do not appreciate this. So the gastronomic experience is not the most pleasant. Not to mention the looks of it, taking into consideration that the animal is hurt and so the meat is kind of smashed.

To avoid these situations, there is another technique which is being used by the majority of the fishermen replacing the stick. They are using salt; this technique consists of introducing the salt (sodium chloride) or brine (this is a saturated mix of sodium

chloride and water) in the holes of these bivalves. The salt forces the bivalves to come up to the surface. (Fig. 7)
This method of collecting the grooved razor shell is a lot less harmful to the animal than the stick method. This allows to increase the survival time of this bivalve from the collecting moment until it reaches the market stands with the quality desired and without any soil grains inside after it goes through the depuration process, as it is mandatory to do in this study area.

Figure 7. Collecting grooved razor shell by the salt method

4. Problems of collecting bivalves

One of the problems existing in the area is the collection of samples below the legal size [14]. The legal sizes are:

- cockle – 2.5 cm
- grooved razor shell – 10 cm
- pullet carpet shell – 3.0
- grooved carpet shell - 4.0 cm

What happens is that people collect bivalve mollusks in all sizes as Fig. 8 is showing.
But the main problem in here is not this kind of collection itself, but not putting the small samples back to the water and instead, cooking them to their own consumption (as the sale of it would be prohibited).

5. Conclusion

Although the collecting of bivalves on foot is thought to be better quantity-wise because it is collected one by one and not in large amounts at once, we conclude that it is not that sustainable as it is thought because the units collected are of all sizes, being the majority below the legal size. This reduces significantly the stocks of bivalve mollusks in all this study area. This impact is already visible in the specific case of the grooved carpet shell, which is already very rare.

Figure 8. A grooved razor shell and a cockle, both below the legal sizes

5. Conclusion

Although the collecting of bivalves on foot is thought to be better quantity-wise because it is collected one by one and not in large amounts at once, we conclude that it is not that sustainable as it is thought because the units collected are of all sizes, being the majority below the legal size. This reduces significantly the stocks of bivalve mollusks in all this study area. This impact is already visible in the specific case of the grooved carpet shell, which is already very rare.

It is essential that urgent environmental sensibilization measures are implemented with professionals and also with the local population, complementing that with supervision reinforcement and the improvement of the management of the existing natural resources in the Mira channel.

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Hands on Science: The Case Study of Pedra do Sal Interpretation Center

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Abstract. *Pedra do Sal Interpretation Center offers an original experience, and the possibility to observe and touch all of Avencas beach fauna and flora, once it is equipped with a touch tank, representative of a rocky shore tide pool. In 2013 the Municipality of Cascais developed and installed the permanent exhibition "Cascais, from Land to Sea" and adjusted all of its scholarly activities to this theme. Since the opening of the exhibition, the number of visitors of Pedra do Sal Interpretation Center has been increasing and is currently four times higher than in the past year (2012 vs 2013).*

Keywords. Cascais, coastal zone, hands on sea experiences.

1. Introduction

Environmental Interpretation Centres are of key importance to raise awareness, in both children and adults, for the environmental problems of the planet [2]. They make it possible to take a class outside the classroom, using didactic materials present in the centre [1].

In the early days, Environmental Interpretation Centres consisted only in static exhibitions with panels containing information on the natural values of the place where they were inserted.

With the evolving society it was clear that with this type of exhibition, the main goal of public environmental awareness for the visitors wasn't being achieved [3], therefore efforts were made to make the exhibition more appealing to adults, also including some children games to capture their attention.

With the technological revolution, the audiovisual systems are now a focal point in all of the Interpretation Centres enabling the visualization of films and documentaries that easily capture the audience attention.

In our days, the Environmental Interpretation Centres went from static exhibitions to fully interactive ones. The audiovisual means have evolved to enable virtual visits to the natural places, and the natural values were brought inside the centre itself, whenever this was possible.

In Cascais, the first Environmental Interpretation Center to be built was "Pedra do Sal" located at São Pedro do Estoril, in Cascais council (Fig. 1). This Center opened in 2005 with the main objective to raise awareness for the Biophysical Interest Zone of Avencas (ZIBA), a marine protected area located in a rocky beach nearby, however it *never had a permanent exhibition focused on the Ocean or the Coastal Zone.*

The Interpretation Center has innovative tools and exploration systems, which enhance the interaction between the visitor and the biophysical values present in the outdoor space, such as the geological formation that lead to its nomination as "Pedra do Sal".

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Figure 1. General view of the Environmental Interpretation Center

This Center began as an exhibition room and auditorium that hosted many temporary exhibitions, along with a permanent one dedicated to the natural values present on the outside of the centre. These natural values are visited through an interpretative pathway along the cliffs, passing by the Caparide stream (Fig. 2) and by a natural auditorium where outdoor classes can be attended (Fig. 3). The pathway ends at a coastal defensive spotlight and generator house which took part of an old coastal defensive construction.

Figure 2. Caparide Stream

In 2008 the Center was equipped with two fundamental pieces: a "Touch Tank" (Fig. 4) and a "Virtual Sightseeing" (Fig. 5). The "Touch Tank" is an aquarium that intends to replicate a tide pool with some of its animals and plants like see-urchins and sea stars. These animals can be touched by the visitors enabling the interaction with the species without going to the beach. The "Virtual Sightseeing" allows the visitor to access information about Cascais coast natural, landscape and cultural values, namely ZIBA, in a simple and intuitional way.

Figure 3. Natural Auditorium

Figure 4. Touch Tank

Finally in 2013, the Center was completely renovated and a permanent exhibition was

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installed, along with a small educational laboratory. The exhibition "Cascais, from Land to Sea" was developed in order to raise people's awareness about the Cascais coastal zone richness with a "hands on" methodology.

Figure 5. Virtual Sightseeing

With this paper we intend to analyze the visitors' response and evolution to the new dynamic of "Pedra do Sal" Interpretation Center.

2. Methods

The whole concept of the exhibition was to provide 4 spaces in a once opened space. A multitask space that can be adjusted to a children's area or to a conference area (Fig. 6); the exhibition space with 6 different stages and experimental boxes (Fig. 7); the auditorium for training classes; the laboratory for practical experiments (Fig. 8).

Figure 6. Multitask space, Children area or conference area

The exhibition guides the visitor from the physics of the ocean and functioning of the tides, to a trip in the geological history of Cascais coastal zone, passing between the tidal area of ZIBA and its underwater habitats. It also focuses on Caparide stream and its inhabitants. The exposition ends at

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an essential point, the explanation of sustainable fisheries and sustainable fish consumption. The key point of the whole exhibition are the experience boxes connected to each information panel, which were developed to suggest a practical activity related to each panel of information and that are changed every 6 month.

Figure 7. Exhibition space with 6 different stages and experimental boxes

The laboratory offers several water/ocean related experiments that the visitor can also perform, like water chemical tests that can be conducted in water samples from Caparide stream, otholit and scale visualization to determine the fish age, fish dissection and plankton observation.

For the scholar public there were also profound changes in the activities offered by the centre. All the activities are now adapted to the scholar curricula and the Center currently offers five different activities. All of these activities have a theoretical and practical (laboratorial) component, adjusted to the national scholar curriculum.

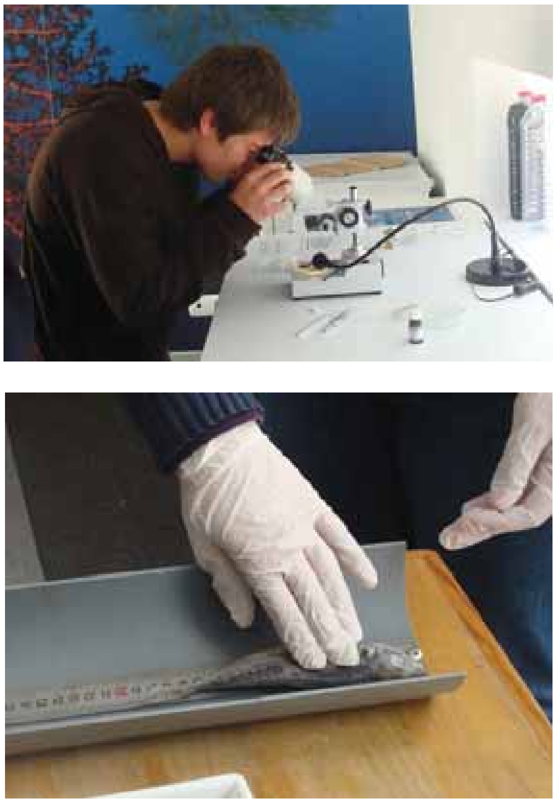

Figure 8. Didactical laboratory for practical experiments

The pre-school activities focuses on the water cycle, the primary school focuses on

sustainable fisheries and ocean pollution, the preparatory school (normally 10 and 11 years old students) has the flora of the cliffs in the spotlight, the secondary school focuses on the physics of the light in the Ocean and the consequences to the net productivity. Finally, the high-school activities focuses on the sustainable consumption of fish and problems of overfishing. All of the referred activities have a theoretical introduction and a "hands on" experiment at the lab, which helps to understand the concepts presented in theory. Each student has the possibility to perform the practical activity and at the end a learning revision is conducted. Satisfaction questionnaires are performed to the teachers attending these activities.
Each day the total number of visitors is counted. Their age, nationality and how they learn about the exhibition is also recorded.

3. Results and Discussion

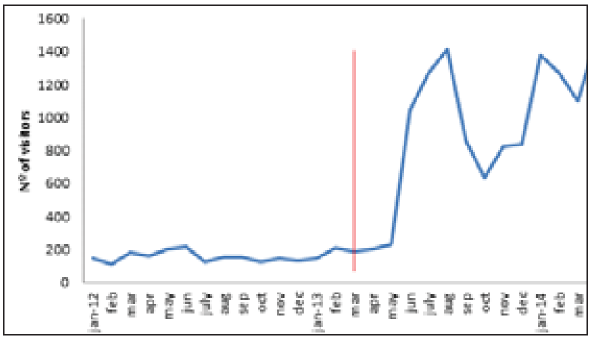

Figure 9. Number of visitors recorded in Pedra do Sal Interpretation Center

The new exhibit "Cascais from land to Sea" of Pedra do Sal Interpretation Center opened in March 2013 with a communication campaign associated with this inauguration. Since the opening, a total of 13 025 visitors were recorded, and the number of visitor in 2013 quadrupled when compared with the same period in 2012 (Fig. 9).
Most of the visitors are adults between (19 and 50 years old) from Cascais council; they come in family or as individual visitors. Most of the visitors knew the exhibit by friends or family that have already visited the Interpretation Center.
As for the scholar public, the activities were only changed in September 2013 and comparing to previous years a decrease noted in the number of school visits. However, the scholar year is not over yet and therefore there isn't enough data for a whole year of functioning.
The decrease of school visitors was due to the lack of free municipal transportation from schools to the Interpretation Center and not to a decrease in the school solicitations, once these were maintained throughout the scholar year.
The new contents of Pedra do Sal Interpretation Center brought a new philosophy to an old equipment attracting more visitors, and were able to fulfil the goal of providing marine environmental education to its visitors.

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New Color Pencils, for a New Drawing

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Abstract. *This short essay attempts to summarize a dedicated, courageous, passionate and comprehensive work by a young engineer in the Environment City of Portugal, seeking that it can be just as inspiring to more and better work (and does our country need it!). Keeping in mind the citation recorded in memory: "A Country without the participation of young people, is a bankrupt country", this is also a work by, for and with Young. More competitive cities will also give a better, fairer and more balanced country, in defiance of a complete experience.*

Keywords. Joy, environment, creativity, passion, persistence.

Since the United Nations designated this decade as the Education for Sustainable Development, it is fair to recognize that this fact revived in us all forces in the regeneration and/or construction of a more Environmentally Friendly Citizenship, always and increasingly! Protecting the environment is first and foremost educate and Knowing. Teaching and learn to look within ourselves, and have one, two, or many reasons to smile. Know in order to love and preserve what surrounds us. Inseparable warning to all of us was raised in 2007 with the award of the Nobel Peace Prize to Al Gore and the Intergovernmental Panel on Climate Change. It was the second time this award has been associated with the environmental theme (the first was Wangari Maathai in 2004), which is nonetheless also the reflect of growing influence in this theme in peacekeeping and contemporary societies.

Figure 1. The magazine of Environmental Education Activities «The Ambúzio»

It is also why we work more and more with and for that we consider one of our most valuable assets (perhaps the most valuable of all): Children and Youth. It is for them that we want, right now, designing the future of our county, using the magic pencils of his

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creativity, full of life, functioning as a catalyst for wills and motivations to do "more and best".

Figures 2 and 3. «A Student, A Ecoponto» - Distribution of ecobags (the household type ecopoints

Vital, however, the harmonious development of any Street, Town, Country and Planet follows the active participation of genuine parents nature concerned but, more than that, participating in this innovative and creative way to educate.
«I feel like… not giving up» could well be the motto for this basic work we are doing in Ílhavo, for almost 12 years (grew up so much! ...), but above all could very well be the war phrase of this environmental young engineer.

Figures 4 and 5. Environment Communication and Information/ Municipal Environment newsletter (examples)

It seems to me that what portugal needs, and more than that which challenges, is to create and foster authentic imagineers (half imaginative, half engineers)...
It's complicated, when you live in love, a passion summarize in a few words.

Figures 6 and 7. Environment Communication and Information/Ads for the municipal agenda (examples)

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Include in it two major areas: Environmental Education and Solid Waste Awareness - Selective Collection / Recycling of Waste.

We want the creative and joyful work of Environmental Education, to serve the basis for the implementation of all measures that embody the Municipal Environmental Policy:10 years ago, shortly after starting my job in Ílhavo, we started by organizing an Educational Programme for the Environment (we were one of the first municipalities in the country to do so), that we intend to review every year, selecting for the same projects and campaigns that are best suited to the realities of our County ... That program is a grassroots project, the Eco-Schools, where we belong to the top of the Municipalities with more Eco-Schools in our whole country. We started by having zero Eco-Schools, but also everything here boils down to a matter of time and above all convictions. Shortly after starting work were invited by the National Coordinator - Association Blue Flag of Europe - to be the representative of all National Municipalities that project in the Portuguese TV program. Today we are still on the "national top"!

But there is more, much more:

- “The coastwatch Europe project” - european coverage, and where we are Regional Coordinators, wandering through more than 50 kilometres of coastline - from riverfronts (Ria de Aveiro) and sea front.
- “Our “paper” is to value your own!” project that enhances the good environmental practices of employees of the municipality, especially in the more rational use of a fundamental tool in your daily life: the paper!
- “+ ECO - Environment Week” - We booked a week devoted entirely to the Environment, with exhibits, seminars, Municipal Camp Scouts, among other activities.
- We have another week devoted entirely to issues of Forests and another to the Biodiversity, as a way to raise awareness peel for its preservation.
- But there is more, much more... We intend to follow this passionate creative work of clear measures that interfere with the day- to-day at all of us...
- 20 km of bike paths and 5 walking trails to streamline that clearly invite exploration that many already consider the best and most beautiful county in the country – Ílhavo.
- 1 Ecocenter (see figure 2), only in the district of aveiro, for the selective deposition of waste with a view to their respective materials recovery – recycling.
- 42 Ecopontos distributed by 4 different Parishes.
- 100% of the School Network equipment served by the selective deposition of waste materials with a view to recovery - RECYCLING.The Selective Waste Collection is also common practice in Network Valencies Municipal Educational and now in many of our County IPSS.
- Selective collection of used cooking oil available in 14 public places.
- First National City to establish a technical partnership for Recycling Nespresso Coffee Capsules.

- Partnership with the Gil Foundation for the Appreciation of cartridges and toners and consequent support to needy Children and Youth.
- Units in Restoration County are certified in the practice of good environmental procedures.
- 12 cloth equipments installed in the city for Selective Collection of Apparel and Footwear Used.
- Until March 2014 were distributed 7500 ecobags - the household "ecoponto" type – within the campaigns «A Student, A Ecoponto» (see Figures 3 and 4) and «Less Waste, More Savings», with the motto to the maxim that «Reduce is very important to recycle more and better».

Betting on our schools Children and Youth training is obviously the right path, the acomplishment of our goals will always have to go through them, turning each and everyone of them on the "Environment Councilor" back home.
The most innovative facts undergo materialize clear focus on environmental education - and thus in our Children and Young People - with objective measures and practices on a daily basis while in the family context. Add to the magazine of Environmental Education Activities «The Ambúzio» (instrument across the entire community, unique in the country, counting 11 years of existence), one *ecoponto* per student (having had 7500 ecopoints already distributed at this point) is an excellent way to Environmentally reach each one home.
This is a job that does not know / uses social distinctions, on the contrary seeks to include all this broad challenge to help preserve what is both one and all - the Environment.
At a time when so profound crisis affects everyone, nothing better than to reinvent our way of life as well as our gestures, Citizenship concerns. Encourage the reduction and at the same time enhance the Recycling Family can be decisive in municipalities that want Competitive and Innovative: Nation out to win!
Today, at June 2014, we not only win the "battle" of reducing the production of waste, but also are increasing annually the amount of waste we send to recycling (as opposed to what happens for the rest of our country).
At the end of this very comprehensive and passionate work, who daily seek to develop, who will not be able to say «Fancy living in IÍlhavo!»?!?...

Hands-on Science
Science Education with and for Society
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Ponds with Life: a Hands-On Environmental Education Campaign on Ponds Conservation

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Abstract. *"Ponds with Life" - Researchers at School is a science communication project that aims the conservation of ponds for biodiversity, raising the young public awareness and encourage interest for careers in the area.*
The project was applied to 8 high-school groups of students, allowing the direct contact with the conservation scientific research through a set of scientific and pedagogical activities, contributing to the knowledge, aware and engagement with ponds.
The two-phase project evaluation is being applied and already showed a poor previous contact, interest and knowledge about ponds as well as negative attitudes towards biodiversity that this project aims to change.

Keywords. Conservation, evaluation, in-formal education ponds.

1. Introduction

Ponds are small shallow water bodies, natural or artificially generated by humans, permanent or temporary, characterized by an accentuated hydroperiod [1]. They are present in all continents and encompass a lot of important species being considered biodiversity hotspots [2]. However the number of ponds is decreasing dramatically due mainly to intensive agriculture practises and urban development having a great impact on biodiversity loss [2; 3].
Biodiversity loss problems are one of the main concerns of the scientific community and it constitutes an important issue in the educational curricula in Portugal. However the decreasing of experiences and contacts with nature are limiting the efficiency of the efforts to reverse this trend [4]. From this point of view Hands-on activities may help to overcome this gap by providing to the students experiences, enhancing their literacy and their active participation in conservation demands.
From an educational standpoint, ponds revealed to be excellent models for environmental education as they allow a variety of outdoor Hands-on exploration activities and a close contact with numerous life forms, flagship and bio-indicator species almost anywhere, including urban areas and schools gardens. This proximity relation with biodiversity, its importance and threats is essential to raise public awareness and engage the population in community-driven biodiversity conservation and monitoring programs.

2. "Ponds with Life" - Researchers at School

"Ponds with Life" - Researchers at School is a pond conservation, environmental education and science communication project that aims to raise the public awareness and engagement on the conservation of these habitats for biodiversity, taking into account the Ramsar

and European guidelines for the protection of wetlands. The project provides information for the general public through its website www.charcoscomvida.org (Fig 1).
The information available regards ponds importance, ecological services and biodiversity, pond construction and management, as well as a vast set of pedagogical activities for pond exploration, and the first National Pond Survey.
"Ponds with Life" - Researchers at School was designed to reach high-school public, allowing a direct contact of the students with researchers through a set of scientific and pedagogical exploration hands-on activities that contribute to the knowledge, contact and better attitudes about ponds and their biodiversity. The project also aims to aware and engage the entire school community on the conservation of ponds as biodiversity reservoirs and living laboratories by an temporary exhibition about one of the most important groups of biodiversity in ponds, the amphibians.

3. Activities description

Three lectures were presented during "Ponds with Life" - Researchers at School project in each school and included the following themes: presentation of the Ponds with Life project (what are ponds, their importance, threats and characteristics); Amphibians and reptiles conservation in Portugal; Investigation on genetics, evolution and biodiversity conservation (Fig.2).
Each school also performed other Hands-on activities: support to adoption and pond construction (Fig. 3); support to the monitoring and management of the pond; field Hands-on activities and classroom hands-on activities (Fig. 4).

Figure 1. "Ponds with Life website

Field Hands-on activities included pond characterization and monitorization, pond biodiversity survey, night filed trips to the pond, biological traces detection, aquatic macroinvertebrates observation, habitat colonization.

Figure 2. Lectures presented during the project "Ponds with Life - Researchers at School"

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The classroom hands-on activities included participation in the national pond inventory, bat nest-box construction, light-box construction, amphibian call training, and biodiversity knowledge games. Every activity has a protocol available in the website.

Figure 3. Pond construction during the project "Ponds with Life - Researchers at School"

In addition to the lectures and hands-on activities, a temporary exhibition developed by the Ponds with Life team was carried to each school for an approximated period of three weeks. This exhibition was coordinated, presented and maintained by the students in the project in order to achieve the entire school community. Because of these, a part of one of the 5 visits at each school was dedicated to the assembly of the exhibition as well as monitors (the students) training. The exhibition called “A paw in the water, another in land” is about the ecology, biology and life cycle of amphibians, one of the most important groups of biodiversity in ponds, and included 10 roll-up panels and several terrariums with life animals (Fig.4).

Figure 3. Field (top) and classroom (bottom) hands-on activities during the project "Ponds with Life - Researchers at School"

Figure 4. Exhibition presented during the project "Ponds with Life - Researchers at School"

4. Project Evaluation

The impact of "Ponds with Life" - Researchers at School project was evaluated in 8 groups of high-school students between 16-18 years old, from different location and background, during the scholar year of 2013/2014.
The student groups were followed in 5 visits to their schools by a project team member and an invited researcher in the conservation and biodiversity scientific areas. During the five visits to each school group, at least 10 activities were developed: lectures, workshops, exhibitions, and experimental activities in the classroom, laboratory and field.
The evaluation process comprehended questionnaires in two major phases: one pre-project and another post-project. The questionnaires aimed to achieve information about environmental conscience, knowledge and attitudes about ponds and their main biodiversity groups, in particular, the amphibian group.

5. Main Results

Preliminary results from the pre-project questionnaires showed a poor previous contact of the students with ponds mainly through Internet and books over any kind of direct contact.
Half the students are indifferent to this habitat but retain some knowledge about ponds when figuring the global image of ponds. Yet knowledge about pond plants, invertebrates and exotic species is absent. Considering pond biodiversity, better attitudes go to turtles and plants and the worst to other reptiles and amphibians. Generally, ponds are valued by aesthetic reasons and the habitat and biodiversity protection are defended by moral obligation. Environmental conscience is good, but students use to think that man will be able to control nature.
After post-project questionnaires, we hope to be able to check any alteration on the student's knowledge, attitudes about ponds and biodiversity, environmental conscience, will to be in contact with nature and be active in protecting it. The results of this study will also be important to better understand the project impact, to identify its gaps, to make it grow more effective and be a model for a more regular evaluation of hands-on science projects.

7. Acknowledgements

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The "Ponds with Life" - Researchers at School was financed by Ciência Viva, the Portuguese national agency for scientific and technologic culture.

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How Illegal Capture of Glass Eel (*Anguilla anguilla)* Affect Biodiversity in Tagus River

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Abstract. *The eel is a catadromous fish that grows in rivers and spawns in the sea. Every year, between November and the end of March, when glass eels migrate up river, illegal nets catch them in the Tagus River (downstream of the estuary, in Portugal). Every day, authorities organise policing actions to capture illegal nets placed in river specifically intended to capture glass eels. Usually, the seized nets are filled with glass eels and other species, since the net is very narrow (1-2 mm); it therefore captures everything. The mortality rate caused by these is huge and affects the eel's preservation and the river's biodiversity.*

Keywords. Eel, glass eel, illegal nets, policing actions, biodiversity, Tagus river.

1. Introduction

1.1. Species

The European eel, *Anguilla* (L.), is a catadromous fish that grows in rivers and spawns in the sea.
The eel or European eel is found in several environments, such as fresh, brackish and coastal waters.
Several works mention European eels spawning in the Sargasso Sea, in the Atlantic Ocean, but according to the Workshop on Evaluation Progress with Eel Management Plans of ICES (International Council for the Exploration of the Sea) its life cycle has not been fully determined [1,2].
The larvae, called *Leptocephali*, approach the continent and transform into an unpigmented round-shaped animal, called glass eel, prior to their entrance in continental waters.
When they reach this stage, they start their migration to the rivers and are found near the river mouths. Afterwards, during their first year following their recruitment from the ocean, they become pigmented and are called elvers.
Subsequently, when they are more colourful and longer, they are called yellow eels and live in continental waters (Fig. 1).

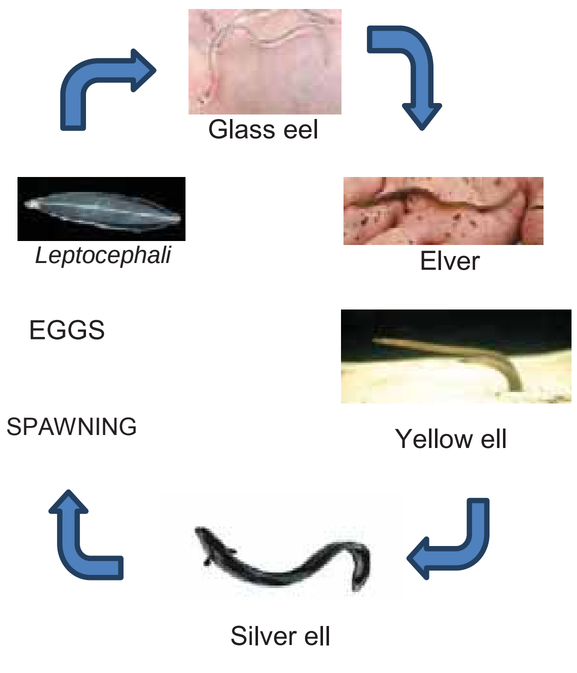

Figure 1. Life cycle of the European eel

ICES (2013) mentioned that the animals can live for up to 20 years or more. When eels mature and migrate into the Atlantic Ocean, a new colour alteration occurs and they are now called silver eels. In this stage, females are longer than males, almost doubling their size.
In Portugal, the Red Book of Vertebrates classifies this specie as a considerably "endangered species" due to their enormous reduction in numbers in the last few years [3].

1.2. Legislation

According to Council Regulation (EC) No. 1100/2007, of 18 September 2007 [4], which establishing measures for the recovery of the stock of European eel. Member-States must establish management plans for eels in their territories: "Member-States shall identify and define the individual river basins lying within their national territory that constitute natural habitats for the European eel (eel river basins) which may include maritime waters. (…) Member States shall prepare an Eel Management Plan. (…)The objective of each Eel Management Plan shall be to reduce anthropogenic mortalities so as to permit with high probability the escapement to the sea of at least 40 % of the silver eel biomass.".
In December Portugal established the Eel Management Plan 2009-2012 [5], undertaking to implement several actions aimed at studying and preserving the species. One of these actions consists of the control of the illegal catch of glass eels, which is only allowed in the north of the country, in the Minho River. Glass eel capture is allowed in the Minho River due to its international status, divided between Portugal and Spain; the fact is that Spanish people capture eels for eating. This action stipulates that an inspection must be carried out 2 times per month, between October and March, besides a monthly inspection in April and May.
In 2010 legal restrictions were incorporated in Portuguese law that forbid the catch of eels in the months of October, November and December in continental waters, in order to allow eels to follow downstream and reach the sea for spawning [6].
In June of 2012, it was established that eel professional fishing is only allowed in the areas defined for that purpose [7].

1.3. Tagus River

The Tagus River is the longest river on the Iberian Peninsula.
The source of the Tagus is Fuente de García (Spain) and its mouth is near Lisbon (Portugal).
The area of study is just close to the estuary, as can be seen in Fig. 2.

2. The Eel in the Tagus River

As to the Tagus River, the literature mentions that every year, between November and the end of March, glass eels migrate up river, and the Tagus River is no exception.
In the past the eel population colonized the entire Tagus River basin, reaching its Spanish portion. Since the construction of the Belver dam, in 1952, eels are limited to the lower 158 km of the river. The eel is now restricted to about 1.250 Km of streams and rivers, corresponding to an area close to one-half of the original one [8].

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Figure 2. Area of study (Source: Google maps)

3. Inspections by the authorities

Currently, the inspections done by authorities take place 2 to 3 times per week, beginning in November and ending in March.
The authorities responsible for this supervision are GNR (Republic National Guard) and the maritime police.
It is the kind of activity that does not please everyone, so sometimes people break the wheels of the inspection vehicles, so as to avoid the seizing of the nets.
Usually police authorities seize part of the net, and not the net as whole, due to its size and weight. This procedure is designed so as to prevent ghost fishing.

4. Gears for illegal fishing of glass eels

In the past, glass eels were not captured in the Tagus River, as can be observed in Baldaque da Silva (1891), who reported on fishing gears in Portugal [9].

Last century, in the 80's, the fishing gear used to illegally capture glass eels was called *rapeta* or mosquito net. This gear was similar to a big, round and narrow shrimping net. This gear was used at night during a 2-3 month-period. The strategy consisted on travelling by boat carrying this fishing gear. People said that, in a good night, the captures could reach 5 Kg [10]. In that period, all the glass eel was sold to Spanish customers that came to buy it locally.
Nowadays amateurs and non-professional fishermen use more complex illegal fishing gears in the river.
The system used by these fishing gears can be seen in Fig.3.

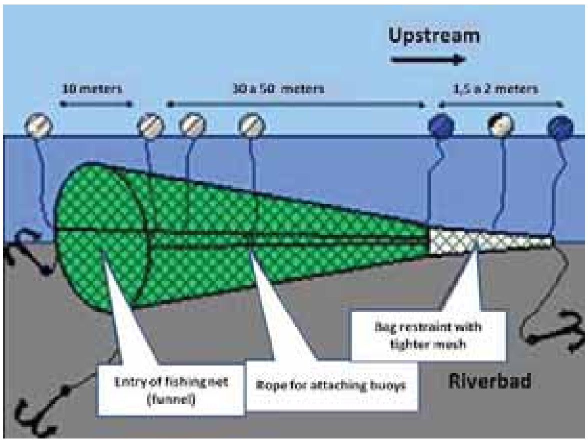

Figure 3. Scheme of illegal fishing gear used to capture glass eels

The nets consist of a green canvas, about 30 to 50 m long (Fig. 4). This canvas is identical to the one used to harvest olives. This net has a very fine mesh, as we can see in Fig. 5. In its extremity a second whitish bag-shaped net is installed, which imprisons all animals that enter its mouth (Fig. 6). This last net is very fine-meshed (1

mm) (Fig. 7) and is about 1.5 to 2 metres long.
These nets are fastened on the river bottom using anchors and, at the surface, jerry cans are placed and used as buoys (Fig. 8).

Figure 4. Part of the fishing gear

Figure 5. Mesh of a green net

5. Attitude of the population by the river side

In 1986, the second author carried out interviews among fishermen; these men said that several fishermen were doing that to complement their income.
Fishermen are not immune to the deep economic crisis and the greed to immediately extract from the river, at any cost, all its profitable resources, leads them to misunderstand the concept of sustainability.

Figure 6. Bag belonging to fishing gears where glass eels concentrated

Figure 7. Mesh of a net where animals are imprisoned

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Figure 8. View of fishing gears in the river

These riverside populations reveal a feeling of possession towards the river and this feeling is passed on from generation to generation.
This feeling is quite patent in the statements an anonymous fisherman shared with the media: "*A fisherman living from the river and who loves the river, born by the river, if he does not profit from that valuable source, then he is probably nuts*".

6. Future of the glass eel

The collection and the transport of the eel is done by intermediaries that contact suppliers/fishermen with equipment for preserving living animals during transport until it reaches Spanish buyers, whether as end consumers, or as intermediaries for exports aimed at Japan (Fig. 9).
Part of the eel is consumed in this stage of its life, and is named the «Portuguese caviar» (Fig. 10).
Another portion is used in aquaculture for growth purposed. There are no reports referring that any part of the eels, after reaching adult age, is released for repopulating waterways.

Figure 9. Capture by authorities of a transportation of glass eel in Portugal

Figure 10. Glass eels for human consumption in other countries
source: http://www.camporel.com/productos/edicion/precocinados/surimi-de-angula-en-aceite
source: http://www.tienda.com/food/products/se-93.html

7. Loss of biodiversity

The loss of biodiversity is enormous because this fishing gear captures everything: glass eels, little fish, adult protected fish, shrimps, crabs, etc.
When glass eels are captured, its quantities in the population are strongly reduced, jeopardising the future of European eels in the Tagus River.

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Several small unidentified fish are captured, in considerable proportions, as demonstrated in Fig. 11.
The species *Lampetra fluviatilis* is considered to be "very endangered", according the Red Book of Vertebrates, is also capture Fig. 11.

Figure 11. An exemplar of *Lampetra fluviatilis* in illegal fishing gears in the Tagus River

8. Conclusions

The great effort by the police authorities, not only towards the release of the eel and of the remaining species imprisoned due to this illegal craft, but also in identifying its perpetrators, is not duly supported by the law, since it is very difficult to frame this activity as an environmental felony; we are left with the illegal mesh of the nets used, as well as the small size of the fished animals.
These legal frameworks are scarcely meaningful, and are often restricted to small fines.
As long as a harsher criminal framework is lacking, we can only promote a culture of environmental knowledge among all stakeholders in the process, in order to save the *Anguilla anguilla* (L.), along with all other species harmed by this *modus operandi.* Unfortunately, law enforcement can only capture part of the illegal fishing gears.

9. Acknowledgements

To Ana Pinto Mendes, translator, for her willingness to proofread this article's English version.

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Hands-on Science
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Hands-on-Science in the "European Research Game" Project

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Abstract. *Present day teaching and learning paradigms acknowledge proactive and curiosity driven attitudes as crucial for the development of competences at cognitive, intrapersonal and interpersonal levels. Skills for the 21st century often refer non-cognitive skills as fundamental, such as critical thinking, problem solving, collaboration, effective communication, motivation, persistence and learning to learn. Projects such as the European Research Game (ERG) were developed to fulfil such need. ERG is a European project developed under partnership between Italy, Portugal, Turkey, Germany and the UK. It aims to engage students in the methodology of scientific research through an Internet-based Serious Game.*

The game was divided in two phases, the first consisting of a hands-on-science approach with an experimental project and the second an online competition. The experimental project was developed within the field of Biodiversity and supervised by the mentor (played the teacher). This project required the application of the scientific method, namely the identification of a research question and the ways to reach answers. The project results were communicated and shared on the project platform with the other participants, in English, using video, a poster, or any other suitable means.

A total of 35 teams from 8 European countries participated in the Game, of which 14 teams and close to 100 students from Portugal, aged between 11 and 18.

The teams were given freewill to implement any experiment to apply the principles of the scientific method. The University of Aveiro project team in collaboration with the science centre Fábrica Centro de Ciência Viva de Aveiro, implemented two experiments to support the mentors, one focusing on invertebrate soil diversity and the other on effects of different light wavelengths in plant photosynthesis.

Photosynthesis experience performed by the Portuguese students in the first phase of the European Research Game

The students could readily apprehend the various steps of the scientific method as well as the advantages of sound experimental design, the use of controls, replication and avoidance of confounding factors. The reporting of the work allowed them to train

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presentation skills and the use of media. Video presentations were preferred by many teams and the involvement of the students and mentors was visible on the quality of the work submitted. Learning-by-doing and mentorship played a crucial role in the acquisition of new knowledge and overall in the way the Research Game intended to engage the participants.

Keywords. Learning-by-doing, biodiversity, serious games, scientific method, 21^{st} century skills

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CIIMAR at School: Hands-on Activities in Marine and Environmental Sciences

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Abstract. *Hands-on science activities provide a lively effective approach to introduce school students important topics related to marine and environmental sciences.*
The project CIIMAR at School combines an offer of specialized talks and experimental activities, aimed at developing interest and curiosity about these themes and improve scientific literacy. The activities were taken to five high-schools in a novel approach allying the collaboration of university students.
Anchored on CIIMAR researchers and technicians, the university students performed the activities with their high-school colleagues helping to enhance curiosity about the scientific activities. The youngsters were very receptive to their presence and their experience as university students. The experience suggests this interaction may bridge the gap between high-school and university education, and encourage interest for careers in these scientific areas.

Keywords. Experimental activities, marine and environmental sciences, high-school and university students, interplay within the educational system.

