HSCI2011

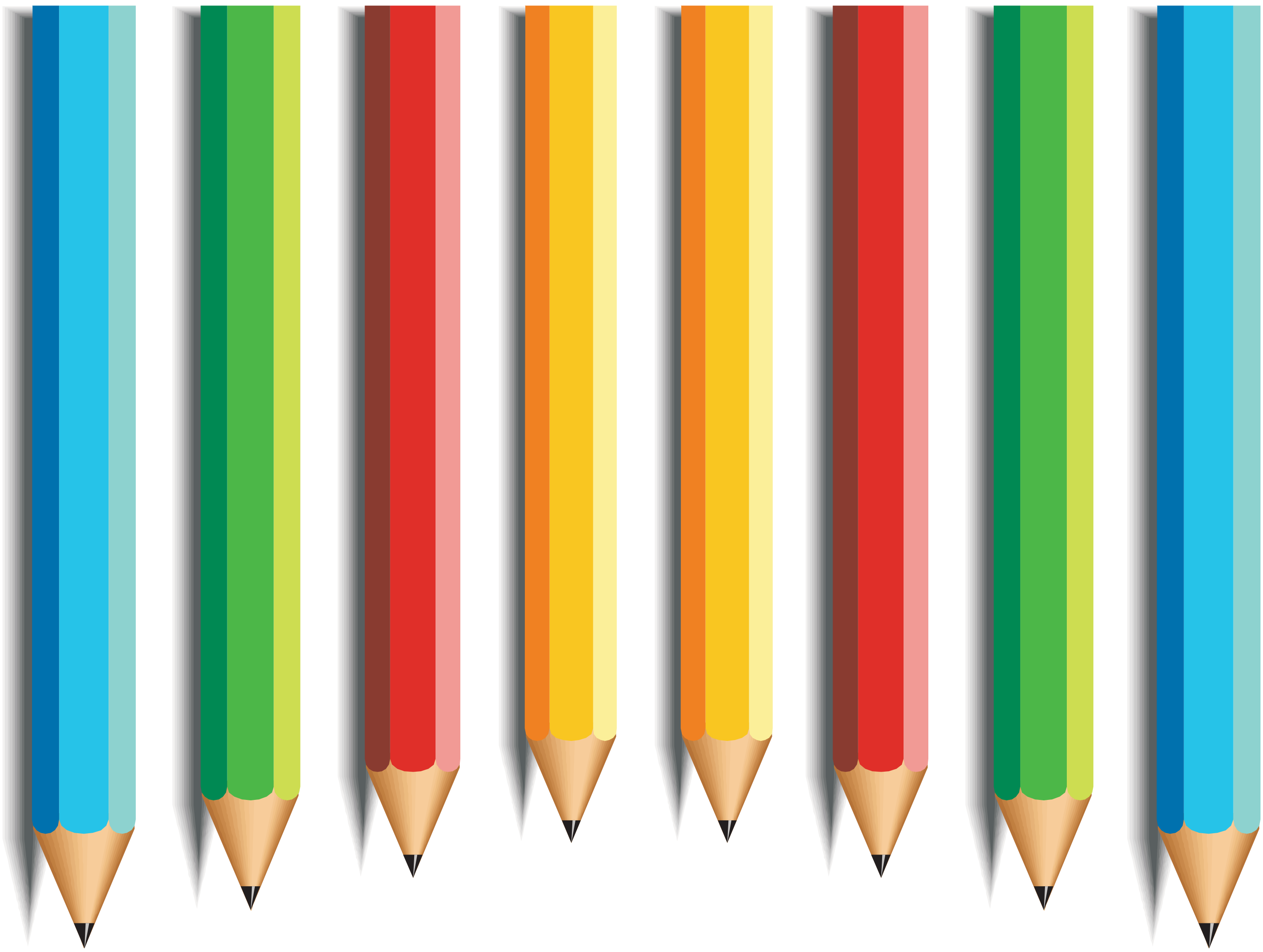
Proceedings of the 8th International Conference on

Hands-on Science

Focus on multimedia

(Jointly co-organised with MPTL'16 - Workshop on Multimedia in Physics Teaching and Learning)

September 15 to 17, 2011
University of Ljubljana, SLOVENIA



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Foreword

Back in July 2004, Ljubljana welcomed the first International Conference on Hands-on Science organised in the frames of the Hands-on Science Socrates/Comenius 3 network project partially financed by the European Commission.
Being our first major conference we devoted it to the presentation and discussion of the state of the art and perspectives for future development on science education –"Teaching and Learning Science in the XXI Century". Already there the importance of ICT for science and technology education was stressed and a good number of contributions in a varied number of subjects were presented (and are since then freely available through the Hands-on Science Network website www.hsci.info).
Seven year after, on invitation from Professor Sasa Divjak of the Faculty of Computer and Information Science of the University of Ljubljana, we gladly return to Slovenia' welcoming capital for our 8th annual conference focused this year on multimedia and for the first time jointly organised with the 16th Workshop on Multimedia in Physics Teaching and Learning, MPTL'16.
The workshop on Multimedia in Physics Teaching and Learning is a reference meeting in the field of physics education. We expect this to be the beginning of a long lasting fruitful cooperation on the sake of the development of Physics and Science Education.
We would also like to stress the support and commitment of the CoLoS (Conceptual Learning of Sciences) association, founding member of HSCI, in making this joint conference a success.
This proceedings book apart from the works submitted to the HSCI part of the joint conference also includes several full paper submitted to MPTL'16 tracks. After undergoing a reviewing process all papers will be electronically published in the MPTL'16 – HSCI'2011 Joint Conference' proceedings to be made available by September 2012.
The Hands-on Science Network is today a non-profit international organization legally registered in Portugal. It enrols over 200 institutional members, and many excellent and most welcomed individual contributions, from the most EU countries but also from all over the world. With a broad open understanding of the meaning and importance of Science to the development of our societies, each individual and of the humankind, the main goal of the Network is the development and improvement of science education and scientific literacy by an extended use of investigative hands-on experiments based learning of Science and its applications, while promoting extend cooperation and mutual understanding and respect among its members within our Societies.
As President of the International Association Hands-on Science Network I would like to thank all contributors and participants to the Joint Conference MPTL-HSCI 2011 wishing you a wonderful stay in Ljubljana!

Braga, August 24, 2011.

Manuel Filipe Pereira da Cunha Martins Costa
HSCI'2011 Chair

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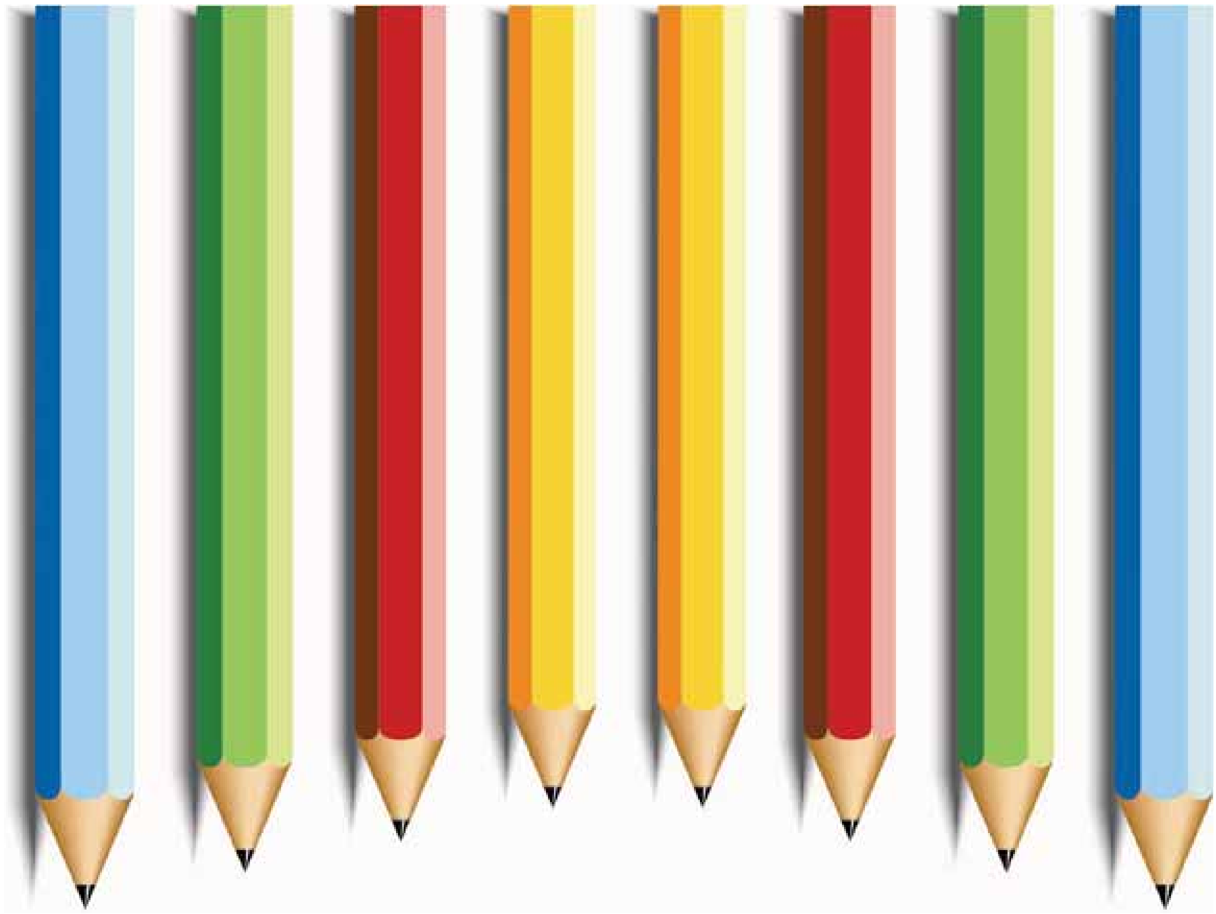
Science Education



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THE HUNVEYOR-PROJECT - A NOVEL WAY OF TEACHING SCIENCE AND PHYSICS

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Abstract. *Building HUNVEYOR-4 brings a fresh air into the education taking place at Óbuda University, Alba Regia Educational Centre located in Székesfehérvár. The project is giving the students an opportunity to build different sensors, instruments, develop sophisticated measurements and methods, hardware and software components and solutions in order to exercise their engineering skills. During this process, they learn a lot of science and physics.*

1. Introduction – The HUNVEYOR Project

The HUNVEYOR project is a minimal space probe construction program, which is running in several educational institutions in Hungary. The name "HUNVEYOR" stands for Hungarian UNiversity SurVEYOR. The program was initiated by Bérczi at the Roland Eötvös University, Budapest in 1997. The Hunveyor-1 was built with camera and telescopic arm instrumentation. Later a rover was developed, with a test-field around. By the time other Hunveyors were built with their own electronic and experiment constructions. The second one (Hunveyor-2) was built at the Pécs University, the third one (Hunveyor-3) at the Berzsenyi College in Szombathely.

2. HUNVEYOR-4 at the Óbuda University, Alba Regia University Centre

The Alba Regia Educational Centre of Óbuda University (once called Budapest Polytechnik Kandó Kálmán Faculty of Electrical Engineering, Institute of Computer Engineering) joined to the project with the Hunveyor-4 in 2001. Our realization is based also on individual solutions. The project is an educational experiment, and consists of engineering and building the probe itself as well as the public outreach.

2.1. Aims

No one can seriously think that our HUNVEYOR space probe will fly in space. The primary teaching aims of the HUNVEYOR project at our Institute are:

- forming an attractive, meaningful and long term framework for the research and development carried out by our students
- offering subjects for diploma and other project works
- obtaining skills in engineering, organization and realization of products
- get acquainted with the latest technologies
- serve as reference in job hunting

These goals have not changed over the years, but the HUNVEYOR-4 itself.
Our students will not become astronauts or geologists, of course, but electric engineers. Yet the project is part of the "Space Education Program" through building different sensors, instruments and software in order to exercise and improve their engineering skills.

2.2. First Steps

The first step of the HUNVEYOR project at our Institute was to gain interest among the students by formulating and post the project. This was done by constructing and displaying the metal frame of the probe (Fig.1). After a while some students participated to the project by mounting a computer mainboard into the frame. Because we wanted HUNVEYOR-4 to be open to the public, the students created a web-site for the probe. After these initial steps the next generation of students started creating different instruments and software in order to control and organize the measurements. In the following years the HUNVEYOR-4 was continuously extended and some parts and building blocks are completely redesigned by different students of course, fulfilling the aims of the project.

2.3. General system overview

The HUNVEYOR-4 consists of

- frame and other mechanical parts
- computers and on-board electronics
- scientific instruments, like sensors etc.
- software control modules and web server

Each of them gives much opportunity to the students to meet physics and real world problems to be solved.

2.3.1. The frame

Our frame – which is a little bit smaller than the earlier Hunveyors - is a tetrahedral light-weight

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rigid skeletal structure, made of aluminum. The whole frame consists of about 100 pieces.

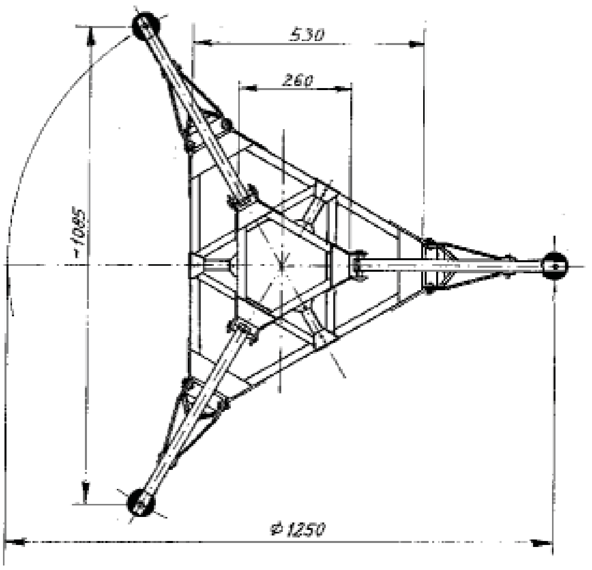

Figure 1. *The frame of the Hunveyor-4.*

2.3.2. The computers and on-board electronics

The electronics of the probe are based upon a PC motherboard mounted into the frame and some special controller boards engineered by the students.

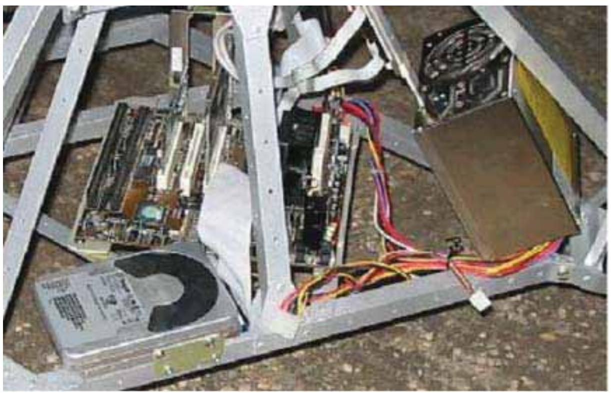

Figure 2. *The first version of the electronics of HUNVEYOR-4.*

2.3.3. Scientific Instruments

The purpose of a space probe is to collect data and information about its environment, both visually and numerically. So the HUNVEYOR-4 has an USB webcamera to look around and a weather station engineered and built by the students, which can measure the temperature, the wind speed (cup anemometer) and direction (weathercock).

In addition to the above, the HUNVEYOR-4 is equipped with a particle radiation detector and a self-made spectrometer, estimating the composition of the soil.

Figure 3. *The camera, the cup anemometer and the weathercock.*

Figure 4. *The LED spectrometer.*

2.3.4. Software Control Modules and Web-server

The operating system of the HUNVEYOR -4 is a Debian GNU/Linux 3.0 Woody system. Since we planned minimal energy consumption, therefore only the most necessary processes are run. The camera connects by an USB port to the computer. The data are stored in a Postgre SQL data base. The direction and control of the camera movements are solved by the motherboard's parallel port. This server also communicates with the web-server.

In the last few years we redesigned the HUNVEYOR-4. With the new hardware solutions the probe became mobile so able to work in a field, and we can add significantly more sensors or other devices than before. We separated the "Terrestrial Control Unit" from the "Probe Control Unit". The "Terrestrial Control Unit" was moved to a separate computer. The two units communicate with each other using XML-RPC via secure version of the HTTP protocol. The students completely rebuilt the user interface and the data base as well.

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Figure 5. *The HUNVEYOR-4 in construction.*

2.4. Experiments

The students tested the space probe inside and outside of the building more or less in normal environment so far, because testing in extreme conditions would be too expensive for our Institute. In moderate temperatures the NTC showed up near linear response. The direction sensing was tested using a fan, moving around the meteorological station. The trickiest part of the calibration was the speed measurement. The device is sensitive enough indicating about 0.5 km/hour wind that means the wheel starts turning if you just grab and slowly walk in the room. Testing for higher speed we fixed the unit on to the roof of a car, and obtained data driving from low to moderate speed. The camera and its moving assembly working well as expected. Despite of its simplicity, the LED spectrometer produced nice results. We tested different materials, each seem to white for the human eye, but the spectrum reveals differences among them.

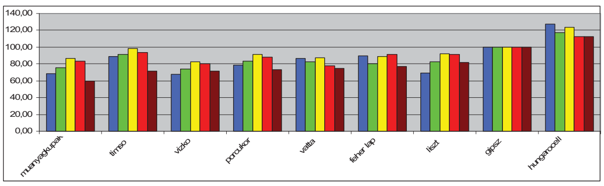

Figure 6. *Spectrum collection of different white materials obtained with the LED spectrometer*

We also conducted field trips for different planetary analogous terrains across Hungary.

2.5. Public outrich

The HUNVEYOR project is more than mere building a space probe. We publish booklets, render animations, organize seminars to discuss and share the results in the community, and we participate national and international conferences. We give out all the information, documents and our more than a decade experience to anyone, who wants to join to this inspiring teaching experiment.

Figure 7. *HUNVEYOR-4 in an Martian analogous terrain (left) and remote communication with the space probe (right)*

Figure 8. *Two booklets about building and experiencing with HUNVEYORs, and a poster lecture at NASA.*

3. Conclusions

The HUNVEYOR project has been successfully conducted for years. More and more popular, many students found it interesting and suitable to exercise engineering. The project is recognized by the NASA as well, accepting numerous publications. As a result, the project fulfilled its primary aims.

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BRIDGING ART AND PHYSICS IN TEACHING PROCESS

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Abstract. *This paper intends to introduce a special way of looking at paintings, poems and the sounds of music. It will be shown how they can illustrate physical phenomena or laws, helping the better understanding. On the way to achieve our aim, we have to find the meeting points of the so called "two cultures", especially of art and physics.*
The selected examples mean to provide illustrations to teaching some special chapters of physics: mechanics (the space and time, the theme of dynamics and acoustics), optics (the law of reflection, the perspective, the camera obscure), and quantum mechanics (the duality and the complementarity).

1. Introduction

Physics and art (let it be painting, music or literature) give different approaches of the world around us but their descriptions complement each other. At our university in the introductory physics course for engineering students, and in an optional history of physics course, one of the aims of the teaching process must be to help our students with gaining possession of an overview not only of physics but that of the whole culture, too.
Elements of physical laws can be found in some form or other, - directly, or indirectly - in numerous paintings and poems. We can use them in our courses to teach important physical concepts, because of their motivating power. They can also be helpful in the introduction of some phenomenon. The direct or indirect connection between physics and music or sounds of music is also suitable for illustration or for modelling physical phenomena.
At our university the Cultural history of physics, as an optional subject, has a special function in process of cognition of the physical ideas. Here we have more time and possibility to connect art and physics.

2. Physics and art in the only culture

It is interesting to discover the fact that Galileo, Shakespeare, Velázquez, Pascal, Tycho Brahe and Monteverdi were contemporaries; usually we do not discuss their lives and works in parallel ways. (Figure 1) But these personalities, who were far from one another in space and in the most cases in activity, can get on well together side by side in the course of history of physics which is embedded in the general history of culture.

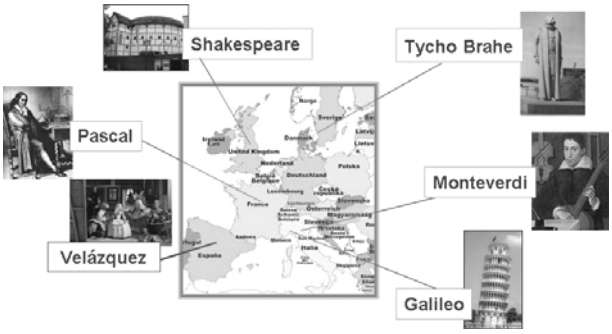

Figure 1.

3. 3. Illustrations from art for some chapters of physics

3.1. Motions

The discussion of mechanics starts with concepts about the change of places of the bodies in time. So the concept of *space and time* has important role here and later in special relativity as well.

"What then is time? If no one asks me, I know what it is. If I wish to explain it to him who asks, I do not know." (Saint Augustine)

In Italy in the 17th century Botticelli painted his fresco depicting Saint Augustine, where behind the mediaeval scientist, a clock of the age can be seen on a shelf, beside scientific tools and books. The clock shows the last hour before sunset on its dial plate which is divided to 24 units.

The development of our concepts about space and time can be followed also in the history of painting. Let me illustrate it here by a single example. William Dyce' painting, *The Pegwell bay – a recollection of October 5th 1858* can represent the sum of knowledge about space and time in the middle of the 19th century. The unusual title refers to the fact that a comet was at its brightest on the mentioned day from the given place. The artist, standing at the edge of the picture, is just looking at its passage. The comet means the astronomical time, the collected shells and rocks talk about the "geological time", similarly to the cliffs, which have evolved over millions of years. The people who collect them symbolize the "daily time". So the comet and the cliff illustrate the vastness of space and time, and on the other scale the effect of perspective means the possible space for the observer and the length of the human life means a relative short time. (Lippincott K 2002)

We can discover the process of the movement itself in Giacomo Balla's painting, *Dynamism of a dog on a leash*.

The law of action and reaction (Newton's 3rd law) can be illustrated by Rodin's sculpture, *The kiss.* It can suggest to the physics teacher that this touch can only be mutual, in other words, there is no action without reaction.

3.2. Acoustics

In Raphael's fresco, School of Athens ancient scientists (sometimes with exact references to their activities) connect to the features of contemporary painters and architects, showing a special possibility of the synthesis of science and art. Let me emphasize here only three Greek characters: Aristotle, Plato (we can recognize Leonardo da Vinci in the latter scientist) and Pythagoras. Pythagoras explains the musical ratios, which is illustrated by one of the figures on the tablet in front of him. This suggests a clear connection between the ratios of the lengths of the plucked strings and the intervals producing harmonious sounds if these ratios are the ratios of small numbers. The meaning of the Greek words on the tablet is: tone, fourth, fifth and octave. The numbers (VI, VIII, VIIII as IX and XII) are the numbers in the ratios of the harmonious intervals.

Leonardo da Vinci met Gaffurius, who emphasized in his book of musical theory the importance of the ratios of Pythagoras. So Leonardo divided the background of The Last Supper according to the musical ratios: the width of the second tapestry is the half of the first one, then the next ones is the third of it, and the following one is the fourth part of the first one.

In London, in the exhibition in the Globe theater you can see an interesting poster about the connection between Shakespeare's works, the contemporary music and Robert Fludd's encyclopedic work (The Technical, Physical and Metaphysical History of the Macrocosm and Microcosm) which contains the investigation of the musical intervals (besides optics, perspective depiction, mechanics, etc.).

The resolve of the musical sounds and making them visible is suitable to the modelling of numerous physical concepts. The following examples intend to illustrate this.

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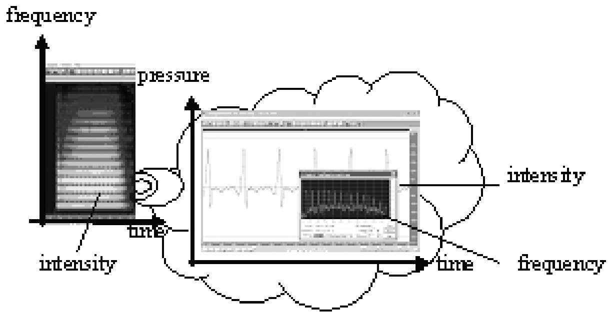

Figure 2.