1. Introduction

Topics related to climate change, the impacts of pollution, ecosystem services or blue biotechnology are an integral part of national educational curricula, several of them contributing to ocean literacy. Hands-on activities provide a way to focus on-and relate these topics and relate them to practical application in real case scenarios. Simultaneously, they help increasing students' awareness on the need for biodiversity conservation, the rational use of the chemicals in our lives and the sustainable exploitation of living resources and their products. To stimulate the curiosity of young students about marine and environmental sciences and introduce them to such concepts, CIIMAR researchers developed the outreach programme 'CIIMAR at School'.

2. CIIMAR at School

CIIMAR at School [1] is a multi-approach outreach project designed especially for students and teachers from elementary to secondary education. The project fits the goals of the national Ministry of Education and Science, which identified as its major intervention priority education and training of a new generation interested and able to value knowledge and culture, and motivated to work with effort and scientific rigour, approaching the student population and the professionals working in the field of science, arts and literature. The CIIMAR programme was intended to create and/or consolidate strong two-way interactions of knowledge transfer and sharing of resources by taking scientists to schools to give lectures within their field of expertise and assist teachers

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with free experimental protocols in Marine and Environmental Sciences available in a web-based platform. With the support of Ciência Viva - Agência Nacional para a Cultura Científica e Tecnológica - the programme was further extended to perform experimental activities in northern Portuguese schools to strengthen interaction and to promote the interplay within the education system.

3. Experimental activities

To stimulate the curiosity of young students about marine and environmental sciences, introduce relevant concepts in the classroom, and encourage the interest for professional careers in these areas, CIIMAR researchers developed a set of hands-on experiments. These are spread over themes such as ocean acidification, effects of household chemicals in organisms, benthic communities and water quality, industrial pollution and fish reproduction, fisheries management, invertebrate zoology and physiology, marine organisms and potential applications of their products (Fig. 1). In the activities students are also acquainted with a variety of aquatic organisms, some living in extreme habitats, with key roles in trophic chains. These activities are available on-line on a Do It Yourself basis [1] and have been accessed by teachers and science educators from all over the country (Fig. 2). Organisms are easily made available through resource sharing between CIIMAR and schools.

The experimental protocols related to marine issues were framed within the project "Knowing the Ocean" a navigation chart for ocean literacy [2] coordinated by Ciência Viva in collaboration with CIIMAR and other research institutes, to adapt the seven Main Principles about the Ocean identified by the initiative "Ocean Literacy" [3] to the Portuguese reality and national school curricula.

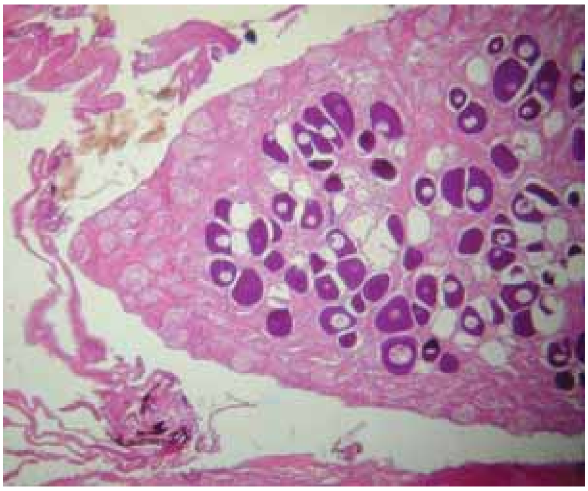

Figure 1. Testicular sections of male mullet showing testis-ova [4]. Impact of man-made chemicals in estuaries

4. Interaction between secondary school and university students

The hands-on activities were taken to five high-schools in the North of Portugal, in an innovative model involving the collaboration of university students. Between April 2013 and May 2014, together with CIIMAR researchers and technicians, 25 undergraduates from the University of Porto did 175 activities with 919 high-school students. The university students voluntarily engaged in the project. They were mostly attending the second and third years of courses on Biology, Aquatic Sciences and Biochemistry at the University of Porto. At CIIMAR they prepared in advance the

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science activities to be carried out. They were acquainted with the themes and concepts involved, prepared all the materials required and practiced the experiences to be conducted with their young colleagues. At school, they were very well received by students and interested communication was rapidly established.

Figure 2. Geographical distribution of accesses to experimental activities available in the CIIMAR at School web platform

Inquiries were made to assess the opinion of high-school and university students about this interaction model. The surveys included sets of items based on a Likert scale with five response levels, ranging from “Totally disagree” to “Totally agree”. Main items related to the presence of the university students in the classroom are presented in Table 1.

High-school students
A. The experimental activities encouraged somehow your interest in Marine and Environmental Sciences **B.** The presence of the university student in the classroom facilitated the development and understanding of the experimental activity **C.** The presence of the university student was important for the exchange of experiences, knowledge and expectations about university education **D.** The presence of the university student helped you to feel closer or to encourage you to pursuing your studies in university education
University students
A. I volunteered to this project to help address the shortage of experimental activities in Secondary Education **B.** I volunteered to this project for the interest in science communication **C.** I volunteered to this project to contribute to improve the preparation of high-school colleagues for the final exams **D.** I volunteered to motivate high-school colleagues for the importance of pursuing university education

Table 1. Sample of the items included in the surveys performed to high-school (n=148) and university students (n=21)

Main survey results suggest that university students were willing to volunteer to the project because back in high-school they felt a lack of science activities through their study (Fig. 3). Their aims were, thus, to help

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minimize this problem for their young colleagues and introduce themes they did not had the opportunity to discuss at their time.

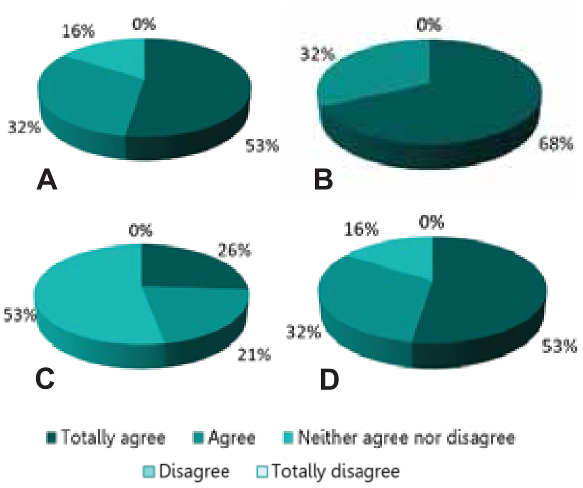

Figure 3. Main results of opinion inquiries performed to university students

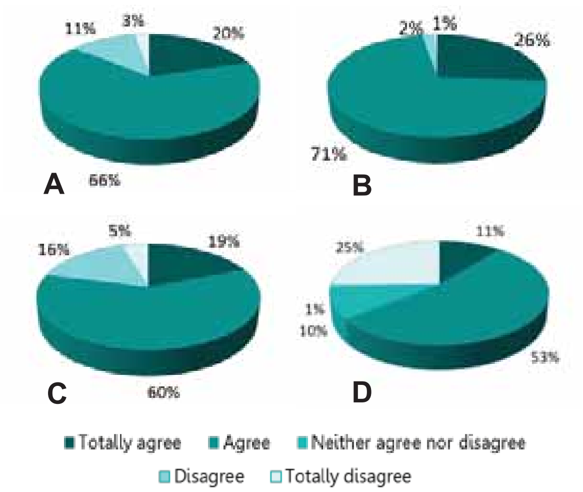

Figure 4. Main results of opinion inquiries performed to high-school students

Young students were enthusiastic about having their university colleagues in the classroom, who helped enhance curiosity about the science activities and shared experience on higher learning institutions with avid youngsters (Fig. 4).

Overall school teachers and science educators were very receptive to the approach followed. Their main interests were: i) the possibility to provide their students with state-of-the-art knowledge and technologies employed to address societal challenges in marine and environmental sciences related to important issues in their curricula; ii) the contribution of the experimental approaches and the scientific method and rigour to prepare high-school students to their final national exams. The results also suggest that the interaction between secondary and higher level students may contribute to help bridge a pertinent gap, bringing together high-school and university education to improve earlier training and encourage interest to pursue professional careers in science and technology.

5. Acknowledgements

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Linking Science Garden to School and University: Teacher Education, Research and Dissemination

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Abstract. *Science Garden [SG], located in the Department of Education at University of Aveiro [UA], is a non-formal science education context designed to promote children's explorations (4 to 12 years old). It offers challenges and outdoor exhibits focusing on key themes of Science – Forces and Motion, Light and Water. This communication aims to clarify SG's strands: education and dissemination of science and technology; research in science education; and teacher education.*

Keywords. Education and dissemination of science and technology, teacher education, research in science education, articulation between school and a non-formal science education context.

1. Introduction

As an educational extension of the Open Lab for Science Education sited in the Department of Education of the UA, SG is a non-formal science education context (Fig. 1).
SG was conceived to promote the scientific culture of children with special regard to the collaboration with schools, as argued by Gadotti [1]. In this sense, it pursues the following strands which will be further detailed in this article, giving emphasis in the last stated: education and dissemination of science and technology; research in science education in early years of schooling; and science teacher education.

Figure 1. Partial view of Science Garden

1. Presenting Science Garden

SG integrates outdoor and indoor settings offering hands-on, minds-on and hearts-on activities which seek to stimulate visitors to observe, question, preview, compare, analyse, connect and communicate.
In the outdoor setting, visitors are invited to explore an interactive exhibit with large devices focusing on the following key themes of Science: Forces and Motion, Light and Water (Table 1). The following were developed by the SG team: Look for the living beings; Bet on the faster marble; Control the water; and Find your image. In addition, SG presents Expression Boards where visitors may register messages about the field trip.
The indoor setting is called *Challenging workshop*. It has benches and tables where visitors are challenged to build, test and

explore devices, models and mechanisms with relevant scientific and technological knowledge, such as telescopes, kaleidoscopes, flat and curved mirrors, fly eyes' glasses (Fig. 2), magnetic marbles and puzzles and building blocks.

Forces and Movement	Water	Light
Go up with the least effort	Look for the living beings	Find your image
Test your balance	Bet on the faster marble	Find the rainbow
Ring the bell without effort	Control the water (Archimedes screw, Release the water and Water spin)	
Speed the wheel		
Spin the balls		

Table 1. Key themes of Science Garden and interactive devices

SG is placed in the Department of Education at the University of Aveiro [UA]. It opened to the public in December 2006.

2. Education and dissemination

In the scope of education and dissemination of science and technology, SG has been seeking to encourage the excitement of discovery, taste, curiosity and questioning among its visitors.
Since its opening until July 2014, it received about 5343 visitors, mainly children, besides adults.
There are two kinds of guided field trips for school children, chosen by their teachers or educators: general and customized.
The most requested ones are general visits which involve the exploration of all outdoor interactive devices and indoor science challenges in groups of up to 6 children. When dealing with the interactive device and in order to overcome the science challenge, children are asked to: observe and describe the main scientific and technological features; predict what is going to happen based on concepts and principles of science and technology; discuss in group how they have felt and possible explanations for it; present examples of daily life where those concepts and principles acquire much importance.

Figure 2. Science Garden's visitor exploring fly eyes' glasses

Besides that, the SG team provides support for planning visits which are customized according to teachers' pedagogical objectives and pupils' school curriculum. So they are focused on the exploration of interactive devices integrating just one or two key themes of Science and/or the exploration of teaching resources developed by researchers and pre-service teachers. These teaching resources can be explored in the *Challenging workshop* or in the Open Lab for Science Education.
The SG team also provides the possibility to explore those teaching resources during events promoted by UA such as Junior Summer Academy (scientific occupation

programme for 10 to 12 year old children) and Science & Technology week (http://semanaberta.ua.pt/pub/default.asp).
In the last edition of this event (18-22 November 2013), in the Open Lab for Science Education, primary school children were invited to explore 5 teaching resources about the theme *Discovering objects and materials*, adapted for this event. One example is the teaching resource *The journey of the materials: from raw material to object* where children were challenged to identify raw-materials, materials and objects, as well as to match them, using their senses and working together under the supervision of their teacher and a SG monitor (Fig. 3).
SG also receives the visit of science education researchers, government technicians of education and science and technology teachers from around the world. Some guided tours are included in education programmes promoted by the Department of Education of the UA.

3. Research

Research has been showing that teacher resources focused on promoting scientific knowledge and skills which link classroom and non-formal science education contexts are desirable by teachers but scarce. In order to enlarge the offer, research projects have been developed in SG [2,3,4,5]. They involved the development of teaching resources that articulate SG and schools with activities before, during and after the field trip for primary school pupils, some of them including teacher education, as mentioned below.
Some products of research linking SG and school rely on Science, Technology and Society [STS] orientation [2,3,4]. For instance, results obtained from teaching resources aiming at the promotion of critical thinking skills [8] showed that children who explored them had higher scores in post-tests appealing to critical thinking skills than the ones who didn't explore them.

Figure 3. Children exploring the teaching resource The journey of the materials: from raw material to object

Those research projects [3,4] were considered in the development of the collection "Exploring the Science Garden" by the SG team. It includes Teaching Guides to help teacher planning the activities before, during and after a field trip to SG. Each one is focused on a SG key theme: Water [6]; Light [7]; and Forces and Motion [8]. It presents activities for classroom (before and after the field trip) and for SG (during the field trip) and the associated curricular and conceptual frameworks. Other teaching research based resources are intended to lead to new Teaching Guides.
Furthermore, research [9] that relied on the development of teaching resources was conducted in order to improve science and mathematical skills on primary school pupils, in particular, related to problem solving and communication. The research provided

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evidence that most of the pupils improved those skills, especially, communication.
In its turn, research involving teacher education was also carried out. In the root of it there was evidence that teaching resources focused on STS orientation are desirable, yet scarce [10, 11], especially, for pupils in the early years of schooling [12] and in non-formal science education contexts [13], where the field trips can be one way to promote it [14]. Research involving the exploration of teaching resources with those features in SG showed different scenarios: it strengthened the STS pedagogical orientation of one teacher; introduced pedagogical innovation in the practices of another; and had no contribution to the reorientation of the third one.
To sum up, research that included the development of teaching resources linking classroom and SG activities has shown that they may promote scientific knowledge and skills in children attending early years of schooling, as well as favorable attitudes towards science,.

4. Teacher education

SG has been a pre-service and in-service kindergarten and a primary school teacher education resource, as described in the next second-order headings.

4.1 Pre-service teacher education

Pre-service teachers have field trips to SG with the support of their Professor and the SG monitor, when attending curricular units of the undergraduate course of Basic Education of UA. This Degree (1st Cycle Bologna - 3 years - 180 ECTS) aims at a broad-based professional training, both in terms of employability as well as access to various 2nd cycle specializations (Pre-School Education, Primary and Middle School) which vary from 90 to 120 ECTS (Masters). Those field trips are driven as follows.
In the first year of the course, under the curricular unit of Integrated Natural Sciences the focus of the field trip is on concepts and principles of science and technology. After observing each interactive device feature, they are told how it works and the science challenge associated to it. Then, they are asked to predict what is going to happen when they experience it (whenever it is possible) based on scientific and technological knowledge and principles in action. Pre-service teachers aren't corrected for two reasons: it is intended that they share and discuss their predictions with each other and draw conclusions based on the observation and hands-on experience.
In the third year of the course, under the curricular unit of Didactics of Natural and Social Sciences the focus of the field trip is on didactics of science in a non-formal science education context. Pre-service teachers are told what they should consider when planning a field trip to SG, such as the educational offer of SG, how to book for a visit and safety rules. They also get to know how they should explore each interactive device. In addition, they are told how children may behave when exploring it, including the most common predictions and how they react to hands-on experience. This is important in order to anticipate children's behaviours. These learnings may be applied to other non-formal education contexts.
Such field trips may occur in different moments of the curricular units. It may be aimed to introduce scientific and technological content knowledge and skills,

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presented later on, in classroom or to consolidate the already presented ones.
The SG field trips with pre-service teachers are conducted differently from the ones with school children: children explore interactive devices in groups of up to 6 people but the class of pre-service teachers do it together. In addition, they are only allowed to explore a few devices, like Speed the Wheel (Fig. 4) because not all are also dimensioned for adults.
Overall, in the field trips conducted under both curricular units, pre-service teachers are stimulated to explore hands-on and minds-on dimensions of the interactive devices. This is very important because they are expected to apply these learnings about science teaching in school and in non-formal science education contexts. In fact, some mobilize them when attending master courses both supporting SG field trips and/or planning field trips as teacher trainees.

4.2 In-service teacher education

In-service teachers have been participating in jardim.com/professores (Fig. 5). This is a session to help them planning and booking field trips to SG, considering school curriculum and programs and the articulation with classroom activities before and after the field trip, including a guided tour and presentation of the collection "Exploring the Science Garden".
Since 2012 there have been 5 editions. Those totalized 48 participants, the majority kindergarten and primary school teachers besides tutors and promoters of leisure activities. Most of them are from the centre and north of the country.
In the end of each session, participants are asked to fill in the "Questionnaire *garden.com/teachers*", available online (http://questionarios.ua.pt/index.php/14294) about the session and the SG educational offer. In the last one, in September 2013, we obtained the following results from 18 participants. In the first question "As a professional of education register your general comments and or suggestions about Science Garden", all answers were positive, such us: "The visit was extremely useful to prepare school visits with precise details, but quite enlightening summary with explanations regarding the contents. Undoubtedly a place to explore!"; "The [Science] Garden becomes important for addressing scientific concepts... first on a non-formal context and subsequently an approach in the classroom."; "I think it is an excellent way to stimulate and awaken (in a playful way) children to science."

Figure 4. Pre-service teacher exploring Speed the wheel

In the second question "As a professional of education register your comments and or suggestions about the session you have attended.", also all answers were positive, for instance: "It was very interesting because

experiencing SG allowed the kindergarten teacher to schedule a field trip." and "The session was very explicit and enlightening.".
The third question "After your participation in this session and considering the possibility of a future field trip to SG with children mark the degree of importance that you impute to" included the items presented in the following table (Table 2).

Figure 5. In-service teacher attending jardim.com/professors (garden.com/teachers)

The fourth question included the same items but with focus on the adequacy imputed by the inquired participants (Table 3).
The overall results of the questions 3 and 4 of "Questionnaire *garden.com/teachers*" suggest that this edition was considered: "Very important" by most of the inquired participants in all items; "Very adequate" by most of the inquired participants in all items. In general, the session was considered positive, taking into account its importance and adequacy to planning a future field trip to SG with children.

After your participation in this session and considering the possibility of a future field trip to SG with children mark the degree of importance that you impute to	**1**	**2**	**3**	**4**	**5**
(a) the booking of the visit system;	0	0	5,26	89,47	5,26
(b) the support given to the visit planning;	0	0	10,53	84,21	5,26
(c) customized activities offer to be carried out during the visit;	0	0	5,26	89,47	5,26
(d) the support given in linking science activities in formal (e.g. classroom) and non-formal settings (e.g. SG);	0	0	10,53	84,21	5,26
(e) the collection "Exploring Science Garden".	0	0	21,05	73,68	5,26

Subtitle: (1) Very little important/ no important; (2) Little important; (3) Important; (4) Very important; (5) No answers.

Table 2. Results (%) of the Question 3 of the online questionnaire

After your participation in this session and considering the possibility of a future field trip to SG with children mark the degree of adequacy that you impute to	**1**	**2**	**3**	**4**	**5**
(c) the booking of the visit system;	0	0	26,32	68,42	5,26
(d) the support given to the visit planning;	0	0	26,32	68,42	5,26
(c) customized activities offer to be carried out during the visit;	0	0	26,32	68,42	5,26
(d) the support given in linking science activities in formal (e.g. classroom) and non-formal settings (e.g. SG);	0	0	10,53	84,21	5,26
(e) the collection "Exploring Science Garden".	0	0	31,58	63,16	5,26

Subtitle: (1) Very little important/ no important; (2) Little important; (3) Important; (4) Very important; (5) No answers.

Table 3. Results (%) of the Question 4 of the online questionnaire

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5. Conclusion

As shown, SG is giving evidence of its contribution to support education and dissemination of science and technology among young visitors, research in science education and pre-service and in-service teacher education. Still, there is much to do in order to reinforce the investment in these strands that make SG unique. Overall, SG intends to continue promoting the articulation between school and non-formal science education contexts.

6. Acknowledgments

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HoloNet: Hands-on Holography

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Abstract. *Holography is an experimental technique based on optics and photonics [1]. It involves different topics on physics, such as waves, interference and diffraction. These subjects are include in the curricula of formal education.*

We believe that holography can be an important strategy, for science education and outreach programs, based on hands-on activities and problem solving [2]. Holograms can be a contextualise way to promote scientific culture and technology.

In this sense, we have developed the HoloNet project [3], which is dedicated to experimental teaching of physics and science communication. This project involves a framework with two main purposes: scholar teaching and public engagement with science.

At the scholar level we have imple-mented holography labs at 30 Schools in Portugal, involving middle and second-dary students and teachers. This network is working on holography producing different types of holograms. Students can construct reflexion holograms [4], transmission holograms [5], pseudo color holograms, scratch holograms, computer generated holo-grams and holographic interferometry. During the scholar year an outreach program is implemented at schools with teachers' training and workshops for students. During these sessions, students and teachers work on different optics procedures [6], such as: tabletop setups, laser light safety, alignment, spatial filtering, beam expander, illumination setups, preparations of chemical solutions for development of holograms and chemical processing of holograms. Typically, a group of students works during a year on a holography project. At the end of the year they present their results to the scholar community and they also participate at a national context for young scientists.

At the general public level, we have implemented holography labs at 7 Science Centres in Portugal, involving training workshops and science communication programs. The training workshops are focus on explainers taking into account the context of each Science Centre. The science communication programs are dedicated to the general public and families, and they involves tree types of activities: 3D holograms, scratch holograms and "Holographer for one day". The 3D holograms activity is dedicated to the general public and it deals with laser light and production of reflection holograms or pseudo color holograms. The scratch holograms activity is dedicated to the young public and it deals with simple materials and non laser light. This technique allows the production of simple planar images. "Holographer for one day" is an activity dedicated to families and it has the goal to put a person in the position of a scientist (holographer). The "holographers" needs to do some problem solving and critical thinking to assemble the experimental setup in order to produce 3D laser holograms.

All activities developed and implemented at Schools or Science Centres use two types of holographic systems. The advanced holographic system with better equipments and materials which allows the production of

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different type of holograms and bigger holograms. And the portable holographic system which allows the production of smaller reflection holograms. The advanced system is based on 20 mW He-Ne laser, spatial filter, first surface mirrors, beam splitter and breadboard optical table. The portable system is based on 5 mW semiconductor laser with lens and metal base.

During the last years, we have developed outdoor activities dedicated to general public and schools. These activities have the goal to popularize holography as a state of the art technique for 3D imaging. These activities involve one hologram exhibition for a Science Centre at Cape Verde and one holography interactive exhibition dedicated to shopping centres and schools.

This paper will present in detail all equipments, materials and setups used on experimental holography. The educational program, activities and contents will be explore and discuss. All results obtained will be present and analyse. Exhibitions and different holograms produced will be present and final conclusions will be drawn.

Keywords. Science outreach, science communication, physics education, optics, holography.

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Advanced Courses: A Novel Strategy in the Teaching of Advanced Science Concepts to High School Students and Teachers

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Abstract. *The Instituto de Educação e Cidadania (IEC) is an institution that works closely with schools, the municipality, research institutes and the universities of Coimbra and Aveiro. The IEC is an interface to facilitate the interaction between these institutions. The IEC developed an advanced studies program for schools including practical courses in the sciences, seminars, and promotes the organization of Science clubs in schools. The advanced courses are taught by young scientists from research institutes and facilitate the transfer to schools of advanced concepts and experimental approaches. The IEC is mobilizing the community around schools in the Bairrada Region, in Portugal.*

Keywords. Experimental science, advanced courses, engagement in science, non-formal education.

1. Introduction

The teaching of Science at Portuguese schools includes little contact with experimental work, and the principal concepts taught are seldom illustrated in the laboratory. Nevertheless, the best students which go in to higher education are able to frequently be very successful, and in the last twenty years the Portuguese scientific community has grown both in dimension and quality. This does not mean that students would not benefit from being introduced early to more serious experimental work, at least during high school years [1].

We have developed a strategy that allows the more ambitious high school students and teachers to take advanced courses with a large emphasis on experimental work. These courses are run both at our institute, IEC, located geographically between the universities of Coimbra and Aveiro and near the biotechnology institute, Biocant in Cantanhede. All these institutions have excellent outreach programs that allow students to be in contact with research and laboratories at universities, and frequently scientist from these institutions visit schools [2]. Furthermore, there is a national program designated Ciência Viva which promotes the interaction between scientist, schools and populations through Science centres in various parts of the country [3]. This effort to make Science popular has been very effective in introducing the language of Science outside the universities. However our perception is that these programs have not been very effective in overcoming the deficient understanding of scientific concepts by school students, because there is not a continuous intervention in schools, since most programs intervene in schools only sporadically [4].

The IEC was created seven years ago in collaboration with the municipality of Oliveira do Bairro, and benefits from protocols with universities and research institutes from Coimbra and Aveiro. The IEC has excellent laboratory facilities and is otherwise well equipped for the teaching of Science (Fig. 1). During the last seven years, the institute has signed agreements with nine schools of the Region of Bairrada which have permitted the teaching of Science to high school students and teachers both at IEC and schools by highly qualified researchers. The courses are taught by young successful scientist from research institutes under optimized conditions in which the students have access to modern laboratories both at our institute and in the high schools which are able to provide sufficiently well-equipped laboratories (Fig. 2).

Figure 1. Laboratory at IEC

Figure 2. Molecular Biology course at IEC

The courses we teach cover a wide range of disciplines, such as Molecular Biology, Neurosciences, Biotechnology, Microbiology, Physics and Chemistry, among others. Each course is run for ten weeks, three hours per week, and accepts ten high school students and two teachers who are willing to participate in experimental work side by side with the students.
In this paper we present: 1) the concept of our program for high schools designated "Advanced studies"; 2) we also present a first evaluation effort of our strategy in teaching advanced concepts to students and teachers; 3) our perception of the response of the schools to the program.; 4) integration of the project in the community linking universities, schools, the municipality and organizations, such as parents associations.

2. The concept of advanced studies

We have developed the concept of "advanced studies" for schools. This concept includes: 1) advanced courses taught by young scientists to high school students and teachers; 2) regular seminars and symposia both at the IEC and at the schools also given by scientists; 3) the organization of Science clubs at the schools where courses and seminars take place; 4) Science exhibits; 5) visits to research institutes and universities; 6) meeting of the students with young successful scientists.
These six activities, courses, lectures, science clubs, visits to Science institutes, science exhibits and meetings with young scientists are coordinated in such a way that the whole school benefits from these Science related activities. Thus, at the beginning of each trimester, one week before each course begins, a lecture is given

by a distinguished scientists to present the subject matter that will be covered in the course. This lecture is open to all students, teachers and to the parents associations. All are encouraged to attend this lecture which becomes a big event at the school. Well known members of the community, such as the mayor, and other local representatives are invited for the event, which is publicised in the local newspaper.

The concept of advanced courses, as applied in this scenario, does not necessarily mean that the courses include cutting edge knowledge. The concept of advanced courses means that well-defined concepts presented to the students and teachers go beyond what is expected for their school age or background that both students and teachers may have. Nevertheless, we found that these concepts can be perfectly well understood by both students and teachers, especially if they are subsequently introduced in laboratory work to cement their understanding of the concepts presented in the theoretical lectures. We found that challenging the students with advanced concepts motivates them highly and promotes their interest in science. This is in fact a program to propel schools forward toward higher excellence.

3. Evaluation of our strategy in teaching advanced concepts

During the last five years, more than 800 students and teachers have taken our advanced courses in Biology, Biotechnology, Neuroscience, Chemistry and other Science courses. Invariably, the students that register for the courses complete them with success. We have measured the success of the courses in two ways, by an anonymous process. This process involves: 1) asking the students at the end of each course to evaluate the quality of the courses and of the teaching staff by responding anonymously to a questionnaire; 2) testing the effective acquisition of knowledge by the students during the course by giving them a multiple choice test at the beginning of the course, before the teaching of the Science concepts, and at the end of the course, ten weeks later. In both cases, the responses are given anonymously, and the general results indicate that the students grade very highly the courses and the teaching, frequently giving marks of 9 in 10 (Fig. 3). Our information about the knowledge acquisition by the students in the course is less precise because we have not yet stored a sufficient number of responses, since we started this process much later. However, it is already obvious, from the limited responses, that the students acquired and understanding of the principal concepts that are taught.

4. Response of schools to the program

The IEC has created partnerships with nine schools in the nearby municipalities. We first presented our project to schools and invited the students and teachers to apply to take the courses at IEC with the prospect that the courses would eventually be given at the schools if that proved to be useful from the point of view of the schools. The admission procedure to recruit students and teachers for the courses requires that each student or teacher specify in writing his interest in taking the course.

It was made clear that the new Science courses would be organized according to a

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philosophy different from that of the normal procedure of teaching at schools and that there would be no interference with the daily course of work of the school, since the courses are given at schools after regular school hours during the week, and at IEC are offered on Saturdays.

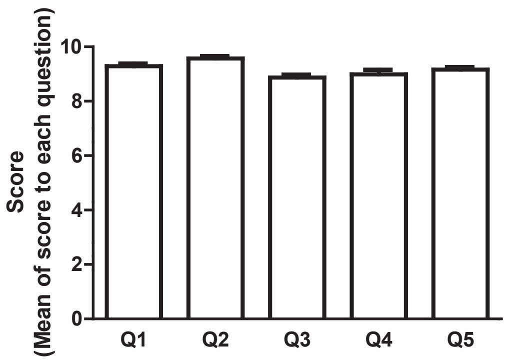

Figure 3. Student's evaluation of the quality of advanced courses and of the teaching staff. Question 1 – General quality of the course; Question 2 – Teacher competencies; Question 3 – Utility of the theoretical component of the course; Question 4 – Utility of the practical component of the course; Question 5 – Global appreciation of the course. Mean ± S.E.M of n=25 independent courses

Concurrently, the school took the responsibility, with the help of IEC, modernizing their laboratories so that the courses could be given at the schools, under optimized conditions, by young scientists recruited by IEC. Each course admitted only 10 students and two teachers. Invariably, the courses were a success and were praised by both students and teachers who took the courses.

It took about one year to each school to become convinced of the value of the program on the basis of observed results obtained by students and teachers that first took the courses at the IEC laboratories on Saturdays. This long procedure was very useful to generate confidence on the program on the side of the school. It was also very useful to generate a friendly atmosphere between the staff of IEC and school official teachers and students. We now have accomplished this close and fruitfully relationship with nine different schools, and six of them have already created laboratory facilities so that now many of the courses have giving at the schools.

5. Linking schools to universities, research institutes and the community

The project involves schools, the municipality, parents associations, research institutes and the universities. In addition, links have been created with other organizations such as theatre groups, museums, Science centres, in addition to mobilization of the general public to conferences and other events regularly organized at the IEC accessible to the public.
The fact that IEC is located relatively near the universities of Coimbra and Aveiro and near Biocant, a biotechnology institute in Cantanhede, facilitates the interaction of the IEC with higher education institutions and research centres. On the other hand IEC has established close links with nine schools and has facilitated the transfer of knowledge and competences to these schools.

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The long range objective of the project is to mobilize the whole community around schools to break the isolation of schools from the community and from other institutions from which schools could benefit in becoming more versatile in dealing with the great challenges in Education now and in the future. It is essential that the various elements of the community interact more with schools and exert their influence on the changing process of education for future success.
The IEC, in addition to promoting a dynamic process that enriches the education system, is collaborating with schools in promoting a higher autonomy of the schools from the Minister of Education, so that each school can also become more responsible as an institution. Thus, a study group at the institute is setting the stage to organize a Regional Council to assume the coordination of the school system in the Region of Bairrada and to request a larger autonomy from the central system of education.

6. Conclusions

The teaching of advanced concepts of Science to the most motivated high school students, by young successful scientists, has proven to be highly rewarding to both students and scientists. The students soon realize that they can understand the approach of scientists to Science and how scientific knowledge progresses. For the young scientists, teaching of Science to highly motivated bright high school students, engages them in a relationship of proximity to students, and vice-versa, which usually is not possible at the universities, because of the large number of students in each class with heterogeneous backgrounds and motivations.
We have developed a program of teaching Science designated “Advanced Studies” which embodies ten week advanced Science courses, three hours per week, with emphasis on experimental work, regular conferences at IEC and at the schools, symposia in the school libraries, organization of Science clubs with the participation of students, teachers and researchers, and the involvement of parent associations in promoting some of these activities. The concept of Advanced Studies applies to the overall of these activities with the involvement of schools and the general community, including research centers, and signifies a body of activities with high standard requirements which go way beyond what is expected at the high school level. This is in fact a program to propel schools forward toward higher excellence, and to offer continuous challenges to the most interested students who normally tend to become less interested in the absence of challenge.
The strategy developed at the IEC to make Science more relevant at schools is to challenge schools, teachers and students with a very attractive offer of making available, free of charge, ten week experimental courses, three hours per week, taught by successful scientists affiliated with the research centers and the nearby universities of Coimbra and Aveiro. The IEC established informal agreements with the research centers and with nine schools of the Bairrada Region to launch the project which is now seven years old. Over 800 students have taken the courses which include, among others courses in Physics, Chemistry, Biology, Microbiology, Neuro-

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science, Biotechnology, Biomedicine, Ecotoxicology, Applied Mathematics, Social Sciences. Each course accepts ten students and two high school teachers who are willing to learn in the laboratory side by side with the students. The success rate is nearly 100%, since very few students or teachers drop out or fail to master the main principles of Science taught.

The IEC is mobilizing the community to create a new concept of parent associations. In Portugal, does not exist the concept of Parents Teachers Association (PTA). We are now bringing together the teachers and the young scientists who participated in the program and the parents of the students who took the advanced courses to create a PTA with office in the IEC. There is also a movement among students to organize an *Alumini*.

The next step is to organize a Regional Education Council of the Bairrada Region, recognized the Ministry of Education, that will assume greater regional responsibility in Education, including more autonomy for schools so that part to the school curriculum and the hiring of teachers on the basis of merit would be regional responsibilities.

7. Acknowledgements

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MicroBio 12: from the Lab to the Classroom

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Abstract. *The project microBIO 12 – from the lab to the classroom, funded by Ciência Viva in the context of the program Escolher Ciência, aims to promote learning of biology-related issues, through the implementation of experimental activities in high school.*
Topics addressed in the course of this project include antibiotics use, antibiotics resistance and sunlight exposure habits. In the activities proposed, students perform basic microbiology procedures; interpret and discuss experimental outcomes; develop scientific knowledge and creativity skills; strengthen the ability to understand and position themselves critically with regard to the topics discussed; and become familiar with a number of useful concepts for their academic and personal life.
It is expected that these activities may foster other hands-on science initiatives.

Keywords. Experimental activities, high school, microbiology, science education.

1. Introduction

Practical work, in particular in its laboratory component, is a hallmark of scientific research and education. Specifically in science education, laboratory work has been valued because of its contribution to learning and student motivation [1]. The role of laboratory work in this context has been examined by numerous authors [2] and this active and learner-centered teaching strategy has been recommended in international documents, as well as in the Portuguese 12th year grade biology program (17-18 years old) [3].
The educational goals of laboratory activities are diverse and include: promoting learning of scientific concepts; developing procedural skills; developing objectivity, critical thinking and scientific reasoning; and fostering interest in science [4]. It is globally recognized that laboratory work, when properly contextualized within curricular topics that students perceive as relevant, enables the application of knowledge in real situations and mediates the development of scientific literacy [2, 5]. Additionally, it appears that this teaching/ learning strategy is usually appreciated both by teachers and students, which underlines its motivating character in the learning process [1, 5].
Thus, the implementation of laboratory activities at secondary school levels should enhance students' interest in scientific topics, as well as their critical thinking regarding science-related issues in which the society is called to intervene.
The establishment of partnerships between secondary and higher education institutions allows to narrow the gap between distinct contexts, facilitating the exchange of skills and resources necessary to the success of implemented activities.

2. Learning Objectives

The main objectives of this project are to promote the development of students'

scientific knowledge, reasoning ability, procedural skills and motivation towards laboratory practice and scientific research in biology.
In addition to these objectives, the project aims to ensure that students develop the following competencies:

- Understanding of basic principles associated with microbiology, bioinformatics, evolution, cell biology and biotechnological applications, among others;
- Ability to gather information to support the assumptions made;
- Ability to make predictions based on scientifically-based information;
- Ability to master laboratory techniques and the use of bioinformatics tools used in research;
- Understanding that individual decisions have influence on the success of scientific and technological applications;
- Understanding the importance of making informed decisions about issues affecting individual and public health.

3. The project

This project includes the implementation of two *wet lab* and one *dry lab* activity.
All activities were designed to ensure the alignment between educational goals, methodologies, skills to be developed and evaluation procedures, which is considered a prerequisite for the effectiveness of any educational intervention.
The activities have been carefully planned to meet the adequate 12th grade biology syllabus and to be implemented in a formal context.
To fully achieve the goals proposed, and to harmonize as much as possible the implementation of the activities among the different participant schools, a comprehensive set of supporting materials were provided:

- Introductory presentations – providing a selection of the most relevant topics and questions for discussion related to the contents studied, to be explored by the teachers with their students;
- Scripts with proposals for topics to be discussed with the students, to prompt the reflection upon issues raised;
- Teacher protocol, presenting the topic and purpose of the activity, description of the main tasks, list of materials and equipment needed, detailed procedural instructions (including sterilization of materials and maintenance of biosafety), additional information on processes under study and expected results;
- Student protocol, stating the purpose of the activity, and providing practical and procedural instructions; and A selection of proposed topics for discussion with students,including methodological and conceptual aspects to consider.

3.1. The Bactericidal Effect of Sunlight

An activity aiming to help students assess and understand the lethal effect of sunlight on bacteria cells [6].

- Learning Objectives
i) demonstrate the bactericidal effect of sunlight; ii) discuss the impact of ultraviolet

radiation on living cells; iii) learn and practice microbiology procedures; and iv) interpret and discuss experimental outcomes resulting from qualitative observations.

- Curricular Framing

The activity is framed within the Portuguese 12 th year grade biology program: second thematic unit "Genetic heritage" [3].

3.2. Natural Antibiotics: Garlic's Antibiotic Properties

In this activity, students investigate the existence of bioactive compounds with antibiotic potential in garlic extracts (or other plants commonly used for culinary and/or therapeutic purposes), by carrying out microbiological tests based on the diffusion method in solid medium [7].

- Learning Objectives

i) demonstrate the existence of phyto-antimicrobials; ii) understand the concepts of antibiotics, antibiotic susceptibility and biosafety; iii) learn and practice microbiology procedures; and iv) interpret and discuss experimental outcomes.

- Curricular Framing

This activity is framed within the Portuguese 12 th year grade biology program: third thematic unit "Immunity and disease control" [3].

3.3. A bioinformatics approach to the evolution of antibiotic resistance

Students perform evolutionary analyses of genes involved in antibiotic production and resistance, by exploring the National Center for Biotechnology Information (NCBI) databases and using two bioinformatics tools: the Basic Local Alignment Search Tool (BLAST).

- Learning Objectives

i) verify that antibiotic resistance is more widespread than antibiotic production; ii) verify that antibiotic resistance genes can be transmitted between different bacteria through horizontal gene transfer (same generation), in addition to vertical gene transfer (across generations); iii) learn to use bioinformatics tools to perform evolutionary analyses; and iv) discuss outcomes resulting from qualitative observations.

- Curricular Framing:

The activity can be framed within the Portuguese 12th year grade biology program: third and fifth thematic units, "Immunity and disease control" and "Preserve and recover the environment" [3].

The protocols used in these activities are available from http://microbiodoze.wordpress.com/.

Figure 1. Educational resource developed to promote microBIO 12 project

This website is another resource resulting from this project, which, in the future, will

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allow to make the activities available to the whole school community.

4. Assessment

All activities have been optimized to ensure their feasibility in school settings and will undergo a continuous validation process to enhance their educational effectiveness.

The project comprises an assessment component aimed at evaluating the impact of the activities implement regarding student's interest and learning at conceptual and procedural levels, based on quantitative and qualitative methodologies previously tested in formal and informal context [8, 9].

5. Acknowledgements

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Visiting Science Museums

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Abstract. *To improve science and chemistry learning in our society it is necessary to think about different educational approaches. In this sense, visiting a science museum nearby is also an excellent opportunity for primary school students and secondary school students as well as their families. There are two museums we have successfully worked with in the past to the benefit of secondary school students. The Museum of the History of Pharmacy at the University of Barcelona located inside the Faculty of Pharmacy and the Barcelona Perfume Museum. It is important that young students comprehend that drugs, medicines, perfumes and scents are chemicals. Visits to a science museum are usually preceded by preparatory work in the classroom, imparted by science secondary school teachers. To make the students do some preliminary work on the subject by Internet at home is also discussed in this work.*

Keywords. Medicines, perfumes, science, secondary school.

1. Introduction

Science museums represent a new approach to bring science closer to society. They are based on scientific objectivity, the teaching of science, the popularization of science, and the geography of science. In the same way, the Museum of Pharmacy [1] and the Museum of Perfume [2] are used to improve secondary school student's understanding chemistry.

(This text was found on the backside of the menu in a café in Bratislava.)

"*Scientists began to study why the number of Heart attacks is much lower in the Mediterranean region (France, Italy) in comparison to several countries of Northern Europe (England, Scotland) a few years ago. The answer to the French paradox was relatively simple. The French and the Italian drink at least one glass of red wine for lunch and dinner. Chemical analysis of red wine showed that it contains a powerful antioxidant called resveratrol, and it is known that antioxidants (which include some vitamins and trace elements) protect blood vessels from hardening-Atherosclerosis. Drinking a glass of good quality red, as well as white-or pink-wine, in good company, however, has another positive effect, which is the protection against stress. Protection from stress by drinking wine is to be taken wisely. Rational diet and plenty of exercise are other ways to prevent heart and vascular diseases.*
Prof. Oliver Rácz
(Biochemist)"

These are examples of how science museums and a text found in a café menu can contribute to increase people's understanding chemistry and science.
To encourage the interest in chemistry among Catalan secondary school students [3 and 4 for reviewing the Catalan and Spanish secondary school curriculum in chemistry] we have prepared some activities

developed into science museums.
All these actions are preliminary prepared by secondary school students by Internet at home and, in addition, into chemistry classroom. Finally, students have to finish them into the museums answering some questions.
Activities in the Museum of Pharmacy and the Museum of perfume are focused on helping young students [5] to get better their chemistry knowledge.

1.1. The History of Pharmacy

Pharmacy [6] is a word of Greek origin that means drug, poison and toxins. Pharmacy is the science and practice of preparing, preserving, presenting and dispensing medicines. This is the current concept which has been forgotten over time.
The use of substances found by man for therapeutic purposes is very old. The history of pharmacy [7] attempts to collect the advances and discoveries from this science discipline. In ancient days science was inseparable from religion, as well as pharmacy and medicine. Written proof of the composition of formulas, preparation methods and properties has been found in ancient Mesopotamia, ancient Egypt as well as in the pre-Columbian world and other ancient Empires.
Some of these pharmaceutical operations such as drying, filtration, decantation, maceration, digestion, boiling, etc. made their ‘medicines’ truly effective.
During the medieval age the only important advances in science were made in the Arab world where alchemy, a practice combining the elements of chemistry, metallurgy, physics, medicine, astrology, mysticism, spiritualism and art, was predominant. Arab doctors and philosophers also translated and extended Greek and Roman science knowledge.
As a final point, tradition, ignorance and superstition were identified and forever separated from science, in the Age of Enlightenment also known as the century of reason. In the 18th century, the number of pharmaceutical discoveries increased greatly and led to an important progress in the area of pharmacy.
Some of the most relevant figures were Edward Jenner (1749-1823), who invented the first vaccine against smallpox in 1796, who is also called “the father of immunology” [8] and Antoine Lavoisier (1743-1794), who is also called ‘the father of Modern Chemistry’ and endowed chemistry with a new nomenclature [9].
Thereafter, pharmacy continued growing in the past centuries. The last important step in this scientific branch was the change of the practitioners name from apothecary to pharmacist which was due to a different teaching plan at the universities in the 19th century. And the old apothekas are now known as pharmacies.
An example to bring science and the history of Pharmacy to society could be The Museum of Pharmacy housed in Bratislava (Slovakia). The building, a pharmacy named “The Red Crayfish” dates back to the 14th century.
The museum itself shows the original pharmacy equipped with faience, stoneware, wood and china glass containers for storing medicines from the time period between the ends of the 17th century until the mid-20th century.
Figure 1 shows the door of the museum building and some containers from some of the oldest pharmacies.

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Figure 1

1.2. The History of Perfume

Perfume derived from the Latin word, "per fumus", meaning through smoke. The art of making perfumes (Perfumery), began in ancient Egypt but was developed and further refined by the Romans, the Persians and the Arabs [10].
The oldest perfumery that existed 4,000 years ago during the Bronze Age was discovered in Cyprus. In addition, The Bible describes a perfume which was only used by the priests.
In the Arab world, the alchemist Geber (or Jabir ibn Hayyan, 721-815) improved many techniques such as distillation, evaporation and filtration. This enabled the conversion of plant aromas into vapour and then into water or oil. Later the perfume industries started producing a variety of cosmetics and scent products.

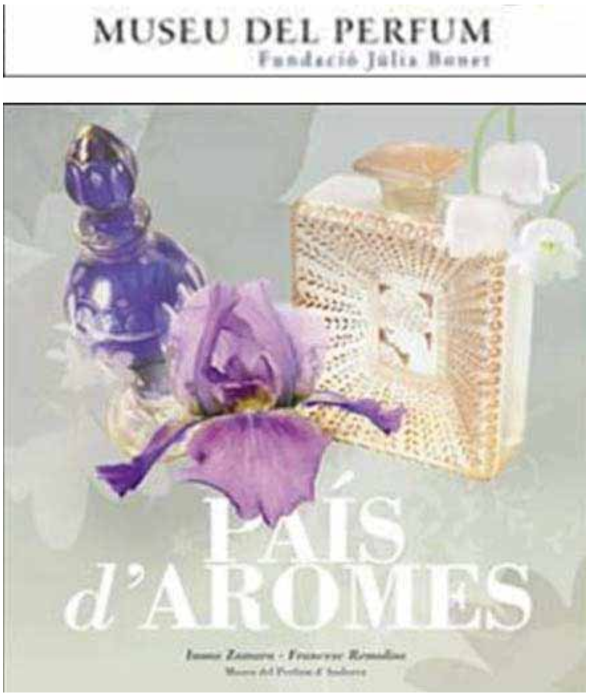

Figure 2

In the 14th century the promotion of flowers for their concentrated perfumes started in the south of France. And, finally, in the 17th century France became the European centre of perfumes and cosmetics and the federation of perfume-makers was also established.
An example to bring history of perfumes closer to society is the Museum of Perfume,

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Júlia Bonet Foundation in Andorra [11-12] which collects stories and feelings about as well as atmospheres of thousand essences.
This museum establishes a direct connection between the essences, scents, and the evolution of the history of perfume. It also shows an exposition of bottles and items associated to the art of perfumery during the 20th century (Figure 2 shows the museum logo and a book about “A country of essences”).
Now, we present the work done with our secondary school students, trying to improve their chemistry knowledge by visiting both the Museum of Pharmacy and the Museum of Perfume in Barcelona.

2. The museum of the History of Catalan Pharmacy

It was created in 1957 by Dr. Jesús Isamat. The museum was opened during the 1957-58 academic year in the University's Faculty of Pharmacy at the University of Barcelona. The museum, a place for teaching and for the diffusion of knowledge, had to install its showcases in the faculty's corridors and stairways; the museum is present on each of the faculty’s floor [1].
Glass containers already belonged to the equipment of the oldest pharmacies; the inert character of glass makes it a suitable material for all kind of pharmaceutical containers and wide range of laboratory equipment.
However, the transparency of the glass represented a great drawback in terms of quality of the preserved drugs. The negative effect of light on the stability of drugs was eliminated by using milk glass from the end of the 18th century on. Glass containers preserved syrups, liquid extracts, liquid chemicals and medicinal preparations with specific form.
Tin containers preserved oils, fragrant substances, resins, as well as dragon blood, medicinal honeys, narcotics, and semi-fluid medicinal preparations.
Wooden containers were used to preserve dried parts of plants, mixed herbal teas, resins, solid and powder minerals.

Figure 3. Chemical products and tools to prepare pills

3. The Museum of Perfume

The Museum of Perfume, Planas Giralt Foundation, inside “The Regia Perfumery” was opened in 1961 in Passeig de Gràcia Boulevard 39, Barcelona, Spain [2].
In order to explain the evolution of perfume bottles and glass containers through history and geography many containers from the Egyptians, the Greeks, the Etruscans, the Romans, the Arabs and other ancient civilisations are on display (Fig. 4). The museum's collection is made up of five thousand pieces of ancient and modern

perfume vessels, in addition to some miniatures, books and old advertising material.

Figure 4. At the top two areas and several shelves of the museum of Perfume, at the bottom, objects made in Corinth in the 5th century BC

4. Student's work

For preparing these activities, several questionnaires were arranged and sent to science teachers from secondary school who were teaching chemistry at different levels of secondary school students.
Two goups of questions were prepared. However, both questionnaires started with personal questions, name of students, sex, age, name of school,...,etc.

Working in groups is one of the most valuable strategies to promote students' autonomous learning [13]

4.1. Questions to prepare at home

- What is a medicine?
- What is a pharmaceutical drug? Give examples.
- Describe an oldest Pharmacy.
- When and how was the first perfume made?
- What is a perfume? Give some examples.

4.2. Questions to develop into the museum visit

Museum of Pharmacy:

- Find three active ingredients. What does an active principle consist of?
- Draw the apparatus to obtain pills.
- Describe chemical steps to obtain a medicine.
- Find three glass containers.
- Mention three historical objects donated by the Colegio de Sant Vitoria.
- What is the date on the oldest description of a pill maker?
- Draw several pharmaceutical instruments?
- When and how was the injectable filler made?

Museum of Perfumes:

- When and where has the habit of using perfumes begun?
- Describe the sense of smell

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- Make four statements about the chemical principles of perfumes.
- Find three glass bottles.
- Mention three flowers and their concentrated perfumes.
- Draw several perfume containers.
- Describe chemical steps to obtain a perfume.
- What are pheromones?

5. Results and discussion

Students considered these activities as a great experience because it helped them to obtain interesting and new knowledge about chemistry, pharmacy and perfumes.
Some sentences given by students that indicate their thinking are:

- "*I found many drugs in the museum and now, I know their (re)actions*"
- "*I have also smelt some good perfumes from some flowers*"
- "*I never thought how much could enjoy a museum day*"
- "*Chemistry = Museum and Museum = Chemistry*"

Furthermore, secondary school students and teachers from different Catalan areas can also visit other museums related with chemistry such as the Museum of Pharmacy in Cardedeu (Barcelona, Spain) created by Tomàs Balvey from the Balvey pharmacy, dating back to the year 1780. The museum is displaying its original furniture, pharmacy jars and tools for making and storing medicines.
In addition, the oldest Esteva pharmacy in Llivia (Girona, Spain) with special polychrome boxes and recipients, mortars and pharmaceutical library could be visited by secondary school students. Or in the next village you can probably visit science museums related with chemistry.
It is essential to incorporate elementary chemistry between young people. The final objective is that young students, our future society, can establish a connection, an motivating relationship between chemistry and many "ordinary" things which surround them in daily life [14-15].
This educational approach has contributed to reinforcing the presence, the interest and the study of chemistry in and out of the classroom.

6. Acknowledgments

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Reading Stimulus in Science Center Visits

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Abstract. *This study, developed at the Science Center Exploratório – Ciência Viva, aimed at observing, describing and verifying the visitors behaviour (in terms of learning) during a school group visit to a science exhibition in a non-formal learning environment, but also at testing the effectiveness of exhibit labels Reading Stimuli. To conduct this study, we selected two interactive exhibits in the exhibition "Keeping fit… with science". To achieve our objectives, a study was made (with students from the third cycle of basic education) based on questionnaires, observation grids and a Reading Stimuli as instruments of data collection. Despite the exploratory nature of these studies, results indicate that in response to the Stimuli tested, many visitors read the exhibit labels in the search for the answer.*
Visitor-based studies are intended to contribute to the improvement of the relationship between the school and the Center and to improve the quality of the visits to Exploratório – Ciência Viva.

Keywords. Hands-on activities and texts, museums and science centers, non-formal learning of science, reading stimuli, science communication.

1. Introduction

A Science Centre's (SC) dynamic environment contributes to the cumulative process of learning. Nowadays, in the knowledge and information society, this fact is growing more and more important, as we face new educational challenges. A central challenge lies on the connection of the multiplicity of ways, kinds, spaces and times learning occurs with the diversity of life experiences, knowledge and cultures and the constant social and economic changes. School is still a place for gathering and learning, where we acquire much of the knowledge and values we need to live in society, but SC are stating their place as didactic resources to formal education. In order to fully accomplish this synergy, it is mandatory that we understand the learning that occurs in a SC. This investigation area has grown in the last decades, but there is still a long way to fully unveil a SC´s full learning potential. The fact that each visitor enters the Center with different interests, prior knowledge and motivations makes it difficult for researchers to assess learning using traditional quantitative and descriptive-based approaches (pre- and pos-test designs). Few international data exists regarding this theme and we found no validated instruments to evaluate learning and reading comprehension in this environment.

1.1. Study

This study, conducted in the framework of a Master's degree course in Science Education, branch Education and the Knowledge Society [1] was developed at Exploratório – Ciência Viva.
To conduct this study, we selected two

exhibits: Atero & Artero (Figure 1) and UV box (Figure 2).
The exhibit Atero & Artero (Figure 1) allows visitors to explore the occurring of blood flow (speed) changes in arteries and other blood vessels caused by a progressive hardening of the artery walls – Arteriosclerosis – or by artery walls changing due to cholesterol deposits – Atherosclerosis.

Figure 1. Exhibit "*Atero & Artero*"

The exhibit UV box (Figure 2) allows visitors to explore UV light (excitation) effect on materials and to observe the resulting phenomena of luminescence and in particular fluorescence.
These exhibits were selected given that:

- One of the exhibits (UV box) relates to the school curricula and the other (*Atero & Artero*) does not;
- The researcher could simultaneously observe both, not interfering.

We conducted this study with 78 students from the 8th grade of basic education, in school group visits to the Center.

Immediately before the free part of the visit (that lasts 30 minutes after 1 hour guided visit), each student was given a piece of paper with an incomplete sentence. The students knew that in order to complete the sentence, they could read the exhibit labels. These were the Reading Stimuli. There were six different Reading Stimuli (Table 1) (three related to each of the exhibits in study).

Figure 2. Exhibit "UV box"

The use of Reading Stimuli (a practice already tested at Exploratório [2]) is in line with the cognitive psychology principles, as they stimulate and guide the visitor.
Immediately after the visit (one and a half hour after the beginning of the visit), the students were given a Test, with six multiple choice questions. Each of these questions was adapted from one of the six Reading Stimuli.
The student's interaction with the exhibits in study was observed during the free part of the visit. The results were registered in observation grids.

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1.2. Results

During the free part of the visit, several visitors read the exhibit labels. These visitors seemed to be looking for the answer to the Reading Stimuli.
For each of the six different Reading Stimuli, we statistically analyzed [1, 3] the average Stimuli and Test results:

- For each different Stimuli.
- For students who did not take the Stimuli but took a Stimuli about the same exhibit.
- For students who did not take the Stimuli and took a Stimuli about the other exhibit.

1. Exploring the exhibit Atero & Artero, we can compare the blood flow of a person with __________ or __________.
2. Exploring the exhibit Atero & Artero, we can verify that the arteries of an individual with Atherosclerosis are __________________.
3. Exploring the exhibit Atero & Artero, we find information about arterial aneurisms, __________________ that may be caused by ________________________.
4. Exploring the exhibit UV box, we can verify that UV light effects on materials is __________ than normal light effects, and can be __________ by the use of sunscreen.
5. Exploring the exhibit UV box, we discover that sun light exposure causes skin reactions that lead to __________, contributes to the synthesis of __________ and is essential to the absorption of __________ by the intestine.
6. Exploring the exhibit UV box, we can test the validity of bank notes by exposing them to UV light, in order to test the ___________of determined figures.

Table 1. Reading Stimuli

Preliminary results, which are still being analysed, elucidate on the effectiveness of the Reading Stimulus.The students who took these Stimuli may have been learning during the visit.

2. Conclusion

This study aimed at the evaluation of the visits, but also at making a modest contribution to measure the cumulative and complementary influence of both in- and out-of school Science learning, as one of the exhibits studied directly relates to the school curricula and the other does not.
Although these results can not be generalized, they point to the effectiveness of these Stimuli in school group visits to the Center. As several researchers [4,5,6,8,9] we would argue for the need of continuous investigations on this area, in order to unlock the full potential of visitor studies and for the use of different approaches, maybe even epidemiologic approaches [4].
Finding the balance between formal and non-formal education is not an easy task [8, 9]. As Caldeira [7] states: “Dedication and good will are not enough: the task is hard and demands deep knowledge, investigation and constant evaluation”.

3. Acknowledgements

We would like to acknowledge the students and teachers who made this study possible, the Direction of Exploratório and all the staff.

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PmatE – 25 Years at the Forefront of Education

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Abstract. *"Projecto Matemática Ensino" (PmatE) was created in 1989, by the Department of Mathematics of the University of Aveiro. Bearing in mind the weak outcomes in Mathematics, PmatE introduced new methods for the study of this scientific area, namely online games and competitions for all degrees of education. These competitions and games were recently extended to other scientific areas. In order to accomplish the goals initially projected, PmatE developed specific software, the Question Generator Models (QGM). This software is the basis of all computer games and competitions that take place, each year, among Portuguese students through the projects' online platform.*

Keywords. Competition, education, question generator models, science.

1. Introduction

The majority of people consider that playing games is a funny activity, in opposition to learning, a "boring" activity. Moreover, the "thrill of victory and agony of defeat" is experienced repeatedly throughout playing games, maybe because the immediate mental stimulation that the game player experiences can be exhilarating [7]. So, the fun and mental stimulation of games can be used as an important component in formal and informal education. Educational games are seen as technologies that have an application beyond entertainment [11] and are a good example of activities that can be used as a learning device to complement other teaching methods and to assist teachers in a daily basis [1].

In what concerns science education several authors agreed on the use of games as a motivating activity, which is clear in the sentence "*gaming in the science classroom has the potential to deeply engage students*" [4]. As a result, educational games can act as an extension of the classroom, helping students, who don't succeed with conventional teaching methods, and providing interesting methods that these students are already familiarized with. When students are playing, their goal is to win the game, which is a very motivating feature that acts as a motivation to the continuation of gaming. On the other hand, these games involve the player in the task, contributing to increased creativity and critical thinking, abilities that are increasingly important for everyday life [5].

2. PmatE

PmatE is an R&D project that arose in the University of Aveiro in 1989. Its main purpose was to create and/or to increase the interest for Mathematics, through the promotion of computer literacy and study habits. Initially projected only to Mathematics, this project has been extended to other scientific areas, such as Portuguese, Biology, Geology, Physics and recently to Financial Education and Chemistry.

With this objective in mind, PmatE prepared computer software to support learning, teaching and evaluation [2]. This software is also used as computer games and competitions that can be freely accessed on the Internet.

Each year, the games and competitions gather about 15,000 students in the University of Aveiro from all over the country. The best teams and schools are awarded according to the rules of the competition.

The games and competitions are based on a specific software developed for this purpose, the question generator models (QGM).

3. QGM and PmatE's competitions

A QGM is a question generator that follows a classification combining scientific and educational learning objectives and difficulty levels. The concept of QGM contains two very important features: flexibility and modularity. Additionally, the main attribute of a QGM is its high randomness, which allows several outcomes within the same QGM. Thereby, the questions in consecutive games are always different but maintain the same difficulty level and learning targets. Consequently, two players that are side by side will have different games, but with the same difficulty level.

An accomplishment of a QGM will result in an enunciation which is always composed of a common text and a set of four propositions taken at random from k, with $k \geq 4$, where k is the total number of groups of propositions (R1, R2, R3, R4…). When a QGM has more than four groups of propositions, in the moment of its accomplishment, only four of them are randomly selected.

QGM also contains a system that allows wider dynamism to the propositions presented and, as a consequence, it stimulates the level of concentration of the students, since the students never know how many of the propositions will be true or false. Thus students must be aware of all propositions since all may be true or false.

The complete preparation of a QGM involves several stages. First, it's necessary to write down all the possibilities (text and propositions) that will constitute the QGM and classify each answer (R1, R2, R3, R4 …) by scientific and pedagogical objectives that will be highlighted each time the QGM is used in a game. In this stage it's also necessary to transcribe all of this information to a LATEX file (fig.1).

Fig. 1 shows a portion of a QGM that belongs to the scientific area of Geosciences. This QGM is dedicated to the study of faults and folds and has four groups of propositions, however this picture only represents two of them (R2 and R3). The first column indicates the group of propositions, the second one shows all propositions possible for that group and the third indicates the conditions in which a certain proposition becomes true (symbols: "$\otimes$" – and; "$\oplus$" – or). These conditions depend on the parameters, the signs and the expressions generated. This step is known as the propositions' validation.

After the validation process follows the attribution of an identification code according to scientific area, theme, sub-theme, main and secondary objectives, cycle of instruction (1 to 5, being 1 the first cycle of Portuguese Basic Instruction and 5 the University) and difficulty level (1-very easy, to 5-very difficult). At this point it's also indicated the type of QGM that was elaborated and, if necessary, any additional information. The final step is the evaluation process, to assure the QGM's scientific and educational quality. At this point, QGM are ready to use and to be included in the games.

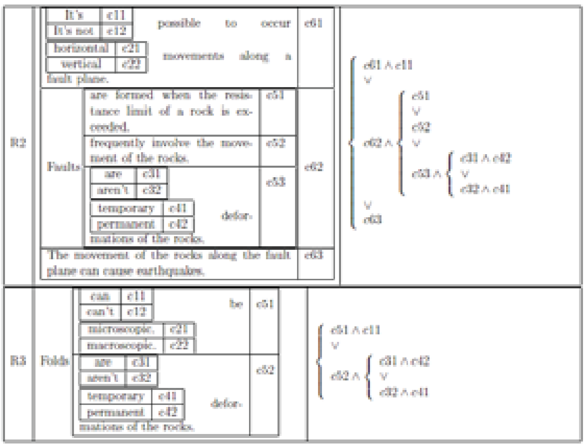

Figure 1. Portion of the LATEX file from the QGM "Faults and Folds"

It's also important to point out that there are different types of QGM, which is related, in some cases, to the existence of pictures side by side with the initial text and, in others, to the existence of pictures accompanying the propositions.

In the competitions, QGM are organized by levels of difficulty. Each level can be formed by one or several QGM. If a certain level has more than one QGM, one of them will be randomly selected each time a student starts to play. The randomness allows players to visualize different propositions and QGM every time they start a new game.

The QGM presented here (fig. 2) is dedicated to the study of faults and folds and has a difficulty level of 3. The main purpose of this QGM is that students identify geological structures such as faults and folds. Besides that, its propositions also focus on the formation of such structures and their relationship with the forces that act on Earth.

This QGM has an initial text followed by a picture. This is a type of QGM where the picture influences the validation of certain propositions. Thereby, in those cases, the player has to make an association between the proposition and the picture, what appeals to their concentration during this particular level.

Figure 2. Example of one accomplishment for the QGM "Faults and Folds"

In this example, players must mark true answers (numbers 2 and 3) and false answers (numbers 1 and 4). Only this validation will allow transition to the next level of the game [9, 10].

The next QGM (fig. 3) has a different aspect, once it has pictures in all answers, but it also has a difficulty level of 3. In this particular QGM, in each answer, players must relate each proposition to a picture and analyse the whole proposition plus image set. In this

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example, players must signalize true answers (numbers 2, 3 and 4) and false answers (number 1) and only this validation will allow transition to the next level of the game. The main purpose of this QGM is to recognize the parts of a volcano, the manifestations of secondary volcanism and the areas of intense volcanic activity. It's also intended that players distinguish lava from magma and the types of volcanic activity. Finally, in some accomplishments, players will have to recognize some materials that people should have available in areas of intense volcanic activity.

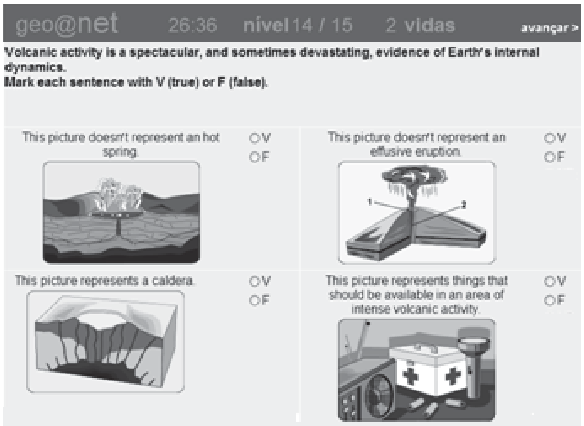

Figure 3. Example of an accomplishment from QGM "Study of Volcanism"

QGM can only be accessed using PmatE's Platform of Assisted Learning (PEA) that anyone can use freely after registering (http://pmate.ua.pt).

PEA "*is based on a learning philosophy by evaluation and it complements both the manual and classroom, never substituting or diminishing the important role that the professor has in traditional education*" [3].

In order to register in PEA users have to choose the most adequate profile (student or teacher) first, before they can access the different games, organized by scientific areas.

During each competition, the challenge is very simple: players must overcome all levels in the shortest time possible, correctly answering to all the questions in the screen. To do so, each player has two "lives" per level and questions are never repeated [2]. Every year, all competitions begin with practice games. Their main purpose is to prepare players for the competitions held at the University of Aveiro each year. The high number of accesses to PmatE's webpage, especially in the days before the competitions, clearly demonstrates the success and impact PmatE has in Portuguese schools.

The randomly generated questions are formed by an initial text and four sentences ("answers"). For each sentence, students must indicate if it is true or false. Only the correct validation of each answer allows transition to the next level [6]. The winner will be the player who is able to go through all levels in less time.

Before the nationwide competitions, students can practice. At this stage, students can play anytime they want and their results become immediately available for teachers. In consequence, teachers can examine which topics are more difficult to their students and adjust their lesson plans to overcome those difficulties. Therefore, QGM can help teachers to be more ingenious and creative in their teaching methods, although, teachers still play an essential role when it comes to clarify questions that may arise when students play the games available at PEA. PEA also allows teachers to assemble QGM and build assessment tests. This is extremely helpful as the results of those

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tests are returned promptly, saving teachers from the painful task of marking.

PEA also allows students to check their answers. Finally, and because this software is presented as games, organized by school stages, QGM link the school curriculum to the challenge inherent to all computer games.

4. Conclusions

The games of the type that was presented here are not only dedicated to entertain the player. It is expected that, at the same time students are playing they are studying and, in some cases, learning new things. Sometimes they don't even realize they are learning given their involvement in the game.

Trying to overcome the problem of mechanization, it is possible to elaborate new QGM. As a consequence, every year the games will have different questions and players are confronted with new propositions and, even, new contents from the curriculum.

Instead of using questions of only true/false type is now in study the introduction of different types of QGM that allow, for example, that players select propositions from a group.

Once there are high numbers of games ending at the initial levels, it's possible to make games in which players automatically see all the questions. However, we believe this is a possibility in which the very spirit of the competition (overcome levels of a game) will be lost.

Given the popularity of PmatE's games and competitions in Portugal (thousands of students participate each year in the competitions), it is now possible to evolve to another type of games, organised not by specific scientific areas, but transversal to several related areas. For example, the same competition could perfectly include scientific areas such as geography, biology, geology, physics and chemistry. This new type of competition is now under study and we think it could contribute to the increase of player's scientific literacy and to prepare them to face the problems of modern society.

Regarding the presentation we can expect accomplishments of QGM with a variable number of answers, not only four, and with several types of input: combobox, free text, and dropdownlist, among others. This modification will allow more interactivity between the player and the content presented. We expect that in the future we will be able to make games with all these types of QGM.

The 25 years' experience of PMatE games and competitions has demonstrated to be a good method to increase motivation for the study of the different areas in competition.

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Keeping Fit… With Science

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Abstract. *This presentation describes the main permanent interactive exhibition "Keeping fit … with science", associated with the second stage of the new Exploratório Ciência Viva, in Coimbra, Portugal and reveals the theoretical framework of its development. The name of the exhibition is deliberately ambiguous, to encompass the various dimensions of the aimed objectives. Health and Medicine, as well as Sport, – under a science perspective – are among such dimensions, but this is, above all, an exhibition that uses Health and Education for Health as a context for the exploration of fundamental scientific facts and concepts.*

Keywords. Health, interactive exhibition, non formal education, public involvement with science.

1. Introduction

The non formal nature of a science centre facilitates a contextual approach in comparison to schools, where a balance is to be reached between the benefits of a methodology of teaching in context and the need of following a structured sequence of observations and ideas as reflected in a curriculum. It so happens that Health, in the WHO sense of physical, mental and social well-being, is something that interests everyone … and thus should science, providing that the adequate level and the appropriate methodologies are used.

Exploratório designed and constructed the hands-on exhibition "Keeping fit … with Science", an exhibition that uses the Human Body, Health and Education for Health as a context for the exploration of fundamental scientific facts and concepts.

In fact, critical appropriation of basic knowledge is central to scientific literacy in any area, in both formal and non formal systems, namely when a contextual approach is used [1,2].

2. The exhibition

The expression "Keeping fit … with science" for the exhibition is the result of some premises:

a) We need science to be happy, because both our well-being and our natural curiosity depend on it.

b) We need to know and practise some basic science – contents and processes – to understand and deal with the world.

c) We need to understand our bodies for our own benefit and that of others.

The fitness referred to should thus be taken both in the sense of Education for Health and in the sense of Basic Science Education, the latter gaining from the interaction with the former. It is such a direct interaction, as well as the ludicity of the activities, that justify the increasingly important role of non-formal initiatives such as Science Centres as a complement to school education.

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The Biology of human body – morphology and physiology – naturally receives special attention. But the whats and the hows and whys require Physics and Chemistry, in particular, and other domains including Statistics and Earth Sciences.

Seven venues are considered related to the several systems, the nervous system including a central multi-exhibit on the brain. This offers seven types of activities which – directly or indirectly – point to the seven areas that deal with:

1. Skin ("Revestindo"): 12 exhibits
2. Bones and muscles ("Movimentando"): 12 exhibits
3. The circulatory and the urinary systems ("Circulando"): 25 exhibits
4. The digestive system ("Digerindo"): 15 exhibits
5. The respiratory system ("Respirando"): 11 exhibits
6. The reproduction system and genetics ("Multiplicando"): 10 exhibits
7. The nervous system ("Coordenando"): 30 exhibits

The central multi-exhibit on the brain includes 7 activities related to actions, sensations and emotions – body mechanical equilibrium, speaking, the senses of touch, hearing and vision, memory, concentration and shock – the corresponding main areas involved in the brain becoming illuminated in each case. Position and the appropriate use of colour refer to the various venues.

Each sector (avenue) begins with information on the main function of the corresponding system, a cloud of keywords on the basic science concepts involved, and an activity about the morphology of the system, namely some kind of puzzle.