The fact that the musical sound can be resolved for harmonious components can be thought as an illustration of the superposition (Newton's 4th law). In the case of a source of sound the resultant force of more forces works and the result is a complex vibration. Accordingly, we can specify the harmonic vibrations which created a given periodic motion. Following the analysis of the sound, the result can be seen in three forms, as the Figure 2 shows. (Mathelitsch L, Verovnik I 2004)
The rate of the resolution has a limit because of the Heisenberg uncertainty principle. Here the uncertainty principle is expressed in terms of time interval and frequency. We can see here an illustration of another physical law.

3.3. Optics

The convex mirror in Quinten Metsys' The Moneylender and his Wife can be used to illustrate the law of reflection. In the mirror we see a window and probably the portrait of the painter himself, according to the imagery of the mirror.
We also can meet the law of reflection in Dante's work, Divine Comedy:

As when from off the water, of a mirror,
The sunbeam leaps unto the opposite side,
Ascending upward in the selfsame measure
That it descend, and deviates as far
From falling of a stone in line direct,
(As demonstrate experiment and art,)
(Purgatorio XV. translated by H. W. Longfellow)

The various tricks of the perspective depiction being in close connection with optics we can call perspective swindling. In William Hogart's picture, Absurd Perspectives, numerous illogical details can be found where the painter deliberately breaks the laws of perspective.
During the previous centuries many physicists dealt with the description and development of the camera obscure, but it was also used by many painters to create their paintings. So the Italian Canaletto probably used a special camera obscure to create his works, which was developed by Kepler.

3.4 Quantum mechanics

One of the important laws of quantum mechanics is the principle of complementarity. We can use some paintings to modelling the wave-particle duality of light, or electron, and the complementarity, which is in connection with this concept.
George Seurat's paintings contain tiny dots of pure colour (particles) or show continuous picture (wave), where we can recognize figures and objects or a landscape. Art historians believe that Seurat's technique of pointillism was based on his understanding of the physical nature of light.
Connecting physics and art (painting, literature or music) can also be used as example for the complementarity by itself. It can be said that physics – or in a wider sense, science – and art also form a duality, as different, but complementary aspects of the description of the world.

4. Conclusions

Instead of summary let me make a conclusion by quoting a well-known saying, which can be motto of physics or history of physics courses:

"A student is not a vessel to be filled but a lamp to be lit"
(Variously quoted as a Hebrew saying, or as an adaptation of a quotation by Plutarch.)

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CHEMISTRY EDUCATION: CHILDREN AND CHEMISTRY

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Abstract. *Discovering things by playing is common in childhood and in this way our activities are focused on "teaching and learning chemistry" outside of the standard classroom, children have played games such as: "crossword puzzle; chemistry history cards; chemistry quiz and broadcasting chemistry" all the games are pointed out in chemistry science. The final objective is that children, our future society, have to incorporate basic chemical knowledge that in the future allows them to make their own decisions and to influence the resolution of scientific problems in a more and more technological society.*

1. Introduction

In December 2008, the 63rd General Assembly of the United Nations adopted the resolution proclaiming 2011 as the International Year of Chemistry, IYC 2011 (www.chemistry2011.org), placing The International Union of Pure and Applied Chemistry, IUPAC (www.iupac.org), and UNESCO, at the helm of the event. Under the theme "Chemistry our life, our future" IYC 2011 offers many activities for increasing the public appreciation of chemistry, for encouraging interest in chemistry between young people, and for generating enthusiasm for the creative future of chemistry.

Catalonia is one of the 17th Spanish Autonomous Communities with their own independent education system (www.mec.es/educa/sistema-educativo). Catalan students, older than 13 years old, have chemistry as a subject in their curricula but, younger students do not have this subject (www.xtec.es/estudis/eso/curriculum_eso; phobos.xtec.cat/edubib/) For this, we have paid attention in "encouraging interest in chemistry among young people" and we have proposed several activities (chemistry games) which apply the relaxation function of the play to stimulate children (Zaragoza, C. and Fernández-Novell, J. M. 2010). Discovering things by playing is common in childhood and in this way our activities are focused on "teaching and learning chemistry" outside of the standard classroom, children have played games such as: "crossword puzzle; playing cards from the History of chemistry and broadcasting chemistry".

All the games are focused in chemistry science and directed to 10-12 year old students, boys and girls in their last two years in Spanish primary school education. It is essential to promote chemistry between young people if we want to improve their understanding on this field of science. In the early 21st Century a new way of social organization has initiated, mobile, web, wikis, facebooks, etc., which are simple to manage by young students however, introducing initial chemistry's knowledge in the same group of young students is not presented in Spanish primary schools, it seems that chemistry is not important in our society, wrong thought.

The purpose of this article is to present our chemistry games, a new educational experience, to make it more enjoyable and with the aim to relate initial chemistry's knowledge and playing games between primary school students.

2. Methodology

To bridge the gap between primary school students and the initial chemistry's knowledge led us to design several games that can be developed in the classroom and out-of-school.

Students from some Catalan primary schools prepared the games in the classroom in groups (Dennick, R. G. and Exley, K. 1998) this increases the participation and collaboration between young students and they started to understand that "everybody learns from everybody" is possible. Then, they played the games in groups too.

2.1. Create a crossword puzzle

Students spent around 10 days to prepare their own crossword puzzle. Always were 10 chemical definitions, understandable for all of them, five with a vertical reading (down) and five more with an horizontal reading (across). Each student decided which words used, where he or she obtained the information and, students created their own crossword puzzle (www.crosswordpuzzlegames.com/) on chemistry.

Here is a summarize crossword puzzle using the most repeated definitions prepared by the students and the solution.

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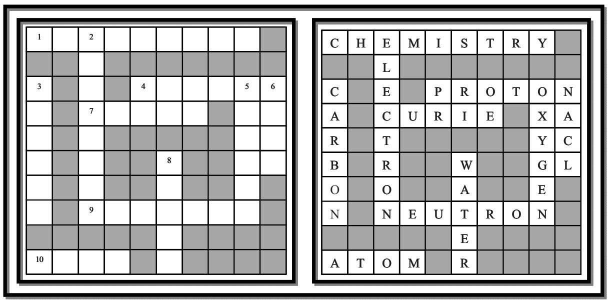
ACROSS	DOWN
1. Science that study matter's properties.	2. Particle with negative charge into the atom.
4. Particle with positive charge into the atom.	3. Element present in the organic compounds.
7. Surname from the first woman who won the Chemistry Nobel Prize.	5. Element present in the atmosphere, now we are breathing it.
9. Particle without charge into the atom.	6. Salt, sodium chloride.
10. The smallest part of one element	8. H_2O compound.

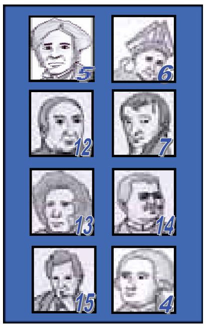


2.2. Playing cards from the History of Chemistry.

Instructions to play (for teachers):

1. Show the card with 15 chemists and one participant-student have to choose one of them mentality without to say anyone.
2. Show one of the card with 8 chemist and ask the participant if his o her chemist is in that card.
3. Repeat the situations with the rest of the three cards.
4. At this moment you must read participant's mind and say the chemist name.
5. Students never understand the situation, teacher is a magician!. They always asked for to repeat the play to finding the trick.

Here we presented several cards' examples, all the figures-portraits were done by Josep Fernández Zaragoza, (Jepi, who has pictures' Copyright):



Some student's groups can prepare questions about BLUE chemists, other student's groups can also prepare questions about RED chemists (of course, we have another group of cards in red with different chemists).

Furthermore, they can play; can fight "blues" against "reds". Blue group decide one chemist from their cards (blue-chemist) and red group must find it. For this, red's group show each blue cards and ask blues ones if the blue-chemist is in the card. In addition, for each card showed blues-group ask and answer a question related with the blue-chemist. At the end the red group must find the blue-chemist. And, come back, red group decide one chemist from their cards (red-chemist), the processes continue in the same way.

You can see examples of chemists and the questions prepared by the students.

Democritus realized that everything must be made of small pieces, very small pieces. He called the smallest an "atom". Students prepared questions about the four elements, the earth, the water, the fire and the air.

The list of BLUE CHEMISTS
Boyle-Dalton-Mendeleev-Lavosier-Faraday
S. Albert Magnus-Avogadro Empedocles-Jabir-Jacob Berzelius
M. A. Pierrete-Martí Franquès-Wöehler Le Chatelier-J. H. Van't Hoff

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Dmitri I. Mendeleev arranged the 63 known elements into the first periodic table. Students thought that Mendeleev was very important for chemistry because he knew there were missing elements needed to finish his chemical puzzle, and he predicted their weights and chemical properties. Questions about the elements and compounds were prepared by young students.

2.3. Broadcasting chemistry

Authors have developed several programs about science in an effort to present them with a new perspective to the students and society (Fernández-Novell, J. M. and Zaragoza, C. 2001 and Fernández-Novell, J. M. and Zaragoza, C. 2010). We developed a chemistry radio program focused on IYC 2011 and directed to young people. Authors presented a radio program on the 7th International Conference on HSCI, Bridging the Science and Society gap, in Crete, Greece, for this here it is only presented (Sara) student's valuation. Authors have maintained Sara's explanation.

"Playing with Chemistry" is the name of the radio program in which I participated this 2011, the International Year of Chemistry. It is a program that everyone can listen and which anyone can learn a little more about chemistry.

Our teacher encouraged pupils to participate in the radio program and two classmates (Mª Rosa and Patricia) and I (Sara) had accepted the plan. We had never been before on a radio program and that was the reason we were some nervous, but all was ready and when we arrived to the studio everything went well.

The program was about chemistry. The radio program was structured in two parts: the history and the quiz. We prepared every part of the program at school and studied previously whatever to do on the radio.

Firstly we were introduced by the presenter as guests, and then we started with the chemists' biographies. We spoke about the origins of live, origins of fire and chemistry on the Earth, where we used the different theories of Oparin, Urey and Miller, following with Lavoisier, named the father of chemistry.

Making a chemistry history revision, which could be the first chemical reaction with our ancestors found? It wasn't the eternal youth elixir, neither the philosopher's stone, like alchemists used to say. Fate was a quite simply chemical reaction; it was caused by the fire. Since another chemical, science or humanity point of view, we found another questions without answer like: Who we are? Where we go? Where we came? How can explain the origins of the live?

Then, we read our school presentation: the first scientist theory that try to explain the origins of the live, was explained by Oparin at 1924, a Russian biochemist who imagined that in a chemistry evolution process just as some simple molecule evolved, by means of chemical reactions which give as a result live organisms. That idea was adopted and improved by Miller and Urey, both obtained the Nobel Prize. Lavoisier (1743-1794) was considered the father of the modern chemistry, he studied the oxidation of the compounds, the animal breathing phenomenon and the air analysis, and also by the use of the balance he measured relations between the substances which participated in the chemical reactions "his famous law of conservation of the matter: the amount of reactants' mass in a specific chemical reaction must be equal at the quantity of products' mass".

Afterwards was the most entertaining part of the program, the "Quiz". Where we did a mental fight to discover who one of the three guests had the top correctly answers. The quiz was formed by four questions with three answers, but only one was correct. My four questions were:

1. To improve the environment we need to use the three R. R of reduce R of reuse and R of?

A) **Recycle** B) Revive C) Relaunch.

2. The rocks are formed by minerals; with some minerals we quarry chemical elements. What element we could get from the Pyrite?

A) Mercury B) **Iron** C) Copper

I remembered my father's mineral collection and "Pyrite is the sulphur of iron".

3. What technology could produce acid rain?

A) Radioactivity
B) **Thermal power station**
C) Wind power station

I remembered a TV program "Coal combustion produces sulphur oxidize. Then it could become in sulphuric acid that with the water vapour cause acid rain".

4. What is the common salt's formula?

A) **NaCl** B) H_2O C) HCl

Very easy, salt is the sodium chloride.

I had the top score and my classmates obtained the top score too, in other words we had to make a mental war again to know who is the cleverest on chemistry! Chemistry is very interesting, and prepare this radio program was a great experience.

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These comments reflect the aim of "playing chemistry"
Next picture shows a moment when presenters were interviewing a primary school teacher about chemistry presence in primary curricula.

3. Conclusions

Primary school students have played, have related chemistry with life, and have increases their interest in general sciences. The opinions of the students and their teachers were assessed. Both considered that these games were a great experience.
Students pointed out some parts of their new knowledge about chemistry as the most impressive:

- Elements are made of small particles called atoms (neutron, electron and proton).
- All atoms from an element are identical (a specific iron's atom is identical to other iron's atom).
- The atoms from an element are different from the atoms of any other element (iron's atom is different to gold's atom).
- Atoms of one element can combine with atoms of other elements to form compounds (two hydrogen's atoms combine with one oxygen's atom to form a water's molecule).

We feel that these games could give chemistry a new and balanced perspectives, and making it more interesting for our young students. Games leads the students to pay attention to the "facts" they already have been noticing such as, atoms, electricity, acid concept, heat concept, etc.
The final objective is that children, our future society, incorporate basic chemical knowledge that in the future allow them to make their own decisions and to influence the resolution of scientific problems in a more and more technological society. This educational approach has contributed to reinforcing the presence, the interest and the study of chemistry in and out of the classroom and could be used by primary and secondary science teachers in their chemistry classes.

Acknowledgments

We thank primary school students for their input and teachers for their fundamental cooperation. We thank Jordi Fernàndez Zaragoza for preparing this presentation and for him assistance in preparing the English manuscript.

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1st HANDS-ON SCIENCE SCIENCE FAIR

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Abstract. *In-school learning of science through investigative hands-on experiments is in the core of the Hands-on Science Network vision. However informal and non-formal contexts may also provide valuable paths for implementing this strategy aiming a better effective science education.*
In May 2011, a first country wide "Hands-on Science' Science Fair" was organized in Portugal with the participation of 131 students that presented 38 projects in all fields of Science. In this communication we will present the main goals behind this initiative. The strategy employed problems and difficulties faced, as well as the solutions found will be reported. The evaluation of all the process is of utmost importance and will be discussed here including with the presentation of the statistical analysis of the students and teachers replies to participation surveys.
The science fair was considered a success by both teachers and students. A study was performed to understand the motivation behind students and teachers participation. Teachers were extremely pleased with their students' enthusiasm during the development and presentation of the projects and also pointed out the benefits to the student's school performance at the discipline directly related but also in general.
The students also demonstrated their satisfaction because they learned new concepts and acquired skills that helped them on the academic level. Almost all of them are looking forward to participate in future science fairs.

1. Introduction

Science fairs are cultural and pedagogical activities, hands-on based, where students have the opportunity to display and discuss scientific projects they developed actively (Grote, 1995) within or outside of their school context, in different themes (Bencze and Bowen, 2009; Ministério da Educação, 2006), and that allows the involvement of all the community (Ministério da Educação, 2006).
These activities allow scientific research in any science subject (Ministério da Educação, 2006) to be developed and interdisciplinary should be most welcomed (Bencze and Bowen, 2009). It facilitates the establishment of relations between science and daily life phenomena (Scheneider and Lumpe, 1996), helping students to understand the nature of the problem to be solved, gaining problem solving capabilities (Bencze and Bowen, 2009), make decisions, create hypothesis, and develop their creativity and imagination (Bencze and Bowen, 2009; Esteves, Cabral, and Costa, 2008; Ministério da Educação, 2006; Montes, 2006). They also develop others skills such as resilience and self confidence as well and social interaction (Sumrall, 2004) or communication ones (Montes, 2006).
To understand if and how this activity, highly regarded in many countries, could be successfully applied to the Portuguese students, the 1st Science Fair Hands-on Science was organized. Students from 5th to 12th grades (10 to 18 years old) were welcomed to participate.

2. The organization of the Science Fair

During the 2010/2011 school year, a national science fair was organized by the Hands-on Science Network[1], with the support of the University of Minho[2], and the Portuguese Association for Science and Technology Education [3]. The Science Fair toke place May 13, 2011, at the campus of the University of Minho in Braga, Portugal.
To publicize the initiative a website[4] was created, and the information was send to the official e-mail of all Portuguese schools and published at the website of the University of Minho.
On the fair' official website[4] important information was posted, such as the deadlines rules and support material. The participation at the science fair was open to all students from 5th to 12th grades (students with ages around 10 to 18 years old) from both regular and professional/vocational schools. The participants were divided into 3 categories: students grades 5th to 6th, grades 7th to 9th and grades 10th to 12th.
Contribution were welcomed on all subjects of science. Students presented projects related to physics, chemistry, mathematics, robotics, environment, geology and biology. Interdisciplinary was encouraged.
Each group could have a maximum of 4 elements belonging to the same age category and at least one teacher as tutor.
The science fair organization was timed in 3 phases. The first phase, that lasted around 2 months, (until mid of January) students had to fill up a form with information about their project, such as the title, the main goal, a short description and a list of material needed. The organizing committee analyzed the projects and verified if they were appropriate for presentation at the science fair and if all the

1 www.hsci.info
2 www.uminho.pt
3 www.aect.pt
4 https://sites.google.com/site/feiradeciencias2011/home

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necessary conditions could be provided for each project.
The second phase runs until March 7, 2011. Until this date, students had to confirm their project registration or present any changes to the final project data.
Finally on science fair day May 13, of 2011, the students presented their works that were evaluated by the fair jury.

3. The Science Fair Day

A total of 5 projects of 18 students, from the same school, were not presented at the science fair by economical reasons. That school communicate 2 days earlier that by economical reasons it was not possible to attend at the science fair day. Also, from the initial 46 subscribed projects, only 3 groups gave up as a student's option, as is possible to see on table 1.

	Subscribers	Present at the science fair day
Groups of students	46	38
Number of students	160	131

Table 1. *Number of subscribers during all process*

At the science fair day the participants arrived at 10h30 to assemble and prepare the presentation of their projects. After a common lunch was all participants could informally interact, the fair was officially opened at 14h00 and lasted until 17h00. During that time, students had the opportunity to present their projects to others participants, visitors and to the jury.
The jury was confirmed by eight university and school teachers in physics, chemistry, biology, math's and arts, and was divided into four pairs of judges. Each pair visited and evaluated a number of projects. Each jury' pair was constituted by two teachers, one from the university and the other from an elementary or secondary school. After evaluating all projects, each jury pair reported to the ensemble of jury member. A number of projects were selected from each jury pair' favorites and were therefore visited by all the jury together with the purpose of selecting the best ones at the different categories. In each category, 1st, 2nd, 3rd prizes and one or two honor mentions were selected, as is possible to see on Table 2. At the end the awards diplomas and prizes were handed to the winning teams by the President of the School of Sciences of the University of Minho and the President of the Hands-on Science Network, at the closing ceremony. All students received participation prizes, such as HSCI t-shirts and caps.

Category	Projects
1st Category – 5th and 6th grades (ages between 10 to 12 years old)	1st Place – Pressure 2nd Place – Gas-powered boat 3rd Place – Handmade water treatment station Honor Mention – Explosion of colors
2nd Category – 7th to 9th grades (ages between 12 to 15 years old)	1st Place – "Espeolharium" 2nd Place – Low cost interactive whiteboard 3rd Place – Matinter@ctiva
3rd Category – 10th to 12th grades (ages between 15 to 18 years old)	1st Place – Greenhouse 2nd Place – A matter of balance 3rd Place – Electricity, did you as for? Honor Mention – Thermal paste Honor Mention – Seebeck effect of the atom to the Universe

Table 2. *Winning projects*

4. Results

To measure the opinion of teachers and students during their involvement on this activity, an inquiry was prepared and distributed.
Only 19 teacher's replies were gathered. Therefore it is difficult to draw significant conclusions. However, the opinion of all the teachers about the initiative was very favorable giving a good evaluation to the science fair event.

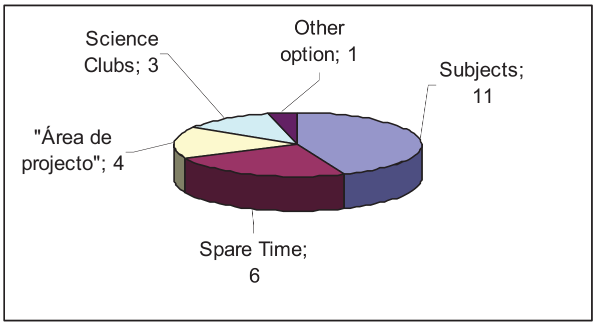

Figure 1. *Places where teachers work with their students*

As it is possible to see on Figure 1 teachers mostly worked with their students during class time. The 11 teachers that mentioned having worked during classes pointed out to the involvement of classes of physics and chemistry. The other subject used was math (5 teachers).6 of teachers helped the students during their spare time. The others 4 worked at Área de Projecto, which is a curricular non-disciplinary subject, whose main objective is the development of projects.

All teachers agreed that they will repeat the experience if they have the opportunity. Only 5 of them would like to repeat the experience but with the collaboration of other teachers. The remaining prefers to work in the same conditions. That's easily understandable since these teachers already worked in an interdisciplinary way, as is possible to see on figure 2.

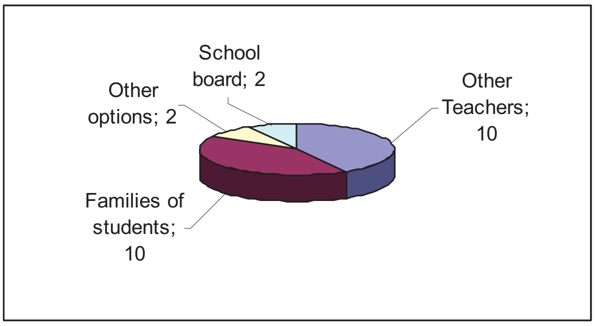

Figure 2. *Other collaborators on science fair projects*

Only two of the tutor/responsible teachers worked alone with their students, the rest asked for the collaboration of other teachers. Due to the fact that the tutors were mostly physics and chemistry teachers they essentially looked for the collaboration of biology, informatics and arts teachers. On the other hand, it is possible to see that the student's families also had an important role on this activity. Also an engineer and a school employee were referred as collaborators.
From the 19 teachers that "coordinated" the projects with their students, 6 stated that worked less than 10 hours with their students, 4 worked between 10 to 20 hours and 9 works more than 20 hours. However, it is important to stress out that students work with other teachers, familiars and on their spare time without the coordinator teacher.
The question whether they think it is possible to develop this kind of projects during the classes, 14 of them said yes. The other 5 said that it is not possible due to curricula related time constraints. This is mainly a typical high school teacher's answer, since they strongly feel the pressure of "preparing" the students for the final exams.
Despite this fact, they classified their work with their students as a very positive experience and all of them agreed that their students worked with enthusiasm, effort, autonomy, accuracy and imagination. They agreed that the students benefited with their involvement on the subject of their project. However, they recognized that the benefits were mostly on the acquisition of skills, attitudes and knowledge.

Another inquiry was distributed to the 131 students that participate at the science fair. The first thing that we tried to understand was the reasons that made them participate, as is possible to see on figure 3.

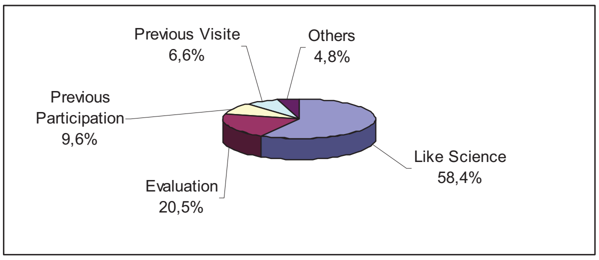

Figure 3. *Reasons presented by the students to participate at the science fair*

The most important reason pointed out is the fact that students like science. However, 20,5% of them pointed out that they participated because they were evaluated. Despite that, from this group, 9,9% said that they also participated because they like science.

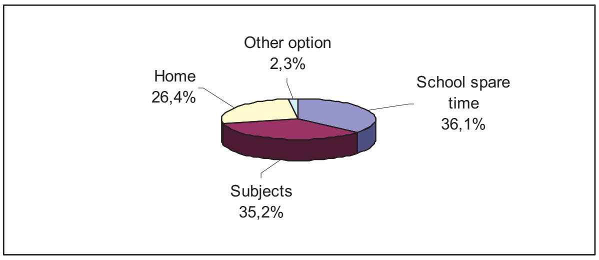

Figure 4. *Places where students developed the science fair projects*

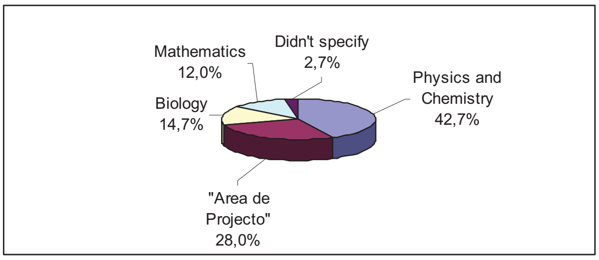

Figure 5. *Subjects involved on the development of the science fair projects*

From Figure 4 we realize that the places where the students developed the projects were diversified since they had the opportunity to work at classes but also at school on their spare time, in clubs or even at home, with the support from their families and friends. The classes where students worked on their projects are presented at Figure 5. It is important to remember that some of the students gave more than one answer. However, the most popular answer was

physics and chemistry, followed by “Área de Projecto” as already stated by their teachers.
The students reinforced the teacher’s opinion that the science fair was a nice activity to repeat. 95,4% of them wanted to participate in a second edition if they have the chance. The rest 4,6% justified the fact of do not wanting to participate in other edition with the pressure they felt imposed by their teacher to participate and present a good work. Students stated that they learn many things with this experience. They learned concepts and acquire skills that feel can be useful in their lives as students.
Finally we asked the students to evaluate the event and the organization. The evaluation was favorable. The improvements that students pointed out were related to the space that should be larger and also on the projects evaluation. For example, students said that the same jury should visit all the projects. However, it is difficult to manage the available time.

5. Conclusions

Despite the science fair concept being still unusual in Portugal, the first edition of this science fair was very successful accounting with the expressed satisfaction of the participants, students, teachers and visitors.
Mostly due to practical constraint at their schools the number of groups that registered was higher than the number of effectively presented projects at the science fair day (**¡Error! No se encuentra el origen de la referencia.**).
The number of schools wasn’t high, mostly from Minho region but yet spread across the country. It was clearly proved that this is an initiative that students and teachers like, feels as important and want to repeat. We expected that next year this event could become more popular and attract more schools.
All of the projects seems to had been developed in an interdisciplinary way, with the collaboration of teachers from different areas, such as informatics, arts, mathematics, biology, but mainly physics and chemistry. It is important to stress out the effort of this students, that spend most of they spare time at school, or at home, working on these projects also with the help of their family and friends. Time constraints curricula and specially exams’ derived were among the most negative aspects conditioning students and classroom involvement in this kind of Science Fair projects.

6. Future Work

The 2nd Hands-on Science Science Fair will organize during the school year of 2011-2012 aiming also to select students teams to participate in international fairs like to one that will take place in Antalya, Turkey in October 2012 inscribed in the 9th annual Hands-on Science conference, HSCI 2012. The fair will be advertised nationwide among schools teachers and students right at the beginning of the school year early September. The suggestions from the 1st edition fair’ teachers and students will be taken in account in the fore coming organization and their opinion will be collected once more to further improve the statistical validity of the pedagogically relevant conclusions.

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REMOTE LABORATORIES AND SCIENCE EDUCATION BY INTEGRATED e-LEARNING

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Abstract. *The present state-of-art of remote laboratories enables to build experiments on the principle of server – client communication across the Internet suitable for education of science. This fact in turn calls for their incorporation in the educational system of e-learning using Learning Management System (LMS). In the contribution we present the e-laboratories with experiments suitable for science education (Characterization of electrochemical cell, Organic and inorganic photovoltaic cells, Photoelectric effect and Magnetic field mapping) as the starting building block of Integrated e-Learning (INTe-L) strategy, delivered by LMS system MOODLE.*

1. Introduction

1.1. Main idea and motivation of remote experiments

The traditional science curricula for engineers e.g. Physics, Chemistry or Materials Science are based on two forms of education: lectures, where the basic laws and abstract models are presented and laboratories, where the "real world" phenomena are examined. This format, suffering sometimes from lack of interconnectivity, is mostly copied by the e-Learning concept. The vast majority of e-Learning teaching tools present theoretical concepts of the respective science branch in form of mathematically formulated laws, models, simulations, applets or animations, exercises, graphs and presentations. Practically no e-textbook presents virtual or remote experiments (RE). With progress in information technologies the chance to grasp real objects by application of RE has emerged. The RE support the learning of theory by illustrating-demonstrating phenomena, applying theory to real situations, giving the limitations of theory and by interacting with phenomena in authentic situations. On top of this, the RE develops a body of skills involving critical observation, interpretation and assessment, planning and organization and practical problem solving, and, additionally, the skills in Information and Communication Technology (ICT).

1.2. Remote experiments in science

Science experiments play an indispensable role in the curriculum of Natural sciences education at all levels of education – from primary, secondary to university level. The absence of experiments and experimental work of pupils and students in all forms of science education brings about the loss of motivation and of deep understanding of real world phenomena. One of the ways where the Internet may help is web-based remote laboratories. An examples from Material science is the MALDI – MS remote experiment (Marginean 2002) or the phase transitions in ferromagnetic materials, where abstract and experimental aspects are treated in the scenario of e-Learning, e-Teaching, e-Research (e-LTR) (Jeschke 2005). From the chemistry the remote experiment on the chemical reactor was launched at Cambridge University, UK (http://usefulchem.blogspot.com/2006/12/remote-controlled-labs.html). Also biology remote experiment, observing the plant growth with interactive influencing the conditions for the plant environment, was started (http://ldt.stanford.edu/~educ39109/POMI/ROSE/). Several projects, subsidized by universities and several projects of EU or state grant agencies were started and finished supporting the building of science experiments. Unfortunately, both the wide range of platforms and interfaces used do not enable integration of science RE into reasonable networks that would enable sharing of experiments by a wide audience of interested.

To help and bring the unifying possibility in constructing the science RE in a simple way we want to show the possibility of universal and modular physical hardware (plug and play Internet School Experimental System (ISES) and the library of informatics software for typical elements in RE (play system - WEB CONTROL ISES kit) (see www.ises.info) in the design of rather sophisticated science experiments from chemistry and physics disciplines. The simple RE, where the plug and play approach is applied for the bringing up of pupils as a new generation of scientists, are reported in adjoining paper on this conference (Lustig 2011).

First, we want to present in more detail the example of the technical realization of the RE. Then we will introduce all new science experiments built in the Consortium of Charles University in Prague, Tomas Bata University in Zlin and University of Trnava in Trnava for the interested in sciences and for their free use in the teaching process of Sciences, in individual work of students, and in examinations. It is all shown on new quantitative (with data output)

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and interactive RE spread across the Internet from Chemistry (Characterization of electrochemical cell), Solid state physics (Organic and inorganic photovoltaic cells), Quantum physics (Photoelectric effect) and Electricity and Magnetism (Magnetic field mapping).

2. Technical realization of remote experiments

The physics hardware is in our case ISES (see Fig. 1). The system is composed of the interface card with A/D and D/A converters, a set of modules and sensing ISES elements (about 40) V-meter (±10 V, step 5 mV), A-meter (0.5 mA÷1A), Ω-meter, F-meter, thermometer (-20 °C +120 °C), microphone, optical position detector, adjustable preamplifier, current booster, relay switch, pressure meter and others. The ISES modules are easily interchangeable, their presence and adjusted range is automatically sensed by the computer, with the automatic calibration facility. The service program enables the measurement simultaneously of 10 different channels (8 analog and 2 binary) and capability to use 4 programmable output channels. All these modules are fully programmable, using the programming ISES panel. For data processing and evaluation is the service graphical and evaluation ISES program.
The software for the establishing the control and data transfer of RE serves ISES WEB CONTROL kit (which creates automatically on the server side four subservers: WEB server, Image Server for the support of WEB cameras, Measure Server for the control of the hardware and HTTP Relay Server) (Schauer 2009a). In operation, the server side generates, using preprogrammed Java applets embedded in the web pages, which create control keys and bars for the control of outputs, applets for measuring and digital displaying of input values, applets for graphic displaying of input values, applets for the transmission of measured data, applets for the image transmission from a web camera, etc, which are forwarded to the client computer using web service. On the client side of RE, a standard browser (Internet Explorer, Net-Scape, Mozilla, Opera, etc.) and implicit Java support is used, without any additional modifications or software installations.
Technically, RE takes place in a location different from the experimenter. Consequently, it consists of two parts, one is the experimental physical hardware (with a phenomenon to be examined), and the second is the informatics hardware and software for transferring instructions from the experimenter to the experimental setup, and for transferring resulting measured data to the experimenter. All communication is through the Internet, using web services, and a corresponding communication interface. The general scheme of the remote experiment (using a so called server-client approach and web services) used in the presented paper is shown in Fig. 2.

2.1. Remote experiment Electrochemical cell characterization

The first chemical RE on reaction kinetics for teaching to our knowledge was launched in December 2006 in Cambridge (http://usefulchem.blogspot.com/2006/12/remote-controlled-labs.html) The RE Characterization of electrochemical cell in our e-laboratory (http://kf.truni.sk/remotelab), or directly (http://remotelab2.truni.sk), was one of the first attempts to introduce RE into chemistry. It should be noted that for the functioning computer controlled RE the ISES titration pump, the ISES electromagnetic valve and the ISES stirring device were built. The detailed description of remote experiment and its data evaluation are presented in the adjoining paper on the present conference (Gerhátová 2011).

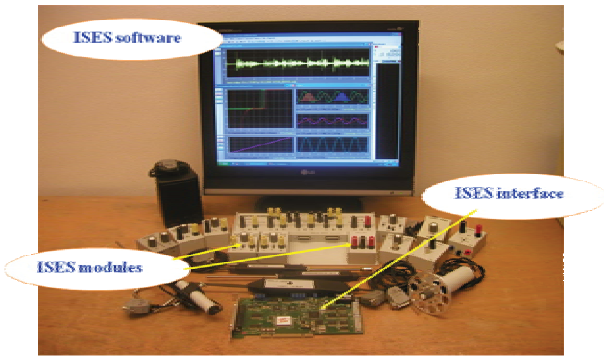

Figure 1. *ISES – Internet School Experimental System (Schauer, Lustig and Ozvoldova 2009)*

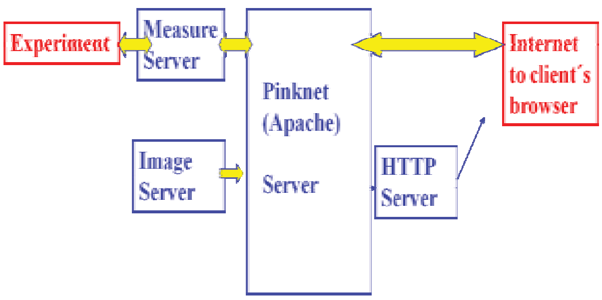

Figure 2. *The general scheme of the server-client remote experiment with several servers: measure, image, and http servers, established by ISES WEB CONTROL kit*

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Let us demonstrate the procedure of building the remote science experiment using ISES and ISES WEB CONTROL kit using the example of the Electrochemical cell characterization experiment.

Figure 3. *Schematic diagram of the remote interactive experiment Electrochemical cell characterization*

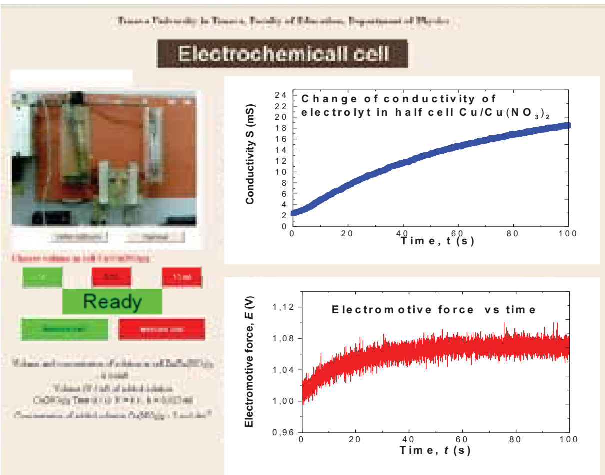

Figure 4. *Web page of the remote experiment Electrochemical cell* *http://remotelab2.truni.sk*

The electrochemical properties of the galvanic cell are expressed by the measurements of electromotive force and conductometric data. Schematic arrangement of the experiment is shown in Fig. 3 In the process of constructing RE it was necessary to build first the computer controlled hands on experiment, using the ISES components, where in a reaction chamber, composed of two half cells provided with metal electrodes, connected by the semitransparent membrane, the concentration of the electrolyte was changed in a programmed way in one of the half cell and the validity of the Nernst equation for electromotive voltage of the cell is tested by measuring the electromotive force of the cell, combined with the conductometric measurements. After extensive experiment characterization and finding the proper measuring procedure, we can proceed to the transferring hands – on experiment to its RE counterpart.

For this the controlling program for the RE has to be compiled on the basis of the flow chart and to be nested into the corresponding web page (Fig. 4 the web page is presented) provided with the explanatory notes (see http://kf.truni.sk/remotelab).This procedure is relatively a simple one, as all ISES typical controlling (as rulers, potentiometers, switches, etc.) and displaying (live camera view, digital and analog displays, various graphs, etc.) are preprogrammed in form of executable Java applets and available on WEB ISES CONTROL kit CD. These are just copied and pasted into html program of the web page with only several evident parameters to be adjusted.

2.2. Remote experiment Organic and inorganic photovoltaic cells

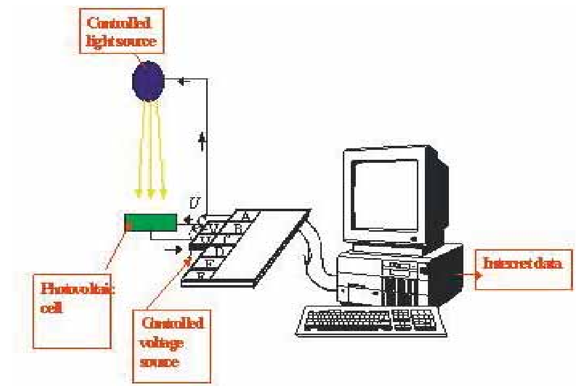

Figure 5. *Schematic diagram of the remote interactive experiment Photovoltaic cell*

In Fig. 5 is the schematic arrangement of the RE Organic and inorganic photovoltaic cells http://remotelab1.fai.utb.cz/, built on ISES. It consists of the controllable lamp (using the ISES output channel and ISES power booster) and the ISES modules to measure the *I-V* characteristics of the photovoltaic cell. In Fig. 6 is then the Java generated virtual experiment web page with enables the voltage and the light intensity adjustment, graph with the data and data transfer. The instantaneous value of the voltage, current and produced electric power is digitally displayed with the measured data in graphical form. The experiment is provided with a real time web camera view of the experimental arrangement. The experimentator may choose among several cells: bulk p-i-n c-Si PV cell, and p-i-n poly-Si thin film systems of a-Si:H, and electrochemical organic and nano - heterostructural organic cell.

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2.3. Remote experiment Photoelectric effect

In Fig. 7 is the web page of RE photoelectric effect, http://kdt-29.karlov.mff.cuni.cz/ . It is built using the standard PHYWE experiment Photoelectric effect (5.1.05) and for the filters adjustment and the voltage ramp are used the standard ISES outputs, inputs and modules. This RE shows how the combination of the standard physics instrumentation may be combined with ISES for its controlling and data collection and its transfer.

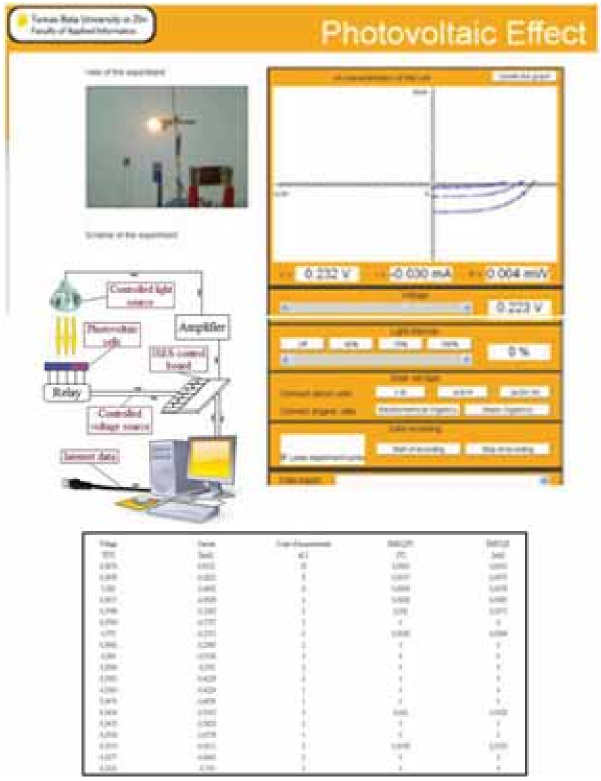

Figure 6. *Web page of the remote experiment Photovoltaic cell http://remotelab1.fai.utb.cz/*

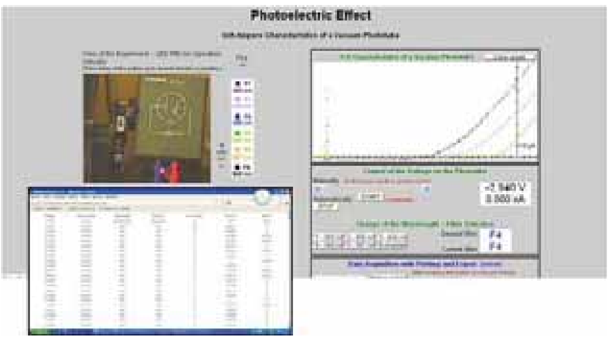

Figure 7. *Web page of the remote experiment Photoelectric effect http://kdt-29.karlov.mff.cuni.cz/*

Photoelectric effect is a basic introductory quantum physics experiment from photon nature of radiation, where the *I-V* characteristics of the photocathode for different wavelengths of the radiation are measured. For the evaluation is used the Einstein equation of the photoelectric effect and RE may be used for different purposes, e.g. Planck constant evaluation. The data are transferred to the experimentator and serve for the numerical evaluation.

2.4. Remote experiment Magnetic field mapping

The experiment Magnetic field mapping, http://kdt-27.karlov.mff.cuni.cz/, is another universal, highly sophisticated science RE, built on ISES components (see Fig. 8a and Fig. 8b).

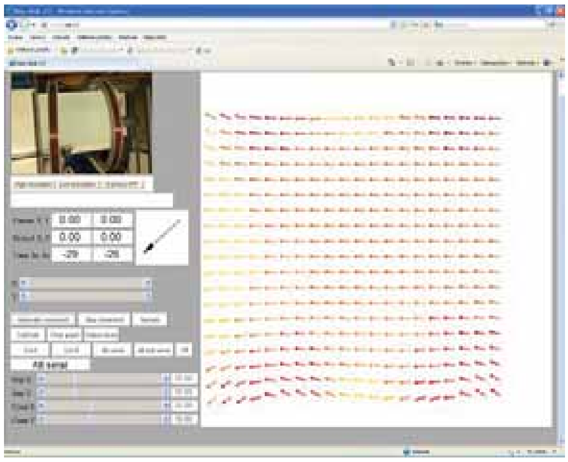

Figure 8a. *Web page of the remote experiment Magnetic field mapping – parallel connection of coils*

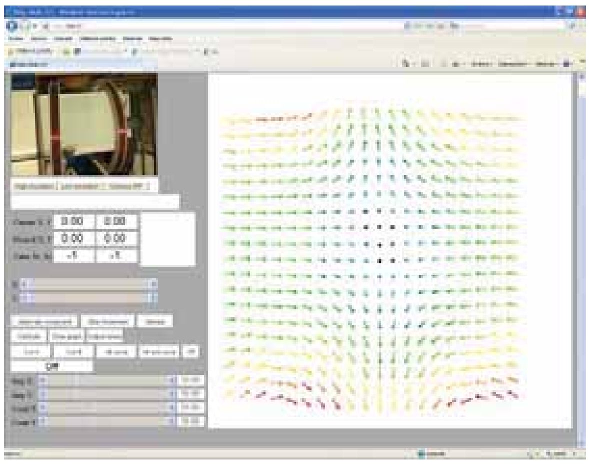

Figure 8b. *Web page of the remote experiment Magnetic field mapping –antiparallel connection of coils*

The magnetic field is generated by the couple of coils in Helmholtz arrangement that may be connected in series, antiparallel, or any of the coils independently with or without magnetics. The field detector, formed by two perpendicularly oriented Hall probes, move in two directions and enables reconstruction of the magnetic field strength vector in any preselected position by the arrow of variable direction and color, representing its value. The magnetic field distribution map in Fig. 8a and Fig. 8b are form standard Helmholtz coils connected in series and antiparallel way.

3. Discussion

The teaching of Science subjects, especially for nonmajors in Science needs rebuilding of the strategy of education (Wieman 2005). One way how to achieve this is to change the strategy of education and to base teaching on the elucidation of real world phenomena by experimentation and observation, we called this Integrated e-Learning (Schauer 2009b). In this new strategy of education the experiments in teaching Science are indispensable. The presented examples of science RE serve just for this purpose. On top of this the RE may be with advantage used in seminars, laboratory exercises and self-study any time any place, With advantage the Learning Management system MOODLE was used with direct links to the RE and the explanatory texts, assignments and the submitting (Schauer 2009c).

Acknowledgment

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THE USE OF ICT IN PRESCHOOL EDUCATION FOR SCIENCE TEACHING WITH THE VAN HIELE THEORY

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Abstract. *This research reveals ICT uses in Greek preschool education and explores this use of ICT based on van Hiele model for science education. In this study, we use mathematical (Early Numeracy Test - ENT) and natural tests to explore the use of ICT in preschool classroom for teaching basic mathematical and natural science concepts. The ENT is a task orientated test which attends to measure the level of early mathematical competence developed for Kindergarten. Pupils in the control group received only the traditional science instruction about a variety of topics concerning main natural science phenomena and mathematical concepts. Pupils in the experimental group received only the science instruction based on van Hiele model with the use of ICT for the same natural scientific phenomena and mathematical concepts. Both the experimental and the control groups consisted of classes from the same participating schools. Our research is in progress and the first indicative results show that teaching and learning through ICT is an interactive process for children at preschool level and has a positive effect for science education. We argue that a change is necessary so as an innovative teaching method can be successful, not only concerning materials, but also concerning approaches and beliefs.*

1. Introduction - Theoretical Framework

In the context of preschool education, studying science with the use of ICT seems to be a very challenging process. In Greece, pre-primary classrooms are organized with separate 'corners',

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including a 'science corner', which the teachers are expected to design and equip the activities. Because science is so engaging for children, it serves as an ideal content area for supporting children's learning and development. It is well known that children learn faster in an interactively functioning learning environment. This is probably the most important advantage of ICT use in the teaching process against traditional teaching methods. Science education at the preschool level with the use of ICT that emphasizes active learning, may be expected to promote higher student motivation than what occurs in traditional classroom settings with teacher oriented learning.

Young children seem to have a good grasp of the workings of the standard keyboard, even though 3-year-olds take longer to become familiar with it than 5-year-olds (Sivin, Lee and Vollmer, 1985; Zaranis and Oikonomidis, 2009). A pointing device, such as a mouse, is the preferred tool of choice for activities that involve selecting, moving or drawing objects (Muller and Perlmutter, 1985; Borgh and Dickson 1986; Lipinski et al., 1986).