Here are examples of the basic science words (10 for each case):

1. Skin
   - *Cell*
   - *Friction*
   - *Infrared*
   - *Ions*
   - *Microscope*
   - *Pressure*
   - *Temperature*
   - *Thermal conductivity*
   - *Thermography*
   - *Ultraviolet*
2. Bones and muscles
   - *Angular momentum*
   - *Calcium*
   - *Inertia*
   - *Lever*
   - *Moment of inertia*
   - *Phosphate*
   - *Phosphorus*
   - *Rotational inertia*
   - *Unity Newton*
   - *X rays*
3. The circulatory and urinary systems
   - *Blood groups*
   - *Cells*
   - *Dialysis*
   - *Filtration*
   - *Frequency*
   - *Liquid flow*
   - *Pressure*
   - *Pump*
   - *Solubility*
   - *Sound*
4. The digestive system
   - *Acids and bases*
   - *Carbohydrates*
   - *Enzymes*

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- *Glicose*
- *Hidrolysis*
- *Lipids*
- *Nutrients*
- *Optical fibers*
- pH
- *Proteins*

5. The respiratory system
    - *Air pollution*
    - *Carbon dioxide*
    - *Gas pressure*
    - *Oxidation*
    - *Oxygen*
    - pH
    - *Radioactivity*
    - *Superficial tension*
    - *Surfactant*
    - *Voice*
6. The reproduction system and genetics
    - *Chromosomes*
    - *DNA*
    - *Fertilization*
    - *Genes*
    - *Hydrogen bonding*
    - *Nitrogen bases*
    - *Puberty*
    - *RNA*
    - *Sexual cells*
    - *Stem cell*
7. The nervous system
    - *Electrical potential*
    - *Hormones*
    - *Ions*
    - *Isomers*
    - *Myelin*
    - *Nervous impulse*
    - *Neurotransmitter*
    - *Perception*
    - *Reaction time*
    - *Sensations*

These keywords will also make part of short follow-up leaflets showing the basic science – Physics, Chemistry, Biology, … – present in the exhibition.
The hands-on activities themselves are a result of several compromises and options [3, 4].
The various topics are as follows:

1. Skin ("Revestindo")
    - *Functions and biological structure of the human skin*
    - *Magnified images*
    - *Difference between cell and molecule*
    - *Temperature and infrared radiation*
    - *Ultraviolet radiation and skin protection*
    - *Force and pressure*
    - *Friction and motion*
    - *Electrical conductivity*
2. Bones and muscles ("Movimentando")
    - *Functions and composition of the human skeleton*
    - *Joints, muscles and the physics of bone motions*
    - *The unity of force*
    - *Walking and balance*
    - *Mechanical energy and motion*
    - *Angular momentum and rotation*

Figure 1. Exhibit "Function and composition of the human circulatory system"

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3. The circulatory and the urinary systems ("Circulando")
    - *Function and composition of the human circulatory system*
    - *The heart as a special pump*
    - *Blood circulation and fluid mechanics*
    - *Blood pressure*
    - *Blood groups and blood transfusion*
    - *Blood analysis and pathologies*
    - *The circulatory system at risk*
    - *Function and composition of the human urinary system*
    - *Blood purification by kidneys*
    - *Insoluble salts in kidneys*
    - *Urine analysis*
4. The digestive system ("Digerindo")
    - *Function and composition of the human digestive system*
    - *The mechanics and the chemistry of digestion*
    - *Enzymes as biocatalysts*
    - *From food to nutrients*
    - *Optical fibres to see inside the digestive system*
    - *Energy conversions*
    - *The risks of ethanol consumption*
    - *A balanced diet*
    - *Inorganic chemicals and nutrition*
    - *Water as the main chemical*
5. The respiratory system ("Respirando")
    - *Functions and morphology of the human respiratory system*
    - *The mechanics of ventilation*
    - *Surfactants and surface tension*
    - *Pressure and volume of gases*
    - *Air pressure and the Bernoulli effect*
    - *Oxygen and the role of haemoglobin*
    - *Carbon dioxide and respiration*
4. The reproduction system and genetics ("Multiplicando")
    - *Functions and morphology of the human reproduction systems*
    - *Sexual cells and human fertilization*
    - *Growing up and puberty*
    - *DNA and the factory of proteins*
    - *Genes and chromosomes*
    - *Genes and forensic studies*

Figure 2. Exhibit "Functions and morphology of the human reproduction systems"

5. The nervous system) ("Coordenando")
    - *Functions and composition of the human nervous system*
    - *Sympathetic and parasympathetic systems*
    - *Hormones*
    - *The nervous impulse*
    - *Reflexes and reaction time*
    - *The human brain and main active regions for actions, sensations and emotions*
    - *The human brain, perception and the five senses*
    - *Sensorial homunculus*
    - *Brain and mechanical control*
    - *The brain can deceive: illusions*

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Instructions for the activities are kept to a minimum and illustrated. After each activity, the visitor/explorer is invited to read a short explanation, usually at two or three levels of depth. English versions will be gradually available. Illustrated panels present further information, curiosities, questions as challenges, and, to some extent, will include information on prevention and health education, diagnostic means and therapies.
As part of the whole exhibition, an interactive screen presents a game on the best choices for a healthy life offered by Bluepharma, the pharmaceutical company of Coimbra.

3. Evaluation and development

The exhibition greatly benefits from a pre-configuration that was offered to visitors during the first stage of the new Exploratório, for 4 years, both from the point of view of contents, activities and communication strategies and from the aesthetical point of view.
Regarding communication and learning strategies, some studies involving visitors have been carried out [5] which became useful at the second stage. In addition, thematic games and exhibits in close connection with school curricula and teacher in-service training have been developed in several areas (more recently in the field of Education for Sexuality [6], which will maximize the benefits of the whole exhibition.
It is expected that the new exhibition will serve not only the school public – here included the special education needs – but the ordinary citizen as well, namely on a life-long learning perspective; the elderly, in interaction with other generations, will surely be one of the aimed publics.

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Coordination Chemistry: a Bridge over Troubled Waters (or not) in a Wonderful World (or even better)

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Abstract. *Coordination Chemistry appears in chemistry programs or text books as a chapter of "Inorganic Chemistry" being taught like that and in general no one gives it the enormous relevance this subject has in modern chemistry. This work intends to present coordination chemistry as a bridge towards the majority of the "other" chemistry chapters, and try as well to demonstrate its capacity to link chemistry to biology, biochemistry, health sciences, new materials, energy generating devices, and environmental solutions, just to list a few possibilities. In today´s scientific world, interdisciplinarity is a major education goal and, in our opinion that can be reached using coordination chemistry.*

Keywords. Bridging sciences, modern chemistry in today´s world, coordination chemistry, interdisciplinarity.

1. Introduction

Coordination Chemistry appears in chemistry programs or text books as a chapter of "Inorganic Chemistry" being taught like that and in general no one gives it the enormous relevance this subject has in modern chemistry [1, 2, 3].

This work intends to present coordination chemistry as a bridge towards the majority of the "other" chemistry chapters, and try as well to demonstrate its capacity to link chemistry to biology, biochemistry, health sciences, new materials, energy generating devices, and environmental solutions, just to list a few possibilities. In today´s scientific world, interdisciplinarity is a major education goal and, in our opinion that can be reached using coordination chemistry.

2. Pedagogical and scientific frame-works

Coordination Chemistry, introduced as a "section" or a "branch" of Inorganic Chemistry can be seen spread all over the chemistry programs or text books, in what chemistry teaching is concerned. In some countries this area of studies is taught at the final years of High School, side to side to biology, by the use hemoglobin or chlorophyll molecular constitution as common examples. In Portugal, for example, it is "softly infiltrated" in what is called "Metals in human organisms", or is pushed to the 1st or 2nd years of the first degrees in Bologna courses, linked to Inorganic or Bioinorganic Chemistry.
Coordination Chemistry can be looked, and utilized, as an extraordinary way to make bridges to a multiplicity of different areas of chemistry, physics, biology, biochemistry, pharmacology, medicinal chemistry or health sciences (Fig. 1). If a deeper attention is given to this subject its underlying "rich" chemical concepts can ameliorate the interest of students in chemistry studies, research, industrial processes and applications, or even in environmental issues. It can easily, as well, be a tool to

study transition metals pollution, soil remediation, photovoltaic cells, chemical sensors, magnetically and optically new materials, new designed drugs, clarification or discovery of enzymatic mechanisms, and the list has no end. Some coordination compounds possess bridging ligands capable to put together important metal centers, and then creating a myriad of new applications. And last but not least, coordination chemistry can provide students with a wide vision of todays´ chemical global world, helping to flow knowledge from different science branches.

Figure 1. Closely related keywords about "Coordination Chemistry" in a "Cloud" [4]

In this work a reflection on the importance of Coordination Chemistry is presented and some proposals/ways of how to improve its teaching in a scenario of the 1st degree of Bologna (Bio)-Chemistry, Biochemistry and Materials Sciences will be provided, trying to establish bridges over troubled waters and to show a new wonderful world (or even better) [5].

3. Acknowledgments

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'Time to Plant Science': a *Choosing Science* project in the Botanic Garden of Coimbra

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Abstract. *"Time to Plant Science" is a project developed by the Botanic Garden of the University of Coimbra, in Portugal, approved by the program Choose Science supported by Ciência Viva, the National Agency for Scientific and Technological Culture. This project is being developed in collaboration with the secondary school of Quinta das Flores (Coimbra, Portugal) and the Department of Life Sciences of the University of Coimbra since September 2013 and will continue until December 2014.*

The main aim of the program Choose Science is to provide secondary students with opportunities to contact with science and scientific research in university centres, in order to stimulate the option for choosing scientific courses at the university.

There are several reports from different countries showing persistent declines in the last decades in science enrolments, in students' perceptions about school science as well as in aspirations towards further study and careers [1].

Some of the factors that may have contributed to such decline are, among others, the failure of school science to engage a wider range of students, the decrease in the utility value of key science subjects relative to their difficulty, or the prevalence of disenchantment with school science among students in developed countries [2].

With the general goal of engaging students with science, "Time to Plant Science" was conceived to promote interest about life sciences, particularly botany, by means of the development of different educational sessions organized in the Botanic Garden, in collaboration with the Department of Life Sciences. Botany has particularly declined in its representation in university courses, participation in scientific meetings and also in educational programs [3,4]. But it is possible to invert this situation by changing the attitudes of students towards plants [5], for instance by means of promoting a greater collaboration between formal and informal sectors, conducing a more effective science education [6].

The Botanic Garden, with its' foundation closely linked to the university studies about plants, represents an unique resource for contacting with the natural environment, by creating positive relationships with plants as well as providing exceptional contexts for learning and researching [7].

The project and its' aims were initially presented to the students at secondary school of Quinta das Flores, from 10th to 12th grades, which corresponds to 15 to 18 year-old students. The students individually applied for participation, in an autonomous way, independent from class organization and without the teachers' accompaniment and supervision.

There were 33 students initially registered, from which two groups were created in different schedules. Each group visited the Botanic Garden once each month, for a two-hour session related to a specific subject.

The main theme across all the sessions, from October to June, was the evolution of plants, throughout the geological time and emphasizing paleobotany, considering the main groups and its adaptations in the following sequence: algae, bryophytes (mosses and moss allies), pteridophytes (ferns and fern allies), gymnosperms and angiosperms. The first session was mainly an introduction to the Botanic Garden, with a general visit across its main spaces and also a dynamic group activity for students and the project team to get to know each other. Then, the thematic sessions began, with a strong variety of strategies and approaches adopted to conduct the activities, along with the different subjects covered. There was always a strong emphasis on field work in the garden, valuing the diversity of species in situ, as well as the different garden areas and spaces, some of them usually not accessible to the public. Practical work and hands-on activities were a very strong component, from collecting microalgae and water samples from different places, to exploring different paths on the garden by finding clues and answers to questions about the species, and to the observation and exploration of specimens or botanical structures in the laboratory. The collaboration with teachers and researchers from the Department of Life Sciences was also a priority in these sessions, providing a closer contact with their research and their working space(s) and resources.

Besides those scientific activities, and in the meantime, there was also a session about science communication, at the science centre Rómulo de Carvalho, in the University of Coimbra, where it was discussed and decided what outputs the students would like to develop concerning the themes approached and the developed activities. Therefore, apart from the sessions in the Botanic Garden, students are developing small projects on their own initiative, concerning music, dance, photography, illustration and writing. A Facebook page was also created for disseminating the project to general public, where the students and the botanic team members are administrators (https://www.facebook.com/TempoDePlantarCiencia). After the sessions in the Botanic Garden, a full day field trip to Mata da Margaraça (Serra do Açor, Portugal) was organized, where students had the opportunity to contact with its natural reserve flora and to recognize and apply the contents covered in the garden sessions. After that, a presentation about the development of the project and some of its results was presented to the classes and teachers of the involved students. After this presentation 15 new students revealed interest in participating in the project. As a result of that, and since all the students were very enthusiastic about continuing the activities during July and August, we are now planning summer sessions, along with the preparation of the following sessions until December.

Since it is an on-going project, some preliminary results that are mainly based on direct observation during sessions are going to be presented, as well as some students' oral and written feedback during and after the activities. Also, a small written questionnaire was applied to the students concerning all the sessions until June. Besides giving concrete data to discuss some insights, it will also be quite useful to plan the following sessions.

Concerning the results achieved until the moment, we emphasize the general positive opinions from the students and their level of engagement and enthusiast. Students have enrolled in the activities in a very autonomous and responsible way. The mean number of participants, from the past 8 sessions (until June) was of 24 students per month.
As the main initial reasons for participating, students highlighted the "curiosity", "willingness to learn about science and botany", "a single opportunity to know and explore the botanic garden", "learn more about research". They also have stressed the main positive aspects of the sessions, for instance "the chosen themes", "the interesting way sessions were organized and conducted", "the growing knowledge about botany", "the contact with researchers and their work", "the sympathy, good work and commitment of the team", "the socialization and amusing moments". Students were also very fond about spontaneous learning, driven by their own interest and motivation, without the pressure of curriculum or of being assessed. The fact that this was an exclusive project, addressed only to this school and these students, was also very appreciated by the students.
Likewise, the opinions from their school teachers is very positive, reinforcing the disposition and motivation of students for learning and contacting with science, as well as the sharing of their experiences from the Botanic Garden enriching classroom experiences.
The willingness of students to continue in the project until the end, and the fact that new students also want to participate from now on, are also very important outputs and indicatives of the success of the project.

Keywords. Botany, *Choosing Science*, non-formal education, plant evolution, secondary students.

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Motivate to Learn: Other Ways of Learning Biology, Maths and Other Sciences

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Abstract. *The development of teaching and learning strategies that effectively assist in the understanding of scientific knowledge is an ongoing challenge. Doing experiments outside the classroom, one of the recommended approaches, presents some risks, because students can divert their attention from the pedagogical objective of the activity [1]. However, experts agree in considering that learning outside the classroom can be used to facilitate Education. Providing students with learning activities in relevant situations beyond the walls of the classroom is vital for helping them to appreciate their experiences from a variety of different perspectives. Furthermore, experiences outside the classroom provide opportunities to practice skills of enquiry, values analysis and clarification, as well as problem solving in everyday situations, thus enhancing learning [2].*

The Educational Resource Centre of "Externato Infante D. Henrique" in Ruilhe, Braga, Portugal has multipurpose facilities and a dynamic and committed teaching team, ready to embrace new challenges. This team decided to bring to school the project Homo numericus, a STOL-Science Through Our Lives initiative that includes an exhibition of eight attractive roll-ups and a set of hands-on activities. The initiative has a work in progress (WIP) character and its main goal is to alert for, and to bring light to different curious aspects (morphological, physiological, biochemical, behavioural, of the relationship with others and with the environment) of Man in general and the human body in particular. As a strategic unifying procedure, all information is translated into numbers, in a truly multidisciplinary perspective where Biology, Mathematics, Physics, Chemistry, Ecology, Sociology, Geography and many other Sciences are present [3].

The presentation of such initiative at school intended not only to achieve programmatic objectives of the syllabus of Natural Sciences for students from 6th to 9th grades but also to promote interdisciplinarity and interaction among science, culture and school, as well as to display students' curiosity for facts about their body and their environment.

The strategy used to assess the activity occurred in three stages. Firstly, students were invited to fill in a questionnaire on related themes suggested by the planned activities; secondly groups of 4-5 elements were formed to explore, in an informal and interactive way, the exposed materials and resources. In addition, books, writing material and tapes were provided for measurements and mathematical calculations associated with the concept of the Vitruvian man. To finish the assessment, a survey was applied to all the students to evaluate the learning progress after their participation in the activity.

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A preliminary analysis of the results suggests that the initiative boosts the curiosity of students, especially in what concerns some particular details like the information about the brain, the amount of produced fluids and the size of the digestive tract. Students used different numerical representations and performed calculations to figure out if they had the "perfect" Vitruvian body measurements. Students of the 9th grade were specially engaged within this task, powering the "vanity" in their perfect measurements. The aim of the present work is to assess whether this activity, clearly exciting and motivating for students, also contributes to make school syllabus more relevant and meaningful for them and to promote the overall quality of their education.

Keywords. Hands-on, students, motivation, learning, exhibitions.

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Citizen Science as a New Strong Form of Social Engagement with Science

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Abstract. *Citizen science is emerging as a new form of interaction between society and science, allowing for social participation and involvement with scientific activities. It has a great potential for social engagement with science, through the participation in real science projects, interacting directly with scientists and acquiring a perception of the scientific activity, or by the educational and engaging value that these projects can have in particular circumstances. However, this possibility is still very little explored both in terms of involving scientific teams in promoting this kind of projects and in the possibilities open to science educators.*

Most of the initial citizen science projects were directly associated with environmental education, involving monitoring of bird populations, such as the first citizen science project the Christmas bird count developed by the Audubon Society more than 100 years ago. Since then many projects have developed, and the tendency is increasing in recent years. There are now projects in areas ranging from astronomy to cancer cell analysis, from protein folding to flu epidemics, from climate change to biodiversity monitoring. A considerable number of projects deal with great societal challenges and threats, such as climate change, biodiversity loss, pollution, habitat destruction, or health quality. The environmental education role is still an important one, and it was recently proposed the merging of science education and environmental education [1], with citizen science being particularly involved on what some have called Earth stewardship.

Presently millions of individuals are being engaged in thousands of research projects, through collecting, categorising and analysing data which contribute to scientific knowledge and also at the social level. New IT technologies allow connecting, engaging, but mostly collecting, gathering data, storing in databases readily accessible to any person practically anywhere and contributing to a diverse array of projects. In the west coast of Mexico a citizen science project monitors turtles and attempt to save them from fishing nets. In a poor area of the US, the West Oakland Environmental Indicators Project tries to empower citizens to monitor the degree of air pollution of their neighbourhood and to act upon it. In the Republic of Congo illiterate persons monitor illegal logging and poaching in their areas. As these examples illustrate these citizen science projects have the potential to empower populations and to give stronger senses of identity to threatened cultures.

As more people get involved in these projects the quality and usefulness of the data gathered improves, as the eBird project illustrates [3]. Despite the trend for more scientifically directed projects, sometimes not addressing problems of immediate concern in the society, the practice is still not universally accepted as a valid method for scientific research. Some question whether through it citizens do really participate in the scientific enterprise and sustain that it is just a form of scientific education.

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We contend that citizen science projects can be really scientific projects where citizens can contribute, as a scientist, to scientific knowledge. Silvertown [4] characterizes a citizen scientist as someone who is a volunteer who collects and/or processes data as part of a scientific enquiry. This is a perspective that we share. We report here the case on the involvement of the Science Museum of Coimbra University and a research group of the University of Coimbra in a large scale international citizen science project: the SOCIENTIZE (http://www.socientize.eu/). The project involved an interdisciplinary team of researches and science communicators from Portugal, Spain, Austria and Brazil. Providing adequate instructions through diverse media, and through a well-structured platform for data distribution, collection and validation, which is essential for the quality of the data, we were able to set and conduct a series of scientific projects proposed by several scientific teams which were seeking the contribution of citizens to accomplish the tasks of their projects.

Dozens of schools and other groups such as senior academies, in Portugal, actively participated in analysing data, as normal scientists would. They gave a strong push in the accomplishment of projects as Cell Spotting, on the development of chemicals to fight cancer, or the Sun for All, counting solar spots from a large photographic record from Coimbra Observatory, or the Mind Paths, a game that attempts to draw cognitive maps of association between words.

The results of the interactions with the project, including discussion sessions with the scientific leaders of each experiment revealed to be extremely engaging. Also, participating citizens referred that they understood the tasks in which they participated, understood better what is to do science and felt involved in the process.

Certainly there are different and various levels of engagement of citizens in citizen science projects. But they are a completely new possibility for social participation in science and even for the development of new kinds of projects which would not be possible in the past and in the traditional ways of doing science.

Keywords. Social engagement, science, project.

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Technology on Science Education

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Hands-on Science
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A Newton's Cradle Model for Science Fair Events

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Abstract. *Most commercial models of Newton's Cradle are too small for exhibitions and science fair events. Some bigger models developed for that purposes are not easy to carry and store, which may be a problem between exhibitions. This paper describes a Newton's Cradle which is big enough for science fair events but easy to assemble and disassemble. Its volume becomes substantially reduced after being disassembled.*

Keywords. Newton's Cradle, principle of conservation of linear momentum, principle of conservation of kinetic energy, science-fair events.

1. Introduction

Newton's Cradle is an eye-catching device used to demonstrate the Principle of Conservation of Linear Momentum and the Principle of Conservation of Kinetic Energy [1, 2]. Most commercial models of Newton's Cradle are suitable to be kept as decorative objects in the corner of a desk. But they usually are too small for exhibitions and science fair events. Much bigger models have been developed for that purposes [3]. However, big devices are not easy to carry and store, which may be a problem between exhibitions. This paper describes a Newton's Cradle made with five snooker balls fitted with brass wire holders and a bearing structure composed of stainless steel plumbing pipes and elbows (Fig. 1). It is big enough for science fair events but easy to assemble and disassemble. Its volume becomes substantially reduced when the bearing structure is disassembled. It has five balls, which allows the collision modes shown in Fig. 2.

Figure 1. Newton's Cradle

2. Materials used to build the Newton's Cradle

The main materials used to build the Newton's Cradle were the following:

- 8 stainless steel plumbing pipes (ϕ15mm), with the following lengths:
  - 44,5cm x 4 (vertical pipes);
  - 40cm x 2 (upper horizontal pipes);
  - 38cm x 2 (lower horizontal pipes).
- 8 stainless steel elbows for ϕ15mm

plumbing pipes;
- 5 snooker balls;
- 5 nylon wires, each one with 60cm;
- 5 brass wire holders;
- 5 steel screws.

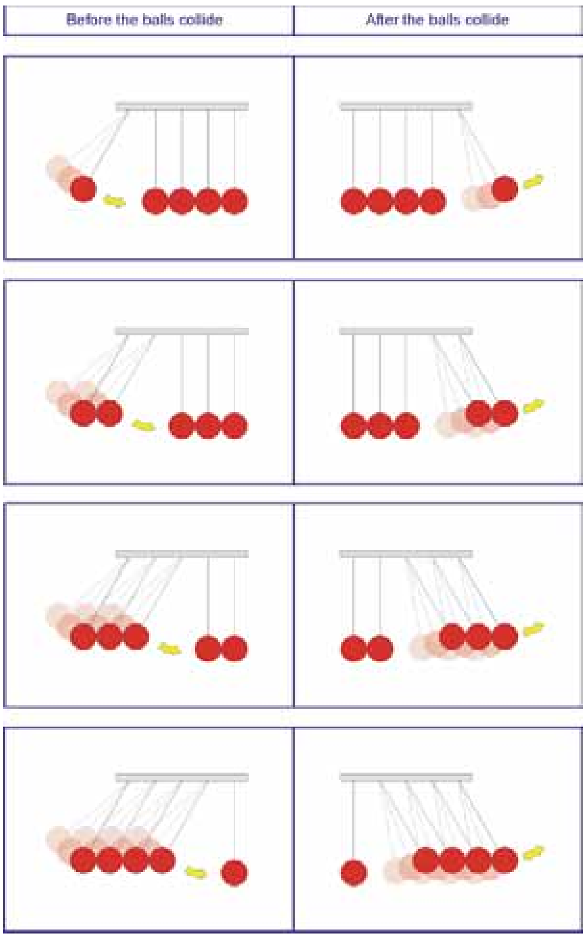

Figure 2. Collision modes of a five-ball Newton's Cradle: 1, 2, 3 or 4 ball swing. Drawings show balls configurations before and after balls collide, for each mode

Figure 3. Snooker ball with a drilled hole. A brass wire holder will be fastened to the ball with a steel screw

Figure 4. Brass wire holders

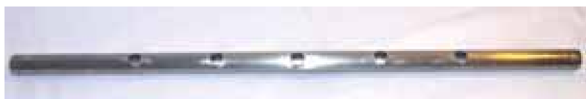

Figure 5. One of the upper horizontal pipes of the bearing structure. The tips of the nylon wires holding the snooker balls pass through the holes in the pipe and then are tied to it. The distance between the holes is the diameter of the snooker balls

3. Some details on the construction of the Newton's Cradle

After drilling a hole in each snooker ball (Fig. 3), the brass wire holders (Fig. 4) are fastened to the balls with steel screws. Then, the nylon wires are passed through small holes drilled in the wire holders and the tips of the wires are tied to the upper horizontal pipes of the bearing structure (Fig. 5). This structure is composed of eight stainless steel plumbing pipes with different lengths, joined by eight stainless steel elbows, as suggested in the simplified model presented in Fig. 6. It is lightweight but sturdy. It is inexpensive, too.

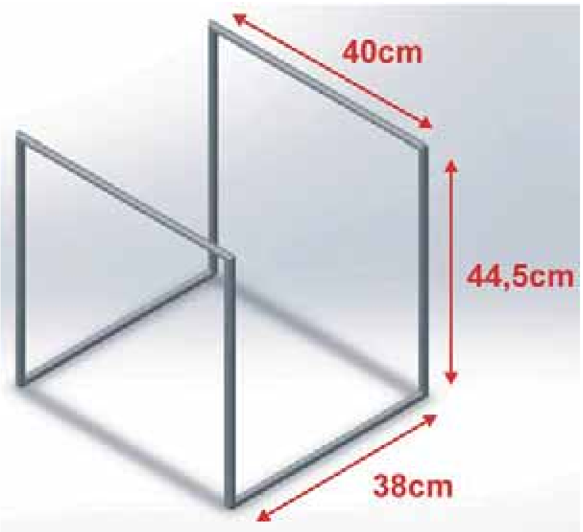

Figure 6. Simplified *SolidWorks* model of the bearing structure composed of stainless steel plumbing pipes and elbows

4. Conclusions

A Newton's Cradle big enough for science fair events but easy to assemble and disassemble has been described. It uses five snooker balls fitted with brass wire holders. The inexpensive bearing structure, made of stainless steel plumbing pipes and elbows, is lightweight but sturdy. Its volume becomes substantially reduced after being disassembled, which is very convenient for carrying and storing.

5. Acknowledgements

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The device construction was funded by the *Projecto Ciência na Cidade de Guimarães* (Science in Guimarães City Project), which was sponsored by the *Programa Ciência Viva* (Living Science Program).
The authors are grateful to Leonor Barbosa and Vitor Braga for the *SolidWorks* drawings. The authors are also grateful to Catarina Silva, Marisa Jesus and João Noivo (Centre Algoritmi) and Sofia Teixeira (Fábrica Centro Ciência Viva de Aveiro) for their support.

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Environment-Friendly Slot Cars Circuit

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Abstract. *This paper presents an environmentally friendly cars system that does not require batteries or the mains to power the cars. Instead of simply using energy from those sources, players have to pedal bicycles in order to keep their cars running. The faster a player pedals, the faster his car runs. The system parameters were adjusted so that a considerable physical effort is required in order to make a car run. Associating electric energy generation with considerable physical effort is pedagogical and makes this system very suitable for science fair events.*

Keywords. Electric energy, electric generator, science-fair events, slot cars.

1. Introduction

During a brainstorm meeting arranged in order to organize a science-fair event, Júlio Gonçalves (a 1st year student of the Integrated Master on Industrial Electronics and Computers Engineering at the University of Minho) came up with the idea of implementing an environmentally friendly slot cars system that does not require batteries or a power supply connected to the mains in order to power the cars. Traditional slot cars systems use, at least, one of those power sources and each player adjusts his car speed using a handheld controller. Winning a race does not require a great physical effort. With the new system, each car is powered by a generator attached to a bicycle rear wheel running on rollers. The faster a player pedals, the faster his car runs. Adjusting the system parameters it is possible to ensure that a considerable physical effort is required in order to make a car run. The association between electric energy generation and considerable physical effort is pedagogical. In fact, generating electrical energy is much harder than spending it.

With the help of his classmate António Campos and under the supervision of the authors of this paper, Júlio Gonçalves implemented the new slot cars system (Fig. 1), which is described in the next section.

2. System description

The layout of the slot cars circuit is shown in Fig. 2. Two DC (Direct Current) voltage sources are required to power the two-lane track. The main components associated with each lane are the following (Fig. 3):

- A bicycle running on rollers, fitted with an AC (Alternating Current) generator attached to the rear wheel (Fig. 4).
- An electronic circuit developed in order to convert the AC voltages delivered by the bicycles generators into DC voltages suitable for the slot cars. The circuit has a rectifier, a filter and a voltage limiter (Fig.5).
- A slot car (Fig.6) fitted with a DC motor (Fig.7).

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Figure 1. The new slot cars system

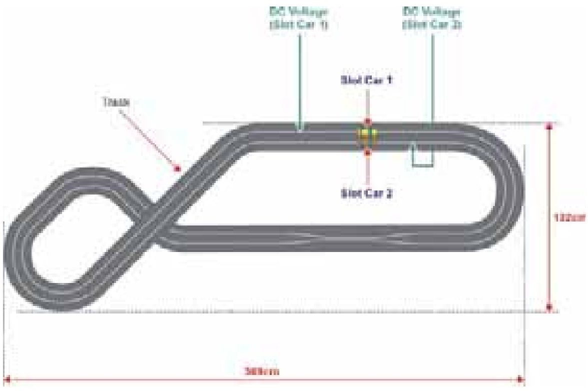

Figure 2. Layout of the slot cars circuit. Two DC voltage sources are required in order to power the two-lane track

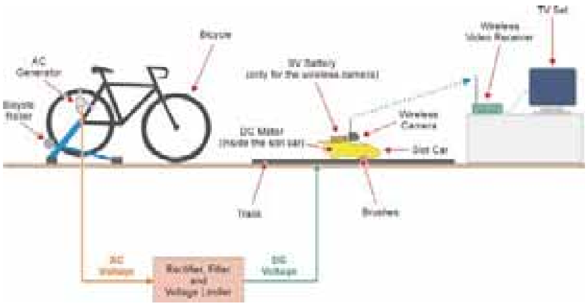

Figure 3. Components required for each lane of the slot cars circuit (except for the wireless video receiver – which may receive signals from up to four wireless cameras – and the television set; only one wireless camera was used, attached to a car)

Both the rollers and the DC voltage levels were adjusted so that a considerable physical effort is required in order to make a car run (Fig. 8).

A small wireless camera was attached to one of the cars (Fig. 3 and Fig. 6). It sends real-time car level images to a wireless video receiver attached to a television set.

Figure 4. AC voltage generator fitted in the back wheel frame of a bicycle

Figure 5. Box containing a rectifier, a filter and a voltage limiter for each lane

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Figure 6. Two slot cars on the track, near a lap counter. A wireless camera, powered by a 9V battery is attached to the car running on lane 2, closer to the lap counter

Figure 7. Internal view of a DC motor, similar to the ones used by slot cars

3. Bicycle generators

The generators used to power the slot cars are common bicycle lighting generators, fitted in the rear wheel frame of a bicycle, powered by the friction with the rear tire sidewall (Fig. 4). These generators are very easy to fit in a bicycle; they usually have a rotor composed of a cylindrical magnet, which is the inductor that rotates when the bicycle wheels are moving.

The stator contains windings around an iron core. An electromotive force is induced in the windings when the magnetic field varies due to the inductor rotational movement. Although this type of generator is known as bottle dynamo (because of its shape) it is, in fact, a single-phase AC generator, or single-phase alternator, with fixed magnetic excitation [1].

The main reason for this topology is the increased reliability and efficiency over a DC generator because it has no moving contacts, as the magnet is mounted in the moving part and the windings in the fixed part. In this type of generator, the amplitude and frequency of the electromotive force are directly proportional to the rotating speed. Since a DC power source is required for each lane of the track, a rectifier diode bridge and a capacitor (to filter the voltage oscillations) were connected at the output of each generator.

Figure 8. A considerable physical effort is required in order to make a car run

4. Slot cars motors

The slot cars are fitted with 12V DC motors with two permanent magnets in the stator (Fig. 7), providing a fixed magnetic excitation. The motors have a three slot wound rotor with three coils (Fig. 7) and a three-segment collector to provide electrical contacts with two graphite electrical brushes. DC motors like these should have an even number of magnetic poles in the stator, an even number of brushes and an odd number of coils and collector segments in the rotor [2]. This is done in practical motor implementations in order to make them asymmetrical, avoiding a possible stall condition when the motor is started.

5. Conclusions

This paper presented a slot cars system that does not require batteries or the mains to power the cars. Instead, players have to pedal bicycles. A considerable physical effort is required in order to run the cars, which is pedagogical. Such a system is environmentally friendly and very suitable for science fair events.

6. Acknowledgements

This work has been supported by FCT – Fundação para a Ciência e Tecnologia within the Project Scope:
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The slot cars system implementation was funded by the *Projecto Ciência na Cidade de Guimarães* (Science in Guimarães City Project), which was sponsored by the *Programa Ciência Viva* (Living Science Program).
The authors are grateful to Júlio Gonçalves and António Campos for the implementation of the slot cars system, and to Carlos Silva, President of the *SASUM* – SASUM *Serviços de Acção Social da Universidade do Minho* (Social Services from the University of Minho), for the loan of two bicycles from the *BUTE – Bicicleta de Utilização Estudantil* (Bicycle for the Student Utilization) Project.
The authors are also grateful to Catarina Silva, Marisa Jesus and João Noivo (Centre Algoritmi) and Sofia Teixeira (Fábrica Centro Ciência Viva de Aveiro) for their support.

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Using ICT and TwinSpace for Knowledge Construction

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Abstract. *In 2010, I was the coordinator of an eTwinning project named "ICT, You and Me". Schools involved were from Romania, Poland, Spain, Greece and Latvia. This project won the second place in the European eTwinning Prizes 2012 competition, 12-15 age category. This project aimed to improve pupils' skills in Information and Communication Technologies, Science, Maths and foreign languages. In this paper I will present modern technologies used in this eTwinning project which made the lessons more attractive to everyone.*

Keywords. Collaboration, knowledge construction, eTwinning, ICT.

1. Introduction

This project aimed to improve pupils' skills in Information and Communication Technologies, Maths and foreign languages. Through creating films, presentations, videos and surveys, collating data about themselves with the help of on line statistical tools, pupils learned about cultural differences and similarities of their partner schools in other countries in an enjoyable way. The subjects involved were ICT, Mathematics, English, Science and Art. The students' age group was 8-14. Duration: 1 school year.

2. Project's main objectives

- To teach pupils to use and/or improve their communication skills using ICT;
- To become familiar with basic norms and etiquette for virtual communication to be able to collaborate appropriately in a virtual community;
- To encourage pupils to learn to know each other, have a better understanding of their partner pupils, school and country and finally become friends;
- To learn to evaluate information based on exact data. This will help avoid prejudice and will enhance a scientific approach to working;
- To help pupils develop needed skills for knowledge construction.

3. Pedagogical innovation and createvity

In the beginning of our project, pupils created personalized speaking avatars using Voki, uploaded their photos and avatars, then pupils of the partner schools tried to match every photo to the correct avatar writing their guesses in the comments to the avatars. A new form of cooperation with the use of VoiceThread site resulted in a better understanding and a mutual discussion about ways of spending free time and healthy lifestyles, which made the English lessons more appealing. The participation in online 'brainstorms' allowed us to share opinions with our foreign colleagues and encouraged the pupils to express themselves in English. Interactive forms of writing exercises increased the degree in

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which pupils were involved with the project. Games and quizzes created by the participants were also an interesting way to gain, consolidate and test the acquired knowledge and skills. The pupils proved to be very creative while taking photos, creating videos and slideshows as well as presenting the following subjects: the project participants, the schools and the towns. The pupils also improved their creativity by designing a project logo, common online drawings and interactive holiday greetings. Each country collected names from the partner school and created a word cloud using ImageChef, WordItOut Wordle, Tagul or Tagxedo. Modern technologies used in the project made the lessons more attractive to everyone.

The goal, which was to create a model of the average project participant, encouraged the pupils to get familiar with statistical tools and improved their mathematical knowledge (Fig. 1).

4. Knowledge construction and curricular integration

All project activities required knowledge construction. Learning activities were interdisciplinary. Students were required to apply their knowledge in new contexts. Also, we tried to integrate the project work in the curricula. During Maths classes, the pupils gathered information about themselves and their project partners. Using online tools they interpreted the acquired data in forms of diagrams and created a model of the statistical project participant. They also created quizzes and mathematical problems concerning partnership countries. During Science classes and form periods they learnt the rules of a healthy lifestyle and shared their opinions on the issue with their foreign peers via VoiceThread site.

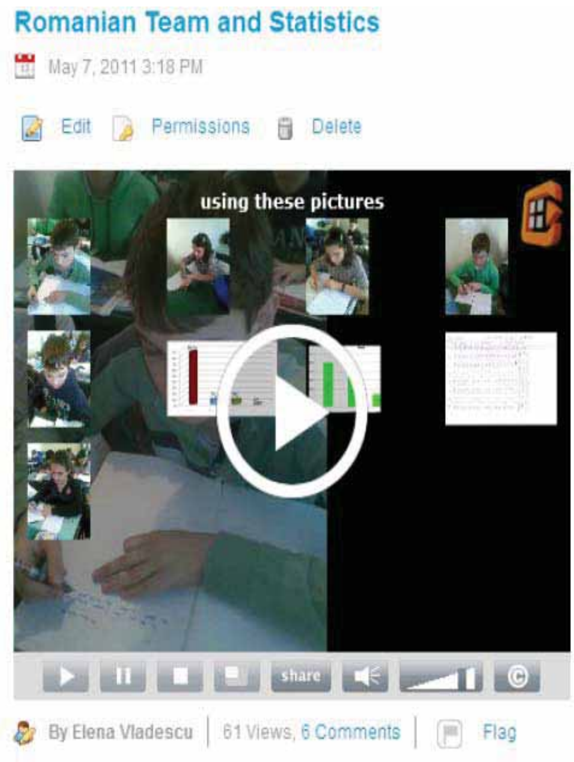

Figure 1. Romanian Team and Statistics

Mind maps, quizzes, presentations and surveys were created to summarize the topic of pro-health and ecological behaviours. During Healthy Week the pupils analyzed and rated their own diets.