Numbers and natural phenomena invoke the interest of children from a very young age (Bryant 1997; Case, 1992; Geary, 1994; Chen, 2009). Literature proves the existence of logical principles of counting from the age of three years old already (Gelman and Meck, 1983; Aubrey 1993). The basis of number sense begins very early with the growth of counting skills, as the development of the concept of number is analogous to that of counting (Gelman and Gallistel, 1978; Fuson, 1988). Indeed, concerning natural phenomena the majority of children discover the action of attractive magnetic forces on nonmagnetic materials and the attractive and repulsive forces between magnets, as well as distinguishing magnetic and nonmagnetic materials (Ravanis 1994). Young children have a much more sophisticated understanding of shadows than their verbal explanations imply (Chen, 2009). Moreover, children showed an ability to take account of both positive and negative evidence in developing their ideas about circuits (Glauert, 2005) and they manifested a great difficulty to recognize electricity outdoors (Solomonidou and Kakana, 2000).

Various research results relate the appropriate use of computers with the ability of students to understand more efficiently the different science notions (Dunham and Dick, 1994; Groves, 1994; Kramarski and Mevarech, 2003). Thus it becomes obvious that in kindergarten level a very attractive environment of investigating the computer use in science education emerges. A vast number of studies show a positive correlation between the use of computer and the development of mathematical thinking in kindergarten (Clements 1987, 1991, 2000, 2002).

For Leach et al. (2011) learners' existing beliefs about the nature world influence the understandings that they develop as a result of science teaching and these beliefs about what science is influence the understanding of scientific concept that they develop as a result of teaching. Ravanis (1994) argues that the open activity of the children with the materials, in conjunction with the appropriate support of the teachers, to lead to the construction of the desired 'scientific' knowledge. Nonetheless, computer based activities should reflect the theoretical ideas behind them (Clements and Samara, 2004). Following this principle, the software designed, developed and examined for the purposes of the current study is inspired by the framework of the levels of van Hiele model.

2. Revising the Van Hiele Model

The theory of van Hiele model deals specifically with geometric thought as it develops through several levels of sophistication under the influence of a school curriculum (Clements and Battista 1992). The van Hiele levels are slightly from source to source; however, all references to levels are based off of this system.

- Level 1 – Visual.
  Students identify such figures as square and triangles as visual gestalts, often after viewing prototypes. For instance, they might say that a figure is a rectangle because 'it looks like a door.'
- Level 2 - Descriptive/Analytic.
  Students identify shapes from their properties. For example, a student shows a rhombus as a figure with four equal sides.
- Level 3 - Abstract/Relational.
  Students can classify figures hierarchically by analyzing their properties and give informal arguments to justify their classifications.
- Level 4 - Formal Deduction.
  Students are capable of constructing original proofs by producing a sequence of statements that logically justifies a conclusion from consequence of hypothesizes.
- Level 5 - Rigor/Meta-mathematical.
  Students can analyze the consequences of manipulating axioms and definitions.

In this research, revising the above theory for mathematical concepts and natural phenomena, the following model was suggested based on the van

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Hiele levels (Clements and Battista, 1992) for the preschool.

- Revising Level 1 - Visual.

Students reason about numbers and physical phenomena on the basis of their appearance and the visual transformations that they perform on images of these objects. They identify such figures as number three and earth as visual gestalts, often after viewing prototypes.

- Revising Level 2 - Descriptive/Analytic.

Students reason experimentally; they establish properties of numbers and phenomena by observing, measuring, drawing, and making models. They identify them not as visual wholes but by their properties.

Moreover, our model is based on the five skills proposed by Alan Hoffer. He has proposed a set of five categories of basic skills (Hoffer, 1981) relevant to school students:

- Visual Skills: recognition, observation of properties, interpreting maps, imaging, recognition from different angles.
- Verbal Skills: correct use of terminology and accurate communication in describing spatial concepts and relationships.
- Drawing Skills: communicating through drawing, ability to represent numbers and physical phenomena.
- Logical Skills: analyzing the form of an argument and recognizing valid and invalid arguments in the context of mathematical and physical figures.
- Applied Skills: describing phenomena mathematically, analyzing a model and providing information about the original phenomena.

Following the above revised model, the software designed for this research is inspired by the framework of the levels of van Hiele for the numbers and natural phenomena.

3. Methodology

This study was carried out during the 2010-2011 school year in four public preschools located in the city of Rethymno in Crete, with two classes per school. The sample composed of 126 preschoolers. The eight preschool classes were divided so that four classes were taught mathematics, (n = 67) referred to 'math classes', and four classes were taught natural phenomena, (n = 59) referred to 'natural classes'. Two of the 'math classes' classrooms were taught math with ICT instruction (n=35 - experimental group of math) and the other two with traditional instruction (n=32 - control group of maths). Respectively, two of the 'natural classes' classrooms were taught natural phenomenon with ICT instruction (n=29 - experimental group of natural science) and the other two with traditional instruction (n=30 - control group of natural science). For the uniformity of the survey, instructions were given to teachers who taught in the experimental groups and control groups who had similar qualifications. In the experimental group the schools had a computer, which was available for daily use.

The present research was conducted in three phases. In the first phase the Early Numeracy Test (ENT) was given as a pre-test to the 'math classes' during the first week of November 2010 to isolate the effects of previous results concerning the mathematics achievement of the experimental and control groups. The ENT has been developed to determine the level of early mathematical competence of toddlers (Van de Rijt et al., 2003; Van Luit and Van de Rijt, 2005). Respectively, a pre-test was given to the 'natural classes' during at the same period, referred to as the 'Natural Test' (NT). This test was conducted by the research group and determines the knowledge about the natural phenomena of children. It focuses especially on: magnetism, electricity and shadows. The following questions are examples of what we asked the students: Which of the objects you see are attracted by the magnet? Which of the devices you see operate using electricity? Match object with its shadow. Circle the correct answer, etc. (Fig. 1).

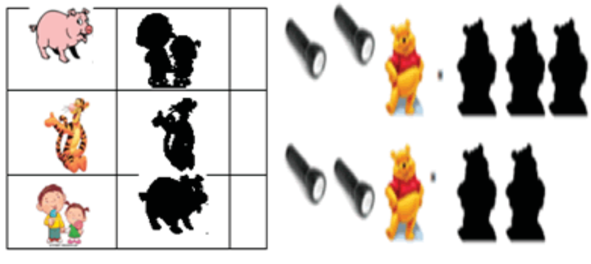

Figure 1. *Match object with its shadow (left), and circle the correct answer (right)*

In the second phase the control group of the 'math classes' coordinated with traditional teaching. Group and individual activities were given to children every day (Fig. 2).

The experimental group of the 'math classes' covered the same material at roughly the same time, but spent one class hour per week with the computer. The software was designed using the Flash 8 Professional Edition, in an effort to implicate the levels of the van Hiele model in a

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computer based environment addressed to kindergarten children. It consists of a story and activities for each number from one to ten. Each one of the activities implicates students into different aspects of counting situations. For instance, counting, matching, comparison, classification, number recognition and story problems presented by the computer. Students are asked to solve problems, in which counting plays an integral role.

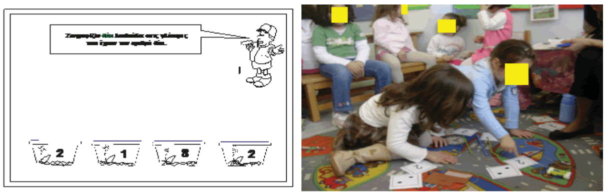

Figure 2. *The child has to paint two flowers, where there is the number two (left), and matching numbers with dots (right)*

Software that asks children to solve problems can be very valuable (Clements and Sarama, 2002). The computer activities (Fig. 3) were selected according to the kindergartens' curriculum and complements what children had been previously taught in class. The content of the four week syllabus was about numbers from 'one' to 'ten'.

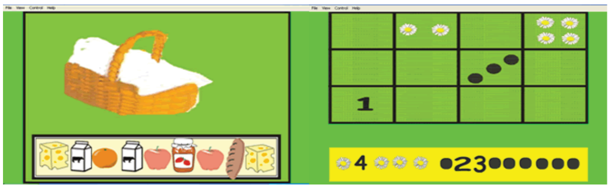

Figure 3. *Put 1 bread, 1 cheese 1 milk, 1 apple, and 1 orange in the basket (left), and fill the table with the correct symbols (right).*

The control group of the 'natural classes' functioned with traditional teaching. Group and individual activities were given to children every day (Fig. 4), for the understanding of shadows, discovering the action of attractive magnetic forces and explaining how the circuits worked.

Figure 4. *Children created shadows with different objects (left), and drew an animal and its shadow (right).*

The experimental group of the 'natural classes' covered the same material at about the same time, but spent one class hour per week with the computer. The software included stories and activities about shadows, magnetic forces and electricity (Fig. 5).
During the third phase of the study after the teaching intervention, the same test (post-test) was given to all students to measure their improvement. This was used to test the scientific achievement for the experimental and control groups.

Figure 5. *A tale about magnetism (left), and the children watched a video on how they could create different shadows with their hands (right).*

The independent variable was the use of educational software. It was designed by a group of kindergarten teachers and developed in cooperation with the researchers in the Department of Preschool Education of the University of Crete according to the kindergarten curriculum. The main purpose of the software is to foster young students' science concepts and to engage them in self-regulated learning.
The dependent variable was the students' science achievements test scores. The students of the 'math classes' were administered the Early Numeracy Test (Van Luit and Van de Rijt, 2005), which has been developed for kindergarten, 1st, and 2nd grade and grade-1 of primary school. The ENT consisted of 40 items, which were divided in eight parts. In this study the concepts of comparison and classification were measured using the ENT with ten questions. The students of the 'natural classes' were given a test which covered the field of natural phenomena. Due to the young age of the students the pre and post-tests were administrated individually to each student.

4. Results

The ENT and NT were taken by 126 students. Sixty-three of the students were male and sixty- three were female. Data analysis was done by the SPSS (ver. 18) statistical analysis program. Independent samples and paired samples t-test were carried out. The independent variable had two categories the

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experimental group and the control group. The dependent variables were the students' ENT and NT scores.

The t-test for equality of means for both the ENT and NT were not significant (t_{ENT} = -1.860, ρ_{ENT} = 0.067 - t_{NT} = -0.405, ρ_{NT} = 0.686), indicating no significant differences initially, in numeracy and natural achievements between the experimental and control groups. Though the experimental group had a mean score higher than the control group, the mean difference in the ENT scores was less than -0.804. The results of this pre-test are summarized below (Tables 1, 2):

Group	N	Mean	Std. Dev.	Std. Error
Experimental ENT	35	8.085	1.820	0.307
Control ENT	32	7.281	1.708	0.301
Experimental NT	29	20.784	2.403	0.446
Control NT	30	20.508	2.793	0.510

Table 1. *Group Statistics of ENT and NT pre-tests.*

	t	df	mean difference	Sig. (2-tailed)
Test ENT	-1.860	65	-0.804	0.067
Test NT	-0.405	57	-0.275	0.686

Table 2. *Independent Samples Test of ENT and NT pre-tests.*

In order to determine if the performance of the experimental group is significant, a paired t-test was performed using the grades of this group for a comparison between pre-test and post-test of the ENT and NT scores. The mean grade for the pre-test of the ENT in the study was 20.78 (SD= 2.40) compared to 9.74 (SD= 0.56) of the post-test. At α = .05 and df = 34, the critical value of the t ratio was less than 0.001 (Table 3). The mean grade for the pre-test of the NT in the research was 8.08 (SD= 1.82) compared to 26.33 (SD= 2.23) of the post-test. At α = .05 and df = 28, the critical value of the t ratio was less than 0.001 (Table 3). Therefore, the post-test of the ENT and NT scores were significantly different from the pre-test scores in the experimental group.

Similarly, to determine if the performance of control group is significant, a paired t-test was performed using the grades of this group for a comparison between pre-test and post-test of the ENT and NT scores. The mean grade for the pre-test of the ENT in the study was 7.28 (SD=1.70) compared to 9.28 (SD=1.22) for the post-test. At α = .05 and df=31, the critical value of the t ratio was less than 0.001 (Table 4). The mean grade for the pre-test of the NT in the research was 20.50 (SD=2.79) compared to 26.84 (SD=1.78) for the post-test. At α = .05 and df=29, the critical value of the t ratio was less than 0.001 (Table 4). Therefore, the ENT post-test score was significantly different from the ENT pre-test score in the control group.

	t	df	Mean	Sig. (2-tailed)
Pair 1 pre-test-post-test ENT	-6.650	34	-1.657	0.000
Pair 1 pre-test-post-test NT	-9.949	28	-5.550	0.000

Table 3. *Paired Samples Test of pre and post ENT and NT in the experimental groups.*

	t	Df	Mean	Sig. (2-t)
Pair 1 pre-test-post-test ENT	-6.429	31	-2.000	0.000
Pair 1 pre-test-post-test NT	-14.482	29	-6.332	0.000

Table 4. *Paired Samples Test of pre and post ENT and NT in the control groups.*

Finally, an independent sample t-test was conducted. The t-test for equality of means for both ENT and NT were not significant (t_{ENT} = -1.953, ρ_{ENT} = 0.057 - t_{NT} = -0.405, ρ_{NT} = 0.686), indicating no significant differences, in ENT and NT scores between the experimental and control groups. The results of this pre-test are summarized below (Tables 5, 6):

Group	N	Mean	Std. Dev.	Std. Error
Experimental ENT	35	9.742	0.560	0.094
Control ENT	32	9.281	1.224	0.216
Experimental NT	29	26.334	2.236	0.415
Control NT	30	26.841	1.788	0.326

Table 5. *Group Statistics of ENT and NT post-tests.*

Results of this study expand the research on the effects of appropriate programs embedded in a computerized environment for mathematics and natural science (NCTM, 2000; Solomonidou and Kakana, 2000; Kramarski and Ritkof, 2002; OECD, 2003;]; Mayer, 2003; Chen, 2009; Ravanis, 1994; Glauert, 2005).

	t	df	mean difference	Sig. (2-tailed)
Test ENT	-1.953	65	-0.461	0.057
Test NT	0.114	57	-0.507	0.339

Table 6. *Independent Samples Test of ENT and NT post-tests*

5. Conclusions - Discussion

The question posed in the study was to answer if a software application developed under the van Hiele model, would contribute to an improvement of kindergarteners' early science competence. Findings reported above only partially support the hypothesis. Initially, there was no significant difference between the experimental and control group achievements. However, throughout the study, the experimental group of the ENT had higher numeracy achievement than the control group. Despite that, the experimental and control group of the NT had similar 'natural' achievement. The research question has not been answered positively.

The results of this study may be used to further the research of other related studies (Ravanis 1994, Solomonidou and Kakana, 2000; Glauert, 2005; Chen, 2009) with the use of computers in the classroom based on the van Hiele model. The study supports other research conclusions that computers can be an effective method for teaching science concepts (Nastasi and Clements, 1994; Clements, 2000, 2002; Kramarski and Mevarech, 2003; Zaranis and Oikonomidis, 2009; Kalogiannakis, 2010). Our research is in progress and the first indicative results show that teaching and learning through ICT is an interactive process for children at preschool level and has a positive effect for science education. The educational software of this research provides a way of investigating science concepts that will assist some students better understand these concepts.

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REMOTE EXPERIMENT IN CHEMISTRY FOR SCIENCE EDUCATION

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Abstract. *The chemistry education and the methods used in experimentation makes it difficult to design remote experiments. From this stems the reserved approach of chemistry teachers for remote experimentation. The paper intends to present the typical electrochemical remote experiment built on the Internet School Experimental System (ISES) and also show new components built for chemical computer based (remote) experimentation as titration burette, electromagnetic valves for liquids, pressure equalisers and magnetic stirrer). Experiences and results of the remote experiment Electrochemical cell are presented and the results of data processing shown.*

1. Introduction

The teaching of Chemistry experiences decline, the students find Chemistry subjects as useless, demanding and boring, sometimes not related with the Real World. On top of this students of chemistry students show a great deal of misconceptions. According to (Özkaya 2006) the students consider Electrochemistry to be one of the most difficult parts of Chemistry in general. Several research works on the misconceptions in Electrochemistry exist (Carter 1987, Garnet 1992 or Sanger 1997) showing the students believes about the complexities of the topic influence deeply their learning process.

We are convinced that new and more illuminating methods of teaching of Chemistry and other Science subjects, where students would proceed from daily life situations to the abstract once, using ICT, may help. For the development of creative thinking it is desirable to arise his/her curiosity in Sciences and scientific observations, imagination and logics, striving for new knowledge and modern methods, leading to the scientific way of elucidation of Real World by observing phenomena in question and their explaining. In this we may (should) exploit the adherence of the young generation to the ICT in general. In search for new methods of education a new strategy of teaching, called Integrated e-Learning (INTe-L) (Schauer 2009a). INTe-L is the strategy of education of Science and technical subjects, based on the Real World observations mediated by remote experiments (RE) and virtual experiments (VE) in all forms of teaching. Only then the standard e-learning is amended by the missing link – e-experiment. By means of experiment and experimentation the students may better understand the meaning of abstract concepts that in the traditional way of teaching they only passively absorbed without deep understanding.

2. Experiment in chemistry education

Indispensable part of the Chemistry education, as long as in INTe-L, are experiments and experimentation. A Chemistry experiment is in most cases taking place in a chemical laboratory under supervision of a teacher. Ma and Nickerson (2006) found the alarming fact that the real chemical laboratories become more or less controlled by strict order of steps given in the assignment, so called "recipes labs". Paradoxically, this trend is stressed by the more frequent use of ICT for the experiment control, data collection, their evaluation, etc. In this case the quality and amount of the interaction of a student with the running experiment is sometimes very limited and even does not relies on the student's presence in the laboratory (Ma 2006). Our goal in constructing INTe-L and RE was quite opposite. ICT should be involved in a laboratory in a way, they do not influence negatively the cognitive processes running by experimentation, the ICT serving as a helping tool, accelerating and making easy the measuring process, data collection and their evaluation, not as a rigid "robot" for experiment execution. Especially crucial is this demand in designing the RE, with absolutely predominant demand on the lever of experiment interactivity and data processing. The acceptance of RE as a new and barrier breaking element in Chemistry education by the community of chemistry teachers has been limited by now, depending on many factors as acquaintance with RE and rigidity to changes, the curricula stiffness for inclusion of novelties, the maturity of the RE and their reliability and many others (Esche 2002). In spite of the difficulties, connected with the introducing the RE in a chemical lab, many universities start these pioneer activities, as e.g. the Cambridge University announced in 2006 the RE on reaction kinetics (http://usefulchem.blogspot.com/2006/12/remote-controlled-labs.html). We present here the outcomes

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of the building of the demanding experiment Electrochemical cell characterization that started in 2006 (Válková 2009) at the Faculty of Education, Trnava University in Trnava and its sophistication has been continuing since (see e-laboratory with accompanying material for RE http://kf.truni.sk/remotelab or directly Electrochemical cell experiment http://remotelab2.truni.sk).

2.1. Remote experiment arrangement – Electrochemical cell

Our choice to build the RE Electrochemical cell in the field of Electrochemistry and Galvanic cell was discussed in the original paper (Válková 2009). To summarize, we experienced interest from Chemistry departments to build chemical RE and their computer oriented components.

Figure 1. *Schematic diagram of the remote interactive real experiment across Internet – Electrochemical cell (with two vessels and two metallic electrodes connected via a membrane, the measured data is the voltage and the conductivity of the electrolyte; filling of the second reaction vessel and the acid cleaning of the first vessel are omitted for simplicity) see http://kf.truni.sk/remotelab*

The schematic arrangement of the RE Electrochemical cell is in Fig. 1 and it is a classical type of concentration electrochemical cell. It is composed of two vessels made from a transparent material provided with two metallic electrodes connected via a membrane and filled with two ionic electrolytes. The collected data is the voltage on the cell and the conductivity of the electrolyte. The remote experiment apparatus should be computer oriented in the sense that it should enable to control preselected steps, i.e. the preparation of the initial starting conditions, the time realization of the titration process and the corresponding data collection and their visualization, storing and transport for the subsequent processing. The important requirement is the experiment simplicity and self-explaining character of its controlling and manipulation.

2.2. ISES component parts - Electrochemical cell

The experiment Electrochemical cell was designed on Internet School Experimental System (ISES) (see www.ises.info). The system ISES is presented elsewhere, here it is sufficient to mention that it is an universal experimental computer oriented plug and play system for schools based on the hardware (mainly modules covering the common quantities encountered in natural sciences subjects) and software (enabling the data collection, their plotting and processing). It is friendly in use hardware and software for easy building of chemistry, physics and biology experiments with a plenty modules: voltmeter, ampermeter, conductivity meter, pH meter and more others. All these modules are fully programmable. For the envisaged experiment electrochemical cell it was necessary to build several additional modules (titration pump, electromagnetic valve and stirrer), described bellow. The reaction vessels for experiment are made from Plexiglas (Fig. 2). It is as small as possible because of minimizing the volume. The most decisive new component for chemical experiments is the computer controlled titration and the digital burette (Fig. 3) is another device for computer oriented and remote experiments for controlled change of solutions. It is computer controlled (TTL signal) and DC 12 V driven. The volume of a single drop of the liquid is strictly given by the construction of the burette, so the total required amount of the liquid and its rate is controlled by the pre-programmed output signal from ISES by the total number of pulses and their frequency. The gradual and pre-programmed change the concentration of the electrolyte is accomplished by the digital burette in the run of the experiment.

The filling and letting out the electrolytes and cleaning acids from the vessels (in our case it is imperative to minimize it to several seconds only) serve the electromagnetic valves (Fig. 4), controlled by the output digital signal of the ISES by the ISES relay units on the TTL level (Fig. 5). The amount of the liquid may be pre-programmed by the timing. The imperative condition in chemistry experiments is the stirring in order to achieve the fast homogenization of the solutions. Besides, we used in the experiment the standard ISES modules: voltmeter and conductometer units.

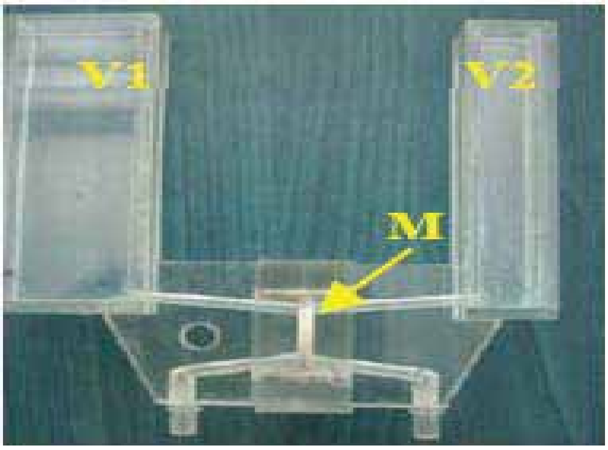

Figure 2. *Reaction vessels (V1and V2) of the electrochemical cell connected by the membrane (M)*

Figure 3. *ISES Digital burette (The inlet (red arrow) and outlet (yellow arrow) of the liquid are denoted)*

2.3 Informatics consideration - Electrochemical cell

Once the hands on experiment is built we have to compile the controlling web page of the experiment, enabling the control of the experiment and data transfer to the experimentator computer.