During English classes they presented the results of their observations in a form of glogs.

Those classes were also used for discussions with our partners via VoiceThread regarding following topics: ways of spending free time and tourist attractions of our countries. A number of other glogs were created on the subject of

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favourite singers, music bands and sports disciplines. Furthermore, we engaged in producing videos and creating and solving quizzes.
During extracurricular classes we discovered the secrets of Internet sites, created games and designed a project logo. by two blank lines before main text.

5. Collaboration between partner schools

The project participants maintained contact using electronic mail, TwinSpace forums and Facebook.
We communicated at least once a week, or sometimes even more frequently in cases of ICT issues. The partners cooperated during gathering data, creating a statistical model of the project participant and took part in discussions by means of VoiceThread and Skype. Using the service Colorillo, the pupils created common pictures while chatting online. Each school was responsible for a different type of surveys and quizzes. The AnswerGarden web was used to conduct brainstorms (picking the name of the statistical participant, choosing the favourite dish, singer, sportsman and evaluating the project). The partners also declared their desire to create and conduct surveys on chosen topics, picked their ideal spot for vacation and the Christmas gift of their dreams, using Nota tool. Lino and Wallwisher webs allowed the pupils to collect question proposals, photographs of interesting spots in partnership cities along with the corresponding information, which was later used for quizzes, surveys, games and discussions on VoiceThread. Interactive maps were collectively created using Tripline and GoogleMaps.

6. Creative use of ICT

We decided to introduce the pupils to some of the newest sites, which are still not popular in our countries. Their variety was highly appreciated by the participants of the project. Depending on our needs we used: Voki (matching the right avatars with participants' photos, greetings, Maths problems, evaluation), ImageChef (word cloud consisting of participants' names, project logo, greetings), Animoto, Slideshow, Smilebox, Flixtime, PictureTrail (videos about: school, town, presenting the project logo), VoiceThread (discussions), Glogster (healthy lifestyle and hobbies), Lino, Nota, Wallwisher, AnswerGarden (cooperation, collecting question suggestions, brainstorming), QuizRevolution, Quizz.biz, ProProfs Brain Games (creating quizzes and games)(Fig. 2).

Figure2. Our Countries – word search game

Other ICT tools used: Blabberize (hobbies), Morpheus, SantaBot (discussions with bots),

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survey services (collecting data, evaluation), Photovisi (collages), Google map, Tripline (journey routes, interesting places, journey diary), - Mixbook (Maths problems), Prezi (presenting the statistical data and a video), GoAnimate (evaluation), Colorillo (online drawing).

7. Results and benefits

Thanks to the project our pupils broadened their knowledge in areas such as Mathematics, English and Computer Science. They familiarized themselves with the newest Internet sites, and perfected their teamwork and self-presentation skills, particularly important for shy pupils. They are now more likely to make use of the newest technologies, which help to save their time, paper and allow for more creativity. The teachers behind the project not only improved their ICT skills but also developed their teaching techniques. They organised meetings for their colleagues promoting the ongoing project as well as eTwinning programme so as to encourage them to benefit from the newest technologies applicable for everyday use in class. The project met with significant recognition from the head teachers, the parents and other teachers. This project won several awards: the second place in the European eTwinning Prizes 2012 competition(Fig. 3), 12-15 age category, National and European Quality Labels for Poland, Latvia, Spain, Greece, Romania, 1st prize in Maths and Science category of Polish National eTwinning Awards competition, Finalist of Latvian National eTwinning Awards competition (among Top 6 Best Projects), the Best Project Diary of March in the Polish competition, 1st prize in a Romanian competition for eTwinning beginners.references.

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Figure 3. Second place to the European eTwinning Prizes 2012, 12-15 age category

Web-Based Builder of Digital Educational Resources

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Abstract. *The goal of the web-based builder of digital educational resources for educators is to provide capabilities for solutions to a wide range of science education tasks using a set of web-services and a library of media objects. There are basic set of digital educational resources related to modern science and technology and these include pictures and photos, videos and animations, 3D models, interactive models and interactive schemes, tests and simulators and virtual practicum in the web-based builder. For ease of use these web based resources for educators contain web-service for work with media resources, web-service for building own lectures and presentations and web-service for building own tests.*

Keywords. Web-based builder, digital educational resources, e-learning, ICT.

1. Introduction

The experience of introducing different ICTs in the classroom and other educational settings all over the world over the past several decades suggests that the full realization of the potential educational benefits of ICTs is not automatic. The effective integration of ICTs into the educational system is a complex, multifaceted process that involves not just technology, but also curriculum and pedagogy, institutional readiness, teacher competencies, and long-term financing, among others [1].

These days there's a lot of media material available on the internet for educators that include papers and lectures for a wide range courses and educational programs. But if one wishes to use some new interesting multimedia resources in a classroom, it takes a lot of time to find good quality pedagogical resources corresponding that might one's own needs and requirements. The second problem is to integrate different interactive resources in joint presentation.

Web-based builder of digital educational resources is different to "YouTube" for educators and contains various multimedia resources with systems of ratings and complex system of classification and search. This framework gets capabilities for adding resources and download files to user computer. Some special web-services enable one to build one's own presentations which integrate various multimedia resources without losing the interactivity.

2. Library of digital educational resources and web-service for work with them

We started this project as a development of an Online Science Classroom [2]. Our multimedia resources on modern science are interactive models and scientific games for school science courses on physics, biology, chemistry etc. We have also taken into account the interest of many school

teachers in the development of this online science classroom and their cooperation has helped us to design an online science classroom that meets their needs.
The educational school resources contained in the Web base builder repository include the following school science courses – physics, biology, chemistry, geography, etc (Fig.1). Each of these courses includes:

- pictures and photos
- videos
- animations
- interactive 2D and 3D models
- interactive tables and schemes
- tests

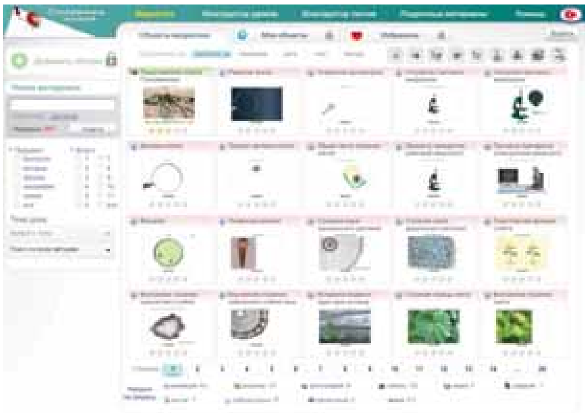

Figure 1. Library of multimedia resources

There are many opportunities to sort resources and to do a search (on ratings, on key words, on author, on level of study, etc). After registration every resource could be studied, rated, saved to favorites and download to user computer (Fig. 2).
A user can also add a library of own resources for exchange and sharing with other users.

Figure 2. A sample of interactive multimedia resource from library

3. Web-service "Presentation / lecture builder"

Service "Presentation/lecture builder" allows you to prepare a presentation consisting of different media objects while preserving inherent interactivity in individual presentation, without special knowledge in ICT.
There are a set of presentations according to curriculum of school course of science. A user can use and edit them, or build new ones (Fig.3). For presentations a user has the same capabilities as for media resources: one can put rating, add to favourites, download to own computer, do a search on ratings, on key words, on author etc.
So presentation is the sequence of interactive multimedia resources (Fig.4), integrated in sections of lecture.
There are capabilities for consistent and direct navigation between slides, and some instruments to use presentation on smart boards or other devices for presentations.

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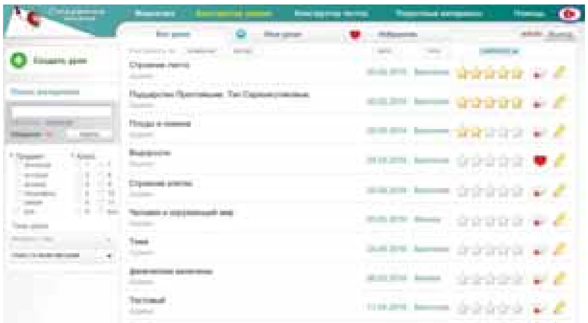

Figure 3. Web-service "Presentation/lecture builder"

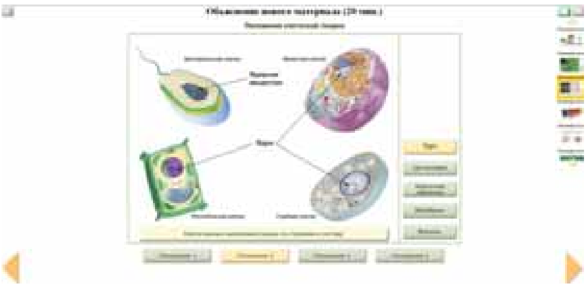

Figure 4. A sample of presentation, building used web-service

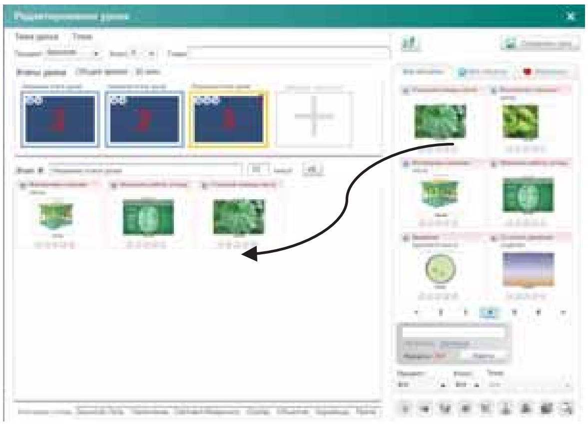

Figure 5. Creation of new presentation

In order to create (or edit) presentation user have to open corresponding window and complete all slides simply drag and drop necessary resources (Fig. 5).
As basic blocks for presentation it could be used not only multimedia resources from library but also own pictures, animations and videos. Furthermore educators can insert to slides some comments and necessary text fragments.

4. Web-service "Test builder"

This web-service allows educator at first to select type of test: written tests, multiple choice, alternative response, matching type etc. Then educator can select test questions from a database or add own questions and fill the form. Test builder includes the capability to insert graphics from media library or from user computer.
Creating tests are the same objects as media recourses in framework from all features described above.

5. Conclusion

The first stage of the Web-based builder of digital educational resources has been accomplished. It can be considered as a framework for using modern multimedia resources in science education.
But as a complex solution this project underlies another project – Virtual Laboratory of nuclear fission [3]. After discussions with our collaborators from South Africa it was decided to continue development of new elements of Virtual Laboratory in the form of Web-based builder. Our vision for the future is the synergies amongst science laboratories, universities and schools in the development capabilities for effective tools for science education. (Fig. 6).

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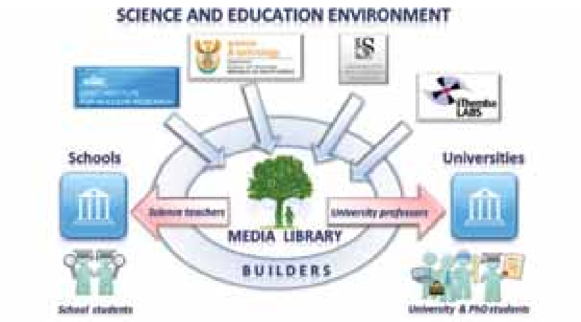

Figure 6. Capabilities of implementation of science and education environment on the base of web-based builder

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Research Centres and Industry as Stakeholders for Innovation Using Nanotechnology. A Social Change

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Abstract. *Nanotechnology is a reality that is growing tremendously, creating and redefining added value products. Presenting an opportunity to revitalize and innovate industries and, consequently, for a more productive, entrepreneur and innovative society. Despite the developments in this scientific area, there are still several constrains preventing a boarder use of it by the industry sector, namely, the lack of information and uncertainty related to human's health and environment impacts. To overcome the latter, awareness of the potential applications and limitations by the industry agents is of great importance, in order to implement an objective strategy, based on dedicated knowledge and an effective and entrepreneurial interaction with the stakeholders. This paper presents the methodology applied to develop an assertive dissemination plan to enhance the connection between research centres and the industry sector in the nanotechnology area.*

Keywords. Applications, human health, environment impacts, nanotechnology.

1. Introduction

Nanotechnology offers new opportunities for the industry sector by the development of new products and/or enhancing existing products, assisting therefore innovation and competitiveness. It may be a key pillar to contribute for the economy's growth [1]. However, this will only be possible with detailed data dissemination and clear information of the advantages of nanotechnology. How to involve, effectively, all the actors, such as academies and research centres, industry and final users, is one of the challenges in this area [2].
In this communication, the methodology to achieve a closer approach between the stakeholders, developed within the CarbonInspired 2.0 network, will be presented.

2. Stakeholders for innovation in nanotechnology

The group of stakeholder with interest in nanotechnology is board, and includes governments; the community (composed by the technology end users and the ones exposed to the environment impacts of it); the knowledge producers, both private and public, and here referred as research centres agents; and the industrial sector agents, which include owner, investors, suppliers, etc.
The cooperation among stakeholders has an important role, especially nowadays, with a higher demand for excellence, competitiveness and differentiation. An effective collaboration can be obtained when tangible interests and fears are well and clearly identified and the communication

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channel is truly established, accomplishing the goals of all the involved.
Research centres and industrial sector agents are the focus of the methodology developed and here presented.

2.1. Research centres agents

Academies and research centres are crucial actors in nanotechnology innovation, because they are the major knowledge creation agents. In this way, it is of great importance that the expertise and knowledge obtained can be capitalized into the industry, by the direct transfer (licencing or share development) or by spin-off creation.

2.2. Industry sector agent

Industry agents are the economic motor for the development, therefore they must pursue innovation, not only with internal R&D but also trough the channels provided by academies and research centres. For the latter, it is of crucial importance that industrial agents develop an improved permeable posture to the innovation and research that is created in research centres.

3. Applied methodology

The methodology applied in the project in order to feed the cooperation of the stakeholders in the specific area of nanotechnology in the SUDOE space industry, rely on the innovation promotion and the constitution of cooperation's stable networks in the technological field.
Due to the current uncertainties that still exist regarding nanotechnology manipulation, lack of knowledge and information, it's mandatory to have a structured and dedicated methodology to overcome it and in order to achieve the stakeholders' deep involvement.
The CarbonInspired 2.0 project aim is to capitalize the results from the previous one, disseminating them through the primary target audience: the companies, especially for a deeper awareness of the nanotechnology potential.
To pursuit this goal, following the project's scope, several actions were defined and are detailed in the subsections.

3.1. Dedicated questionnaires

Dedicated questionnaires to the industry sector were formulated, being one of the key actions of the project. The construction of a database with detailed data concerning the use of nanotechnology, type of projects, major obstacles, fears and health and environment issues is a primordial objective.
Besides the general company information in order to characterize the sector industry type and the professional category of who filled, the questionnaire intends to give a full description of the nanotechnology's current application in the SUDOE space industry and also to understand the gap between the nanotechnology development and its practical utilization in company's context. For that reason, two different categories were defined: nanotechnology's users and non-users, to obtain the major obstacles and concerns of each one.
The nanotechnology user's questions focused in the products quantity and type and the relevance of the R&D in nanotechnology on the company's innovation. Health and security issues and

environmental impact were considered as major concerns regarding the utilization and manipulation of nanomaterials. The nanotechnology non-user questionnaire section intended to obtain the main reasons for the non-utilization of nanotechnology, especially the major obstacles.

3.2. Technological surveillance

A continuous technological surveillance is conducted by universities and research centres with enterprises. To have an effective interaction with industry, the channels and resources applied are wide enough to consider all users types. Presential dedicated meetings have a key role for an effective involvement of the stakeholders, with a clear discussion of the main contributions of each partner for potential synergies. To reinforce and/or complement the latter, the use of ICT's offers access to updated/state of the art information and catalyses the need to presential meetings. Blogs or social networks are practical examples of this. CarbonInspired2.0 project uses a blog, Fig. 1, and a LinkedIn group, Fig. 2.

3.3. Knowledge's transfer

The dissemination of the work developed in academies and research centres, presenting prototypes that were developed by the consortium members and presented to the industry as examples of the nanotechnology applications it's mandatory for a deeper interaction with industry. Specialized technical seminars and workshops are being presented by all CarbonInspired 2.0 consortium partners considering as primary target audience the industry and entities related to innovation and competitiveness, all based on the current national and European standards for nanotechnology, as illustrated in Fig. 3.

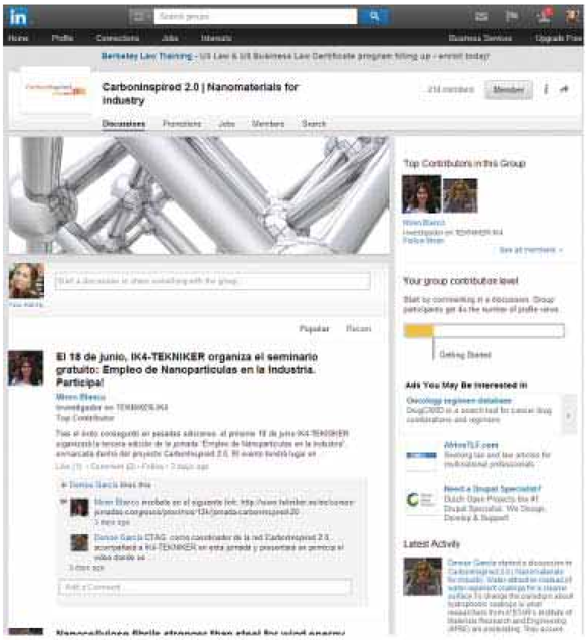

Figure 1. CarbonInspired2.0 blog's template

3.4. Dedicated and specialized formation

Dedicated and specialized formation using several communication channels as technical presential workshops and e-learning specific courses. The e-learning specific courses are online free courses prepared and presented by the five consortium partners of the CarbonInspired network focusing specific thematic related to the research and investigation conducted by each. Being nanomaterials transversal to all technology applications, some of the sectors are detailed as practical examples of the

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nanotechnology application, e.g., maritime, automotive, MEMS, furniture/textile, environmental and aeronautic.

Figure 2. CarbonInspired2.0 LinkedIn's group template

Figure 3. CarbonInspired2.0 seminars and technical workshops

3.5. Industry user's guide

The development of a user guide for the industrial sector with the best practices for a higher awareness of the nanotechnology potential, as a key role for innovation and competitiveness but also the actual major concerns, namely, the health and environment issues is one of the main objectives of the project.
The current industry reality, needs, potential and concerns, based on the inquiries results and the presential meetings were the main source of information to structure the abovementioned guide. Furthermore, its aim is to provide a useful user guide to link the stakeholders in an effective way.
The guide will offer a detailed manual regarding the nanotechnology concepts and applications, as described below:

- Project contextualization;
- Nanotechnology definitions ;
- Overview of the current nanotechnology in the space SUDOE industry;
- Current and potential industrial applications of nanotechnology ;
- CarbonInspired 2.0 demonstrators to be applicable in industry;
- Environmental and health issues concerning nanotechnology.

4. Results

Considering the numerous actions conducted by the consortium to achieve a bigger collaboration among the stakeholders and receptivity of industry for the nanotechnology potential, hundreds of companies were contacted, through virtual and presential channels, to participate in the questionnaires and in the CarbonInspired 2.0 platform and benefits as specialized formation.
Regarding the relevance of their feedback, and as a consequence of this action, 151 answers were achieved from several countries. Most of the answers came from

Portugal, Spain and France industry, but also, from U.S.A., Germany, Belgium, U.K. and Moldova Republic. More than 50% are small-medium size company's and with an activity sector very embracing, mainly in the area of transportation, molding, construction, aerospace, aeronautic, chemistry, materials, food industries, automotive, electronics, biotechnology, environment and health.
One of the goals was confirm the familiarity of the nanotechnology benefits in industry, where, 61% of the surveyed are familiar to them but only 26% are actual nanotechnology's users, as illustrated in Fig. 4 and Fig. 5.

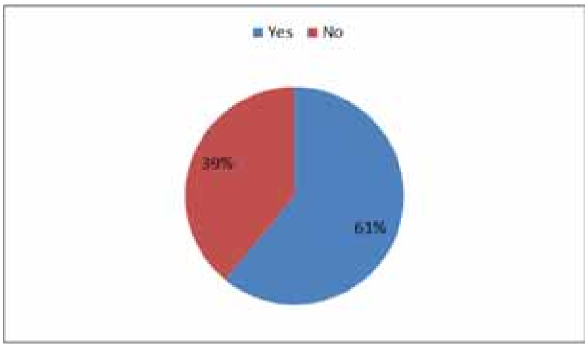

Figure 4. Familiarity of the benefits of nanotechnology in industry

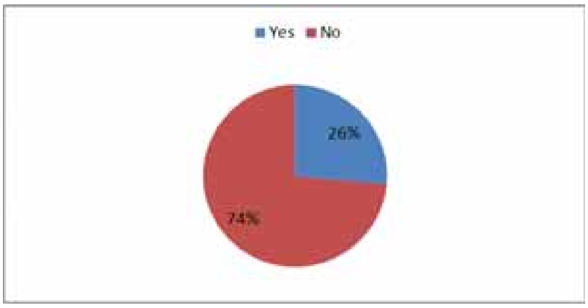

Figure 5. Familiarity of the benefits of nanotechnology in industry

Nanotechnology user and non-user considered the lack of information, the lack of knowledge and the high ratio between the investment and profit as obstacles for the nanotechnology usage. Nevertheless, the human health and security for nanomaterials manipulation and the environment impact weren't preponderant.

5. Conclusions.

The successful creation of community added-value from nanotechnology involves a need for a social change, restructuring the dynamics between research centres and industry, but also by means of the dissemination of knowledge which will promote awareness of the potential and limitations of the technology.
Despite the developments and efforts in this area, including the utilization of several communication channels, there are still several constraints, as the difficulty to gather the industry attention and awareness for an effective interaction between stakeholders. To overcome it, personal contacts were conducted to present the project and to request the stakeholder's feedback. Consequently, the lack of information and knowledge and the concerns regarding health and environment are the major obstacles to a deeper penetration of nanotechnology in industry.
Based in a social change need, a bigger investment in presential actions of dissemination and practical applications examples are relevant in order to increase the collaborations between academies, research centres and industry, and diminishing the gap that still exist.

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6. Acknowledgements

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e-Lab: Implementation of an On-line Course for High School Students

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Abstract. *This article aims to analyze the results obtained after conducting an online e-lab course (e-lab is a real remotely controlled lab available in http://elab.ist.eu and free) for about 20 students of Physics of the 12th year from a secondary school in Lisbon, Portugal (Escola Secundária Padre António Vieira).*
The course was conducted using the e-learning platform Moodle containing all documents and references enabling students to undertake the course independently and lasted for two weeks. The results were very satisfactory and the next step will be to conduct a pilot study with teachers of physics and chemistry.

Keywords. b-learning, e-lab, e-learning, online course.

1. Introduction

It is fundamental to guide teachers through the methods for teaching/learning science. We, as teachers, must be aware of our responsibilities and of the causes responsible for the student´s low motivation in scientific subjects such as Physics and Chemistry. The birth of Internet opened a door to a whole new world of possibilities where almost anything is possible. It allows for teaching to spread its wings and finally reach students and teachers anytime at anyplace. E-learning appeared as a way to obtain information, knowledge and data for learning purposes through appropriate programs using Internet as a vehicle [1]. Teachers seem to be a lit bit apprehensive regarding the use of remote labs. Perhaps because the teacher loses his classical central role in the learning process and also because it is a challenge forcing the teacher to have continuous training in technological subjects [2, 3].
Recently we started to implement online courses for students and teachers using Moodle platform [4]. With these e-learning courses about the practical implementation of e-lab, it is intended that the trainees can use e-lab properly within two weeks.

2. Online course description

It is imperative that the school tracks and even leads the development occurred in other areas and contexts of society. Thus, in addition to ensuring the availability of the required resources, it is essential to prepare properly the educational agents for the regular use of Information and Communication Technologies (ICT) so that they benefit from them in their activities.
These e-learning courses are also aimed to stimulate students and teachers to know, learn, explore and use technological resources to support the use of experimental methods in science education, in particular in physics and chemistry.
The starting point is the exploration of the online and remote laboratory e-lab, which provides experiences remotely controlled by users that are addressed to the disciplines of

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physics and chemistry [5, 6]. The main goals of this courses are: (i) promote experimental teaching of science in primary and secondary education, encouraging and stimulating research in school; (ii) provide students with a tool to support the experimental teaching in the field of physics and chemistry, based on the potential of ICT; (iii) provide a space for reflection in order to implement the experimental methods in the study of physics and chemistry; and (iv) explore the gains of an integrated work in these two subject areas, through the use of ICT.
The Moodle platform has all the documents and references needed to carry out this course. It is important to read them to increase the level of knowledge on this remote laboratories topic.
Two different Portuguese courses were prepared, one for teachers and other for students, both related to one of the active e-lab experiments: verification of Boyle-Mariotte Law.
The course prepared for teachers will be implemented in September 2014 (pilot study) but in May 2014 has already started the first e-learning course with 21 students from a secondary Portuguese school (Fig. 1).

The course has the following structure:

- Presentation of e-lab platform
- Testing e-lab platform
- Reading and investigating on the e-lab experiment "Verification of Boyle-Mariotte Law"
- Launching trials and data collection using a task protocol
- Data analysis
- Perform three assignments and submit them electronically (1- Answer pre and post experimental questions; 2- Fill a logbook with the collected and analyzed data – laboratory report prepared by the students; 3- Write a page with possible future e-lab experiments and the experience in this e-learning course)
- Final evaluation inquiry.

Figure 1. Screen capture of a page of the e-learning student e-lab course from a secondary Portuguese school

The final evaluation questionnaire to be answered by the students is summarized in Table 1.
The answers to questions 3 to 8, inclusive, shall be ruled by the following options: Totally agree, partly agree, neutral, partly disagree, and totally disagree. The question 10 is a Yes/No question.
After the course completion students have a final evaluation that counts to the final grade in Physics and Chemistry course at their school.

QUESTION NUMBER	QUESTION
1	Introduce your first and last names.
2	Indicate your school year and the school you attend.
3	The course objectives and contents were appropriate.
4	The practical activities allowed the course contents application and the course objectives achievement.
5	The course duration was appropriate.
6	The teacher was helpful whenever needed.
7	The Moodle platform worked well.
8	I enjoyed taking the course.
9	On a scale 1-10 how would you classify this course?
10	Would you like to attend more online courses like this?
11	Suggestions and comments Here you should place any suggestions or comments regarding the course you have just completed (you can highlight strengths and weaknesses of the course, for example).

Table 1. Final evaluation questionnaire

3. Results

It was proposed to 21 students from Year 12 who attended the discipline of physics at Padre António Vieira Secondary School (Lisbon, Portugal) during school year 2013/2014, the completion of an online course related to "Determination of Boyle's Law" e-lab experience.
From that pool of 21 students, 19 performed the online course and of these, 18 answered to the final evaluation of the course.
Although the course had a duration of two weeks, the course page was available two additional weeks for final thoughts and considerations about the same.
The course had a strong collaborative component that became evident by the number of interactions performed. During about four weeks 2640 interactions between posts and views were registered.
As shown in Figure 2, during the two weeks after course completion (the course ended in May 23, 2014), a great activity on the platform can be detected.

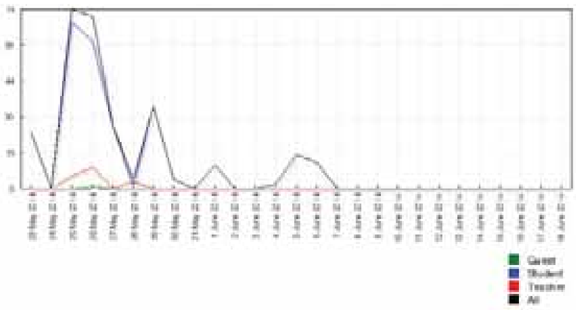

Figure 2. Graph - obtained from the Moodle platform that quantifies the activity performed in the online course from May 23 to June 6, 2014 by guests (green), students (blue) and teachers (red)

Regarding the course evaluation by students, bellow are presented eight figures (Fig. 3-10) showing the results obtained.

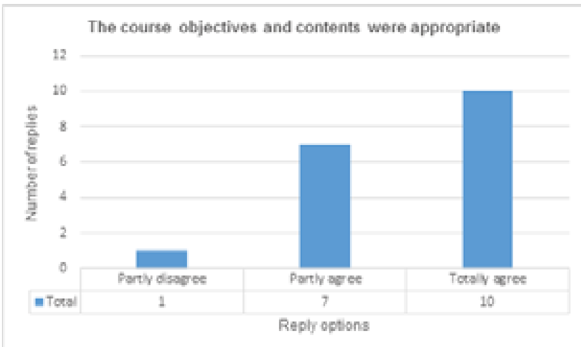

Figure 3. Answers obtained for question 3 of the final questionnaire "The course objectives and contents were adequate"

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Nr. of answers	Answer to question 11 of the final questionnaire "Suggestions and Comments"
1	I had some difficulties to access the program and carry out the experiments. I also had difficulties answering some questions, because I had to use excel with which I do not work well.
2	The only weak point was that to use e-lab it is required a particular program, in this case java 6.45, and so there were many students who have difficulty to have access to e-lab, but a video that one of our colleagues (Miguel) did helped a lot of people on this issue, so I think the e-lab should work on any version of java.
3	In overall the course itself is funny, maybe it requires different types of experiments with more illustrations and that work not only in java 6 and also that have no difficulties working on MAC OS X.
4	I found the course interesting, I thought preferable to conduct an experience like this than in a laboratory, the experimental errors compared occur much less frequently and are smaller, which I think is a strong point of this course. However the course was not very appealing to me personally, perhaps because it is not a matter that I find interesting, or perhaps due to the way it was addressed in this course, however I think it was a positive experience.
5	Place the files to download more visible and solve the various problems of e-lab, for example the possibility to use the updated version of java.
6	The course should have fewer repetitive questions, and should have a tutorial explaining this table in Excel.
7	I found the questions very repetitive. But overall I found the course interesting and productive.
8	I think there should be a way to have more students working simultaneously in e-lab so that there is no need to wait for them to finish the experience, despite being a real lab.
9	I enjoyed taking the course because it allowed me to know a new way to conduct experiments effectively.
10	I enjoyed working on this course. It showed me a new way of performing scientific experiments. It allows making various experiments in a useful and practical way that probably could not be carried out otherwise.
11	I liked being able to take the course without having to leave home.
12	Moodle could be more organized. The forums resulted very well.
13	It should be easier for a new user to download an experience and to run e-lab without having to uninstall and install various programs.

Table 2- Answer to question 11 of the final questionnaire "Suggestions and Comments"

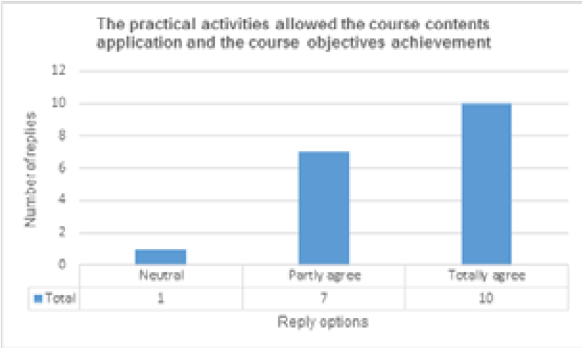

Figure 4. Answers obtained for question 4 of the final questionnaire "The practical activities allowed the course contents application and the course objectives achievement"

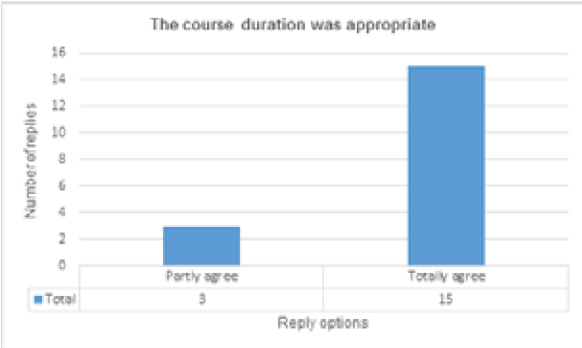

Figure 1. Answers obtained for question 5 of the final questionnaire "The course duration was adequate"

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In question 9 students were asked to rate the online course (Figure 9). The average rating of the 18 students who answered was 7.5 in 10 points.
In question 10 the majority of students (about 78%) stated that they would like to attend online courses like this (Fig. 10).
Below (table 2) are the suggestions and comments made by 13 students in order to improve the e-lab experience through an online course. All answers are relevant and important to take into account in the future of e-lab and in online courses using the e-lab.

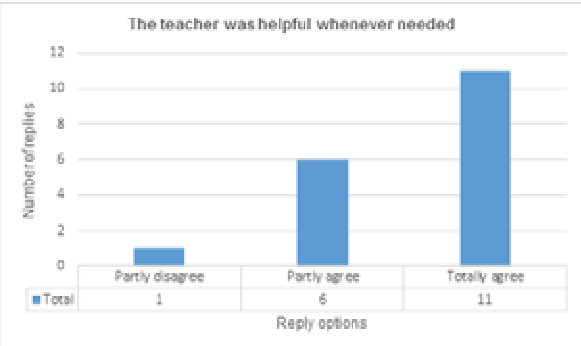

Figure 2. Answers obtained for question 6 of the final questionnaire "The teacher was helpful whenever needed"

6. Conclusion

At this time the final results of the pilot study are optimistic. The forums are really participated and active and it was evident a collaborative help between students while trying to perform all the assignments requested.
The experience of conducting this pilot study was very positive as shown by the results.
Students showed interest, motivation and dedication in the various activities proposed, and there are no students with a classification less than 15.0 values (over 20) at the end of the course.

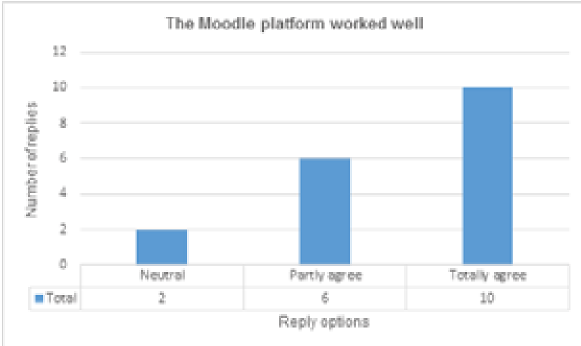

Figure 3. Answers obtained for question 7 of the final questionnaire "The Moodle platform worked well"

Figure 4. Answers obtained for question 8 of the final questionnaire "I enjoyed taking the course"

The fact that the course takes place online has the advantage that students can search online for any information that can help them in the implementation of activities, although the course itself provides all the documents and references required for its realization.
Given the evidence presented, we conclude that the application of this online course is to continue, now using a wider universe of students. Possibly MOOLs (Massive Open

Online Lab) will be the next step.

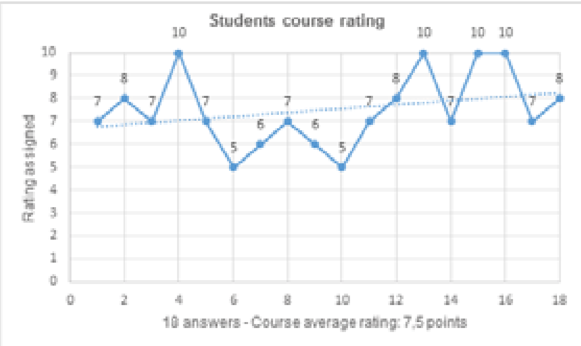

Figure 5. Ratings given by students to the course

Figure 6. Answers obtained for question 10 of the final questionnaire "Would you like to attend more online courses like this?"

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Use Open-Source Hardware for Classroom Research

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Abstract. *The main objective of this project is to study ways to build open-source hardware sensors that can be used on science classes. By searching on the community of open-source hardware users we intend to develop small electronic equipment with practical use in science classes [1]. The use of open-source platforms enables fast learning and knowledge sharing. Based on this information, we tried to identify projects that could be used in schools. We built a humidity and temperature sensor very simple and inexpensive that can either be used independently or connected to a computer as a data logger. This equipment allowed measurements of temperature and humidity in our solar oven for fruit dehydration. This equipment can also be used in experiments monitoring of abiotic factors and growth of plants, in practical activities for measuring humidity and temperature of the exhaled air, on field activities, on the study of thermal efficiency of buildings, … The project involves learning skills in electronics, computer science, programming, biology: we may say that it is interdisciplinary.*

Keywords. Open source hardware, Arduino, *sensors, experimental work, research in the classroom*.

1. Introduction

This project consists of a humidity and temperature sensor using the Arduino's open-source electronics prototyping platform (Fig. 1). This device accurately measures both in real time and can be connected to a computer for data recording and interpretation. Besides showing this specific device, it's also pretended to show the world of usable possibilities that Arduino's platform can provide.