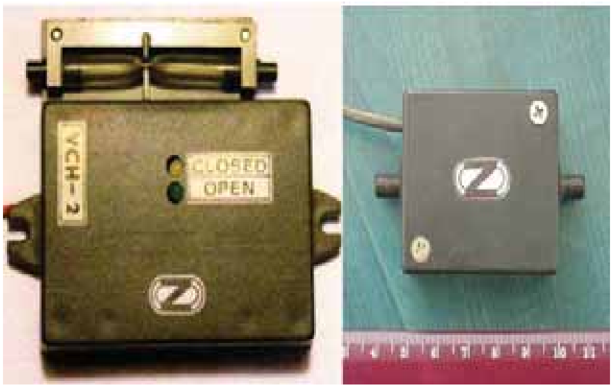

Figure 4. *ISES Electromagnetic valves Acid resistant (left) and electrolyte (right)*

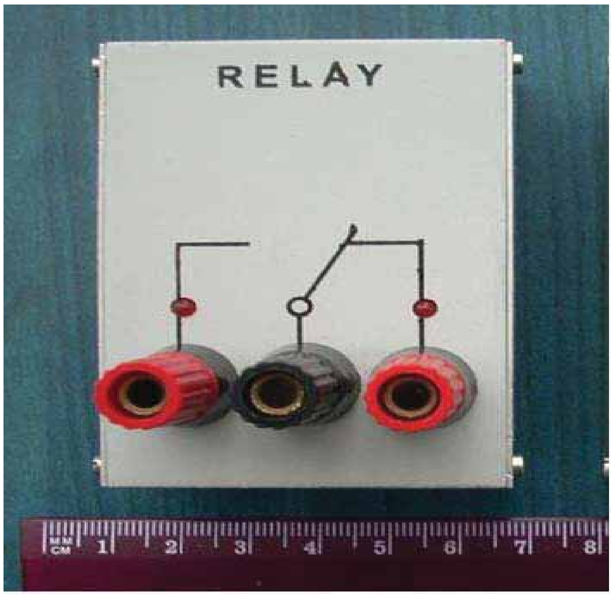

Figure 5. *ISES Relay*

The detailed description of this process using the ISES WEB CONTROL kit was given elsewhere (Schauer 2009a). In Fig. 6 is the controlling web page (see e-laboratory http://kf.truni.sk/remotelab or directly Electrochemical cell experiment http://remotelab2.truni.sk) with the life web camera view of the experiment (left, up) with the reaction vessels and membrane. Bellow are the controlling bars of the experiment, enabling the choice of the starting volume (4, 8 or 12 ml) of copper nitrate ($Cu(NO_3)_2$), and depicting the actual state of the experiment. On the right side there are graphical representations of the electromotive cell voltage and the copper salt electrolyte conductivity and the titration time.

2.4 Theory, data and results

The accompanying material on http://kf.truni.sk/remotelab gives for the experiment physical background, experimental arrangement, questions and manual of experiment. Besides the outlines of the theory are the www pages provided with the simulation experiment taken from Iowa State University(http://www.chem.iastate.edu/group/Greenbowe/sections/projectfolder/flashfiles/electroChem/voltaicCellEMF.html).

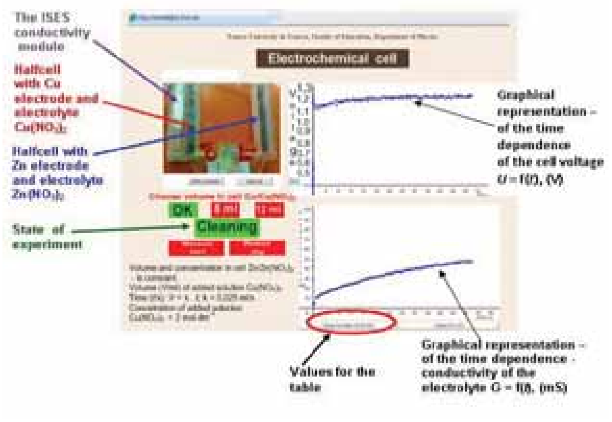

Figure 6. W*eb page of the remote experiment Electrochemical cell* *http://remotelab2.truni.sk*

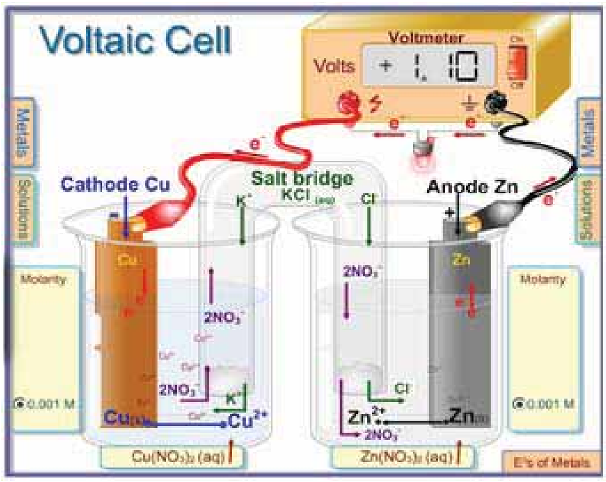

Figure 7. *Electrochemical cell simulation* *http://www.chem.iastate.edu/group/Greenbowe/sections/projectfolder/flashfiles/electroChem/voltaicCellEMF.html*

In the physical background the outline of the theory is given. For the concentration electrochemical cells the electromotive voltage (redox potential) E gives the Nernst equation

$$E = E\circ - \frac{RT}{zF}\ln\frac{c_{red}}{c_{ox}}, \tag{1}$$

where R is the ideal gas constant 8,314 JK^{-1} mol^{-1}, F is the Faraday constant 96 485 C mol^{-1}, z is the valence (in our case $z = 2$), i.e. the number of electrons exchanged during the reaction, c is the concentration and T is the absolute temperature ($T = t$ °C + 273.15).

The electrolyte conductivity is given

$$\sigma = ec^{+}b^{+} + ec^{-}b^{-}, \tag{2}$$

where e is the elementary charge, c^+ and c^- are the concentration of positive and negative ions and b^+ and b^- are their mobility, $[b] = m^2\ V^{-1}\ s^{-1}$,

$$\sigma = G\frac{S}{l}, \tag{3}$$

where G is the measured conductance, l and S are the distance of electrodes and S is their area.

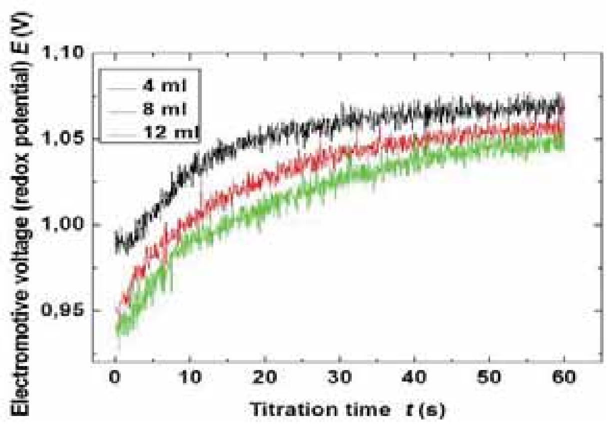

Figure 8. *Titration time dependence of the electromotive force E(t); the parameter is the starting volume (4, 8 and 12 ml) of the copper nitrate ($Cu(NO_3)_2$) (c = 0.001 mol dm^{-3}),titration volume is 0,025 ml s^{-1}, titration concentration 2 mol dm^{-3}*

The assignment was formulated as follows: Using the simulation find the electromotive force for the arrangement of your Electrochemical cell. Is the simulation fulfilling the Nernst equation (1). Find, if the measured electromotive force $E(t)$ and conductivity $\sigma(t)$ dependencies comply with the theory,- From the concentration dependence of the conductivity σ(c) determine the mobility of the mobile ion (Cu^{2+}).

The measured titration time dependencies of the electromotive force $E(t)$ is in Fig. 8 for the starting volumes (4, 8 and 12 ml) of the copper nitrate ($Cu(NO_3)_2$) (c = 0.001 mol dm^{-3}) and in Fig. 9 the corresponding dependences of the copper nitrate electrolyte conductivity σ (t).

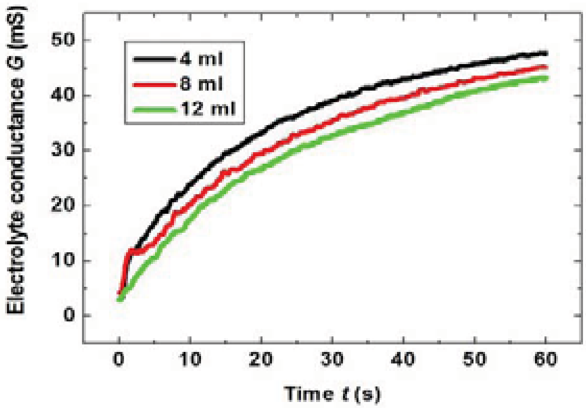

Figure 9. *Titration time dependence of the electrolyte conductivity σ(t); the parameter is the starting volume (4, 8 and 12 ml) of the copper nitrate ($Cu(NO_3)_2$) (c = 0.001 mol dm^{-3}) titration volume is 0.025 ml s^{-1}, titration concentration 2 mol dm^{-3}*

3. Discussion and conclusions

The RE in chemistry is a novelty. With this paper we intended to show the suitability of the ISES plug and play system for building chemistry sophisticated scientific experiments. For this purpose we built several ISES components as titration burette, electromagnetic valves for liquids, pressure equalisers and magnetic stirrer. These ISES components with existing ISES liquid conductometric unit and ISES Ph meter unit enable now the building of the range of RE for chemistry.

From the results achieved the following conclusions may be drawn:

-The plug and play system ISES see (www.ises.info) with special chemistry ISES modules - digital burette, electromagnetic valves for liquids and magnetic stirrer - is very suitable for the wide range of hands on and remote experiments in chemistry,

-The feasibility of the building of the wide range of chemical experiments was again shown without doubt, in accord with the previous work (Bílek 1996).

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THE INFLUENCE OF GUIDED ACTIVE LEARNING IN CHEMISTRY (*GALC*) ON 13-YEAR-OLD STUDENTS' UNDERSTANDING OF THE HYDROCARBONS

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Abstract. *This study investigated the influence of the guided active learning of chemistry (GALC) on the 8 Grade (age 12–13) students' conceptual understanding of the hydrocarbons. Altogether, 48 students participated in the study (24 students in experimental and 24 students in the control group). In addition, the paper presents findings on how a new teaching approach influences the students' attitude towards chemistry, and reports about students' views of the new teaching approach.*

1. Introduction

Developments in cognitive learning theories and classroom research show that students generally experience improvements in learning when they are engaged in classroom activities that encourage developing their own knowledge following a learning cycle (Farrell, 1999). Students need to work together, not only because of their preparation for team work (in science and most of the professions), but because they learn better through social interactions. Students should reach their own conclusions and not be called upon to verify, for example, what the textbook or instructor has indicated to be the expected result of the experiment. The student must be an active learner (Spencer, 1999; Hanson, 2000).

Research shows that there is a lack of evidence that traditional lectures as well as traditional laboratory activities (Tobin, 1990; Lazarowitz, 1994; Hofstein, 2004) in chemistry lessons contribute to promoting meaningful learning. Innovative learning strategies could be used by teachers at all levels of chemistry education to enhance the students' motivation to learn chemistry (Hanson, 2000; Eybe, 2004). One of such innovations is the *GALC* (*Guided Active Learning in Chemistry*) strategy (Devetak, 2010). This approach can be used by teachers in order to facilitate learning to learn strategies in students, who can apply them in the future when learning about new chemical phenomena described by more abstract concepts. The *GALC* is an educational strategy that takes place in an environment where students are actively involved in the process of learning chemistry. When students use the *GALC* approach, they learn new concepts and connections from one another in groups within a social context. Their knowledge is developed by the data analysis and discussion of ideas regarding the learning content. By studying questions at different levels of complexity and by formulating specific conclusions in solving problems, the students are required to meet the demands of the individual *GALC* learning modules.

The *GALC* approach, which was developed in line with the above assumptions, was based on the *POGIL* (*Process Oriented Guided Inquiry Learning*) pedagogical method, the purpose of which was to teach process skills (such as collaboration and written expression) as well as the content using the inquiry based approach (Farrell, 1999; Hanson, 2000; Hanson, 2007) and the theories on cooperative and collaborative learning. This method was developed in the USA for use in teaching general chemistry, but *POGIL* can be applied to teaching other subjects, as well. Because this chapter is not dedicated to *POGIL*, this method will not be described in detail. You can get more information on *POGIL* at its official webpage: http://new.pogil.org/ and in some other references, such as in the paper published by Minderhout (2007). The difference between *GALC* and *POGIL* (Devetak, 2010) is in the organization and adaptation of the *POGIL* method to the Slovenian 45-minute periods of lessons. The *GALC* learning units can be used by the teacher in the classrooms during one learning period and are adapted to serve the teacher according to the standards and competences set by the national curriculum. Another significant difference is also in experimental work, which is incorporated into the *GALC* learning unit. This approach is not characteristic for the *POGIL* method. Other segments of the *POGIL* and *GALC* units are similar.

The *GALC* learning units have their specific parts, which follow consecutively and guide the student through the learning unit. At the end of each learning unit the students should be able to solve problems in connection with the learning content discussed. The specific parts of the learning unit are, as follows: (1) Title, (2) Why do I have to learn this?, (3) Learning goals, (4) Learning outcomes, (5) Prerequisites (6) Additional resources, (7) New concepts, (8) Information and models, (9) Key questions, (10) Exercises, (11) Do I understand?,

and (12) Problems. Each learning unit *title* is set as a problem question, mostly referring to the concrete contextual situation, with which students are more or less familiar.

The problem of the research presented in this contribution relates to the explanation of the guided active learning in chemistry (*GALC*) influences on the 13-year-old students' change in the conceptual understanding of hydrocarbons and the sustainability of the conceptual changes that show as few incorrect and incomplete understandings of these concepts as possible. In addition, the effect will be pursued by some other independent variables (such as motivational strategies, student interest in learning within *GALC* modules, gender...). The contribution will also present *GALC* learning modules, which were designed specifically for the purpose of the research.

2. Method

2.1. Sample

Altogether 48 upper primary school students participated in the research. 24 students were in the experimental group (EG) and 24 students were in the control group (CG). The 8th grade classes (13-year-old students) at primary school of the Pomurje region of Slovenia participated in this research.

2.2. Instruments and research design

In the research we used the causal experimental method since it is suitable for studying »novelties« (the *GALC* approach) which are being introduced into instruction.

Phase 1	Preparation of materials for GALC instruction. Formation of the experimental and control group.
Phase 2	Preparation of the experimental group teacher and students for the implementation of the experimental design.
Phase 3	Pre-testing both groups of students before the introduction of the *GALC* modules. Application of the questionnaires about students' attitudes and motivational strategies
Phase 4	Introduction of the *GALC* instruction into the experimental group. Application of the questionnaires about implementation of lessons in chemistry.
Phase 5	Post-testing (testing of knowledge at the end of the experiment) in both groups. Application of the questionnaires about cooperative learning, and students' attitudes. Postinstruction interviews with some students opinions about learning material.

Table 1. *Presentation of the course of research*

In the experimental group (EG) students were involved into the teaching and learning using GALC modules. In the control group (CG) students were exposed to traditional didactic tools. One teacher performed the teaching and learning activities in both groups. The pre- and post-knowledge test of chemistry contents in the experimental and control group were applied in both groups. The knowledge tests were designed specifically for the purpose of this study. In designing the test the current national curriculum for chemistry in upper primary school and the objectives/aims determined by it were taken into account.

The questionnaires and the knowledge tests were analyzed by the descriptive and inferential statistics.

3. Results and conclusions

The results of the research have shown a positive influence of *GALC* instruction on students' attitude towards chemistry. Students in the experimental group have positive opinion about the lessons organized according to the *GALC* strategy. They also explained that chemistry lessons were more interesting, different form traditional ones and informative.

It can be concluded from the findings that further research should be conducted to identify variables that can influence students learning following the *GALC* educational strategy. It should be also important to adapt *GALC* modules according to the findings so that students can learn also more abstract chemical concepts.

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IMPLICATIONS OF TEACHERS ATTITUDES ABOUT SCIENCE AND TECHNOLOGY RELATION

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Abstract. *At XXI century Science Education recognize the deep relation between science and technology and the strong influence in personal, social and natural world. Science This work determine science teachers attitude about science and technology relation. The sample is one hundred twenty-five Spanish secondary science teacher's. Quantitative analysis provided attitudinal index and more positive and more negative science teachers attitudes. Outcome showed teachers had some adequate attitude about science and technology relation. However also showed a naïve vision they recognized a hierarchy relation between science and technology showed a low comprehension about science and technology relation.*

1. Problem

At XXI century the important social changes are close to scientific and technological evolution. The science education has an important role and in this sense scientific and technological literacy implies an important emphasis on inquiry, technology, science in personal and social perspectives, and the nature of science and technology (Bybee, 1997). Multiple debates focused in science and technology teacher's visions and influences in the classroom practice (Abd-El-Kalick and Lederman, 2000 b; Lederman, 1992). Science teachers had an essential role to providing meaningful opportunities to develop a scientific culture and correct student attitudes about nature of science and technology. In this sense, science teachers needs make connections with a different content relative to epistemological, historical and sociological dimension of science and technology to promote a comprehensive students' attitude about science and technology.

Although in science education relation science and technology is considered an important issue the research about this issue are still scarce. Some studies found teachers recognized a relationship between science and technology with a poorly explanation about it (Morell, 2007; Yalvac, Tekkaya, Cakiroglu and Kahyaoglu, 2007). Directly studies showed some relationship between world views science teacher and theirs visions of science and technology (Liu and Lederman, 2007; Ogunniyi; Jegede; Ogawa; Yandila and Oladele,1993). This study showed some relation between teacher view of the world and nature with a view of on science and technology. In this issue the historical Reichenbach's (1938) distinction between discovery and justification context take an important place and provided a relevant epistemological justification about teacher conceptions on science and technology. The naive teacher views of the world and nature (preferably anthropocentric and pragmatic) related with a naive view of on science and technology. At the same time, naïve vision had positivism foundation characterized with a undervalue technology less than experimental science (Costa and Domenech, 2002) and in a hierarchical relation of technology from scientific activity (Acevedo, Vázquez, Manassero and Acevedo, 2003). Other observed this vision with a very close to scientific method (Morell, 2007).

Likewise science education requires a science teacher with a significant understanding and abilities to teach a complete thought about science and technology. The actual science curriculum include a extensive list of concepts, processes and attitudes linked with this knowledge but usually it's absent at the school science. In contrast it very common to find dichotomy between science and technology, absence of discovery context, a unequal relation between theory and practice relation, and a poor science and technology relation and with a personal and social life students (Mc Comas, 1998).

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1.1. Aim of study
This study is centered to determine attitudes in secondary science teachers about science and technology relation. We explore some ideas and foundations in science teachers about the role and relevance of science and technology in science school.

1.2 Methodology
Mixed method is methodological focus of this study. Quantitative data record with a multiple choise Likert questionnaire COCTS with a no agreement to agreement scale (1-9 points) (Mannasero, Vázquez and Acevedo, 2001). The scale COCTS had an exceptions with a qualitative epistemological options to each phrase in three options according naïve or adequate ideas allowed get a attitudinal index similar to Pearson analysis (-1, +1) (A: Adequate. P:Plausible. N: Naïve). The sample was one hundred twenty-five (125) Secondary Science teachers of Catalonia Public Secondary School in Barcelona responded the questionnaire.

1.3 Analysis
Quantitative data analysis included descriptive analysis and specific analysis about attitudinal index about science and technology relation. Specific analysis data questionnaire involved a data normalization to obtained the teachers attitudinal index. A second analysis focused to determine more positive and more negative attitudinal index with a Tipical Desviations analysis.

2. Results
Attitudinal index: The general results showed a positive attitudinal index (0,14). This result showed only positives index in each categories (Table 1).

	Mean
Mean	0,12
Adequates	0,25
Plausibles	0,07
Naive	0,10
Global attitudinal index	0,14

Table 1. *Means Index attitudinal about science and technology relation*

Level results with each phrase showed specifics science teachers tendencies (Table 2). Teachers accepted science and technology are related but also considerer technology dependent relation to scientific activity. At the same time they accepted contrary affirmation about the nature of technology and its relation to sciences. The quantitative results showed a science teachers characterized with an unclear comprehension about science and technology nature and its relation. They accepted some appropriates ideas about actual epistemological ideas but their tendency attitude highlights a similar nature of science and technology and with a hierarchical relation very closely to traditional or naïve vision about science and scientific method.

Phrases	Category	Attitudinal index
I. Science and technology are closely related:		
1. Because science is the basis of technological advances, although it is difficult to see how technology could help science	N	0,162
2. Science and technology are very closed because scientific investigation guide to practice technology applications and technological applications increase the capacity to make scientific investigation	A	0,538
3. Because although different, are now so closely linked that it is difficult to separate	A	0,176
4. Because technology its in the base of alls scientific advances and not easy to see how science can help to technology	N	0,436
5. Science and technology are very close related and more and less are the same thing	P	-0,292
II. A definition about What is technology can be very difficult because technology its useful to much thing. But technology is:		
6. Technology is very similar to science	P	-0,160
7. Technology is mainly the application of science	N	-0,294
8. New processes, instruments, machines, tools, utensils, computers or objects for day to day.	P	0,276
9. Robots, electronic, computers, communication systems, automatic, machines	P	0,244
10. A technical to make things to resolve practical problems	P	0,116
11. Inventing, designing and testing things (e.g, artificial hearts, computers and space vehicles).	P	0,140
12. Ideas and techniques for designing and making things to organize workers, business people and consumers, and for the advancement of society	A	0,036
13. Knowing how to do things (eg tools, machinery, appliances).	P	0,228

Table 2. *Science teacher attitudinal index to each phrase*

To science teachers technology it a kind of knowledge related exclusively with a manipulative processes.

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Tipical desviation analysis: Results of tipical desviation showed in figure 1. The scheme show two more positive ideas and three negative ideas about science and technology relation. This kind of analysis allowed found a most clear tendency about science teacher attitudes. The lower number of phrases are related with a low knowledge and comprehension about the nature of relation of science and technology.

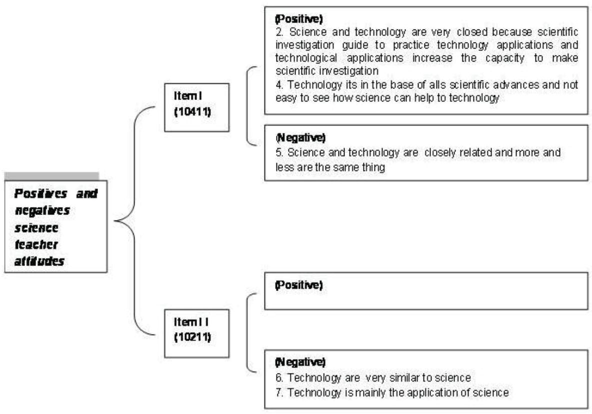

Figure 1. *More positive and more negative ideas about science and technology relation*

3. Discussion and some final considerations

Evidence from attitudinal index agrees with a previous investigation (Morell, 2007; Yalvac *et als*., 2007). Unknowledge and low comprehension about the relevance of science and technology relations its in core of epistemological science teachers fundaments. A naïve idea about science and technology relation arises from considering the pursuit of knowledge for knowledge itself is pure science, while the exploitation in the commercial production of this knowledge is technology. At the same time the results are consistent with the evidence teachers have a strong naïve attitudes about technology and how it relates to science in a hierarchical sense (Acevedo, Vázquez and Manassero, 2002; Manassero, Vázquez and Acevedo, 2004; Morell, 2007., Rubba and Harkness, 1993; Tsai, 2001). Others (Acevedo *et al*s., 2003; Solbes and Vilches, 1997) emphasizes in a positivist logic epistemological teachers positions and with essentials implication to move towards a socioconstructivist school science. Cajas (1991) brings important elements to justify the incorporation of technological knowledge in the science curriculum. He argues that technology how curriculum content can provide pragmatic models that can be useful to connect the teaching of science in the context of the daily life of students. The use of technology to contextualize the teaching of science would mobilize the discussion and reflection on the public understanding of science to public understanding of technology. This position may open a perspective for the teaching of science other than conventional, better known by science teachers. The analysis showed the relevance to promote science teacher improvements to increase the comprehension about science, technology and their relation and theirs implications in the science classroom.

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HANDS-ON EXPERIMENTS FOR DEMONSTRATION OF LIQUID CRYSTALS PROPERTIES

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Abstract. *Liquid crystals have unique optical properties, due to their anisotropic structures. They are materials, on which a number of modern devices or their parts like displays, iPhones etc. are based. Therefore it is worth to introduce them into physics lectures.*
We prepared hands-on experiments for demonstration of liquid crystalline properties and of their methods of measurement. First set of hands-on experiments using different knitting patterns and the second set using a sellotape between the two polarizers demonstrate the concept of anisotropy as crucial reason for optical properties of liquid crystals. We prepared a hands-on fabricated liquid crystalline cell with materials synthesized in the school laboratory for experiments explaining the basic properties of liquid crystals used in applications. Further on, a set of hands-on experiments for optics laboratory explains one of the most common optical technique for measuring the optical properties (optical indicatrix) of liquid crystals - conoscopy. The experiences gained in this introductory set of experiments are than used to experimentally consider the effect of the external electric field on the liquid crystal in the cell.

1. Introduction

Students often have no motivation for learning science. The lack of motivation might be improved by using scientific knowledge in everyday life (Brophy 1998). That is why it is essential for the students' learning to make the gap between the school science and the "real" world narrower (Osborne 2001). We believe that that this could be achieved by performing hand-on experiments, so students can obtain their own experiences and use contexts from the "real" world, especially from their everyday life (Whitelegg 1999). These were our reasons for introducing liquid crystals in education as an interesting and contemporary context by the "help" of hands-on experiments. Liquid crystals are also a perfect example for establishing interdisciplinary connections between concepts in physics and chemistry as liquid crystals can be

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synthesized in the school laboratory and later used for hands-on experiments in physics lectures (Pavlin 2011).
The paper is organized as follows: in the next section we present the sequence, the aims and the experimental set-up of all the hands-on experiments we suggest

2. Hands-on experiments

2.1. Liquid crystalline phase

First of all we have to face the students with liquid crystals or more specifically with the liquid crystalline phase. We can use the liquid crystal synthesized in the school laboratory [4]. The first experiment shows students the difference between different phases (liquid, liquid crystalline and crystalline). Student heat the test tube filled with a small amount of liquid crystal with the hear dryer the liquid crystal in crystalline state, so they can first notice the difference in color (figure 1a).
Next we introduce students the main property that make liquid crystalline phase so useful in display industry – the birefringence, due to which some light passes through crossed polarizers if there is a material in the anisotropic liquid crystalline phase in between. The liquid crystal in a liquid and in a liquid crystalline phase is placed on a microscope slide covered with a cover slip and is put between two crossed polarizers (as in Fig.1b).

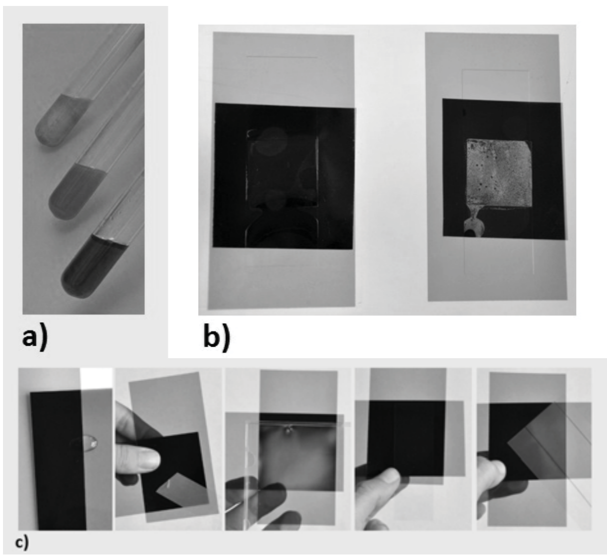

Figure 1. *a) From top to bottom - crystalline, liquid crystalline and liquid phase; b) liquid and liquid crystalline LC between two crossed polarizers and c) different materials between two crossed polarizers (water, sellotape, CD frame, microscope slide and cellophane).*

To get experiences that anisotropic material between crossed polarizers is colored when it is illuminated by the white light, they can replace liquid crystals with other anisotropic materials like the sellotape or the piece of transparency. They can try also with others material (Fig.1c).

2.2. Prototype of the liquid crystal cell

The molecules of liquid crystals in research and application are usually ordered and closed in liquid crystal cells. A prototype of a liquid crystal cell can be made by students. The cell is made of a microscope slide, some plastic foil (usually used for food wrapping) as spacers, a drop of liquid crystal and a cover slip carefully putted over. They made one with non-ordered liquid crystal molecules and one ordered (Fig. 2b). For the orientation of the molecules the microscope slide is rubbed along one side with the velvet soaked in alcohol (Fig. 2a). The cells in between two crossed polarizers are observed under microscope and can be heated with a hairdryer in order to observe the phase transition. Students are asked also to put the polarizers parallel and describe the change in colors (Fig. 2c).

2.3. Anisotropy

For the illustration of the anisotropy as a directional dependence of various properties, one can use many models. However, when one would like to use hand-on approaches and some simple measurements, those models are often less appropriate. To make students aware of the anisotropic properties we propose a knitting model.

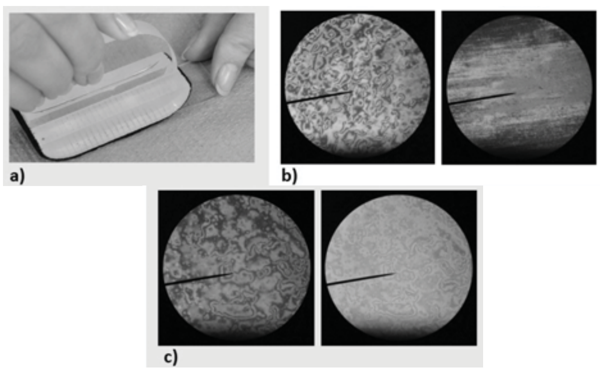

Figure 2. *a) Rubbing the microscope slide with velvet soaked in alcohol, b) A non-oriented and an oriented LC cell under microscope and c) LC cell under microscope with crossed and parallel polarizers.*

Different knitted patterns are stressed in different directions and one can measure the sample extension. Using the patterns having more or less anisotropy, students can explore the difference of behavior in different directions by their own (Fig.3).

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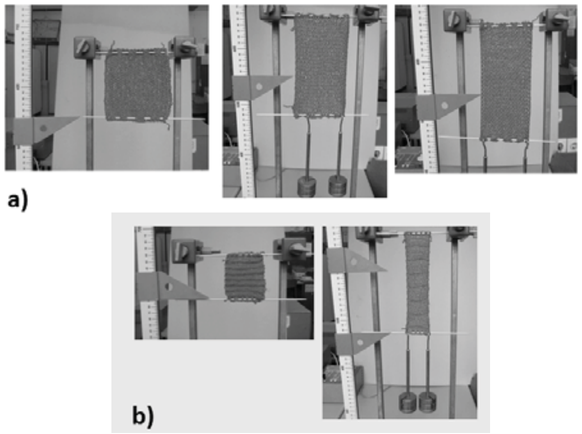

Figure 3. *A knitting model with a) less anisotropic property (equally weighted extended length in one direction 7,5 cm and in the other 12,5 cm) and b) with greater anisotropy (equally weighted extended length in one direction 3,0 cm and in the other 11,7 cm).*

2.4. Double refraction

Because of optical anisotropy the material is birefringent (birefringence or double refraction). Birefringent materials "split" the incident light ray into two rays with perpendicular polarizations. This can be shown by a wedge cell, which is made easily using a microscope slide, cover slip and some plastic foil as shown in figure 3a. The orientation of the molecules is achieved similarly as before by rubbing the cover glass along one side. The wedge cell is placed on a stand to prevent shaking. The laser beam is transmitted through the wedge cell and because refraction indices for both rays are different, the wedge cell filled with a liquid crystal acts as a prism and spatially separates both perpendicularly polarized beams into two. Students determine the direction of polarization for both beams on the distant screen using a linear polarizer (Fig. 3c).

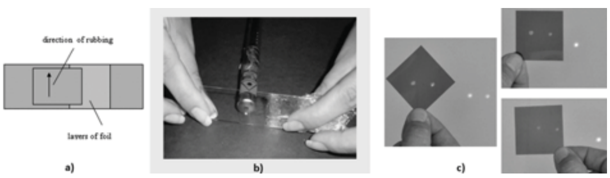

Figure 4. *a) Experimental set-up of a wedge cell, b) observing double refraction of a laser beam and c) determining the polarization of the beams on the remote screen.*

Later on, they heat the wedge cell by a hairdryer and observe a disappearance of two light spots at the phase transition to the isotropic phase.

2.5. Liquid crystals and colors

Students already observed different colors when they placed liquid crystalline cell between two polarizers. The effect can be shown also with other anisotropic materials as sellotape. Every wavelength (color) in the white light passing through the polarizer and the liquid crystal have different polarization state and consequently after passing the analyzer (the other polarizer) is absorbed differently, which changes the spectrum of the incident light. Therefore the light is colored. To understand that the difference in polarization state for different wavelengths depend on the phase shift after passing the sample, which is influenced (by the refractive index and also) by the optical length of the light passing through (because of the small difference in refractive indices in different directions of few layers of sellotape, we can simplify and change just the thickness of the sample for the demonstration). Students observe the color changing in dependence of thickness with adding layers of sellotape on a plate of glass (microscope slide) in between of two crossed polarizers as seen in figure 5a. They can also realize that with rotating one polarizer for 90 degrees (Fig. 5b and 2c), the absorbed wavelengths are complementary to the ones before and therefore one sees complementary colors (Babic 2009).

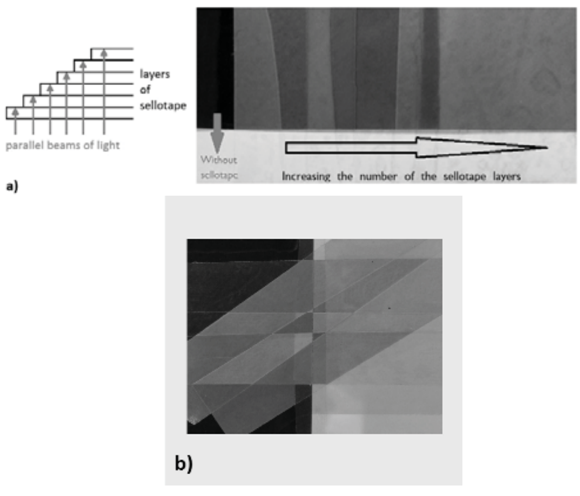

Figure 5. *a) Observing the colours with increasing the optical length of the light passing through the sample of different thicknesses and b) complementary colors of sellotape between crossed and parallel polarizers.*

2.6. How can optical properties be measured?

To measure the optical indicatrix (refractive indices in different directions, the main optical property) of liquid crystals the method of conoscopy is used. Next experiment suggests a construction of a model conoscope, which allow for understanding anisotropic optical properties and differences

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between materials. The model allows students to estimate optical properties out of the conoscopic figure of the material (Fig. 6b and c). For the anisotropic material (analogous to the liquid crystal) the piece of transparency for old overhead projectors is used (Berry 1999). The material for usual transparencies has the birefringence large enough that effects of direction dependency on the birefringence can be observed. The transparency is put between two crossed polarizer and close to the eyes, and slightly under angle as shown in figure 6a. Because the sample has to be illuminated from different directions, therefore one turns to the sky, to some diffuse bright source or to the reflected light from an illuminate white wall for example. For more detailed observation of minima and maxima a diffuse monochromatic light is used.

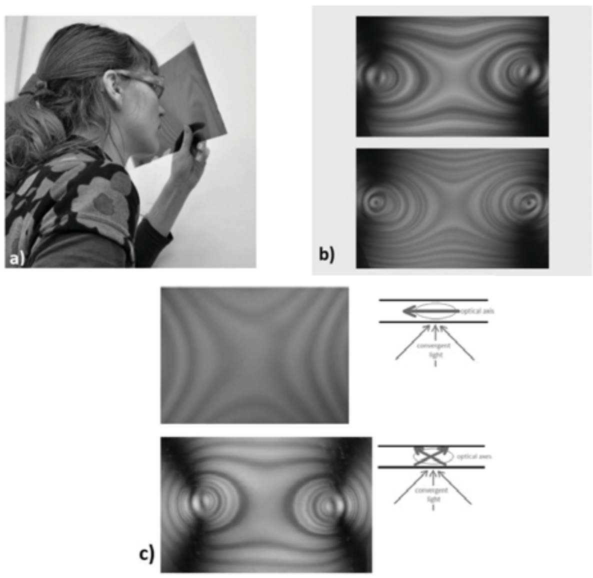

Figure 6. *a) Observing conoscopic images with a model conoscope, b) conoscopic figures of samples with different thicknesses (upper image - thickness d and lower image - thickness 2d) and c) of uniaxial material - upper image (many layers of sellotape, material cut parallel to the optic axis) and biaxial material (transparency) - lower image.*

2.7. The influence of electric field

Experiments with liquid crystals usually require oriented liquid crystalline samples. Simple orientations are two. In the planar alignment long molecular axes are oriented along the glass surface. The planar alignment is obtained by rubbing the surface. In the homeotropic alignment long molecular axes are oriented perpendicularly to the glass surface. The effects of electric field on the molecular orientation and consequently on the conoscopic figure, one needs a homeotropically aligned liquid crystal in the cell and electrodes as spacers.

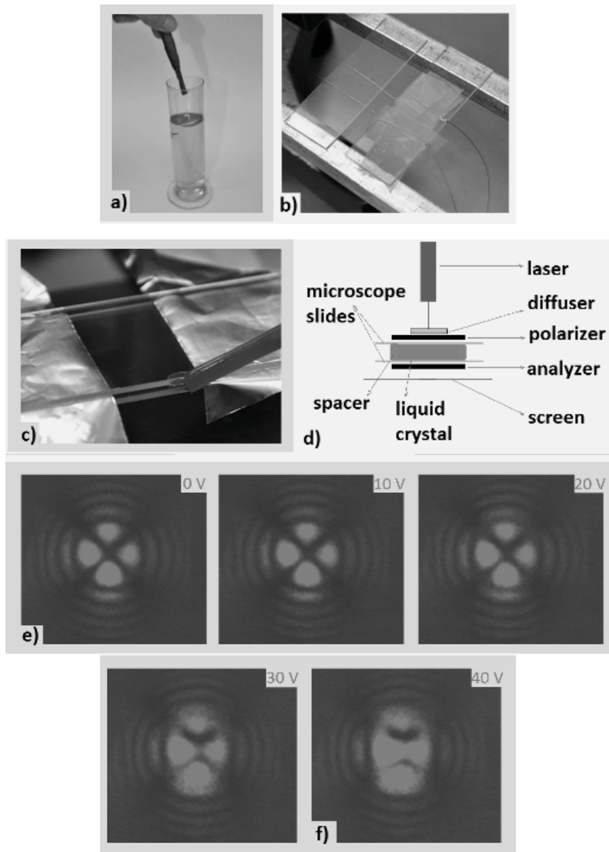

Figure 7. *a, b, c, d) Construction of a liquid crystal cell, e) its conoscopic figure and f) its conoscopic figure after application of an external electric field in a horizontal direction. Liquid crystal used in the experiment was RO-TN 605*

The cell is made by two microscope slides, spacers and the nematic liquid crystal (for example MBBA). For the spacers aluminium foil or thin wires are used (to prevent mechanical movements the construction has to be fixed as in Fig. 7b). For the alignment the lecithin is used, which could be isolated from eggs or simply bought in a drugstore (slides are putted into lecithin mixed with alcohol for about 10 min and after that slowly taken out of it – Fig. 7a). The inner side of the slide should not be touched and should carefully be placed on a stand. After placing the spacers, the other slide is placed on. The liquid crystal is filled by the capillary action by putting a drop of a liquid crystal to the slot (Fig. 7c). For the conoscopic figure, the polarizers, screen, diffuser and a laser are placed as in Fig. 7d. For the diffuser of the laser beam the scotch tape is used or the mat part of some particular microscope slides. When the molecules in the cell are align homeotropically (after about 15 min), than the cell of liquid crystal is uniaxial and one should get an image like in figure 7e. When we apply electric field (voltage on the spacers) the liquid crystal gets biaxial (Fig. 7f). Students become aware that electric field influence on the orientation of liquid crystal's molecules and that a similar effect is used in display industry.

3. Conclusions

Liquid crystals are used in many devices in our everyday life. They are a new topic, which can be motivating for students. With a sequence of hands-on experiments, we try to introduce into education a new phase (liquid crystalline), its basics optical properties and its use in the display technology. At the same time we can achieve the aims of interdisciplinary teaching units, increasing the interest for science and the use of more experiments in school (especially the hands-on type of them). Some of those experiments were already tested in secondary schools (Pavlin 2011).

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PHYSICS OF THE CARDIOVASCULAR SYSTEM

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Abstract. *A simulation of a model of the cardiovascular system taking into account the transport of oxygen, nutrients and heat is presented in LabVIEW. The simulation can be used to investigate blood pressure, temperature, blood volume and blood volume flow of various parts of the human body and the output power of the heart. This can be done under various conditions: a healthy heart, at undercooling or overheating, heart rhythm diseases (tachycardia, bradycardia, phase difference in cardiac contraction), leaking heart valves, and wounds of variable sizes that can be introduced at various body parts. A lesson module is available to introduce high school students into the physics of the human circulatory system.*

1. Introduction

A lesson module of the human circulatory system is developed for upper level high school students and introduces students into the physics of the cardiovascular system. It connects the subjects of biology and physics and aims at showing students interdisciplinary approaches required to understand real life situations. The lesson module allows students to investigate the operation and functioning of the human circulatory system to some detail by running a number of simulations in order to find answers to problems posed to them. The simulation software is based on an extension of the PHYSBE model: a physiological benchmark experiment (McLeod 1966).

2. The PHYSBE model

PHYSBE is a good example of a non-linear continuous system that models the blood flow as a transport mechanism. It can be used to simulate the flow of oxygen and nutrients and heat in the blood stream (McLeod 1966, McLeod 1968). Its goal was to provide a general-purpose simulation for others to adapt to specific needs and requirements. To simulate the human circulatory system the model components are split into three parts: the pulmonary circulation (the lungs), the coronary circulation (the heart) and the systemic circulation (covering the rest of the body). A block diagram of the model is

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shown in figure 1. In this block diagram the flow of oxygen rich blood is shown with bold arrows, oxygen depleted blood by regular arrows.

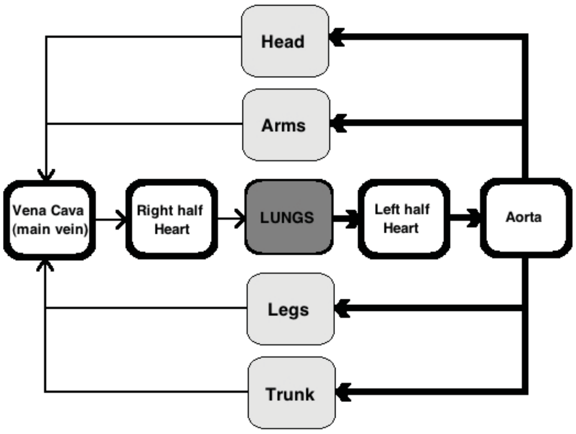

Figure 1. *Block diagram of PHYSBE model*

The input parameters for each element in the block diagram (figure 1) determining the flow of blood are the resistance (in mmHg/(mL·s)) and the compliance (in mL/mmHg), for the heat flow the radiant area (in cm2) and weight (in g). Output parameters for each element are pressure (in mmHg), flow rate (in mL/s) and volume (in mL) for blood flow, and temperature (in K), heat flow (in cal/s) and total heat (in cal) for the heat flow.

3. The LabVIEW simulation

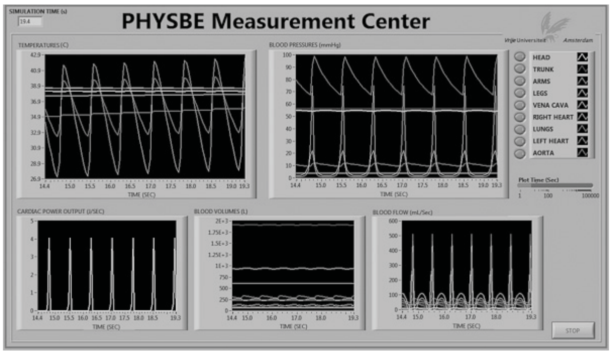

Figure 2. *Main output window of the LabVIEW simulation*

The PHYSBE model has been implemented using Simulink (Simulink 2011).
Using the Simulink description of PHYSBE and its implementation as a basis a new code was written in LabVIEW using its simulation toolkit. Figure 2 shows the main output window with traces for the various body parts shown in each graph. Detailed graphs of with individual traces (autoscaled) can be obtained for any of the graphs in the main window for further inspection.

The PHYSBE model is extended not only to simulate the blood and heat flow. In the LabVIEW simulation in addition the heart beat and phase difference in cardiac contraction can be adjusted to simulate heart rhythm diseases. Effects of leaking of the mitral, aortic, triouspid and/or pulmonary valve(s) can be studied as well. Wounds can be inflicted on the trunk, arms, legs and/or head in various sizes. Also the effect of treating wounds (by exerting pressure to stop the flow of blood from the wounds) can be investigated. Thus, the LabVIEW simulation does not only offer the option to study the human circulatory system for a healthy person. It offers the opportunity to investigate the physics of the cardiovascular system under various conditions of persons with cardiovascular diseases and/or with wounds making it more interesting for students to play around with.

4. The lesson module

In the Netherlands recently a new multidisciplinary science subject was introduced in upper level high school. The subject is offered through a set of lesson modules teachers can select from. Lesson modules have been prepared by teams of high school teachers in collaboration with universities and undergo screening by a national board. For the simulation on the physics of the cardiovascular system a lesson module (Brouwer 2011) was prepared in addition to a lesson module dealing mainly with the biological aspects of the cardiovascular system. The lesson module discusses the cardiovascular system, fluid dynamics, heat and introduces the PHYSBE model and end with a variety of assignments students can work on to investigate the physics of the cardiovascular system under various conditions.

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MOVING BEYOND THE CLASSROOM WITH S.O.S PROJECT: CHILDREN ARE EXPERIENCING NATURE FIRST HAND& DISCOVERING THE SCIENTIFIC PROCESSES INVOLVED

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Abstract. S.*OS (Save Our Species) is an environmental project in which primary school students use scientific processes in outdoor settings so as to understand and interpret the interrelationships in nature. Overall, through S.O.S. Project, students are encouraged to take initiative for saving endangered species and threatened habitats in the vicinity of their schools. Activities that are carried out at regular field trips, field work data that is obtained through the use of scientific processes and the possible answers to the question of how the local environment can be enhanced to improve the survival rates of the selected species are continuously exchanged by the students and their teachers involved in the Project.*
S.O.S Project first began as a pilot study, with 5th grade students in a Turkish private foundation school during the 2005-2006 Academic year and has been coordinated by the participation of several schools since then[1,2,3,4,5,6].
Four primary schools located in Bolu, İzmit, Ankara and Düzce in Turkey were involved in the project in 2010-2011 Academic year. The students in Bolu studied an endangered local plant (Crocus abantensis) and water quality in Abant Lake, the local habitat of this plant. The students participating to the project from İzmit selected an endangered bird (Tringa tetanus) for their research and studied water quality in İzmit Watershed. Another endangered bird (Ciconia nigra) and water quality in Eymir Lake were the study species and study area for the students in Ankara whilst a selected species (Tadorna Ferruginea) and water quality in Efteni Lake were studied by the students involved in the project from Düzce, in Turkey.
The purpose of this paper is to provide a source to environmental and scientific education communities by presenting a brief summary of ongoing developments concerning S.O.S. Project and samples of hands on activities that were carried out by volunteer students and their teachers as part of project's curriculum.

Keywords. *Endangered species, threatened habitats, water quality, scientific processes*

1. Introduction

S.O.S Project, that has been coordinated for six years in Turkey, targets primary school students and deals with endangered species along with their local wetland habitats. Within the frame of the project a water quality monitoring program is used by the students so as to investigate the problems and issues, collect and evaluate data. The students are encouraged to improve the conditions of studied endangered species and to enhance the studied habitats of which those species are a part.

Several field trips are made by the team students and their guides to the selected area during the project term. In these field trips, water quality parameters based on controlled experiments are tested, data is collected, recorded and analyzed which are then exchanged and discussed by the partner schools involved in the project. Not only scientific tests such as measuring temperature, water depth, turbidity, pH and dissolved oxygen are conducted but also the interrelationships between still waters and living species in it are observed and examined by the students at these field trips[1,2,3,4,5,6].