Figure 1. Arduino Uno

In this report, we will demonstrate how to build a cost-efficient humidity and temperature sensor, that is both effective and has a low-learning curve on how to build and use it. We will also base this presentation on the practical uses of this project and the sensors themselves while at the same time point out the wide range of uses of Arduino's platform.

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2. Building a low-cost humidity and temperature sensor

The construction of the prototype was based on two steps: 1) the binding of hardware and building components and 2) programming and setting hardware. In both cases we used the Arduino forums and web pages of component suppliers for information about setting. The humidity sensor and temperature used - DHT2 - allows digital connection, eliminating the calibration and helping the transfer of data. In programming it was necessary to use and load to the chip the digital sensor library, as well as a series connection to the LCD monitor [2]. As an extra it was used the computer interface PLX-DAC that allows to connect the sensor throw USB (via serial port with Arduino drive) to computer and recording of data in excel [1]. All components were mounted in a electrical box, with batteries for standalone use (fig. 2).

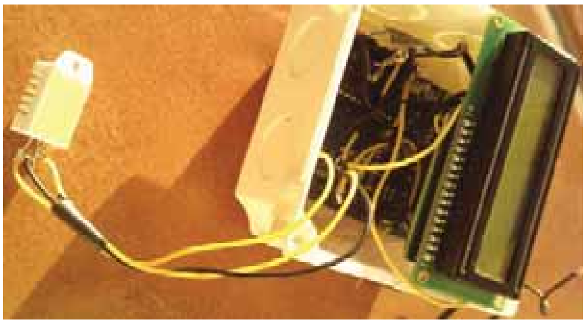

Figure 2. Standalone sensor prototype with Arduino and DHT2

3. Low-cost sensors' practical uses

Some of the potential uses of Arduino sensor in science classes and school are:

- Measurement of a greenhouse's temperature and humidity (Ecology);
- Study of abiotic factors in a warm house and plant's growth (Ecology);
- Development of experiences on the inhaled and exhaled air's relative humidity (Physiology);
- Evaluation of the thermal comfort inside buildings.

4. Project's wide exploration range

In this segment, we explored the multitude of uses that Arduino can have, both in schools and society projects and experiments. By implementing Arduino in schools we are able to develop, for example, a sensor that measures CO_2 in order to evaluate the air quality inside classrooms and city's (www.smartcitizen.me/), physiology sensors (www.bitalino.com) and many other possibilities.

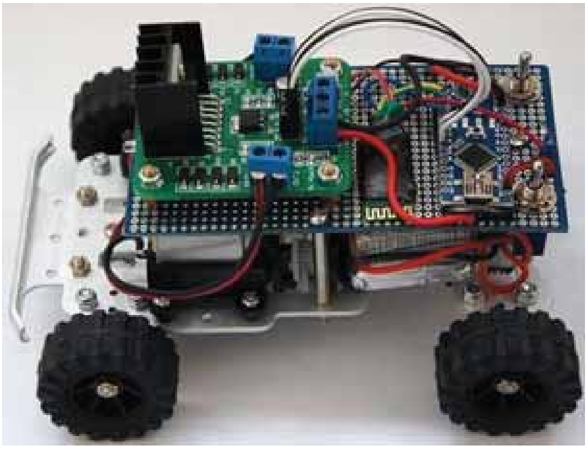

Figure 3. A remote controlled car built with Arduino

Arduino can also be coded to work as a piano or other instrument for music classes.

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It can also be used for pleasure like building robots and games for the break times.
Another use of it can be applying it to security protocols for schools, namely, anti-theft alarms, check-in and check-out control systems, fire alarm. It may also be used to control the school's bell, the interactive boards, the irrigation system of the school gardens and also it's possible to build computers and projectors in the informatics classes.
But this platform can be used in many other scientific areas. Starting with its use for medical purposes, it is possible to code it in order to build equipments like defibrillators, blood pressure measurers, glucoses monitoring devices for diabetic people and, finally surgery machines. It has also shown being useful on animal health control, by being implemented in systems that can locate the animals through infra-red sensors, measure their weight, body mass, temperature, as well as checking the animal's nest's temperature and humidity in order to keep it in most appropriate values for the animal's sake.
A very special use of this micro-controller was dedicated to people with paralysis resulting from Amyotrophic Lateral Sclerosis, allowing them to draw on a computer screen with their eyes, by scanning their movement and translating it into a drawing on the screen. And the best part is the price, because these eye tracking systems only cost about 150€ while the traditional commercial eye tracker costs around 6.600€ to 14.700€ which is way more expensive while doing the exact same thing. And that stands for every Arduino system; it's always cheaper than the already existing versions since anyone can build them with a bit of help. Wheelchairs can also be built for people with leg paralysis or other problems that prevent them from walking.
Another use of the Arduino`s is the creation of equipments used on a daily basis like cellphones and computers, but even more impressive is the use of this in robotic.
For instance, there´s a project called Arduino robot, a tiny robot on wheels, which can be programmed do to do several tasks, depending on what the code for programming was. Some examples is to use it as a computer, or a sensor, or just like a robot.
Arduino can be used for whatever the people need. It just requires some imagination, a code and some components and it is possible to create anything our minds can think of.

5. Conclusion

The use of Arduino on school projects has many competences and development to come. In Portugal it is very used on robotics projects, but it has a great potential on other sciences and many other possible uses.
It's necessary to continue exploring projects, forums and recent developments of the community for better introduction of this technology in the classroom.

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Hands-on Science
Science Education with and for Society
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The Use of Computational Modeling in Teaching Optics to High School Students

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Abstract. *The following paper presents a detailed account regarding the use of computational models, created in Modellus, a freeware, in teaching high school students optics concepts and its results. This work aims to evaluate if models can achieve their ultimate goal: improving students' comprehension of physics. Therewithal, it discusses their employment in class. Supervised by Alan Machado in "Jovens Talentos" scholarship program, the other two authors, also high school students, developed models that represent optics concepts and allow students to interact with them. The models were introduced to the students, who gave their opinions about using such technology in class.*

Keywords. Computational modeling, high school, mirrors, Modellus, optics, physics, technology.

1. Introduction

A typical physics curriculum in high school includes optics as one of its main topics. As the majority of high school contents in Physics, studying optics offer the possibility of observing and measuring its basic concepts, laws, properties and magnitudes in a laboratory. However, the teaching techniques usually adopted in class do not take advantage of that.

Commonly, teachers resort to expositive classes in order to introduce new subjects. Those classes are focused on the chalkboard or whiteboard, where the teacher writes all the information the students need to take a further examination. In this method, all schemes must be either imagined or represented in a two-dimensional drawing. Besides, such classes are usually centered in the abstract and mathematical formulas that allow solving problems previously proposed in text books.

Although this approach offers a simple and quick way of transmitting knowledge, it requires the students to be passive listeners. This way, students do not get stimulated to think, allowing them to lose their focus on the teacher's speech. Moreover, such way of teaching physics restricts the students to the classroom, keeping them from handling instruments, measuring and observing concepts experimentally, which triggers their curiosity, motivating them and drawing their attention to the content that is being studied.

Another essential point that must be taken into consideration when teaching physics to high school students is the potential of inspiring them into pursuing a scientific career. So, flowing the scientific method, students should be able to observe a phenomenon or characteristic, raise questions, search for explanations, explore how the experiment behaves in different conditions, varying variables, etc. In this case, students are stimulated to draw their own conclusions after the exploration activity, allowing further explanations in classroom and further presentation of formulas and laws to be better comprehended and kept in memory;

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Such different teaching method would require a functioning physics laboratory and specific instruments, which is, unfortunately, only offered by very few high schools. Most schools cannot afford such ideal conditions, as laboratories demand constant maintenance.

Also, one laboratory or one set of instruments may not be enough for several classes and subjects. In addition, taking a large quantity of students to the laboratory may damage instruments or harm the students, as they would handle optics instruments, which include mirrors and lenses. Therefore, in general, laboratories may not be a viable solution to the problem described. If experimentation and interaction are the key for learning effectively and laboratories are not available in most schools or offer risk, what could be used to solve the dilemma? The answer dwells in computational modeling.

2. Computational Modeling

A computational model can be defined as a graphical representation of a mathematical model. Those models show values of physical quantities, movements, graphs and even tables on the screen, based on equations, values and instructions previously given.

Computational models also offer users the possibility of altering the value of variables and effectively interacting with what is being shown on the screen. After such interactions, the system will behave according to the new scenario. That way, users can observe an experiment under any desired condition and reproduce it as many times as needed.

2.1. The Importance of Modeling

Computational modeling is able to simulate experiments that would be done in a laboratory. In other words, computational models are actual “virtual laboratories”, as they are able to reproduce a lab experiment virtually.

Thanks to informatics, a physical laboratory is not needed anymore in order to adopt more practical classes, as executing an experiment in a virtual environment is quicker, simpler, and safer besides being a valid approximation of what would be seen in the laboratory. And, as the majority of schools have computer laboratories, many more schools will have access to experimental activities.

However, the importance of computational modeling is not restricted to matters of utility. Models provide more benefits to students than an expository class. Computational modeling does not involve solely physics. It also develops programming skills and logical reasoning. As the “virtual lab” of computational models is still a computer program, it is necessary to understand how an instruction is processed when preparing a model.

Because of that, computational models may be used differently in class, creating two new types of class activities. Teachers can invite students to handle a model and explore it, changing the values of its variables, or to create their own model, as an exercise for their programming skills and reasoning. The act of creating a model itself involves problem-solving skills and knowing how to write the mathematical model and the conditions in which its equations are true. It is important for the students to understand what must be included in a model and what

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should be left out. In this second approach, students must be familiarized to the subject that will be modeled, whereas in the first approach, that is not necessary.

2.2. The Software Modellus

In order to develop the computational model used in this work, a freeware called Modellus was used.
Modellus is the leading software in computational modeling and can be downloaded and installed on any computer, allowing models to be used in a school computer or in a home computer. Thanks to this advantage, students can explore a model whenever necessary and can cooperate in building new ones.
The model used in the activity described in this paper was created in Modellus X 4.05, the latest version available at that time.
As shown in Fig. 1, Modellus initial screen contains a blank space where the model will be built, a top bar which allows access to different settings and features and a bottom bar which contains the "Play" button and the time control, which shows how many seconds have passed since the "Play" button was pressed.
The blank space holds the most important elements of the simulation: the ones that will be used by students when exploring the model. In it, four frames are depicted: the mathematical model, where equations and conditions that will describe the movements and results of the model will be inserted; the graph, which can be used optionally in order to draw a graph that may be relevant to the model; the table, which stores values of variables in different instants; and the notes, where relevant remarks and advises can be put.

Figure 1. Modellus's easy-to-use interface

3. Theoretical Model

The theoretical contents, like formulas, can be introduced to the students before the model exploration or after it. Both approaches lead to positive results in the teaching/learning process. If the theory is explained before the use of a computational model, the model can be used to observe the theory happening in a practical situation, which promotes a better memorization, to understand the reasons why that theory is true or analyzing exceptions or specific scenarios. If explained after the use of the model, it can be used to present the first basic concepts and axioms that will be needed in future classes and, specially, to allow students to deduct how a system behaves by themselves.
In order to create a computational model, it is necessary to know the theory in advance, because it will be needed when writing the mathematical model. So, if students will be responsible for modelling, the theoretical and abstract explanation must be done before starting to develop the model. If the

students will manipulate the model before being introduced to the theory, the teacher or an older student must create the model.
The complexity of the theory involved in a computational model greatly varies from a model to another, depending on its subject and on what it will show on the screen. In the activity described in this paper, equations 1, 2 and 3 were used. Equation 1 describes the relation between the focal point and the distances of the object and its image from the mirror, equation 2 describes the relation between such distances and their heights and equation 3 describes the focal point in function of the center of curvature.

$$\frac{1}{f} = \frac{1}{a} + \frac{1}{b} \quad (1)$$

$$\frac{i}{o} = -\frac{b}{a} \quad (2)$$

$$f = \frac{c}{2} \quad (3)$$

In these equations, f is the distance from the mirror to the focal point, a is the distance from the mirror to the object, b is the distance from the mirror to the object's image, o is the height of the object, i is the height of the object's image and c is the distance from the mirror to its center of curvature (radius).
As the computational model would have to calculate the values of the image's height and its distance from the mirror, equations 1 and 2 have to be rewritten, resulting in equations 4 and 5.

$$b = \frac{1}{\frac{1}{f} - \frac{1}{a}} \quad (4)$$

$$i = -\frac{b \times o}{a} \quad (5)$$

The choice of a simple theoretical model has the objective to permit the students to deduct the models by themselves. In a more complex model, there would be a large gap between intuitive observation and the formulas in the theory.

4. Methodology

Sérgio Lima, physics teacher in Colégio Pedro II, the school where two of the authors study, informed the subjects which would be approached in his next 10th-grade classes. The subject "Gaussian Mirrors" was chosen. Sérgio authorized the use of such model, instead of the conventional expositive class, in three 10th-grade classes in Colégio Pedro II.

4.1. Model Construction

The construction of a computational model starts with the decision what will be presented in it and how it will be depicted on the screen. So, the first decision that must be made when creating a model is what mechanism or system the model will represent, transmitting as much information about Gaussian mirrors as possible. Keeping this in mind, it was decided that the model would depict a Gaussian mirror, an object that would be handled by the user and an image that will be generated by the model based on the object's position.
Now, the model's creators are able to construct the first structures and elements that will appear to the student on the screen, as in Fig. 2, and to insert the mathematical

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model that will be needed to draw the elements shown, as in Fig. 3.

In Fig. 2, the red element represents the object, the yellow element represents the object's image and the blue element represents a concave mirror.

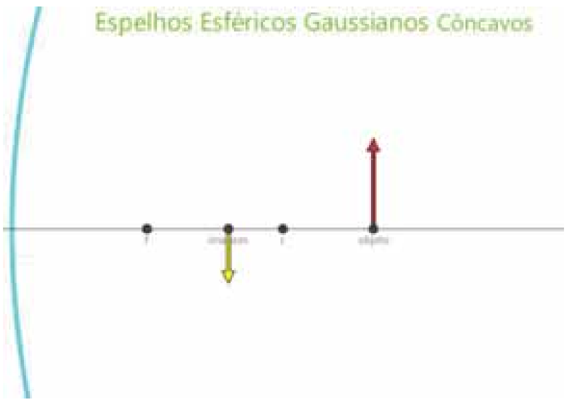

Figure 2. Model's visual elements

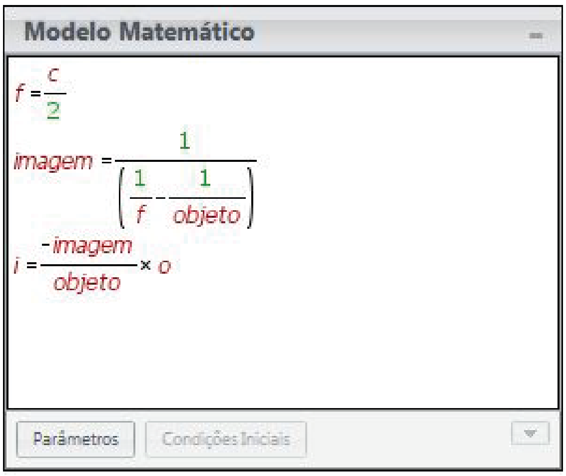

Figure 3. Mathematical model

Finally, the developers must determine which values will be entered by the user and, optionally, which ones will be shown by the program on the screen. The interface seen by the students must also be intuitive and simple. Therefore, the model's creators must display only the necessary variables, which are important in their evaluations. Variables that aren't relevant to the learning process must be left out.

It was determined that students would be able to alter the following values: distance from the object to the mirror, object's height and center of curvature's distance from the mirror's surface. On the other hand, the model would present, using the scheme shown in Fig. 2, the image's distance from the mirror, the image's height and the focal point.

This way, students would be able to identify which conditions the image would be real or virtual, upright or inverted, magnified or reduced and even, the condition in which the image wouldn't be formed (when image's distance tends to infinity). The students are supposed to control the three values said using three controllers, shown in Fig. 4.

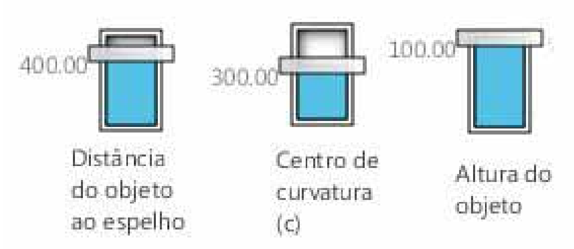

Figure 4. Controllers used by students to interact with the model

In order to represent the two types of curved mirrors (concave mirror and convex mirror), two models were created, one representing one type of mirror. The unique differences between the two models produced are the mirror and the position of the center of curvature and the focal point. The mathematical model is common to both models. Fig 5 and Fig 6 show the final models. The creators were assisted by their advisor, Alan Machado, in a program called "Jovens Talentos" offered to high school students in Rio de Janeiro State University.

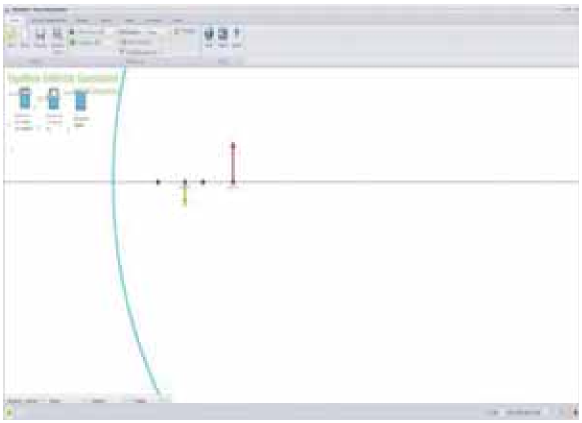

Figure 5. Model for concave Gaussian mirrors

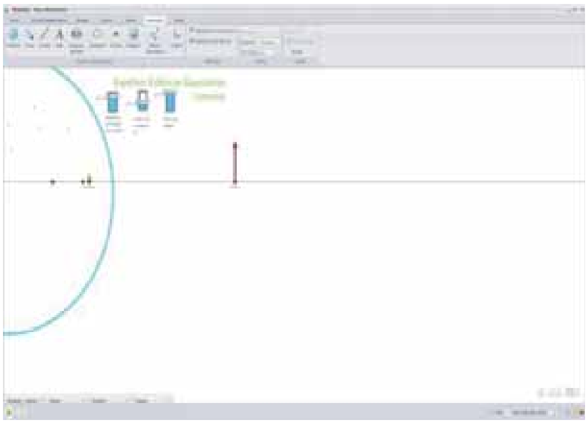

Figure 6. Model for convex Gaussian mirrors

4.2. Model Application

Each class, composed of approximately 30 students, was guided to the computer laboratory. There, the students worked in pairs. Each pair had access to one computer containing the two models and was invited to explore the models. A guide, containing some instructions and questions, lead the students in their exploration.

After exploring freely the models, each pair had to fill in an online form, answering some questions regarding reflection in curved mirrors and describing their impressions about using models in class. One of the authors observed the whole process.

5. Observed Results

All students handled the models correctly and quickly drew their first conclusions about what they were seeing on the screen, due to the intuitive interface. Surprisingly, some students managed to alter the position of elements, zoom in or zoom out the model, or analyze the mathematical model, although they were not instructed to do any of these actions. This shows how students can quickly adopt and benefit from technologies used in class and signs that they will be able to create different models easily in the future.

All pairs were able to answer the online form completely. Although the vast majority of them answered the proposed questions correctly, a wide range of different types of answers was collected. The same questions were answered differently by the students. Many of them resorted to analogies, exemplifications and other means of explaining the concepts behind the reflection phenomenon. This shows that exploratory classes using computational models allow students to form their own line of thought, instead of trying to understand and incorporate the one transmitted by a

teacher, making the learning process more effective, as students will comprehend physics subjects better and faster.
In the future, abstract concepts that cannot be visually represented in a model will be transmitted easily due to the good comprehension of the concepts approached by the model.

5.1 Students' Impressions

One of the authors asked some students about their opinion on computational modeling in class. They were also asked if computational models brought better results, in terms of learning, than the conventional expository classes.
According to the students interviewed and the data collected via online forms, using computational models contributed to their learning process, helping them understand concepts and laws involved in the subject approached. One of the students reported that models contribute to learning because "it seems easier to keep in mind the behavior of light and the position of the object's image when looking at the screen and interacting with them".
Some students reported that, after exploring the models, they searched in the internet explanations and more information regarding the phenomenon observed in the model. That is another advantage of adopting computer modeling as a way of teaching physics: exploration rises questioning and curiosity and, as the exploration takes place in a computer laboratory, students can urge to search mechanisms and find any information desired, making them active learners. That instantaneous search could not be done inside the conventional classroom or inside the physics laboratory. The focus of the teaching/learning process is now centered on the student acquiring knowledge.
Finally, when asked about the application of computational modeling in class, the majority of students also stated that computational models should be used more frequently, as a, interesting way of starting a new theme in the trimester.

6. Future Applications

Up to now, more than 30 different computational models were created by the authors and are ready to be used in class. Those models approach almost all subjects analyzed in physics during high school. Moreover, some instruction sets and tutorials have been developed in order to guide students through the process of building a model.
In the future, models will be used in the introduction and exploration of physics subjects throughout all the school year, perhaps gaining a central position in physics classes. And will also be used as study material in the students' homes.

7. Conclusion

Given the work exposed in this paper, it is possible to vehemently affirm that computational models were applied successfully in Colégio Pedro II, providing benefits to the students. The models helped substantially their comprehension about optics and such positive results can be reproduced in other contexts.
Ergo, computational modeling is an effective way of teaching physics and certainly presents a new tendency in education, pointing the natural and recrudescent future

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of education: the adoption of technology in the classroom.

8. Acknowledgements

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Tele-Loucuras: Hands on Telecommunications Engineering Sciences

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Abstract. *The Telecommunications Engineering Sciences are presented as an embracing field of studies with central importance on both scientific and technological development, and cuts across many areas of knowledge, such as maths and physics. Recognizing this value, the project "Tele-Loucuras" was designed and implemented among hundreds of high school students. Following the main goal of spread the scientific knowledge on Telecommunications Engineering and implementing the philosophy "hands on the mass", the results obtained through an inquiry were evaluated proving the importance of these kinds of initiatives to the students' additional training.*

Keywords. Electronics, engineering, high school, additional training, telecommunications.

1. Introduction

The human being needs to be connected with each other since ever, even at distance. For this reason, the Telecommunications Engineering Sciences are an embracing field of studies assuming a central position on both scientific and technological development, cutting across many areas of knowledge, such as maths and physics. Their practical and innovative character opens the door to the creativity and challenged of their professionals, actively contributing to adding value to the country and to the world.

The Telecommunications are responsible for a strong social and economic impact. On the one hand they enable a rapprochement between people and a facilitated access to the information and on the other hand are responsible for the production of essential goods and services in a modern society.

Recognizing the value of this field of studies, the project which we are presenting in this paper was developed among the high school students, following the main goal of spread the scientific knowledge by providing, in a practical way, additional technical training on this field.

2. The *Tele-Loucuras*

2.1. The Team

The project was developed as a partnership between the Aveiro's pole of the Instituto de Telecomunicações, the Department of Electronics, Telecommunications and Informatics of the University of Aveiro and the Amateurs Radio group of the Electronics, Telecommunications and Telematics Association of the same department and was concretized in the field by the authors of this paper.

2.2. The Project

Inserted into one of the main goals of the Instituto de Telecomunicações, transferring knowledge to the society, the *Tele-Loucuras* arises from the idea of spread scientific

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knowledge on Electronics and Telecommunications Engineering, providing additional technical training on this field of studies to the high school students of the Science and Technology course.

The activities should be attractive, fun, assuming, at the same time, a serious pedagogical character, promoting the challenge, critical thinking and teamwork, characteristics of the engineering professional.

Thus, the development of simple practical activities was proposed, having, at the same time, enough content allowing to learn surrounded by a relaxed atmosphere.

These activities were developed for three hours with a break of fifteen minutes. At each school, two classes were addressed, one in the morning and another in the afternoon, each of them having around thirty students.

On each intervention, the project was presented and the activity was briefly explained, stating the essential contents for the theoretical understanding of what would be developed. Hence, the implementation of the activities was carried out by teams of two or three, occasionally four students, who developed the proposed project, exposing their difficulties during the activity, which were mitigated by the team. All of the projects were then tested and validated at the end of each session.

After each session, the participants were asked to complete a short inquiry, allowing the team to make a progressive evaluation of the project and even acquiesced to some suggestions in the course of time, improving from one school to the next one the quality of the *Tele-Loucuras*.

We should stress the fact of the team had stayed in touch with both professors and students which participated in the project, ensuring future availability and helpfulness to clarify issues that may arise after the interventions related to the topics with which the team feels familiar.

2.3. Technical and Promotional Kits

To each student was given a technical kit, which was composed of the components needed to develop the activity. To each student was offered also a promotional kit, this one composed by a certificate of attendance, a quality inquiry, a project flyer, a DETI-UA flyer, and a Summer Academy flyer, since the students could find on this summer courses an opportunity of carrying out other similar activities to the one proposed in this project, everything package in a DETI-UA case. To the teachers were offered the same material, the UA magazine, a pencil and a bookmark. In the Fig. 1 we can see both the technical and promotional kits.

Figure 1. Technical and promotional kits

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2.4. Proposed Activity

The proposed activity was a simple, but functional, FM transmitter, which can be easily found on the internet, actually spread for several websites, to which we made some technical modifications in order to improve its quality, but keeping the original circuit design [1].
It's a complete circuit, since it's composed by all the fundamental electrical components, for instance, resistors, capacitors, transistors, and even an inductor, which should be constructed by the students. Thus, from a large variety of components without any meaning, from the perforated plate, audio jack, wires, and electrical components, following a given procedure the students could develop, from nothing, a complete and functional RF circuit and hear in a commercial radio the music which was generated from, for example, their mobile phones, and transmitted by their projects.
Issues like audio generation, signal modulation and amplification, antennas design, circuit analysis and physical implementation details were addressed.
Thus, the circuit proved to be challenging and attractive, being also efficient in printing a high degree of satisfaction and achievement by those who made it happen.
This circuit can be found in the Fig. 2.

3. Results

The schools which participated in this initiative were the Escola Secundária c/ 3º ciclo de Madeira Torres in Torres Vedras, Escola EB 2,3/S de Vale de Cambra, in Vale de Cambra, Escola Secundária Serafim Leite, in S. João da Madeira and Escola Secundária de Arouca, in Arouca.
The 250 collected inquiries were filtered on a *make sense* basis, in order to get reliable results. Taking 75% of the collected inquiries, which were considered as valid, from 1 to 5, the activity was evaluated as *Good* by 60.4% of the students, *Satisfactory* to 6.4%, *Unsatisfactory* to 0.5% and was considered *Excellent* by 32.7% of the participants, as we can see in the Fig. 3.

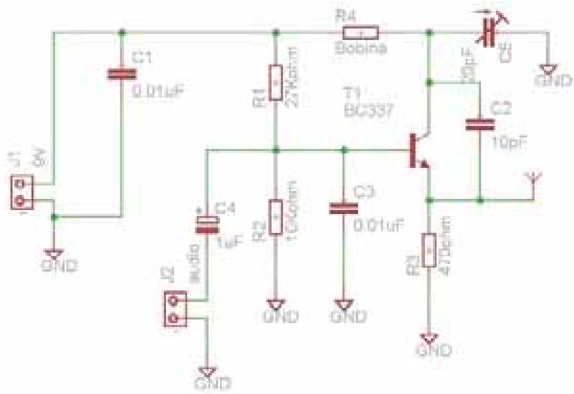

Figure 2. Proposed circuit

Meanwhile, 94.1% of the students showed interest in participating in other similar activities, against 5.9% who answered negatively to the same question, as we can see in Fig. 4.
Finally, 90.4% of the students stated that the project contributed to their additional technical training, against 9.6% who kept indifferent to this main goal, as we can see in Fig. 5.

4. Dissemination

The project was disseminated through the internet, in the Facebook and in a website

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which was dedicatedly developed (http://teleloucuras.wix.com/teleloucuras). Also, articles both in the UA Online Journal and QSP radio magazine were published arousing the interest of radio Antena 1, carrying out an interview to the *Click* programme. The School TV of Vale de Cambra also published a report based on the project flyer, and the Madeira Torres propagated the project through all the school libraries in the country.

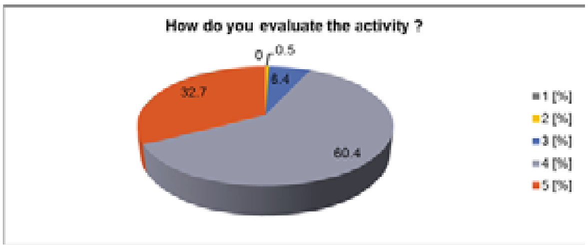

Figure 3. Evaluation of the activity

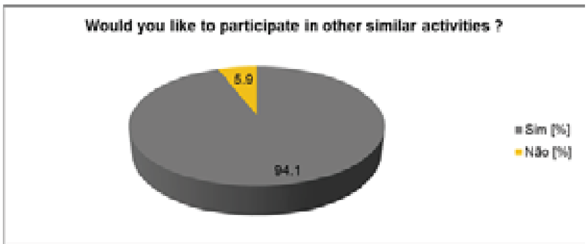

Figure 4. Other activities

4. Dissemination

The project was disseminated through the internet, in the Facebook and in a website which was dedicatedly developed (http://teleloucuras.wix.com/teleloucuras). Also, articles both in the UA Online Journal and QSP radio magazine were published arousing the interest of radio Antena 1, carrying out an interview to the *Click* programme. The School TV of Vale de Cambra also published a report based on the project flyer, and the Madeira Torres propagated the project through all the school libraries in the country.

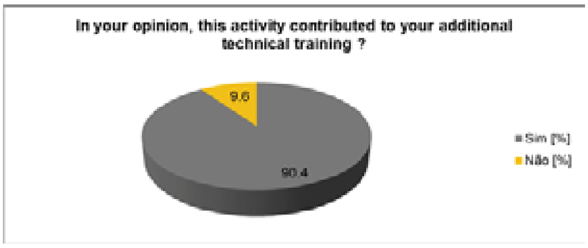

Figure 5. Additional training

5. Conclusions

The Universities' investment on providing additional training for high school students is important and recognized by this community. The project addressed more than two hundred students who faced the challenges of engineering and, based on the results obtained, we consider this project a success among both students and teachers, who welcomed us due to the originality and innovation.

6. Acknowledgements

The team would like to acknowledge the Instituto de Telecomunicações, the Department of Electronics, Telecommunications and Informatics of the University of Aveiro and the Amateurs Radio group of the Electronics, Telecommunications and Telematics Association for their helpfulness, which was fundamental in order to reach the complete success in this project, specially Professor Armando Rocha, who always supported and was committed with this

project developing several MATLAB scripts which helped us to explain both the FM and AM modulations and releasing Flávio from the work whenever it was necessary in order to prepare and develop the activities.

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The Use of Modellus Applied to Studies Regarding Alternating Current Generators

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Abstract. *Describes a teaching experiment and applied learning of a group of high school students using the educational software "Modellus". After simulating the behavior of an AC generator, used in hydroelectric plants, the students had a significant improvement in their understanding regarding such subject, thanks to this work. Through that computational model, the students were able to vary some parameters that influence the AC generator system and observe the effects instantly. Nevertheless, the model enhances the interactions between the students and the teacher and between the students themselves, inciting questions and suggestions, while stimulating the students, unlike the conventional abstract learning.*

Keywords. Computational modeling educational software, learning.

1. Introduction

Nowadays, in the age of technology, when the very latest and advanced devices fit your palm, new software is created and the already existing software is constantly improved.
In this context, it is noticeable that educational software development is also growing and gaining strength. This kind of software turned from a simple question-and-answer system to complex programs, containing user interface, graphs, animations, data tables and many other tools, downloadable in several operating systems. Out of this ease of access and multiple applications, the use of educational software in schools is to round the teaching of science.
Now, after studying the theoretical concepts, students will be able to model their practical applications, assisted by their teachers or by themselves. Through educational software, they will alter variables that influence the system that is being studied and watch how it behaves based on generated data.
In this approach, computers are seen as tools that, when handled by students, allow them to build, to innovate, to create, to modify, to solve problems and to think up projects in order to reach a final computational model that is consistent with the theoretical concepts that had been learned.
This allows completely new learning and teaching processes, favoring interactions and the exchange of constructive criticism between students, and an entirely dynamic process, which, thanks to the internet, turn the exchange of ideas, doubts and suggestions easier between students from all around the globe. Such features improved the process of teaching and learning, making it more dynamic, interactive and drawing the students' attention to the scientific area.
This paper shows the benefits of using educational software, especially the computational modeling ones. Also, it discusses how teachers explore theoretical concepts in a way that provides the students

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a solid and clear basis for comprehending and creating the computational model and what the consequences of using those models in class are, regarding the process of teaching and learning, the students and the teachers.

2. Methods

The execution of this project has been divided in two phases: the introduction of the physics concepts to the students and the use of the computational model that represents the operation of an AC generator.
In the first phase, the conceptual approach, the historic context behind the studies about electromagnetism is debated, as the Second Industrial Revolution, or Technological Revolution, the growing demand for electricity, the necessity of transmitting electric energy through large distances, the invention of the generator and others. Then, a theoretical and more abstract analysis about electromagnetism is conducted, showing basic definitions, mathematical equations behind it and, finally, the everyday practical applications of electromagnetism.
Now that the students have enough theoretical knowledge about electromagnetism and the operation of an AC generator, they are invited to develop computational models that explore how an AC generator works. We'll use the educational software solution "Modellus", a program based on a mathematical model which must include all the equations involved in the animations that are displayed on the screen.
Figures 1, 2 and 3 show the model and the simulation of a hydrostatic plant, using Modellus. Knowing the operation of this kind of motor is truly important. By the law of conservation of energy, a constant water flow goes down a "ramp" where, in one end, the coil's paddles are located.

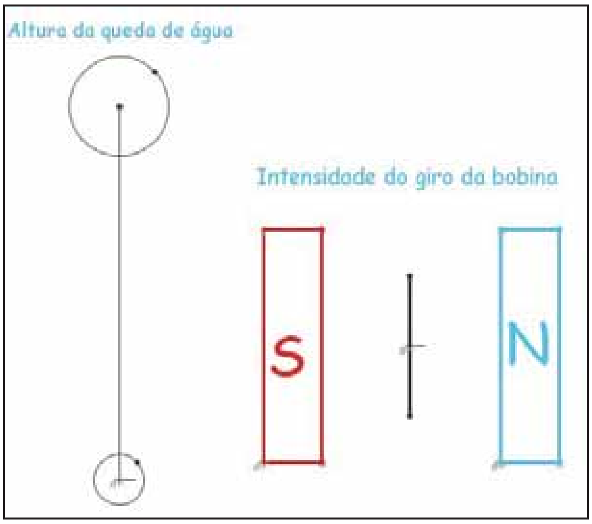

Figure 1. Height and coil simulators

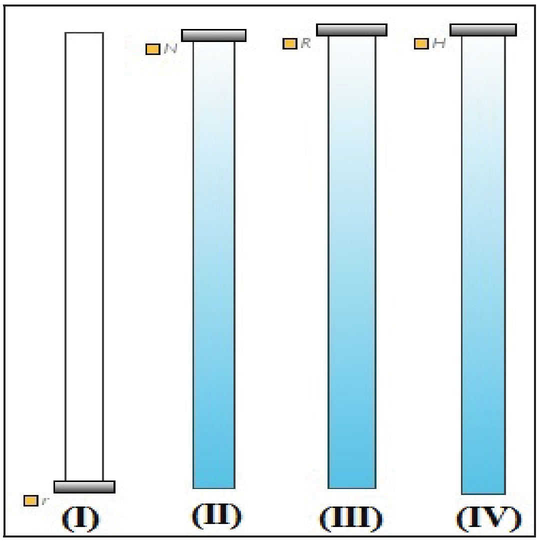

Figure 2. Variables: (I) Resistance, (II) number of coils, (III) coil radius, (IV) height

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$H = 80.00$	m	$E = 0.00$	V
$R = 5.00$	m	$Emax = 4.40E3$	V
$N = 100.00$	espiras	$imax = 4.40E3$	A
$r = 1.00$	micro ohm	$Eef = 3.11E3$	V
$A = 78.54$	m^2	$ief = 3.11E3$	A
$V = 56.00$	m/s	$Potmax = 1.93E7$	W
$w = 11.20$	rad/s	$Potef = 9.67E6$	W

Figure 3. Generated data

The water flow makes the rotor's paddles spin and transmit such rotation to a turn of the wire, immersed under the influence of a magnetic field **B**, generated by north and south poles of a magnet, where the rotation produces an angular variation **θ** and, consequently, induction fluxes appear in terminals T1 and T2, as an induced electromotive force (EMF), which generates electric energy.
This force generates electric potential difference (also known as voltage or electric tension and measured in volts) which will be converted into electric current (measured in amperes) and, finally, will be transmitted to houses and buildings.
At last, students will have the opportunity to alter the variables' values, which will alter the animation, observing that each slight change made in the variables (control bars) will cause an alteration in the system, allowing them to develop a quantitative and a qualitative analysis about the subject.