Prior to field trips, miniature wetland models involving bottles and jars containing water samples from study habitats are set up in the school laboratories so as to observe and discuss the human impact on wetland environments. Building miniature wetland indoors initially helps students learn conducting controlled experiments with selected variables and expose the cause and effect relationship between habitats and the human influences on it [3,4,5,6]. In experimental activities such as testing pH and dissolved oxygen, mainly colorimetric tests are conducted to analyze water samples and La Motte test kits are used[1,2,3,4,5,6].

Figure 1. *S.O.S. Team at Atatürk Primary*

1.1. Summary of Selected species and study sites

The selected species and the habitats studied by the student teams from four schools located in Bolu, İzmit, Ankara and Düzce are framed in *Table 1 as* follows:

Schools and Areas	Endangered Species	Threatened Habitats
Atatürk Primary(Bolu)	Crocus Abantensis	Abant Lake
Petkim Primary(İzmit)	Tringa tetanus	İzmit Watershed
Kavaklıdere Primary (Ankara)	Ciconia nigra	Eymir Lake
Uzunmustafa Primary(Düzce)	Tadorna ferruginea	Efteni Lake

Table 1. *Summary of studied species and sites*

Figure 2. *S.O.S Team at Petkim Primary*

2. Methodology

2.1 Participants

Figure 3. *S.O.S. Team at Kavaklıdere Primary*

In 2010-2011 Academic year, a total number of 64 students from 5th and 6th grades in primary schools each of which is located in different part of Turkey voluntarily participated into S.O.S Project.
Table 2 indicates the number of students involved in the project from different locations in Turkey.

Figure 4. *S.O.S Team at Uzunmustafa Primary*

School and location	Number of Students
Atatürk Primary / Bolu	16
Petkim Primary / İzmit	16
Kavaklıdere Primary /Ankara	16
Uzunmustafa Primary / Düzce	16
Total number	64

Table2. *Number of Students joining the project in Turkey*

3. Summaries of Common Activities Performed During the Project Term

At the beginning of second term in 2010-2011 Educational year, volunteer schools were recruited for S.O.S Project. Project activity plan that had been constructed previously was revised and additional activities were included. Unique lesson plans for the teachers were formed by the project coordinator. One semester action plan along with lesson plans for teachers were published on project web site.
A teacher training seminar for volunteer teachers was held for the first time at TED İstanbul College on 12th March 2011.
The detailed steps of the program, lesson plans and hands on activities were exchanged and brain stormed with the volunteer teachers. Indoor and outdoor experiments were also pre-conducted.
In each school; following the steps of researching on selected endangered species, building miniature wetland indoors and practising controlled experiments by making use of these models, students were taken to field trips at selected local wetlands. At these field trips; water quality tests were conducted, findings were recorded, the results of the tests were interpreted, problems were identified, and their solutions were brainstormed by the student teams. During the whole processes, the

instructions from project handbook *'Nature Education in 22 Steps'* were used.

Figure 5. *Project coordinator and teacher team at meeting*

Figure 6. *S.O.S. Teacher team conducting experiments*

Mainly three types of features were observed and tested so as to get data during the fieldwork. These features were:

Physical features of water quality comprising of; water temperature, depth, and turbidity.

Chemical features of water quality comprising of; DO (dissolved oxygen) and pH

Biological features of water quality, comprising of; phytoplankton, zooplankton, insect larva and amphibians.

Meanwhile, theoretical research was continuously carried out and towards the end of the term reports were written by the student teams. Eventually, letters, reports and thoughts were exchanged with the project partners. Short documentaries and photo essays about species and habitats were prepared and presented by the students in each school.

3.1. Atatürk Primary School, Bolu, Turkey

Atatürk Primary School is one of the two schools which have recently joined into S.O.S Project. At the beginning of the project term, soon after the volunteer S.O.S team was formed, pre project tests were administered to the students. Following a general research period about endangered species, students selected Crocus abantensis, a local endangered plant, as their study subject. As far as the teacher's feedback report is concerned, students were very enthusiastic about studying on not only selected plant but also on other local endangered species throughout the whole project term. They prepared documents, presented them on the school bulletin board and updated them on weekly basis. They also created their S.O.S logo that was then printed on their t-shirts.

Prior to field trips, two wetland models containing water samples from two local lakes were set up in the classrooms so as to observe and discuss the benefits of wetlands to nature in general. Students, by practicing in groups of four, became familiar with terms such as pH, dissolved oxygen, turbidity, eutrophication while they were conducting the tests on water quality at the laboratory.

Figure 7. *S.O.S Team at Atatürk Primary testing water quality*

Before the first field trip, a three-day photography seminar took place at Atatürk Primary School. Using these newly gained photographic skills at field, increased the students' engagement in learning the names and features of several local species in their surroundings spontaneously.

Two field trips were undertaken in the surroundings of Abant Lake. At these field trips, physical parameters of water quality such as temperature and depth of water, turbidity along with chemical parameters such as dissolved oxygen and pH were tested and recorded which were then analyzed and exchanged by the students of all partner schools in the project.

Some of the students wrote poems and created posters about study plant while others composed

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songs and wrote short stories.
Following the post project tests, students were delivered their stewardship certificates at a project closing ceremony.

3.2. Petkim Primary School, İzmit, Turkey

Like Atatürk Primary, Petkim Primary School participated into the project in 2010-2011 academic year. As far as the guide teacher is concerned, not only the volunteer students but also all students at school reflected great interest on the content of S.O.S Project and they were highly attracted to the works of team throughout the project period. Tringa tetanus and İzmit watershed were their selected study species and threatened habitat.
At the beginning of the project term, a presentation about all the partner schools and their study subjects was first delivered at school.
After a research carried out by the student team, forming and presenting first documentaries on the school bulletin board created a large aura of interest at school climate.
A wetland model with water sample taken from a nearby pool, Limtepe, was formed by S.O.S Team at classroom in order to become familiar with the characteristics of still water environments.

Figure 8. *Setting up a wetland model in the classroom*

Another experimental setup involving 5 jars, one control and the other four experimental, with water samples from a nearby pond was formed to test *'the effects of various pollutants on water environments'* in the laboratory.
The outcomes of the observations were recorded in five weeks period and throughout these experimental period, *'Nature Education in 22 Steps'* Handbook. Guide was used by the students[5].
Two field trips were organized to İzmit watershed. The team had support from the Association of National Parks and the Nature Society throughout the trips.

In addition to experimental work, students had bird watching experience for the first time at field. As part of their creative task, students were very happy on producing book markers with *Tringa tetanus* figures illustrated by themselves.

Figure 9. *Testing effects of pollutants on water*

Figure 10. *S.O.S Team conducting controlled experiments*

Figure 11. *S.O.S İzmit Team at field work*

Following post tests, a video show involving a set of activities held by students throughout the project term was presented at school and S.O.S certificates were delivered in closing ceremony.
Although these two schools stated above joined to

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S.O.S Project only this year thus did not have previous experience, they were adopted to the intense load of both indoor laboratory and outdoor field work immediately and completed whole task without any difficulty.
Through all the activities, students' interest and sense of responsibility towards endangered species and threatened habitats were highly awakened as was reported by their teacher.

3.3. Kavaklıdere Primary School, Ankara, Turkey

Project work started on 7th of March with volunteer students from 6th grade who had previous experience from previous year.
Initially, team was administered pre tests. Parentel involvement and support for the project were also considered at Kavaklıdere Primary School during the project term. Parents were informed about goals of the project and the task to be completed. Student meetings were held periodically three hours each week after school.
As far as the teacher's observations were concerned, the illustrations of students about their study species, Ciconia nigra, were much more detailed on their latter trials towards the end of project term.
In addition to documented informations about Ciconia nigra, the signifigance of Lake Mogan for the region was emphasized on the school bulletin board by the student team.

Figure 12. *Testing water quality at field*

In this school, As well as miniature wetland models that were set up by the students in laboratory, pH indicators were prepared out of natural and daily materials like red cabbages and instant coffee filters. By preparing several solutions with vinegar, lemon juice, toothpaste, washing liquid initially and testing pH of these solutions afterwards, they observed color change in each solution and created reference color bands in order to be compared when testing pH of water samples from wetlands.
Two field trips were organized to the surroundings of Lake Mogan where water quality tests were conducted, data was recorded and discussed by students.
Thick layers of foam was reported to be observed on the surface of Mogan lake by students.
Their teacher, who was voluntarily involved in the project, pointed out that the students' sensory awareness of their immediate environment were raised by those field trips. Parents also reported that their children invited them to be concerned about environment more often after they had project experience. All of the students were very enthusiastic about participating into the project and they completed the whole task with deep interest. After the post tests were administered, they were given S.O.S certificates with the pledge to be the stewards of Earth.

3.4. Uzunmustafa Primary School, Düzce, Turkey

Uzunmustafa Primary School from Düzce had second year experience in S.O.S Project. The work took an immediate start on 1st of March, 2011. At the first meeting, parents were invited to the school and they were informed about the project.
After a long period of initial research, all of the local endangered species were listed and finally, Tadorna ferruginea living around Efteni Lake was selected as study species. Student meetings were planned twice a week each of which was two hour long after school.
In this school, beside the work presented on Project bulletin board at school, a nature exhibition unit was constructed and placed at the entrance hall of school by the student team with the natural objects collected at field trips.
As in Kavaklıdere Primary, students in this school, beside setting up model wetlands in classroom, prepared natural indicators by using cabbages and filter papers which they then used at field trips for water testing.
National Forestry Association was visited by the team in Forestry week where each student was given a young sapling to be adopted and cared for.
Two field trips were organized to Efteni Lake. The lake was found to be highly eutrophic by the students.
The third field trip was organized to an urban area. Students, in here, made interviews with the elderly people and witnessed their anguish and feelings of being lost in artificial settings.
An over night camp was also organized to the surroundings of Aladağ region in Bolu. Students observed the sky during the night and with the first glimpses of dawn, the team, with their teacher, went

to the lakeside for bird watching. They were very happy to be able to observe Tadorna ferruginea by the lake and hear it's sounds for the first time.

Figure 13. *S.O.S Team recording data at field*

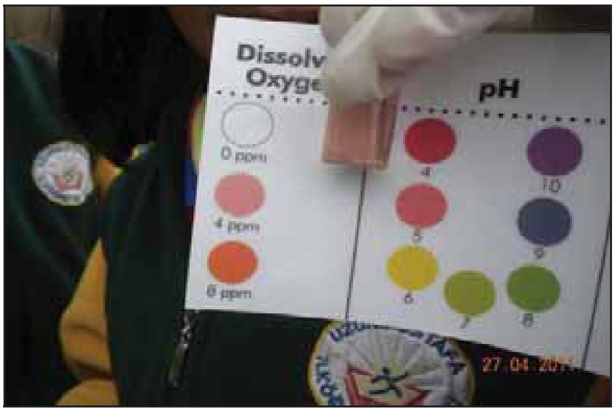

Figure 14. *Testing dissolved oxygen at field*

Figure 15. *Illustrating study species*

Based on the report written by their teacher at the end of project term, it was observed that most of the students were far more familiar with some species living in nearby area than they used to be at the beginning of the project term.
Sentences such as *'I am not scared of some species I observed in nature anymore, I love nature and care for it…'* were emphasized in student essays on the completion of project term.

4. Conclusions

In 2010-2011 Educational year, S.O.S. Project was carried out with 64 students from four schools in Turkey.
One semester action plan was revised and unique lesson plans for teachers were constructed by the project coordinator. A teacher training seminar was held at TED İstanbul College. at the beginning of project period. Project website which was previously constructed as data sharing platform was also enhanced.
Within the frame of S.O.S Project carried out in 2010-2011 Educational year:

(1) Unique endangered species and their habitats were studied by the students involved. Knowing about environment was an important foundation for children to being able to understand and interpret cause and effect relationship in nature thus act in an informed and responsible manner.
(2) Two field trips were organized to nearby wetland areas. In these field trips, students were able to experience nature first hand and discover scientific processes involved.
(3) As well as science, art was another related discipline applied. Students wrote impressive poems, composed songs, took photographs and made illustrations using the information they gained from outdoor settings.
(4) Prior to field works, setting up miniature wetland models indoors supported students' learning by making them familiar with the components of wetlands.
(5) Field trips provided foundation for spontaneous investigation and inquiry for students. Therefore, a rich learning environment that went beyond traditional curriculum-based learning in the classroom was created with field trips.
(6) Discussing ideas, reporting, exchanging the data with peers, presenting their work at school also promoted students' social skills.

As far as the author's and teachers' observations were concerned, S.O.S. Project demonstrated the importance of using field work activities in natural settings for inquiry based learning, developing students' scientific skills and thus promoting them to act in responsible manner towards environment.
Besides the field work activities, conducting controlled experiments through setting up model environments indoors also helped the students examine and understand the cause-and-effect relationship in nature. Therefore prior to field work,

miniature ecosystem sets can be used indoors as an important learning tool.
The author hopes that those strategies used in S.O.S Project, provide a useful source for the environmental and scientific education communities worldwide.

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Dilek Balaban, Teacher at Uzunmustafa Primary School, Düzce, Turkey
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GREEK PRIMARY STUDENTS' ATTITUDES TOWARDS THE USE OF ICT FOR TEACHING NATURAL SCIENCES

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Abstract. *In the last few years it has been observed that young people have moved away from Natural Sciences. The objective of the present research is to identify the attitudes of Greek primary students attending 5th and 6th grade towards the ICT in the framework of the course "Natural Sciences in elementary school: search and discover". The main methodological tool was 12 semi-directed interviews with primary students. Based on these interviews we tried to investigate the relationship between primary students and ICT and the general use of ICT in the educational process for teaching Natural Sciences.*

1. Background

The exact role of Information and Communications Technologies (ICT) in education has occupied much thought and covered many acres of page and screen in the last 30 years (McFarlane & Sakellariou, 2002). By speaking about changes in school practice of participants in the educational process using ICT we refer to wider changes taking place in decisions, planning and organization of teaching. These changes are also dealing with new learning opportunities often in dependence with ICT using interactive experiments and everyday material (Psillos & Niedderer, 2002). Children's fascination with science activities supports their intellectual and linguistic development by providing a context for

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hands-on, personal experience during which they form mental representations of complex phenomena, process complex language, and attempt to communicate their understanding of the experience to others (French, 2004). Nowadays, there is an expectation that teachers will be able to effectively use a range of ICT related resources in the science classroom in order to enhance primary student learning. ICT provide us with powerful instruments for the modelling and simulation of natural phenomena.

For the past 8 years in Greece a new Diathematikon Programma (DP) / Cross-Thematic Curriculum Framework for nursery, primary and middle school education (Hellenic Ministry of National Education - Pedagogical Institute, HMNE-PI, 2003) has been in place and is being tried out. According to this, individual subjects are maintained within the DP, while at the same time the horizontal and vertical linking of subject matter content are promoted (Tselfes & Paroussi, 2008).

In Greek primary school the place of the course "Natural Sciences in elementary school: search and discover" is considered of great importance given the fact that it is the first contact that primary students have with the organized lesson of Natural Sciences. The DP proposes 4 basic categories of goals, which must be accomplished, from the children during the teaching of Natural Sciences: the theoretical scientific literacy, the initiation of "scientific methodology" and to "scientific practices" as well as the link with every day life (Tselfes & Paroussi, 2008).

In the last few years it has been observed that young people have moved away from Natural Sciences. An important effort has been made in order to improve the way these courses are taught so that they can be more attractive for primary students but also bring out their relationship with every day life. The integration ICT in the educational process is an issue that concerns the Greek educational community in all levels of education. Based on semi-directed interviews with primary students of the fifth and sixth grade of elementary school in Greece, we tried to investigate their relation to ICT and the use of ICT for the course "Natural Sciences in elementary school: search and discover".

2. Theoretical Framework

Primary students' ideas are a vague and unequal knowledge with deeply held beliefs and with great interpretive power (Duit, 1995). A key feature of these ideas is the resistance that they present in any attempt to modify them, which sometimes tries to be amended with the help of ICT. But often, primary students are reluctant to enter the negotiation process of their ideas as well as the scientific explanation and seek to learn only the "right" answer (Duit, 1995).

For Leach & Scott (2008) understanding scientific concepts involves understanding something about the nature of those concepts. A change is necessary so as an innovative teaching method can be successful, not only concerning materials, but also concerning approaches and beliefs (Kalogiannakis, 2010).

The incorporation of the ICT to teachers' daily educational practice is a particularly difficult process which demands time and constant effort in the centre of which we find the teacher himself (Selwyn, 2000, Baron & Harrari 2005, Zaranis & Oikonomidis 2009). Teaching Natural Sciences is an area in which ICT find a wide range of applications changing the way primary students are taught in all levels of education. Greek teachers need access to a considerable range of knowledge and skills in order to be able to keep up with ICT and to provide students with the best education possible. According to Demetriadis et al. (2003) teachers are strongly oriented towards fulfilling the established school instructional targets. As a result of this, according to these authors, teachers tend to ignore innovative learning activities because they are disturbing.

2.1. Contribution of Natural Sciences

Much of science education content is focused on the world that surrounds us, nature-living things, non-living things, and their interactions. It is extremely difficult to maintain intrinsic motivation in some cases where the science instruction is just about abstract science theory without connections to real-life applications (Zoldosova & Prokop, 2006). Learning science involves coming to understand and be able to use a new set of tools for talking and thinking about the world, which can be drawn upon when circumstances and context are appropriate (Leach & Scott, 2008). Science activities that are exemplars of "how the world works," (e.g., mixing primary colours, creating shadows, trying to make a piece of clay float, or watching an earthworm crawl through dirt) constitute "events" for the young child (French, 2004).

One of the main objectives of teaching Natural Sciences is to cultivate the primary student's ability to reorganize his/her cognitive schemas whenever he/she realises that they are incapable of explaining the phenomena of the natural world (Novak, 2002). Furthermore, the teaching of Natural Sciences aims to design and organize modern learning environments that facilitate learning and understanding by primary students of the concepts they are taught. With supportive adult guidance, young children are capable of engaging in complex, collaborative discussions involving prediction, observation, and explanation (Peterson & French, 2008).

Children develop their everyday concepts and theories about the world on the basis of daily observations and conversations with adults (Vosniadou, 2002). The overall aim of the course "Natural Science in elementary school: search and discover" in Greek elementary school is the systematic introduction of primary students to basic concepts of the Natural Sciences as well as helping them to have a more scientific way of studying and working.

2.2. ICT and Natural Sciences

ICT is not only bringing changes to the world we live in, but is also transforming the ways in which we learn, providing new potential for interaction and dialogue. To speak of the role of ICT in science education it is first necessary to identify the objectives of that education and then disaggregate the various forms of ICT in order to discuss the potential relevance or otherwise of each (McFarlane & Sakellariou, 2002). ICT and their use in the classroom provide opportunities for individualized teaching, development of collaborative learning as well as saving teaching time while they can exist as a new communication tool (Duit, 1995).

ICT help in understanding the concepts of Natural Sciences and the interpretation of natural phenomena without aiming to replace the experimental activities (Psillos & Niedderer, 2002). McFarlane and Sakellariou (2002) argue that when considering the role of ICT in the teaching of science it is important to place this in the context of the pedagogical model promoted as the vehicle for curriculum delivery. In this context, the use of ICT could ensure some improvements, offering to primary students and teachers tools for more active learning science while giving them networking and cooperation potential to communicate with peers and scientists.

3. Methodological Approach

Due to the young age of the children with whom the research was carried out, a qualitative approach involving face to face interviews was used. The basic methodological tools were 12 semi-directed interviews and their content analysis (Neuendorf, 2002, Ghiglione & Matalon, 2002) with primary students, aged 10-11 years, attending the fifth and sixth class of elementary school. All interviews were conducted in 6 different public elementary schools in the city of Heraklion in Greece in September 2008. According to Neuendorf (2002) the interview is the best method of approaching students' perceptions since it requires more qualitative approach and presents many of the characteristics of the daily debates allowing in-depth interaction of the participants.

The main themes of the interviews were the use of ICT:

(a) outside the classroom,

(b) by primary students during the course "Natural Sciences in elementary school: search and discover" and

(c) by the teacher while teaching Natural Sciences in elementary school.

The duration of each interview was not stable and varied between 20 and 30 minutes depending on whether the child needed more probing in order to express his/her ideas. In carrying out the thematic content analysis (Neuendorf, 2002, Ghiglione & Matalon, 2002) interviews were recorded and decoded and in this article we refer to the first

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indicative qualitative results. Notes were taken immediately following the interviews in order to provide a summary of the main points and ideas gathered from the interview.

4. Results

Nowadays, there is a plethora of ICT resources and products available for use within the physical sciences. Primary students of our sample quite often use ICT outside the classroom which increases significantly their familiarity with ICT. They accept with satisfaction this new educational tool; they have fun with it and approach it with great excitement. According to the primary students of the sample one of the most important factors for the integration of ICT in teaching the course "Natural Sciences in elementary school: search and discover" is the process of experimentation and play during the lesson. They also claim that learning Natural Sciences using ICT is ‘‘original’’ and the course is referred to as ‘‘creative’’ and ‘‘pleasant’’. It should be noted that there were cases of primary students who initially accepted with pleasure the use of ICT within the classroom but eventually were tired by its use.

According to the interviews the course "Natural Sciences in elementary school: search and discover" is more interesting and dynamic with the use of ICT and helps primary students to develop better contact with their classmates and the teacher. The use of ICT in the modern form of the hands-on learning, is essential. Primary students through the interviews indicate the more direct involvement in the learning process with the use of ICT. Several primary students also underline the help that they get with the use of ICT in understanding and interpreting natural phenomena as well as every day life.

Generally speaking, interviews of primary students showed that:

(a) they have a better understanding of the problems of everyday life concerning the teaching of Natural Sciences with the help of ICT,

(b) they are more aware of potential problems they may face in everyday practice,

(c) they come close to the computer at an early stage with a special enthusiasm,

(d) the use of ICT in the classroom for teaching the class "Natural Sciences in elementary school: search and discover" expands the teaching time frame, a factor which seems to be tiring,

(e) the use of ICT extends the possibilities of communication and entertainment stating in this way a strong cultural and recreational interest,

(f) they have access to important information mainly through the internet for the most important concepts of Natural Sciences,

(h) the ICT tools, especially the internet, are collaborative learning resources.

All the above results are of great value, especially nowadays, where memorization is still the kind of teaching that often prevails in the classroom, even in elementary school. It is a fact that even nowadays the learning process in the field of Natural Sciences in primary school is largely based in a teacher-centred model of communication, which seems to make the part of the modern teacher very difficult.

5. Conclusions and Implications

Science and technology are two of the most important areas of the modern human culture. The use of ICT is becoming a part of everyday life in schools. We will not survive the future by simply doing better what we have done in the past (Robinson, 2001). Primary students are generally positive about the role of electronic media and ICT and can make greater developmental gains when compared to children without such experience (Baron & Harrari, 2005). They have also more positive and rewarding experiences with keeping conversation going, cooperating, and planning with peers than with adults or siblings.

Natural Sciences consist of a vital way of exploration and understanding of our environment. Scientific literacy enables us to reach not only responsible and fully justified decisions in important issues of our life but also in issues of social priorities of our time. The assessment of the use of ICT in teaching and learning particularly for the teaching of Natural Sciences is a very difficult task. The creation of abilities and positive attitudes towards ICT demands the existence of an environment favouring their development.

ICT enables the primary students in Greece to perceive and measure natural phenomena in an interesting and very flexible way. It is important to find ways of using the ICT not only as a means of developing knowledge and skills, but mostly to develop motivation and facilitate cooperation.

Nowadays, primary students need to know the current state of their knowledge, build on it, improve it and take individual and collective decisions based on it. We argue that primary students acquire abilities of coordinating and organizing different extra curriculum activities where they will become motivated with the use of ICT. Moreover, it is indicated that the challenge for the science educators of today's primary students will be to improve pedagogy so that it better reflects the changes in technologies and literacies and the intersection between the two. It is necessary for teachers to have both pre-service and in-service educations in order to follow the latest technological trends, to be aware of the potential opportunities of ICT and to have basic information and skills.

Our findings should be interpreted within the limitations of a small-scale exploration study and more systematic study is needed in order to assess the ICT use in the class practice and specifically in the course "Natural Sciences in elementary school: search and discover" for Greek primary students. Today, teaching of Natural Sciences is not limited to the confines of content but seeks all-round personality development of primary students, of an independent way of thinking, developing the capacity for rational response to situations and the possibility for communication and collaboration with others.