3. Results and Discussion

Thanks to this work, it is possible to ascertain that the use of computers as tools in learning is plausible. Applying this through computational models, students observed how a model can be very similar to reality. Such process started with studies regarding the necessary values in order to generate electric energy from a waterfall, also studying the operation of an alternated current motor that was developed based on the values of power and current intensity to light a simple incandescent light bulb, showing that it is possible to achieve complex results which match reality.
During the creative process of a computational model, students are stimulated to think about its development, ways to solve problems that may arise during its confection, ways to deal with some limitations that may be encountered in the software and deeper research about the physical phenomena that are related to the working motor.
Given that, a whole range of learning processes that favor the students' cognition are created, as they were also conducted to perceiving how each parameter influences the motor's behavior and the quantitative analysis of generated data. This composes a correlation between several physical phenomena for students and teachers.

4. Conclusion

Therefore, it is noticeable that the use of software as a complement to teaching sciences, in this case Physics, is extremely efficient, as students have had a solid and correct comprehension about the physics concepts behind the subject and, besides that, have acquired knowledge about the subject's historical context and practical applications.
Finally, the students have gone beyond theoretical abstractions: as they confectioned the computational models, they

had the opportunity to share their doubts, observe how each component affects the system's behavior, make quantitative analysis, think up creative solutions for problems and get in touch with a new behavior, the virtual laboratory, created by the software. This way, their cognitive capabilities were increased, providing them a wider vision of our world and its technologies.

5. Acknowledgements

The authors acknowledge Rio de Janeiro State University (UERJ), Fundação de Amparo à Pesquisa (FAPERJ) and Observatório da Educação (OBEDUC), for stimulating this research.

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Technology and Mathematics

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Abstract. *The evolution of our world from an industrial society into an information society, placed a mark on all of its subsystems, imposed throw its new technological support. In this frame, the education system must rethink everything, from methods, contents to structures. This step needed the introduction of Informatics and ICT in the school curriculum for teaching different disciplines. This way, teachers are using the computer, not only as a didactic material but more as a complementary system in the teaching-learning-evaluation process. In this paper I will present some methods for teaching and learning Mathematics using the new technologies.*

Keywords. Mathematics, technologies.

1. Introduction

What we understand today by new technologies? If we look for a definition, we can say that new technologies are those technical innovations with great impact on our daily life. Smaller and smaller PCs, tablets or mobile phones create both opportunities and challenges for teachers and schools. All these new teachnologies dramatically reshaped the way teaching process is carried out.

Preparing the new generation and the societies in crisis situation is the teacher's mission. We have not to forget that we have a past who generated a huge inherited culture, and we have the moral obligation to transmit it. This is a very interesting thing that the computer and the new technologies became the indispensable support for the education update[1].

Mathematics is everywhere and is very important for our life. In the same time, mathematics is seen as a very difficult and boring topic. A good teacher succeed to attract the students if he or she is very well prepared and up to date with all these new technologies.

2. Milestones in the implementation process of the new technologies in education

We have to have in mind three levels:

a) the planning and financing level;
b) the organization level;
c) the curriculum level.

At the first level, it has to be planned the total computerisation of all education institutions from a country, then to assure the necessary budget for the education system and, in the same time, to encourage the sponsors in the education field in order to accelerate the computerisation process.

At the organisation level, compulsory education to cover all kids aged 7 to 15 or 16, to increase the number of high schools with Informatics profile or oriented on new technologies, to create an adult education system based on the new technologies, to increase the role of non-formal and in-formal education by strengthening the relationship between the worlds of education and work.

At the third level:

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- introduction in the compulsory education curricula of the new educations based on ICT and new technologies;
- developing appropriate programs and textbooks;
- encouraging the use of ICT in all other subjects.

3. Hardware tools

The hardware tools needed for the instruction process can be:

- Presentation equipment: video monitors, multimedia projectors, interactive whiteboards.
- Provides visual or/and audible, passive and interactive perception of digital data for individual or group audience.
- Storage devices: magnetic, optical, mixed. The increasing storage capacity is accompanied by compacting sizes, increase portability and data security.
- Specialized equipment for the acquisition of images, video sequences and sound. The use of scanners allowed the exponential expansion of the amount of digital information and served as an impetus for development of multimedia formats.

4. Software tools

Software tools are different types of digital resources:

- passive resources - documents, images, sound or video clips;
- standardized learning objects – interactive objects, which allow the intervention of the trained person to conduct practical activities, exercises and tests in accordance with international standards in the field, the set of standards known as SCORM (Sharable Content Object Reference Model);
- simulation applications - applications that model real phenomena and events through a set of mathematical formulas. Dominant feature of such applications is the user's ability to observe and to model a phenomenon or action without real involvement in them. In this category affiliate also the educational games;
- applications for assessment - local or online software that allow to create ongoing evaluation tests, intermediate or final, and analysis, storage and transmission of results to the evaluator or learning management system;
- learning management systems (Learning Management System) - software that integrated database containing data on progress, learning efficiency, instructional content and data on their use by those trained in digital format;
- Content Management Systems (Learning Content Management System) - software for management development and subsequent publication of educational resources (content) through LMS.

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5. Communication tools

Communication Tools are software and hardware tools used to organize the communication, both synchronous and asynchronous as well.

Synchronous communication tools of universal individual or group, the most common are: Skype, Google talk, Yahoo messenger, specialized systems and videoconferencing. The number and variety is growing continuously. Of asynchronous communication tools most commonly used are: email, forums, blogs, discussion groups, RSS, repositories for images, text and video (Slideshare, Google albums, YouTube etc). Specific communicative tools software is able to transmit information in real time and store it virtually unrestricted volume.

6. Virtual Learning Environments

A Virtual Learning Environment(VLE) is a set of teaching and learning tools designed to extend the learning experience of students by using ICT tools.

There are several commercial VLE, including Blackboard, WebCT, AEL, Lotus LearningSpace VLE but also the free distribution VLE. The same features are encompassed by the Learning Support Systems (LSS), the Managed Learning Environment (MLE) and e-learning platforms.

7. Examples from Mathematics

In the educational software, can be promoted: problem solving, experimental research / documentation, demonstration, simulation, brainstorming, discussion, teaching games, applications / practical tasks etc.. An example from mathematics is shown in Fig 1, AEL educational materials, Mathematics – 8-th grade, "Shapes representation". Some examples of sites that contain materials that can be used in the elaboration of teaching materials: http://www.mathsisfun.com/ Math explained in easy language, plus puzzles, games, quizzes, worksheets and a forum. For K-12 kids, teachers and parents[3]; www.encyclopediaofmath.org/index.php/Main_Page is Creative Commons Attribution-Sharealike 3.0 Unported License (CC-BY-SA) and the GNU Free Documentation License (GFDL)[4];

Figure 1. AEL, "Shapes representation"

www.doe.virginia.gov/testing/sol/practice_items/index.shtml includes examples of new technology enhanced items for grades 3-8 mathematics, Algebra I, Geometry and Algebra II. Practice items in science and English also are provided as examples of items being field tested in spring 2012[5]; http://math4children.com/Videos/graphs/index.html is a math video lesson on representing information on graphs. Parents

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and teachers can use this to help kids learn how to represent information on graphs. Click on the PLAY button to start the video lesson and pause at will to let kids fully understand) [6].

8. Conclusion

New technologies relying on visualizations, interactions, and kinesthetic experiences can make the key ideas of Mathematics more widely accessible. Besides, a part of schools, colleges and universities are using computers for various utilities viz. pay rolls, time-tables etc. In our country, two students share a school computer only in the ICT lab and only one from five students have computers at home. In the rural area, the situation is much worst.
The available computers sometimes do not work and too often lack a full suite of software. This low and unreliable access to technology means that students do not get enough experience to master complex software tools and teachers cannot assign homework that assumes ready computer availability.
Important, technology-rich curricula materials are rarely implemented, if at all, because there is insufficient access to technology and schools are unable to rearrange the curriculum to exploit the advantages of these materials. In this environment, the potential of information technologies on Mathematics education cannot be realized.

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Numbers and Elementary Concepts for Biology Students

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Abstract. *The validation of hypotheses in order to explain natural phenomena requires data. Many biological phenomena have been discovered and explained on the basis of qualitative analyses, but new insights often follow when they are revisited in quantitative terms. Without a quantitative description, there is no discovery at all. A parameter variation due to changes on environmental conditions is usually detected by measurements on apparatus developed according to certain physical-chemical principles. The knowledge of fundamental principles underlying the techniques used is essential for good understanding of the phenomenon in question and so it is necessary to insist on basic concepts consolidation.*

Recalling the properties of water and using mint leaves as biological material, spectrophotometry and tensiometry are two measurement techniques that allow us easily gathering a lot of data. The analysis of the information obtained by these two methods on similar samples may promote internalization of natural phenomena, related to the frequent mixtures of living or dead organic matter in water.

In this work it is proposed an experimental activity addressed to pre-university and first year graduate students. The first step of the activity is to prepare three batches of mint leaves (biological material easy to obtain) to make an infusion, a suspension and an extract of chlorophyll from their leaves. The preparations are analysed by spectrophotometry and tensiometry. The results obtained by each technique allow us to compare some properties of the three types of samples. Although not being related a-priori*, the combined analysis of the parameters measured by the two techniques provides some insight on natural mechanisms.*

The main goal of this activity is that students recognize the importance of elementary concepts from different scientific areas, enhancing the relevance of interdisciplinary towards the consolidation of scientific knowledge.

Keywords. Interdisciplinarity, parameters, mint, spectrophotometry, surface tension.

1. Introduction

The validation of hypotheses in order to explain natural phenomena requires data. Many biological phenomena have been discovered and explained on the basis of qualitative analyses, but new insights often follow when they are revisited in quantitative terms. Without a quantitative description, there is no discovery at all [1]. The assertive conclusions that Mendel was able to draw from the data of its pea plants experiments, were due to his remarkable intuition for statistical concepts, being quite aware of chance, variability and random errors. Mendel was a man far ahead of his time [2].

The parameter variation due to changes on environmental conditions is usually detected by measurements on apparatus developed according to certain physical-chemical

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principles. The knowledge of fundamental principles underlying the techniques used is essential for good understanding of the phenomenon in question. Advanced knowledge does not preclude ignorance of the elementary [3] and so it is necessary to insist on basic concepts consolidation.
Recalling the properties of water and using mint leaves as biological material, spectrophotometry and tensiometry are two measurement techniques that allow us easily gathering a lot of data. The analysis of the information obtained by these two methods on similar samples may promote internalization of natural phenomena, related to the frequent mixtures of living or dead organic matter in water.
Numbers collected by scientific community that initially appear unrelated are brought together as a tool of inference to shed light on biological mechanisms [1].

2. Water as a medium

Water is a chemical compound essential to all living beings, being a great medium for dissolving and/or suspending various materials. Salts, sugars, acids, alkalis and some gases are hydrophilic substances whose molecules dissociate or ionize in aqueous medium, because water acts as reagent. In contrast, hydrophobic substances, such as soap or organic solvents are immiscible or partially miscible in water, forming stable mixtures, not spontaneously. By providing energy through agitation processes, these substances form emulsions - stable mixtures that in the absence of emulsifying agents (surfactants) eventually separate in their continuous and dispersed phases, with time.
Insoluble solids as small living creatures (mainly unicellular organisms either prokaryotes or eukaryotes), organelles or dead organic matter, when placed in water with reasonable agitation remain in suspension. In either case, the techniques for measuring various properties of substances or particles require that these materials remain in liquid media. This is the case of spectrophotometry and tensiometry methods of analysis, that use instruments where the samples are analysed in a liquid medium.

3. Biological material

The choice of an experimental subject is a key aspect of the structure of any science. It is generally acknowledged that most developmental biology research is performed on a small number of organisms that are genetically tractable, easily manipulated, or relevant to human biomedicine. The organisms are often referred to as 'model organisms', with the term 'model' being used to signify universality of developmental mechanisms within a broad taxonomic group, even though this has been argued to be a misuse of the word 'model' [4]. So, the most popular model organisms are that used in the biomedical research; they have been extensively studied existing numerous databases [5]. Many organisms that are not traditionally used as biological models, may have experimental advantages in data collection leading to the interpretation of physicochemical phenomena underlying measurement techniques.

3.1. Mint

Mint, whatever its species, is considered an

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aromatic and medicinal plant. Effectively its odor is unmistakable, and its medicinal properties are long recognized by popular knowledge of many cultures [6] and have been validated by scientific research.

Used in cooking as a seasoning or in drinks confection, it is record in many pharmacopoeias because of its therapeutic properties. According to several authors *Mentha* spp. has been used as a folk remedy for treatment of nausea, bronchitis, flatulence, anorexia, ulcerative colitis, and liver complaints due to its antinflammatory, carminative, antiemetic, diaphoretic, antispasmodic, analgesic, stimulant, emmenagogue, and anticatharrhal activities [7].

Although originally from Asia its distribution is widespread to almost every continent (cosmopolitan distribution), tolerating different climatic conditions presuming there is no lack of water. Their presence is common in wastelands, growing easily in meadows and landscaped areas, as the green spaces of the Gualtar Campus. Its observation and collection can thus be practical and easy throughout the year, without costs.

4. Parameters analysis

The parameter variation due to changes of environmental conditions is usually detected by measurements on apparatus developed according to certain physical-chemical principles.

4.1. Surface tension

At water-air interfaces, the surface tension arises from the greater attraction of liquid molecules to each other (due to cohesion) than to the air molecules (due to adhesion). The effect is a force that pushes the surface molecules inwards at the same time impulsion opposes, in order to make the resultant force null. This makes water surface to behave as an elastic membrane so that if a body exerts a small vertical force on the surface it can be stretched to some extent before rupture. The surface tension of water is high enough to allow an object to float (e.g. a clip) or an insect to run along the water surface (e.g. water striders), regardless of being denser than water. Indeed, the relatively high attraction of water molecules for each other is responsible for water high surface tension (72.8 millinewtons per meter at 20°C), compared to most common liquids, and is a key factor on capillarity phenomenon.

Some additives strongly modify the surface tension of a liquid. The most common example is that of the detergents which greatly reduce the surface tension of water in which they are dissolved. Thus, surface tension is an important property that markedly influences an ecosystem, and its measurement may provide information on the degree of change of liquid properties after addition of "foreign" substances. Surface tension has the dimensions of force per unit length or of energy per unit area. The two are equivalent.

4.2. Optical density

The use of spectrophotometry to measure the optical density at a wavelength of 600 nm (OD 600) of a bacterial culture, in order to monitor their growth has always been a central technique in microbiology [8, 9]. This technique is also used to estimate the content of photosynthetic pigments on a

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solution [10, 11].
When light crosses a mixture the intensity of its attenuation occurs by two mechanisms: (i) in a homogeneous solution with a single stage, only the absorbance contributes to the attenuation in light transmission between the light source and the detector; (ii) in a suspension containing a mixture of two or more phases, the light reaching the detector is further reduced by the scattering of light. This decrease in light reaching the detector creates the illusion of an increase in sample absorbance.
The contributions of absorption and scattering to measure the optical density (OD), provides a basis for understanding the variability between spectrophotometers and allows a quantitative assessment of the applicability of the Beer-Lambert law [12].

5. Mint in the practice of laboratory techniques

In this paper the choice of mint (*Mentha* sp.) as biological material is due to the fact that it is a plant that in various ways awakens the five senses of anyone (even more distracted students!).
Currently, Sensory Garden has been the subject of studies related to the Teaching of Science as a space for the practical classes in schools of basic education, as well as building up a tool of inclusion for students with special needs [13].

5.1. Collection of plant material

Mint stems can be collected in garden areas (of Gualtar Campus, for instance) where this plant thrives apparently of spontaneous manner.
Generally a mint foot of approximately 30cm, has about 10 fresh leaves (2 to 4 cm in length) with an average mass of 10g per about 80-90 leaves.

5.2. Identification of the plants

The correct identification of biological material that is used in experimental work is fundamental to its validation. Thus, the use of plant material requires not only the morphological analysis of plants *in situ*, but also a more detailed laboratory analysis, using a binocular microscope. The identification of the plant material is made with the help of identification keys [14, 15, 16], and expert opinion.

6. Experimental protocol

An infusion, a suspension and an alcoholic extract were prepared for spectrophotometric and tensiometric determination of respectively, optical density (OD) and surface tension (γ, Nm^{-1}) of the different kinds of liquid samples with mint.
For the infusion, 10g of mint fresh leaves were put on boiling tap water and left to cool down. Half of the infusion was maintained at light and the other half stored away from light.
The suspension was prepared putting 10g of mint fresh leaves on 150ml of tap water and crushed with a blender. The container was washed with additional tap water to a final volume of 350ml.
To extract the chlorophylls, 10g of mint fresh leaves were reduced to small pieces with a scissor, and its subsequent maceration was done on a mortar with slow addition of 100 ml of ethyl alcohol 96%. After sieving, the

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extract was stored away from light.

Optical Density (OD) was determined as absorbance in 190-750 nm wavelength range on Thermo Scientific spectrophotometer AquaMate Plus (UV-VIS) and on spectrophotometer Shimadzu – UV 2501 PC.

Surface tension was determined by the du Nouy ring method [17] using a tensiometer "Surface Tension Analyzer model DST 60". The surface tension value was computed according the mathematical model proposed by *Zuidema & Waters* [18, 19].

The pH and temperature (T°C) of the samples were measured with pHep® by Hanna Instruments.

7. Results

The samples analysed were mint infusion (I) maintained under day light (IL), mint infusion kept in dark at a constant temperature of 20ºC (Id), mint suspension (S) and alcoholic extract of mint leaves (Ea), also kept in the dark at 20º C. The surface tension (γ) and pH of each sample was measured every seven days for three weeks (Table 1).

The surface tension value of the fresh infusion was much lower than that of water at 20ºC (0.073 Nm^{-1}). Virtually no variation has observed in the following weeks. But a small increase of γ, accompanied a noticeable increase of pH, more prominent for the sample kept in the dark (Id).

For the suspension, the surface tension value was not much different from the γ of the infusion; however its pH was lower decreasing over time.

The alcoholic extract presented a constant surface tension, equal to that of ethanol at the same temperature - 20º C [20] and, as pH, shows a tendency to decrease over time.

Samples: I - mint infusion maintained in light (IL); Id - mint infusion maintained in dark; S mint suspension; Ea - mint alcoholic extract

Sample	I	IL		
Sample age (days)	1	7	14	21
γ(Nm^{-1})	0,049	0,048	0,050	0,052
pH	6,29	6,23	6,76	7,20
Sample	I	Id		
Sample age (days)	1	7	14	21
γ(Nm^{-1})	0,049	0,051	0,051	0,054
pH	6,29	5,39	7,10	7,40
Sample	S			
Sample age (days)	1	7	14	
γ(Nm^{-1})	0,057	0,054	0,054	
pH	5,98	5,89	5,81	
Sample	Ea			
Sample age (days)	1	7	14	
γ(Nm^{-1})	0,023	0,023	0,023	
pH	6,13	5,95	5,88	

Table 1. Samples surface tension (γ – Nm^{-1}) and pH during the experimental period

During the same period of time, the samples absorption spectra were obtained on spectrophotometer Shimadzu – UV 2501 PC and on Thermo Scientific spectrophotometer AquaMate Plus (UV-VIS) for comparison. The fresh samples absorption spectra obtained on the spectrophotometer Shimadzu (Figure 1) display an evident peak on the range of 660-670 nm for the extract samples and a more discrete one for the suspension, at a higher wavelength (679 nm), whereas the infusion samples only shows absorption towards the UV range. Over the next weeks, the samples got

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darker, increasing the absorbance all over the spectrum but keeping the relative intensities of the peaks at the same wavelengths.
Despite the different absorbance values obtained from both spectrophotometers the spectra profiles are similar and lead to similar interpretation. Considering only the absorbance values determined on the spectrophotometer AquaMate Plus at 660 nm wavelength (Figure 2), an average wavelength value for maximum absorbance of chlorophyll, the Ea sample display similar values over time.

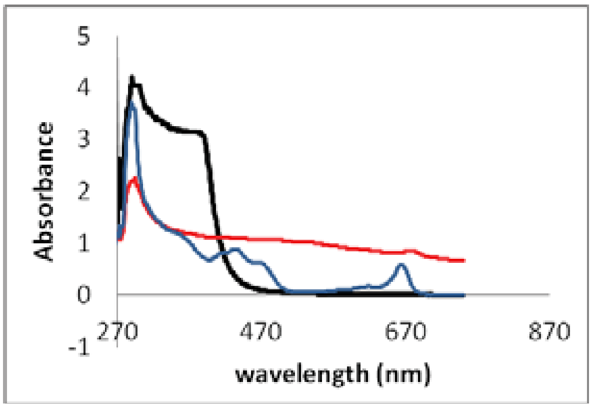

Figure 1. Fresh samples absorption spectra obtained on spectrophotometer Shimadzu – UV 2501 PC

However the IL, Id and S samples, showed an increase of the absorbance values during the experimental period. On the infusion samples (IL and Id) where absence of chlorophyll is due to its denaturation after boiling, the high absorbance values may be due to progressive oxidation of the samples, more noticeable on IL sample. The variability of S samples is similar to that of a typical suspension.

Samples: -- infusion; -- suspension; -- extract diluted (1:10)

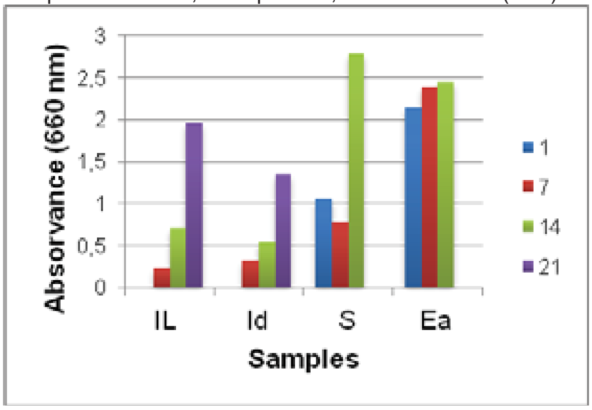

Figure 2. Samples absorbance determined on spectrophotometer AquaMate Plus at 660 nm wavelength, during the experimental period

8. Conclusions

The process of making the mint infusion is destructive to chlorophyll, but not for other components, namely aromatic compounds, which were not analysed but were sensed at all the samples prepared. The mint scent was present all the time.
The extraction and the suspension preserve different substances from the vegetal material (e.g. chlorophyll and other photosynthetic pigments), which seem to remain stable over time. Simultaneously, the pH decrease of the S sample indicates an evolution of the organic material in the suspension.
As surface tension of I and S samples are so close and well below that of water we can consider that the suspension particles are not responsible for the surface tension alteration. Similarly, chlorophyll does not change the ethyl alcohol surface tension.
Considering its main goal this work highlights the importance of elementary concepts to analyse and interpret data from

different techniques and apparatus. The variation and amount of data gathered in this work is a perfect example of how it is important to know how to interpret it. Having in mind the values of the absorbance from both spectrophotometers and how similar their profiles were, even though they were gathered from different machines, they can be explained using the same principles of how light behaves when it passes through different liquid media.

The same works when discussing the data gathered from the surface tension measurements. After understanding which forces interact in liquid surface tension and how can they be disturbed the data obtained are more easily analysed.

So it is evident that one has to know the basics to infer the data.

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Determination of Thermodynamic Parameters of Glycine Acidity Equilibria Using Potentiometric Techniques. A Video Project to Learn Physical Chemistry

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Abstract. *The main objective of this work was the elaboration of a multimedia project by a group of students enrolled in Physical Chemistry for the Life Sciences (PCLS), a course that takes place in the 2nd semester of the 1st year of the degrees of Biotechnology and Biochemistry of the University of Aveiro. The project here reported is the first exploratory step towards the set up of a wiki for the course that is meant to be expanding continuously from here on. The starting theme, the determination of thermodynamic parameters of the acid-base equilibria of an amino acid, was chosen for its relevance and interdisciplinarity. The work was performed by a small group of volunteer students, supervised by the teacher. The different phases (planning, research, writing, production and publication) were scheduled, coordinated and carried out by the students. The final result is an interactive video with complementary calculations and content related documents, as well as links to suitable sites on the web. The project will be presented using a MS PowerPoint show*.

Keywords. Active learning, acidity constant, higher education, multimedia, physical chemistry, student-created videos.

1. Introduction

Physical Chemistry is taught in a one-semester course of the 1st year of the Biochemistry and Biotechnology degrees of the Department of Chemistry at University of Aveiro. The course, “Química Física Biológica”, here designated by Physical Chemistry for the Life Sciences (PCLS) is compulsory for both study plans. The students must attend one 60 min-class devoted to problem solving, and are supposed to attend two 90-minutes lecturing sessions, weekly. Although the subject is taught at an introductory level the rate of success has not been higher than 40-60 % in the past decade [1]. Physical Chemistry is traditionally regarded as a “difficult” subject to grasp due to the workload it involves [2]. PCLS students recognize that the course is usually known among them to be “more difficult than the remaining ones, because it involves three scientific areas concomitantly (Chemistry, Biochemistry and Physics)”. Moreover, they point out that the heterogeneity, the importance and the scope of the subjects of PCLS make it very difficult to approach and to develop all the topics taught during a period of one–semester.

According to the students, the creation and production of a multimedia science project will foster the students’ yearning to deepen what is taught in class and provides an opportunity to clarify possible doubts that they may have. And most importantly, since the instructional materials are created by the students (under the supervision of the

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teacher), the possible doubts about the contents taught in classes are more likely to be answered in a way that is readily understood by the students. That is likely to be so, because they eventually share the same doubts and/or look at the instructional resources from a point of view closer to themselves than a teacher would. As clearly stated by the students, this is *a work done by students for students*.

Video is a powerful and expressive non-textual way to capture and present information. It provides a multi-sensory learning environment that may improve the learners' ability to retain information, as it provides stronger motivation as well as engagement [3-6]. So, the production of a video was chosen for the multimedia project to be started with. To that aim the PCLS teacher proposed a theme for the video production and a few students accepted the challenge. The work now presented is essentially an annotated video on a central laboratory experiment that provided the thermodynamic parameters of the acid-base equilibria of an amino acid (glycine) after adequate data treatment.

As above mentioned, this is the first step of a student centered project that aims at developing a multimedia learning tool within the PCLS course. When attaining the desired quality, the resources are intended to be open to the public in the web. The project is ambitious and dynamic, since new contents may be added according to the users' needs and feedbacks.

2. The Methods

Participants - eight students out of the regular attendant to PCLS lectures who volunteered to participate. The activities were performed out of the regular class schedules.

Theme - The central theme for student video making was chosen so as to be relevant to the students and interdisciplinary: the determination of the thermodynamic parameters of the acid-base equilibrium of an amino acid. The thermodynamic parameters, enthalpy, entropy and Gibbs energy of reactions are a major core of Thermodynamics, and students most often search for them in the bibliography (mainly to solve theoretical problems). Yet, they seldom determine those thermodynamic values experimentally, apart from the calorimetric determination of combustion enthalpy. Amino acids are most important substances per se and as building blocks of proteins and other "life molecules", so they are particularly important in the fields of Biochemistry and Biotechnology. On the other hand, pH is perhaps the single most important variable in the chemistry of aqueous solutions, particularly due to its influence upon speciation equilibria of different molecules, and consequently highly influencing their reactivity. In the case of amino acids, pH determines their deprotonation extent which, in turn, affects their charge and transport properties.

Lab work - In this project, aimed at freshmen students, potentiometry was chosen as the main experimental technique as it is easy to both understand and carry out. All experimental work was performed under the supervision of the teacher.

Data treatment - The calculations may be performed using a spreadsheet, and Microsoft Excel ® (Microsoft ®, Redmond, Washington) was suggested and used.

Video production - The video making and editing was left for the students to elect,

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although support from the University IT services (STIC) was offered if needed.

Multimedia resources anchoring - The resources being made by the students were organized in a platform with restricted access anchored within the web of the University of Aveiro, having a structure similar to a wiki (CodeUA). During the elaboration of the resources, the site was available to participants only; when this project phase was finished, it was open to all the students enrolled in the course for them to consult, analyze and evaluate the outcome [7].

In the future, the multimedia project is meant to be open to the Department of Chemistry and finally to the general public, either in this platform or in a wiki or similar of public domain. In fact, a very important feature of the project is that it is easily amenable to expansion, envisaging the elaboration of by students of successive construction of a wiki for PCLS.

3. Results

The outcome of this project is a student-produced multimedia resource, around a central videoed lab experiment. The acid-base titration of an amino acid was video-recorded and narrated; the calculations of the respective acidity constants are shown. The experiment was repeated at a different temperature, and new Ka values were obtained. Using the acidity constants at two temperatures, the calculation of the correspondent Gibbs energy values was performed and shown. The use of van't Hoff equation to obtain the values for the enthalpy and the entropy of the studied acid-base equilibria was demonstrated. Links were made to relevant documentation or sites whenever necessary.

The result of this collaborative student centered work is a multimedia interactive video that will be presented here.

4. Final Remarks

The innovative feature of this project is the students' involvement and active participation in the whole elaboration process of multimedia pedagogical resources. After the necessary corrections and improvements are accomplished, it is meant to be made publicly available.

Yet, this "hands on" video project is not meant to be "finished" or complete; on the contrary, it should continuously go through modifications, developments and expansions, so as to grow into a more powerful interactive multimedia resource – a PCLS "wiki".

This exploratory student-centered video production was a very positive experiment that amply justifies its extension into the future.

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Video Making as an Active Learning Project for 1st Year Physical Chemistry Students

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Abstract. *The main objectives of the research now presented were to ascertain the expectations of the students regarding e-learning contents and to investigate the potentialities of a multimedia project as a motivational and pedagogical tool. The first goal was assessed by a questionnaire administered to all students enrolled in the course. Next, the pedagogical benefits of student created multimedia resources as a motivational booster and an aid for active learning Physical Chemistry in a first-year university course was evaluated. To that aim, the exploratory multimedia project was carried out by a very small number of volunteered students and presented to the other students of the class.*

Keywords. Active learning, collaborative work, e-learning, higher education, physical chemistry, student-created videos.

1. Introduction

The new Information Technologies (IT) possibilities provide an opportunity to incorporate multimedia and interactive materials in the classroom. The last decade has witnessed a continuous search by educators aiming at more effective ways to engage their students during the teaching and learning processes as well as to increase student learning outcomes [1, 2].

The technologies presumably able to provide solutions in education are changing at a very high pace, but the same pace is not observed for the effect of these technologies on learning outcomes [1, 2].

This research aims at evaluating the pedagogical value of combining the potential benefits of multimedia interactive resources with active learning pedagogies – a student-created interactive video project.

As a preparatory phase, the opinion of the students about the contents currently available at e-learning, as well as their willingness to modify those contents or create new ones was investigated. This part of the project is reported here.

2. Scope and Context

2.1. The Course

The study plans of both the Biochemistry and the Biotechnology degrees taught at the Department of Chemistry of the University of Aveiro devote a sole semester to Physical Chemistry. Since the course, “Química Física Biológica”, hereafter designated by Physical Chemistry for the Life Sciences (PCLS) takes place early in the degree (2nd semester of the 1st year), the subject is taught at an introductory level. In spite of this, the rate of success has not been higher than 40-60 % in the past decade, regardless of the teacher [3]. A relevant contribution for this relatively poor figure is the significant number of students that “disengage” from– or even quit the course, usually just after the mid-semester test. Physical Chemistry is traditionally regarded as a “difficult” subject

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to grasp [4] due to the workload it involves [5] and this is confirmed by the students statements as well as by the results from the surveys regularly promoted by the University of Aveiro at the end of each semester. These results also reveal that the students' motivation needs to be improved. The number of students enrolled in the class is usually high (150-200), and active learning methods are not all easy to implement by a sole teacher when dealing with such large number of students in the class.

In view of the potential benefits that are anticipated from their active participation, having students creating the instructional materials to support the PCLS course is an expectedly efficient educational tool. The increasing sophistication of the available digital tools enables the creation of multimedia resources capable of providing interactive presentations of calculations along with related explanations. In fact, it has been previously demonstrated that the more interactive are the instructional materials the greater is their efficacy [1, 5]. Interactive, self-motivated, and richer media should be more effective than the traditional media, since they enhance learners' attention and aid the process of learning [6].

To address both motivational and quality learning issues in PCLS, a multimedia project was devised aiming at combining the virtues of multimedia flexibility with active learning pedagogies – an interactive video made by the students. In this project, participants were challenged to create videos and complementary material on a meaningful subject of the course.

In this preliminary and exploratory phase, the project was offered to a very limited number of students of Physical Chemistry for the Life Sciences who volunteered to participate. The theme and the outcome of this project, a video and complementary material, is described and presented elsewhere [7].

2.2. Course Management

At the University of Aveiro (UA), as generally happens at Portuguese universities, e-learning systems are widely and almost universally adopted; for more than a decade, e-learning has been used by teachers. The universal course management system currently in use at UA is *Moodle^{TM}*.

For the PCLS course, e-learning integrates Microsoft PowerPoint® slides grouped according each chapter, lecture notes, problem sets to be solved as well as worked out typical examples. A complete course guide is also provided; in it all the relevant information concerning the course may be looked up: from lecture rooms, classes schedule, calendar to course contents, program, bibliography, individual class summaries, and detailed learning outcomes. For each subtopic, the respective pages of the main text book are presented as well as respective learning outcomes.

A book of Physical Chemistry problems is also available, where students can find recommended problems divided b mainin.

Recently, e-learning system has been used to introduce online quizzes – in the previous edition as a practicing tool, but currently as an assessment item, with two 20-multiple-choice-questions online tests accounting for 10% of the final grade.

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3. Multimedia Resources as Learning Tools

According the literature, distance learners prefer instructional videos to other instructional media [8] and a considerable number of digital videos have been incorporated in the classroom, as the literature amply testifies [2-10]. The use of video-based instructional materials is likely to increase learners' motivation, interest, and practical skills acquisition [9].

Multimedia and instructional videos would seem to be indicated and effective to support tasks that are complex and involve a large quantity of information [11] and also when they are abstract and conceptual [11]. However, for quantitative problem solving, the use of step-by-step instructions that allow students to see problems worked out in real time would be considered more effective than multimedia presentations [12]. As mentioned before, a considerable number of video resources for chemistry classes, some of them from professional and trustworthy sources are now available. However, the literature is not so prolific on the subject of student-created videos; nonetheless, this activity should be explored at a college level, due to the high level of student motivation and engagement and consequent potential benefit in their education [6]. When students create their own videos related to coursework, their motivation and engagement increases [13] and new opportunities to engage their creativity arise. Student-produced digital video can also enable more authentic learning experiences and provide students with a sense of ownership [11-13].

4. Methods

This study about the pedagogical value of multimedia resources created by students was designed in three phases, the first of which is reported in this paper. 1) a survey of the students' opinions about the multimedia resources currently available and also on their interest and will in creating new resources, through a questionnaire; 2) a characterization of the students´ participation in a small scale exploratory study with an experimental pilot video project; 3) a global evaluation of the project.

4.1. Survey

Participants were the students enrolled in the course "Química Física Biológica" (Physical Chemistry for the Life Sciences – PCLS), in 2013/2014.

The PCLS site in the e-Learning Management System provided by the University of Aveiro (*Moodle*^{TM}) was used to make the questionnaire available to the students.

The questionnaire on the student's opinion about PCLS multimedia resources included twenty 5-level-Likert type questions about five topics: online tests; resources available in the e-learning platform; individual use of the available resources; chat rooms; inclination to create novel resources. It also included three open ended questions, in order to better understand the students' motivations. The responses to the Likert-type questions were analyzed by calculating the means and the standard deviations. The responses to the open questions were distributed into five categories, considered an appropriate level of detail.

4.2. Experimental Pilot Study

Participants were eight students out of the regular attendant to lectures (mean =82), who volunteered to participate.

This preliminary project consisted of an active learning approach: a lab experiment was planned, carried out, video-recorded, annotated, evaluated, and published by the students under the teacher's guidance and supervision, and will be described in the next section. The innovative feature of this project is the students' involvement and their active participation in the whole elaboration process of pedagogical resources.

The students' participation in this pilot project was evaluated through a twenty 5-level-Likert type questions.

In a later phase, the testimonies of the participant students will be analyzed in order to obtain a deeper understanding of their motivations; moreover, a survey involving all the students will be conducted to recognize their appreciation of the video.

5. Results

Survey on multimedia resources

Ninety students answered the survey about the PCLS e-learning contents. These are representative of the total number of students enrolled in the course (155) and constitute a most significant part of the students that are effectively committed and attending the course (118). The twenty 5-level-Lickert questions alongside with the students' responses are presented in Table 1. The results are reported as the average and the respective standard deviation for each question.

The students seem to be comfortable with the use of online tests for assessment, particularly due to the immediate feedback they convey, as indicated by a mean of 4.4, and do not feel stressed by them.

Regarding e-learning contents, data evidences that the students completely agree to the relevance of contents available (4.9) and look at them often (4.8); they read the contents regularly along the semester (4.3), although more often before assessment tests (4.1). They seem pleased with the PCLS contents as they are and do not reveal a significant enthusiasm in having them diversified (3.3); they are even less enthusiast in improving (3.0) or making new contents (2.6) themselves.

When asked about a chat room or discussion forum in PCLS, the students would generally appreciate it (4.0) but, once again, there is a slight preference that others participate in it (4.0), instead of having an active role (3.6). When interviewing informally a few students, they manifested that not to appreciate the fact that they are somehow "exposed", although they feel that it is useful and important to "share points of view and that they could benefit from their colleagues explanations".

The opinions were highly favorable towards a wiki in PCLS, since the students consider it would help to understand the contents related to the subjects taught in the course. Moreover, it would be a means of having most of the needed contents anchored at one place, making it easy to retrieve the information whenever needed. However, the students only feebly adhere to the wiki being made by students either their colleagues or themselves.

Online tests...	mean	st.dev
....have immediately known results, which is good.	**4,4**	1,0
...are less prone to cheating, so they are fairer.	**3,2**	1,1
...are more stressful than written tests.	**2,5**	1,6
...are suitable for practicing but not for assessing.	**3,2**	2,0
e-learning contents		
I consider the currently available contents fundamental.	**4,9**	0,1
I read them often.	**4,8**	0,2
I read them regularly along the semester.	**4,3**	0,6
I used them more often before the assessment tests.	**4,1**	1,0
I would like the contents to be more varied.	**3,3**	0,9
I would like to edit and improve the e-learning contents.	**3,0**	1,1
I would like the e-learning contents to be edited and improved by my colleagues.	**3,5**	1,2
I would like to make new contents.	**2,6**	0,9
Chat room		
I would like a chat room in PCLS.	**4,0**	0,9
I would like to actively participate in a chat room in PCLS.	**3,6**	1,0
I would like to observe my colleagues participation in a chat room in PCLS.	**4,0**	0,6
Wiki		
...would help me to understand PCLS related contents.	**4,6**	0,4
...would provide easy and quick access to PCLS related contents.	**4,5**	0,7
...would be especially important if made in Portuguese.	**4,1**	1,2
...would be particularly useful if made by students.	**3,2**	1,2
I would like to actively participate in the making of a PCLS wiki.	**3,2**	1,1

Table 1. PCLS survey composed of twenty 5-level-Lickert type questions and respective results (mean and standard deviation)

Altogether these results seem to disclose a lack of willingness in assuming an active participation in the elaboration of learning contents. However the reasons behind this behavior need to be established. On one hand this may stem from the students lack of self-confidence; they may feel that they are not “good enough” to meet the objectives although a contribution of passivity and “inertia” may also play a small role. But part of the cause is the fact that these students are not used to actively participate in the learning process, and do not feel comfortable when asked to do so.

As mentioned before, the survey included the 20 Lickert-type questions already analyzed, followed by an empty text box. In it, the students were asked to write down the suggestions on the contents they would like to have available in e-learning to complement the existing ones. From the 90 students that answered the questionnaire, only a few (7) did not make a single suggestion. The remainder presented one and frequently more than one suggestion for contents they would like to be put on PCLS e-learning module. The 134 suggestion items were separated into 5 groups according to hierarchical active learning levels: 1) formulary/glossary; 2) previous tests 3) solved problems; 4) diversified contents (videos, animations, links, etc) and 5) discussion forum. The results per item suggested are summarized Table 2.

When analyzing the open answers, gender differences became very noticeable; female students wrote more comprehensive and detailed suggestions than their male counterparts; to provide this information data was divided according to gender. In fact 62 female students and 28 male students filled in the questionnaire; yet, a total of 107 items

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were put forward by female students, four times more than those suggested by male ones. The most frequent suggestion for e-learning was the publication of previous tests and solved exercises and problems. The reason behind this may pose some concern since according to students "this may increase the chance to solve a problem identical to the test"- which indicates that the level of learning objectives is not as high as desirable.

Suggestion	*female*	*male*	Total
formulary /glossary	8	5	**13**
previous tests	33	6	**39**
solved problems	32	1	**38**
diversified contents*	15	5	**20**
peer discussions	19	5	**24**
Total	*107*	*27*	***134***
None	*3*	*4*	**7**

*videos, animations, links

Table 2. Responses to open questions divided into five categories

6. Final remarks

This study seems to highlight the little eagerness that students reveal in the making of pedagogic contents in PCLS which can have reflections in engaging in active learning processes. The underlying reasons are still not well established, but may be multifaceted. In fact, cooperative and active learning are not widely implemented in Portuguese secondary schools, and students seem to feel some discomfort and lack of confidence when they are asked to actively participate in the teaching/learning process. At the university there are not many courses where active learning methodologies are used either, due to the high number of students in class and also to some unpreparedness of teachers.

This study underlines the need of implementing methodologies in PLCS that promote more active and deeper learning. The preliminary results of the multimedia project, although with the participation of only a few students involved, indicate that it may be the turning point in the teaching/learning process in PCLS.

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Science Teachers' Views on Robotics Applications in Science Education: A Case of Yozgat

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Abstract. *In recent years, innovations in technology have made a great contribution to science education as well as the other areas of life. Technological applications in education are used in many different teaching methods. Robotic applications in education are one of them. Robotic applications become widespread day by day and started to implement in Science lessons. Although there have been considerable information on robotics applications in the literature, there have been rarely information indicated science teachers' views on robotics. Therefore, this study aims to determine the teachers' views about the robotic applications in science education. Case study method was used in the study and Semi-structured interviews were used as data collection method. The interviews were conducted with 10 science and technology teachers who work in different schools of Yozgat and data were analyzed by descriptive analysis methods. According to the results of the study, teachers stated that robotic applications have positive contributions to science and technology education, creative problem solving and cooperative learning. Moreover, they indicated that it is necessary for science and technology education in Turkey to extend these robotic applications.*

Keywords. Robotics in education, science and technology lesson, teachers' view.

1. Introduction

Different materials have been used in education in recent years in which students pay their attention to and are interested in technological devices. Today, practical technologies are mostly preferred in teaching techniques. One of the practical materials which are used in science education is LEGO robotics training sets. Lego Mindstorms NXT training set is a new technology which was designed by the researchers of Massachusetts Institute of Technology (MIT) and produced by Lego Company and this set enables a primary school student to develop a robot on his or her own.
Literature review shows that there are very few studies in Turkey (Koc and Boyuk, 2013, Cavas et. al., 2012, Kucukceylan, Yuksel and Sezgin, 2007) about LEGO robotics technology which become common all over the world day by day and also there are not any studies that are about teacher views. In this context, this study involves the views of science teachers who have taken part as observer in a project called "*The impact of Robotic Applications related to the issues of Work and Energy on the students' Success, Attitude, Motivation and Academic Process Skills for Science and Technology Class*" which is supported by Bozok University in Yozgat. This study aims to investigate the contribution of LEGO robotics to the teaching of science and technology course. The research question questions that guided the study included: "What is contribution of LEGO robotics to science and technology

education?" and "what are the problems faced with in LEGO robotics?"
The sub-problems of the study are:

1. What are the advantages and disadvantages of LEGO robotics for students?
2. In which courses or in which units can LEGO robotics be used?
3. What kind of problems can teacher face with in LEGO robotics?
4. What are the difficulties in the generalization of the LEGO robotics?

2. Method

2.1. Research Design

Qualitative research approach was used in this study in order to collect the data deeply, to learn the participants' own perceptions, experiences and perspectives directly and to clarify the current state (Buyukozturk et. al., 2009). The case study method was used in the study as research method. The case study method investigates the effects of a phenomenon, event or case on individuals or groups. Researcher tries to examine the subject deeply without any prejudices about it (Ekiz, 2009). Within the frame of this research design, the views of the teachers have been revealed who have taken part in the study of teaching of the Science and Technology course, Force and Movement Unit subjects with robotics applications.

2.2. Participants

The study was carried out in 2013-2014 academic year with 10 science and technology teachers who work in different schools in the centre of Yozgat. These teachers were determined purposefully among a teacher group who observed an activity called "Robotics Applications on Work and Energy" that lasted five weeks as shown in Fig. 1. Purposeful sample provides the collection of necessary and relevant data from participants in the studies. Participants were coded as P1, P2, P2, P4, P5, P6, P7, P8, P9, P10 in the analysis process. Demographic features of the teachers were given below in Table 1.

Table 1: Demographic Features of the Participants

Participant	Gender	Experience (Year)
P1	M	6
P2	M	22
P3	M	4
P4	M	7
P5	F	8
P6	F	7
P7	F	12
P8	F	7
P9	M	11
P10	M	9

The teachers who participated in the study are experienced from 4 years to 22 years and six of them are male and 4 of them are female.

2.3. Data Collection Tool

A semi-structured interview form was used as data collection tool. An interview form was developed which involved six questions in order to determine the advantages and disadvantages of LEGO robotics for both students and teachers. While developing the interview questions, the opinions of the subject matter experts are asked firstly to

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decide whether the form is appropriate for the aim of the study. Then, the question is reviewed in accordance with the opinions of the experts and form is prepared (Ozguven, 1998). Therefore, the opinions of the experts were asked in order to ensure the content validity of the questions in the semi-structured interview form. Content validity can be described as the determination of a measuring instrument's ability to measure the structure and to represent it in a balanced way in accordance with the experts' opinions (Sencan, 2005). It was tried to determine whether the questions are clear and comprehensible and whether the answers reflect the answers of the questions after a pilot interview with two teachers. Another expert was wanted to analyse the transcripts and to control whether the questions are clear and comprehensible, whether they contain the subject and provide the necessary information.

By this way, the validity of the questions was ensured. Besides, the interviews were recorded in a silent environment after taking the participants' consent.

During the interviews, the following questions were asked to the participants:

1. What can be the contributions of LEGO robotics to the students apart from the classical techniques? What is the most important contribution?
2. What can be the contributions of LEGO robotics to you? What is the most important contribution?
3. In which units of the science and technology course can LEGO robotics be useful in Secondary school?
4. What kind of socio-economic problems can both teachers and students face with when the LEGO robotics becomes common in education?
5. What can be done in order to make the LEGO robotics be more fruitful?
6. In which courses can LEGO robotics be used in your opinion?

2.4. Data Analysis

In data analysis process, the interviews were transcripted and written down firstly. After that, the records and transcripts were compared again to find out whether there were any mistakes and then the data were analysed according to descriptive analysis method.

In descriptive analysis, direct citations are frequently made in order to reflect the opinions of the participants in an impressive way. In this analysis, the aim is to present the findings to the reader in an organized and interpreted way. For this purpose, the data are described firstly systematically and clearly. Then, these descriptions are explained and interpreted, cause and effects relationships are examined and some results are concluded (Yıldırım & Simsek, 2011).

Findings

In this part, the data, which were obtained as a result of the analysis, were presented based on the questions asked during the interview. The data were showed in tables for each question.

1. First question of the interview was "What can be the contributions of LEGO robotics to the students apart from the classical techniques. What is the most important contribution?" and the answers of the teachers were given in Table 2.

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Figure 1. Participant teacher and robotics students

Table 2. Contributions of robotics applications to the students

Participants	Contributions	%	f
P1,P4,P6,P9	Enhance imagination.	13,2%	4
P1,P3,P7,P8, P9,P10	Provide learning through experience.	19,8%	6
P2,P5,P8,P10	Provide cooperative learning environment.	13,2%	4
P2,P10	Bring students social skills.	6,6%	2
P2,P6,P10	Students' problem solving skills develop.	9,9%	3
P1,P4,P5,P9	Provide higher-up cognitive development.	13,2%	4
P1,P2,P7,P8, P9,P10	Provide the development of psychomotor skills.	19,8%	6
P2,P6	Provide motivation	6,6%	2
P1	Enhance creativity.	3,3%	1
P5	Increase self-confidence.	3,3%	1

Table 2 shows that participants gave a wide range of answers about the contributions of the robotics application and this indicates the importance of these applications in education. The most frequently stated contributions are "Provides learning through experience (19,8%)" and "Provide the development of psychomotor skills (19,8%)".

2. Second question of the interview was "What can be the contributions of LEGO robotics to you? What is the most important contribution?" and the answers of the teachers were given in Table 3.

Table 3. Contributions of robotics applications to the teachers

Participants	Contributions	%	f
P1,P3,P7	The use of different materials	17,64%	3
P2,P4,P5,P7	Provide in-class motivation	23,52%	4
P1,P2,P8,P9	Develop new horizons and perspectives	23,52%	4
P1,P3,P8	Following the technology	23,52%	4
P6,P10	Using the technology effectively	11,76%	2

Table 3 shows that the participants mostly (23,52%) stated "provide in-class motivation, develop new horizons and perspectives and following the technology". This may speculate that robotics applications are useful for teachers from different aspects.

3. The third question of the interview was "In which units of the science and technology course can LEGO robotics applications be useful in secondary school?" and the answers of the teachers were given in Table 4.

Table 4 shows that participants mostly (56,25%) stated that LEGO robotics can be used in all force and movement units. Besides, 25% of them remarked that these applications can also be used in light and sound unit.

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Table 4. The units of the science and technology course in secondary school useful in robotics applications

Participants	Contributions	%	f
P1,P2,P3,P5,P6, P7P8,P9,P10	All Force and Movement Units	56,25%	9
P4,P6,P8,P9	Light and Sound	25%	4
P7,P8	Energy Transformations	12,5%	2
P2	Chemistry Subjects	6,25%	1

4. The fourth question of the interview was "What kind of socio-economic problems can both teachers and students face with when the LEGO robotics become common in education?" and the answers of the teachers were given in Table 5.

Table 5a shows that 33,33% of the participants stated for students that "there will not be a problem" and "some students may be afraid of using technology" and 25% of them remarked that ""some students may totally break away".

Table 5b shows that participants mostly (33,33%) think that "teachers should always prepare for the lesson" and "teachers may not be master in technology" so they cannot use these robotics applications effectively. 26,66% of the participants also think that "there may be some problems for classroom management". Therefore, teachers should prepare for the class very well.

Table 5c shows that 60% of the participants stated that physical conditions of the classrooms are inadequate for robotics applications. Some of them also stated that classrooms are overcrowded and this technology is impossible for our country because of economic conditions.

Table 5a. The problems for students when the robotics applications become common in education

Participants	For Students	%	f
P1	The students who are good at technology may stand out	8,33%	1
P2,P4,P5,P9	I do not think that there might be a problem.	33,33%	4
P1,P3,P6 P10	Some students may be afraid of using technology.	33,33%	4
P3,P7,P10	Some students may totally break away.	25%	3

Table 5b. The problems for teachers when the robotics applications become common in education

Participants	For Teachers	%	f
P1,P2,P7,P8 P10	Teachers should always prepare for the lesson.	33,33%	5
P3	Teachers cannot give up classical techniques.	6,6%	1
P2,P4,P6,P7 P10	Teachers may not be master in technology.	33,33%	5
P2,P3,P8,P10	There may be some problems for classroom management.	26,66%	4

Table 5c. The socioeconomic problems when the robotics applications become common in

Participants	Socio-economically	%	f
P2,P3,P5,P7 P8,P9,P10	Inadequacy of the physical conditions of the classrooms	60%	6
P1,P3,	Overcrowded classrooms	20%	2
P1,P6	Impossible due to economic factors	20%	2

5. The fifth question of the interview was "What can be done in order for the LEGO robotics be more fruitful?" and the answers were given in Table 6.

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Table 6. What can be done in order to make the robotics applications be more fruitful?

Participants	Actions to be done	%	F
P1,P3,P5,P7 P8	Physical conditions of the classrooms must be enhanced	25%	5
P1,P3,P5,P6 P7,P8	Number of the students in each class should be decreased.	30%	6
P2,P9	The applications should be started locally and pilot studies should be done.	10%	2
P2,P6	The applications must be started in the city and province centres by founding central laboratories.	10%	2
P1	Special tables must be provided in classrooms	5%	1
P1,P4,P6,P10	Trainings should be organized for teachers	20%	4

Table 7. The answers of the Science and Technology teachers to "In which courses can robotics applications be used in your opinion?"

Participants	Course
P1,P2,P3,P4,P5,P6,K,P7,P8,P9,P10	They can be used in all science courses and in vocational courses in vocational schools.

Table 6 shows that most of the participants (30%) stated that classroom are overcrowded for the LEGO robotics and number of the students in each class should be decreased. Besides they also stated physical conditions of the classrooms are not well enough (25%) and extra education should be given to the teachers (20%).

6. The sixth question of the interview was "In which courses can LEGO robotics be used in your opinion?" and answers of the teachers were given in Table 7.

Conclusion

Students are expected to advance their scientific process skills when science and technology course is carried out with LEGO robotics sets (Goldworthy, 2000). According to the findings of the study, teachers mostly think that robotics applications will be useful in education. Teachers stated that robotics applications provide cooperative learning, have positive impact on motivation, increase imagination and problem solving skills, contribute social skills, improve psychomotor abilities, contribute higher-up cognitive development and provide learning through experience. They remarked the disadvantages as being afraid of using technology, the preparation of teachers for all courses, physical conditions of the classrooms and overcrowded classrooms.

Robotics applications are not useful only for students but they are also useful for teachers because they can help motivating the students easily, bringing new perspectives for teachers, using and following the technology effectively.

Participants evaluated robotics applications from the point of becoming widespread and indicated their doubts for both teachers and students and for socio- economic factors. They think that it is impossible for LEGO robotics become widespread due to physical conditions of the schools and socio-economic inadequacies.

In order to make the applications more fruitfully and to gain better results, participants suggested that expert teachers must be trained, the number of the students in classrooms must be decreased and laboratories should be founded in the centre of cities.

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Using Power Light Emitting Diodes (LED's) in the Laboratory of Optics and Physics

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Abstract. *After lighting homes, streets and buildings for over 100 years, the incandescent bulb created by T. A. Edison, will soon become a relic of the past. Many countries have taken steps to replace it to another more efficient light energy source. Additionally, the incandescent bulbs have been gradually replaced by fluorescent bulbs that are more economical and, currently, in residential lighting, their compact equivalents. However, this type of lamp is beginning to be replaced and the alternative that presents itself is the power LED. In Optics laboratories teaching is common to use several types of light sources, from a simple candle to semiconductor lasers. Thus, in experiments involving Geometric Optics and light polarization, among others, it is common to use traditional sources such as incandescence and low pressure gas. In experiments involving the phenomenon of light interference, it is easier to use sources of high grade of coherency, such as gas lasers and semiconductor lasers. The purpose of this paper is to present, in a simple and didactic way, a source of light that uses a LED power and show that it can replace, with many advantages, the light sources traditionally used in many optical experiments.*

Keywords. *Teaching optics. white light, cold light, power LED.*

1. Objectives

The purpose of this paper is to present a simple, efficient, affordable and cost effective employment of conventional light sources used in teaching laboratories optic alternative, replacing them with LED (Light Emitting Diode - LED) power. The main goal is to replace incandescent lamps of old optical benches for power LEDs leveraging the original assembly. These LEDs are easily found in the specialized market and their price, with mass production is becoming increasingly attractive as well competitive, in many cases, with incandes-cent sources, gas lamps and small semiconductor lasers
Thus, with some modifications, for example, the replacement of the existing incandescent lamp by a traditional optical benches LED or by constructing a new optical source, it is possible to have a white - light source AC, high intensity (dependent power LED), with small dimensions, low weight, low heat, long life, low cost relative employment of low voltage, etc..
However, the use of a suitable power source that may supply constant current to the LED's to make replacement for a conventional LED lamp power is needed. It may be purchased in specialist shops or ready built without difficulties.

1. Introduction

The electric lighting had its beginning in the eighteenth century when research showed the use of electricity to generate light by

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electric discharge in a thin quartz ampoule - Ampoule Crookes.

But it was in the nineteenth century that many inventors tried to build light sources using electricity. In 1802, H. Davy, built the first light source with a platinum filament. In this source the filament is heated by the passage of electric current to the point emit visible light. Decades later, Edison, built the first commercial light bulb. This lamp light is emitted by heating a carbon filament that was subsequently replaced by a tungsten filament, allowing higher luminous efficiency and durability. To prevent burning of the filament it burned quickly removed if all air from the lamp and filling it with the mixture of inert gases such as nitrogen, argon or krypton [1].

Despite all the improvements made to the incandescent bulbs since their invention in the transformation of electrical energy into light energy process, it still produces large amount of heat energy. Thus, in order to achieve a lamp which presents superior to incandescent lamps yield the fluorescent lamp was developed.

A fluorescent lamp is classified as a low pressure discharge lamp. Thus, light is produced by the passage of electric current through the gas contained in a tube (or a mixture of gases). When the voltage applied to the electrodes of the lamp exceeds the dielectric strength of the gaseous medium, the lamp ignition occurs.

When compared to incandescent lamps, fluorescent lamps present some advantages, such as longer service life, higher luminous efficiency (they produce less heat - thermal non visible radiation), high color temperature (white light) etc.. On the other hand, however, they have disadvantages, for example, in its composition, using harmful to humans and the environment gasses, require a ballast to your external actuation, thereby increasing its cost, has a great length, which makes its use as a light source in teaching optics, etc. lab. To solve these problems, compact fluorescent bulbs, which in despite of their small size, come with the ballast built into the lamp socket were created. Despite the satisfactory results produced by these bulbs, however, a new alternative is proving very viable in replacing them and can further improve the results presented by these sources, LED’s [1-2].

LEDs are semiconductor devices that emerged in the 1960s and its operating principle is based on electroluminescence, the emission of light through the combination of electrons and holes. Operate in the visible, infrared and ultraviolet. Initially they were used in indicative lighting, but with the development of more powerful and higher brightness LED’s was possible to use them in a wide range of applications [3].

The use of LED power has many advantages when compared with the conventional bulbs, for example, high brightness and intensity, high efficiency, low voltage operation (allowing the use of batteries, solar collectors, dynamos etc..), Firing snapshot, immunity to vibration (great physical strength), high lifetime (~ 50,000 hours), its light intensity can be easily controlled (using electronic controllers), are compact and easy optical control (there are several options for external lenses that can be attached to the LED), etc.. As disadvantages, we can cite the high cost (with mass production the trend is down), need for thermal control and need more technical knowledge to its application. Therefore, the LED has become a compo-

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nent of great interest in situations where high consistency is required [2, 4].
The most common power LEDs are 1, 3 and 5 watts [5]. However, there are LED's whose power can reach 50 watts [4]. Thus, the replacement of the optical sources in traditional low coherence optical teaching laboratory LED power is warranted.
LED's can be classified into three distinct categories: indicative, high brightness and power. The indicator LED's are those used only for indicative lighting in electrical and electronic equipment panels, indicating whether they are running or not. The high brightness LED's are encapsulated in transparent epoxy resin, with an integrated lens. They are used in traffic lights, emergency lighting systems, etc.. These two types of LED's operate with currents from 20 to 70 mA with powers ranging from 0.05 to 0.2 watt. Have the power LED's (or high flow) allow the use of lighting environments, among other applications. They are enclosed in a special housing with a metal base to maximize the heat transfer from the LED to the external heat sink. Figure 1, 2 and 3 illustrate the three types of LEDs mentioned [2, 5-6].

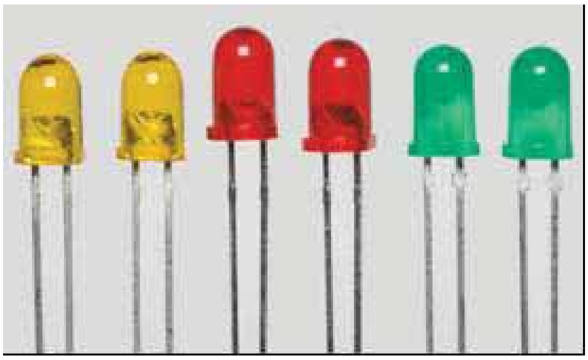

Figure 1. Indicating LEDs

2. Power supply for LED power

For proper operation of the LED power an electronic circuit capable of delivering appropriate voltage and current is needed. It is hoped also that it is compact, efficient, having low cost and can be connected directly to mains. This circuit exists and can be easily found

Figure 2. High brightness LED's

Figure 3. Types of power LED's available on the specialized market: a) White LED (1 or 3 watts); b) White LED (4, 6, 8 or 15 watts); White c) 10 watt LED; White d) LED 30 or 50 watts

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They are ready in the specialized market [7] Circuits for this purpose are commonly called *drivers* for LED's and are actually sources of constant direct current designed to power the LED. These fonts are available with output currents of 300, 350, 500, 600, 700, 1000 and 1200 mA, serving almost all lines of power LED's. Despite its compact size, these sources have high efficiency, wide input voltage range, have protection against overheating, and some models can vary the intensity of the output current (electronic control) [2].
As it said before, the sources for LEDs can be found in the market ready to work and requiring no additional components. The connections to the LED source is extremely easy and is taken directly to their handsets. The only caution is to be taken with the polarity of the LED. Moreover, these can be connected directly to the mains 100 VAC to 240 VAC.

Color temperature	6000 to 7000 K
Lens	Transparent
Lighting angle	120°
Working voltage	3,2 V a 3,6 V
Maximum current	700mA
Power	3W
Lighting power	180 a 200 Lumens
Dimensions	20 x 6,6 mm^2

Table 1. Main features of the chosen LED power [4]

For the assembly proposed in this paper, sources with power of 6 watts were acquired. In Fig 4 below, there is a commercial power connected to the power LED constant current, used in this assembly [7 - 8].

Figure 4. 6 watt commercial power source and power LED

2.1. The choice of LED power

Figure 5. Power LED mounted on the star aluminum

The power LED is the most important element of this work, because it will replace light bulbs in the optical kits available in many optical laboratories.

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Among the alternative power LEDs available on the market, the chosen is similar to that shown in Figure 3a and its main characteristics are shown in Table 1.

Due to the relative high power LED must be mounted on a metal structure to dissipate the heat generated. In ecommerce you can find aluminum brackets, called " stars " that are used for mechanical attachment and electrical connections of the LED. However, besides the star, the use of a small heat sink, which in our case was used in a small copper plate, slightly larger than the star aluminum is required.

With these materials, solder the LED to the star and is holding up to the heat sink. In assembly we used two small screws with nut to secure the star to the metal disc. Figure 5 shows the LED mounted on the star used aluminum sink.

2.2. Optical assembly with bulb

Figure 6. Optical Source of Leybold Optics using incandescent lamp

The original light source was manufactured by Leybold Optics. It - is constituted of a small incandescent lamp 12 volt, 21 watts which is housed within the assembly that is basically comprised of two concentric tubes. This assembly also comprises three screws and a central spring that align the lamp with the axis of symmetry of the assembly. 6:07 Figs allow a better understanding of these details.

2.3. Mounting the optical assembly with power LED

A 3 watts LED was used in each unit of the light source. This LED was mounted on a aluminum star which is attached in turn to a heat sink.

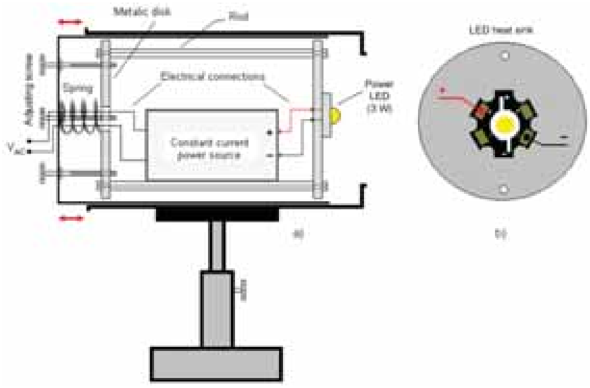

Figure 7. Overview of the LED power source using commercial. a) Scheme of the whole modified Leybold. b) Detail of the LED with star on the heat sink

The modification of the original source (optical source of Leybold Optics) is based on the replacement of incandescent lamp by LED power and placement of the constant current source within the set. The LED is mounted on a mechanical system consisting of two metallic disks, three set screws, two metal rods and a central spring. This arrangement allows aligning the beam with the axis of the assembly. The metal braces

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separating disc which is mounted on the LED of the alignment system. This separation is enough to put the constant current source within the assembly. The original mechanical assembly was maintained. Fig. 7 shows the layout of the modified set.

The aluminum star sink and LED are fixed with screws on a copper disk with about 2 mm thickness. This disk is important to assist in heat dissipation and can be made with other metal materials such as iron, brass, aluminum etc. Fig. 8 illustrates the final mounting in the light source case with the LED power source and the constant current commercial power supply.

Figure 8. Installation of a LED with a commercial constant current source

Then the two assemblies are placed side by side, one using an incandescent lamp and the other a power LED. In mounting the incandescent lamp, a DC voltage range (0 to 12 VDC) was used, thus being able to vary the light intensity.

Since the assembly with the LED power, voltage and current are fixed, and hence the light intensity is constant. Figure 9 illustrate the two assemblies for simple comparison.

3. Applications

With the replacement of incandescent lamp by power LED, the light source proved to be very useful in the Optical Physics Institute of the State University of Rio de Janeiro laboratory. Now it has been used in many optical experiments, such as the verification of Snell's law, the observation of total internal reflection, examining the chromatic dispersion of light in imaging lenses and mirrors, the determination of the distance focal lenses and spherical mirrors, as non polarized light in the verification of Malus' law, building strobes, experiments with color matching etc.

Figure 9. Final appearance of the light source assembly. Aside the power supply is the incandescent lamp assembly and at right that with power LED connected directly to mains

With the addition of a collimating lens coupled to the LED, it can greatly decrease the aperture of the light beam, thereby obtaining a beam with small opening angle, useful in many optical experiments. The

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following are some of the cited experiments, performed with power LED's.

3.1. Adding colors

The color is related to the different wavelengths of the electromagnetic spectrum. They are perceived by the people in a specific range (the visible range), as a sensation that allows us to differentiate between space objects with greater precision.

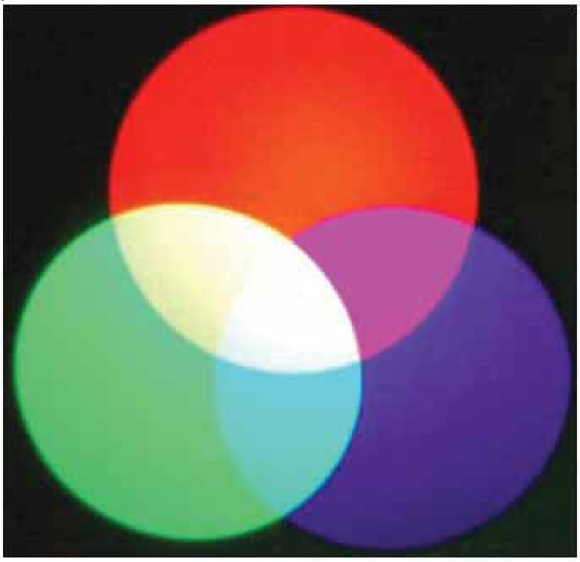

Figure 11. Adding colors obtained with three power LED's

Considering the light colors such as white color results from the superposition of all the primary colors (red, green and blue), while black is the absence of light. White light can be decomposed in all colors (visible spectrum) by means of a prism. The primary colors are indecomposable and colors from the experiences of Le Blond, in 1730, these colors have been considered primary. When speaking of colors, we have to distinguish between those additively obtained (light color) and those subtractively obtained (color pigment) [10].

Figure 11 was produced from an assembly with three power LEDs (red, green and blue) mounted at the vertices of an equilateral triangle of three inches hand, in a printed circuit board. In front of this assembly was placed an opaque plate with a circular with about three inches in diameter (the diameter is not critical) hole. The passage of light through the hole projected on a white sheet of paper colors obtained by the process of addition.

3.2. Refraction of light

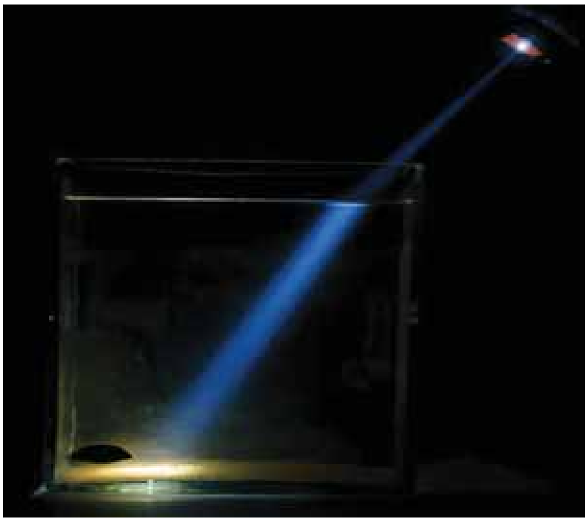

Figure 12. Refraction of light from a cold white power LED

The passage of light on a surface (or interface) that separates the two different media is called refraction. Unless the incident ray is perpendicular to the interface, the refraction changes the direction of light propagation. In Figure 12 were obtained with

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the aid of a LED collimator lens coupled to [9]. It is possible to observe that the change of direction of the light occurs only at the interface; within the interface light propagates in a straight line, as in the air.
The bright beams of photography are represented by an incident ray and refracted ray (you cannot observe the reflected beam in this photograph). The orientation of these rays is measured with respect to a direction, known as normal, which is perpendicular to the interface at the point where reflection and refraction occur. Thus, with the help of a protractor, it is possible to measure the angle of incidence and the angle of refraction.

3.3. Strobe

A strobe is an optical device that allows you to study and record the continuous movement or periodic high speed of a body, aiming to make it appear stationary. The result is a set of discrete images, but which are representative of the path body described. This effect is achieved by alternating between illumination light and an intense blocking of the light by a diaphragm. This device allows to determine the frequency of rotation of bodies, making it coincide with the frequency of lighting of movement, each light beam illuminates the same stage of movement, resulting in an apparent immobility of the rotating body. If the strobe frequency matches the process frequency of the measurement, the time varying process appears to be stopped or *frozen*. If you do not give such coincidence, then the process advances or recedes slowly to a higher frequency.
Until recently, the use of a special lamp (usually a bulb with Xenon gas) which, besides being a sensitive component, has some disadvantages, such as high cost, relatively short lifespan and employment to build a stroboscope was necessary a high voltage source, which is usually produced by inductive circuits are not always easy to construct.
In the version with LED power, the apparatus showed flashes of strong intensity with stable and tunable frequency, such as that produced by traditional Xenon bulb.
Figure 13 is a digital photograph obtained from a simple pendulum moment, lit with a strobe built with a 5 watt LED. The exposure period was only 1.3 seconds.

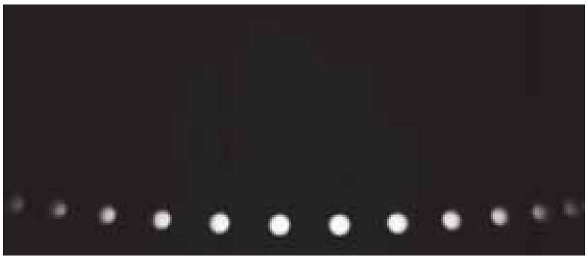

Figure 13. Photograph obtained from a simple pendulum highlighted under motion with a stroboscope LED

4. Conclusions

Traditionally the light sources used in optical benches of laboratories to make use of optical light bulbs. However, more recently it is common use of CFLs in these assemblies. In this work, an efficient source of light and long life, which makes use of a power LED, replacing these bulbs was presented.
For the realization of this work was to modify the old mounting a light source, an optical bench, in order to replace the incandescent bulb with an LED power. Thus, for proper operation of this LED and keep the compact

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form of the set, it was necessary to insert into mounting a power supply that in addition to providing the correct voltage and current, present small dimensions. For this reason, we chose the constant current source commercial.

The proposed source of light was compared with the traditional source and presented some advantages, such as: operation with white light of high luminous intensity, long life, has no harmful environmental elements, works with constant light intensity, small dimensions and weight, immunity to vibration, operation at lower temperature, relative low cost, low voltage operation, able to operate with batteries, or directly via the mains, the possibility of using commercial source with dimmer, thus being able to vary the light source intensity by varying the current operation, etc.

In this context, we believe that the experimental results have demonstrated the usefulness of power LEDs in optical experiments and their technical feasibility of using power LEDs in optical experiments.

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