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CHALENGES FOR SCIENCE EDUCATION

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Abstract. *Science Education is evolving continuously since Renaissance, facing new challenges as every new industrial or scientific revolution happens and as a consequence and of its work, too.*

Currently, due to the informational revolution, to the huge accumulation of knowledge, to the speed of its increase and diversification, to the requirements of the "creative economy", but, also, limited by the human biological and psychological capabilities and by the fast progress of other human activities, Science Education, which is oriented to a future less and less predictable, has to face challenges of right selection, of promoting imagination, creativity, ingenuity and innovation, of attracting young gifted people to Science.

Science Education must be innovative and creative itself to generate creativity and innovation. It has to appeal to the human desires to enjoy, to discover, to create, to compete, to win.

Asking students to solve problems whose solutions are not published or to find and solve problems facing their community and organizing frequent creative and distractive competitions on science topics may contribute to increase the role of Science Education by promoting attractive and creative learning.

There is mentioned the expertise of the international academic consortium HANDS on SCIENCE and of a few national programs, in centering Science Education on promoting competition and pleasure of creation.

One challenge in Science Education today is not only in acquiring information, but also, in determining what information is most accurate and relevant to us. Knowing how to separate good from bad information and knowing which information has value in our quest for knowledge and wisdom would be essential skills. And the demand for a new workforce to meet these challenges is rapidly increasing.

Learning to learn, to find the joy of learning and to discover beauty of Science in an age where people could go through a dozen jobs well before middle age are other challenges of Science Education. Many tomorrow's top jobs haven't even been imagined yet because they'll use technologies that haven't been invented.

Most analysts studying the new global economy agree that the growing creative and innovative economy represents a central ingredient in defining future success. The importance of reinventing business strategies, corporations, communities, schools and more is critical. Nothing can remain the same if we are to survive, let alone succeed, in this new global "Creative Age" economy, today at its dawn.

The future workforce will need to be more innovative. While Math and Science are important, they need to be also infused with the creative spark that may come from different sources.

This is an other challenge for Science Education. It isn't just about math and science anymore.

What must schools—from kindergartens to universities—and communities do to nurture and attract the most innovative and creative workers? And, how to make someone innovative and creative or more innovative and more creative?

Education (particularly Science Education) must be innovative and creative itself to generate creativity and innovation.

To compete successfully, a community, let's say of Science educators, needs imagination, creativity, ingenuity and innovation.

The international academic consortium HANDS on SCİENCE plays an important role, at international level, in stimulating creativity and innovation in Science Education, both in teaching and learning. Each year, new topics are approached at HSCI actions, actions gathering hundreds of participants, HSCI offering new openings to Science Education stakeholders. The 8th International Conference on Hands on Science joint with the MPTL'16 Workshop on Multimedia in Physics Teaching and

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Learning in 2011 is devoted to designing multimedia for and applying to teaching and learning Sciences, particularly Physics, to the increased role of multimedia in innovation in teaching and learning. HSCI partners and conferences devote place to the hard and soft support for in-school and after school innovative (at their level) hands-on experiments.

Research in Physics Education, developing basic investigative skills and the scientific method, Science museums, in-school science education and ways to bridge formal and informal learning of science do receive also much attention. New perspectives, innovative solutions, interdisciplinary approaches in Science Long-Life Education are usually discussed.

Stimulating the desire for the pleasure of learning Science of students of all ages is an other important challenge for Science educators.

The evolution of the desire for pleasure caused humanity to sense a constant need to develop, to invent and to discover new things.

A greater desire means greater needs, which yield keener intellectual and perception abilities. The growth of the will to receive mostly generated humanity's evolution. Firstly, it has been the will to enjoy manifested in physical desires, such as the desire for sustenance, reproduction, and family. These desires have existed since the dawn of humanity.

But because man is a social being, additional desires evolved within humans, social desires, such as the desire for wealth, honor, sovereignty, and fame. These desires changed the face of humanity, contributing to introduce social classes, hierarchical systems and changes in the socioeconomic structures.

Subsequently, there came the desire to enjoy knowledge, manifested in the evolution of science, education systems, and culture. Its traces first appeared during the Renaissance and continued through the Industrial and Scientific Revolutions, and into the present day.

If we observe human evolution in culture, education, science and technology in light of the understanding that desires mainly leads all these processes, we will conclude that evolving desires have contributed also to the generation of almost all our ideas, inventions, and innovations. All of them are merely "technical" tools, "servants" that have evolved to fulfill the needs that these desires created.

This process of desire-evolution happens not only in the whole of humanity throughout history; it happens in the private lives of each of us, as well. These desires surface in us one-by-one in a variety of combinations, and direct the course of our lives.

The evolution of our desires is ceaseless, and designs both our present and our future. In fact, one of the internal engines that propels us forward and induces the processes that unfold in human society is actually our desire to enjoy.

This desire to enjoy is and is to be largely used as a challenge to Science Education by making Science Education more attractive.

To this end, HSCI is organizing regularly Science fairs and festivals. Hands on Science approaches of teaching Physics comply with this need. At the Science Fairs of HSCI, Schools, research institutions, commercial companies, Science clubs, teams and or groups of students or teachers, and individuals may prepare a booth to present their work. At some HSCI Conferences there have been organized successful robotics festivals.

Science Education must respond to the demands of this new age by developing a system that "grounds all students in pleasure, beauty, and wonder to be able to promote creativity; it is the best way to create citizens who are awakened not only to their humanity, but to the human enterprise that they inherit and will—for good or ill—perpetuate (Goia, 2003).

In Sparks of Genius (Root-Bernstein, 2000), following examination of the minds of inventive people it is shown that creativity is something that both artists and scientists can learn and more importantly, that the seemingly disparate disciplines of art and science, music and math, complement and enhance one another.

Some programs in the world are devoted to implement interdisciplinary education between Science and Arts (Eger, 2010).

The Chicago-based effort: Renaissance in the Classroom, also known as CAPE (Chicago Arts Partnership in Education), offers a model of interdisciplinary collaboration, using Arts and Science integration as a way to approach thinking and learning; the program encourages schools to reach out to community resources and to make connections to the school curriculum.

High Tech High (HTH) in San Diego (Eger, 2010), an other successful example of Art Science common infusion, is a charter school well funded by the Bill and Melinda Gates Foundation. It consists of six schools: three high schools, two middle schools, and one elementary school, with a total of 2,500 students and 200 employees. One hundred percent of graduates have been admitted to college, 80% to four-year institutions of higher learning.

At High Tech High, there is no Math class or Art class, though these disciplines are still taught and still relevant. Instead, they are infused in the curriculum, integrated into larger questions like: "How does the world work?" "Who lives here?" "Why does this matter?" Each semester the entire faculty and student body are assigned a topic they work together on that draws on all the disciplines, thereby forcing students to work collaboratively on real-world problems.

These projects bring all the disciplines and all the energy and intellect of the class together. The design principles of the school: personalization, adult-world connection and common intellectual mission are unified.

HSCI itself praises Science Education trough art. "Science and art" are constant topics at HSCI conferences.

An other important human desire is the desire to win, accompanied by the pleasure to compete.

Science Education is responding to the competitive demands of this new age buy organizing various competitions.

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Since long, middle and high school competitions "Olympiads", on different high school topics are organized worldwide, many of them being held yearly and reaching national, regional, continental and even world finals. International Science Olympiads (Wikipedia, 2011) are a group of worldwide annual competitions in various areas of science (since 1959 - Mathematics, since1967 – Physics; 12, to date). The competitions are usually designed for the 4 - 6 best high school students from each participating country, selected through internal National Science Olympiads.

Some international evaluation tests are also considered by managers and politicians as competitions in Science Education:

The Programme for International Student Assessment (PISA) is a worldwide evaluation of 15-year-old school pupils' scholastic performance in Math, Science and Reading, performed first in 2000 and repeated every three years. It is coordinated by the Organization for Economic Co-operation and Development (OECD) and UNESCO, with a view to improving educational policies and outcomes.

The Trends in International Mathematics and Science Study (TIMSS) is an international assessment of the Mathematics and Science knowledge (not including Reading) of fourth- and eighth-grade (Year 5 and Year 9) students around the world. TIMSS was developed by the International Association for the Evaluation of Educational Achievement (IEA), starting in 1995.The tests are repeated every 4 years, to allow participating nations to compare students' educational achievement across borders.

But, from countries ranking on top positions in PISA and TIMSS tests come strong criticism on the value of this tests themselves for evaluating their importance to the actual needs of the society - creative abilities, essential for the progress, creativity being rather ignored and even intensive preparation for the TIMSS and PISA tests impeding the development of students through creativity.

Titles as "#1 in math and science competition, #0 in creativity and imagination "(Chu, 2011) are current in Asian media. "Educators fear the students will become expert test-takers lacking creativity and imagination. The making of superb test-takers comes at a high cost, often killing much of, if not all, the joy of childhood. In a sense, this is the underbelly of a rising China: the fear that schools are churning out generations of unimaginative worker bees who do well on tests. whether they will ease the immense pressure on teens in families hungry for a place in the upper or middle class".

In the world, in USA, in EU and in other European states, in China, in tiger states in Asia, but also in a few emergent economies it is felt the need to redesign high school and college curricula, in particular by designing programmes with an horizon of ~2020, to focus on preparing students for this new competition, on creativity and innovation. The curricula and new methods in teaching are to provide for a good preparation to adapt active members to ensure the progress of future generations across the world. There are national wide programs of competitions in creativity and innovation.

In U. S. A., MATHCOUNTS (Mathcounts, 2011), a national enrichment, club and competition programmme promotes middle school mathematics achievement through grassroots involvement in every U.S. state and territory, designed to secure America's global competitiveness,

MATHCOUNTS offers three programs to middle school teachers and students: The MATHCOUNTS Competition Program, the Free MATHCOUNTS Club Program and the MATHCOUNTS Reel Math Challenge.

MATHCOUNTS is designed to inspire excellence, confidence and curiosity in U.S. middle school students through fun and challenging math programs. MATHCOUNTS is providing today's students with the foundation for success in their Science, Technology, Engineering and Mathematics future careers, involving more than 17,000 volunteers (teachers, engineers, other professionals, parents, and alumni) which participate annually to coach students and conduct competitions. Over 250,000 students, yearly, utilize MATHCOUNTS materials. Since the program began in 1983, over 6 million students have participated. More than 6,000 schools participate in competitions annually, from all 50 states, the District of Columbia, U.S. territories and State Department and Department of Defense schools worldwide. Corporations and individuals donate $1.5 million to $1.7 million annually to the national program and over $500,000 to the local and state programs.

MATHCOUNTS is being recognized in White House ceremonies.

MATHCOUNTS motivates and rewards students by fostering teamwork and a competitive spirit. It is more than a competition. It involves students and teachers in year-long coaching sessions and helps students at all levels improve their critical-thinking and problem-solving and creative skills. MATHCOUNTS builds math skills, promotes logical thinking and sharpens students' analytical abilities. MATHCOUNTS introduces students to science, technology, engineering and mathematics careers through contacts with engineers and other professionals who serve as volunteers.

MATHCOUNTS provides America's middle school teachers with creative, interesting and comprehensive curriculum materials, free of charge. It is educator-driven. Materials and activities are structured to meet student needs, as identified by educators. Members of the National Council of Teachers of Mathematics (NCTM) develop these materials in accordance with NCTM curriculum standards for grades 6-8.

The new largest economy states, tiger states in Asia have comprehensive national programs on creativity and innovation competitions for school boys, the most imprtant world companies competing in organizing such contests on topics interesting them.

In Romania, the Ministry of Education, Research, Youth and Sports is sponsoring the traditional and internet exchange of expertise between teachers of Science, the professional socialization platforms and a large spectrum

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of competitions for students, at national or international levels, among these being, in 2011, 447 competitions open to k-12 students, 59 of competitions being devoted to Maths, Sciences and Technology.

The structure of the Competition MATHEXPERIENCE

Section No.	*Title*	*Age of Students (y)*	*Content*
I	*Making Math more funny and attractive*	*5 – 10*	*Prepare and deliver new PowerPoint presentations on mathematical topics*
II	*Maths is all around us*	*11 – 14*	*Prepare and deliver new applications in various programs such as Excel, MathCAD, Mat Lab, Matple, Lab View*
III	*Applied Mathematics*	*15 – 18*	*Produce new specific applications in various programs such as Excel, MathCAD, Mat Lab, Matple, Lab View, C / C + +, Java*
IV	*Inventika*	*15 – 18*	*Produce new specific applications and/or objects*
V	*TeachingMaths using cartoon*	*7 – 18*	*Produce new specific drawings, cartoons or magazines, with various mathematical topics*

A successful one of these, Maths oriented, is the International on-line Competition "MATHEXPERIENCE" (MATHEXPERIENCE, 2011, II nd Ed.). Its declared goal is to make the students come closer to learn creatively Maths, Physics, Chemistry, Biology and to realize that "Matematica is magistra vitae", stimulating desire to enjoy, desire to create and innovate, pleasure to compete, desire to win. This Competition has an on-line, one day multi media final presentations session, accessible to all participants through Microsoft Live Meeting technology. There are awarded prizes to students, offered by sponsors and diplomas to their coordinating teachers (diplomas valuable for their professional files).

In 2011, there are have participated ~ 110 teams (~ 400 participants) from more than 40 partner schools and children clubs in Romania, Croatia, Serbia and Greece.

The Society of Mathematical Sciences, The Institute for Mathematical Research "Simion STOILOW" and the Faculty of Applied Sciences of the University „POLITEHNICA" in Bucharest are partners in this project as well a few multi national companies and non governmental organizations.

The topics of the contributions are chosen by students, under the guidance of the coordinating teachers. During their on-line presentation in the virtual conference, the teams present and explain why they have chosen the respective topics to create a presentation, a program, an application, an object or respectively to draw a story in order to make one or more of math chapters more funny in the teaching and how they managed to do it. The format of each contribution is at choice, but the presentations are recommended to be in Power Point, for middle school students.

The MATHEXPERIENCE contest is accompanied by a Symposium, preceding the contest, where there are discussed topics of interest, including ones like those approached in this paper. The Symposium is a good opportunity to speak about educational methods and to come with new ideas, to exchange expertise. There are introduced to the participants new Internet products or new opportunities for national and international exchanges and competitions for teachers and pupils.

Always asking students to solve problems whose solutions are not published or to find and solve problems facing their community and organizing frequent creative and distractive competitions on Science topics may contribute to increase the role of Science Education by creative learning.

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QUANTUM MECHANICS' VS CLASSICAL PHYSICS' MODELLING OF SOCIAL GROUPS BEHAVIOURS

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Abstract. *Physics, by its wealth of knowledge, is being expanding in modeling and in explaining social group behaviours and their relationships. The authors have identified social groups (parlamentarians, judges) where relationships are mainly governed by Quantum Mechanics type rules, having some privileged positions and extended duties within the society they belong, society where there are mainly applicable Classical Mechanics type rules. The authors forecast that among Classical Mechanics type Groups and Quantum Mechanics ones my appear conflicts of interests, all groups having the tendency to enlarge their rights and diminish their obligations. The authors exemplify with the current situation in Romania, stressing on the neccessity that Physics Education may empower students, as participative citizens, with such knowledge, to be used creatively.*

1. Introduction

The newly got knowledge on Mechanics principles, both Classical [1] and Quantum [2] ones, at the introductory level, got by almost all school students, would be useful to them in understanding some characteristics of behaviors of different social groups, eventually of possible conflicts of interests to arise among them, offering large area of debate between students, allowing and stimulating creative social approach and helping them to become responsible citizens.

In a previous HSCI paper [3], with the aim to improve the efficiency of teaching and learning Physics in school, the authors have suggested to introduce into the Physics synopsis, at each chapter, a paragraph illustrating the application of the just learned Physics knowledge not only in different traditional scientific and engineering fields, but, too, in non-physics fields, in Economics, Sociology, Law, Politics, depending of the profile and level of the school implied and of the interests of the pupils or students attending the Physics course.

In this paper, there are given examples of modeling two types of social behavior through Classical Mechanics (CM) Newton's laws and respectively, Quantum Mechanics (QM) basic principles.

2. Classical Mechanics laws studied in school

Usually, from Classical Mechanics, students remain with the three Newton's laws of motion [1], laws describing the relationship between the forces acting on a body (considered as a material point or of continuous distribution) and its motion due to those forces:

$$\sum \mathbf{F} = 0 \Rightarrow \frac{d\mathbf{v}}{dt} = 0. \qquad \text{I}$$

$$\mathbf{F} = \frac{\mathrm{d}\mathbf{p}}{\mathrm{d}t} = \frac{\mathrm{d}(m\mathbf{v})}{\mathrm{d}t}, \qquad \text{II}$$

$$\sum \mathbf{F}_{a,b} = -\sum \mathbf{F}_{b,a} \qquad \text{III}$$

I[st] law: Every body persists in its state of being at rest or of moving uniformly straight forward, except insofar as it is compelled to change its state by force impressed This law, called the law of *inertia*, states that if the resultant force (the vector sum of all forces acting on an object) be zero, then the velocity of the object be constant.

II[nd] law: The net force **F** on a particle is equal to the time rate of change of its linear momentum **p** in an inertial reference frame. Thus, the net force applied to a body produces a proportional acceleration. Consistent with the first law, the time derivative of the momentum is non-zero when the momentum changes direction, even if there is no change in its magnitude; such is the case with uniform circular motion. If its mass m be constant, acceleration **a** of a body be parallel and directly proportional to the net force **F** applied and inversely proportional to the mass m of the body (i.e., **F** = m**a**, for constant mass).

III[rd] law: To every action there is always opposed an equal reaction. When there are these mutual actions of two bodies upon each other, the actions are always equal in intensity but directed to contrary parts, where $\mathbf{F}_{a,b}$ are the forces from B acting on A, and $\mathbf{F}_{b,a}$ are the forces from A acting on B. The changes made by these actions are equal, not in the velocities but in the motions of the bodies. There is supposed that the interacting bodies are not hindered by any other impediments (no external actions present). The Third Law means that all forces are interactions between different bodies, and thus that there is no such thing as a unidirectional force or a force that acts on only one body. This law is sometimes referred to as the action-reaction law, with $\mathbf{F}_{a,b}$ (F) called the "action" and $\mathbf{F}_{b,a}$ (−F) the "reaction". The action and the reaction are simultaneous. Simultaneity of action and reaction with the implied time constant is to be understood within the time constant corresponding to the preservation of the stability of the concerned system.

The same is valid for the momenta of forces with respect to a point and for other interactions. The physical nature of the reaction force is identical to that of the action itself: if the action is due to gravity, the reaction is also due to gravity. The dimensional equations of the action and reaction are the same. There is to be asked the dimensional check of the homogeneity of the relationships used or established during solving a problem and the analysis of the symmetries existing in the considered system.

In high school Physics, one, usually, starts from the laws of conservation of momentum, energy, and angular momentum which are of more general validity than Newton's laws, since they apply to both light and matter, and to both classical and non-classical physics. Newton's laws have been verified by experiment and observation for more than 200 years. They hold to a good approximation for macroscopic objects and large groups of small objects under everyday conditions, but are inappropriate for use in certain circumstances, most notably at very small scales, very high speeds or very strong gravitational fields.

The CM laws may model many non physical phenomena. They might have there some characteristics different from those of the genuine physics laws but not affecting them, essentially. The time constant might be different; the nature of the reaction might be also different, f. e.: if the action means expenses (money) the reaction would mean income (money), if the action means more rights, the reaction would mean more obligations (or restrictions), if the action mean larger immunity for smaller responsibility, reaction would mean less immunity for larger responsibility.

Because these CM laws are not and eventually, could not, be completely checked in non-physics applications, the authors will refer to them, in the next part of this paper, as "postulates". In some cases they might be considered even as "principles".

For educating responsible citizens, there is important to teach pupils to try to be inventive, creative in observing the postulates, not in finding ways to infringe them. The observation of the postulates is essential in ecological education of pupils,

The "problem solving" and "solution oriented" approaches might be introduced in teaching Physics by applying the previous postulates to model social behavior, through emphasizing the gains of such approaches as the result of mastering the postulates.

The quantitative approach for the average values is to be completed with a quantitative estimation of the qualitative approach of errors. Usually, the goal is to minimize uncertainty and hence the error to the lowest extent, affordable and acceptable in the respective field of application. The mastering of errors together with developing abilities for measuring will make easier the process of modeling non physics phenomena, eventually, later on, of preparing, passing, granting and implementing the human (judicial) laws.

The checking of the dimensional homogeneity of the relationships modeled will help more the explanation, the understanding and the interpretation of those modeled relationships.

3. Quantum Mechanics basic knowledge got in school

Quantum Mechanics, developed during 1920', to explain the behavior of small objects, is introduced to the students in the last year of the middle school. May be students would understand and retain at least, some principles and conclusions of QM:

1. The description of nature is essentially probabilistic, with the probability of an event related to the square of the amplitude of the wave function related to it (Max Born), the wave function representing an observer's subjective knowledge of the system (Werner Heisenberg). The reciprocal influence of observer and the observed body could not be evaluated. Unlike Classical Mechanics, in Quantum Mechanics, there is no naive way of identifying the true state of the world. The wave function that describes a system spreads out into an ever larger superposition of different possible situations. During observation, the wave function describing the system collapses to one of several options. If there is no observation, this collapse does not occur, and none of the options ever become less likely.

2. It is not possible to know exactly the values of all the properties of a system at the same time (Heisenberg's uncertainty principle). Whenever a particle is localized in a finite interval $\Delta x > 0$, then the standard deviation of its momentum, Δp, satisfies the equation:

$$\Delta x \, \Delta p \geq \frac{\hbar}{2}$$

where ħ is the reduced Planck constant ($\hbar = h/2\pi$=1.05457 10^{-34} J.s). Contrary to CM, in QM one can never make simultaneous predictions of conjugate variables, such as position and momentum, energy and time, with accuracy. Both predictions cannot be simultaneously done to arbitrarily high precision. In other words, the more precisely one property is measured, the less precisely the other can be controlled, determined or known.

3. Matter exhibits a wave–particle duality. An experiment can show the particle-like properties of matter, or the wave-like properties (Louis de Broglie); in some experiments both of these complementary viewpoints must be invoked to explain the results (the complementarity principle, Niels Bohr).

4. Quantization of some quantities (energy, angular momentum) is accepted. The photon (Planck, Einstein) is familiar to students.

5. The energy at ground level in the QM may be different of zero. In CM it is always zero.

6. Measuring devices are essentially classical devices and they measure only classical properties such as position and momentum.

7. The quantum mechanical description of large systems will closely approximate the classical description (the correspondence principle, Bohr and Heisenberg)

In the following, there are given examples of laws and principles of Classical and Quantum Mechanics (some previously developed by the authors, accessible to students, which may be applied as postulates, to identify, characterize and suggest how to better know and model social behavior and eventually, master it.

4. Examples of modeling social behavior through postulates derived from Newton's laws

4.1. The I^st^ law of CM, the law of inertia is present since antiquity in Sociology as *Status quo ante,* (Latin for "the way things were before"). In law, it refers to the objective of a temporary restraining order or a rescission in which the situation is restored to "the state in which previously" it existed, if the external influence does not more exists. It may also refer to: Status quo ante bellum, "the way things were before the war" or Reset button technique, a technique in fiction writing. An example of other possible application of this postulate is the legal institution of "prescription (F and Latin)", *f. e. – Usucapio constituta est ut aliquis litium finis esset* -. Prescription was established so that there be an end to lawsuits. *Praescriptio est titulus ex usu et tempore substanniam capiens ab auctoritate legis.* Prescription is a title by authority of law, deriving its force from use and time. Both examples imply that something may not be changed in present status, because of no action, during the established lap of time, similar to the inertia law.

4.2. The II^nd^ law implies causality.

4.2.1. Causality is the relationship between an event (the *cause*) and a second event (the *effect*), where the second event is a consequence of the first, in the special situation when antecedence (which usually postulates that the cause must be prior to, or at least simultaneous with, the effect) is reduced to simultaneity, understood as before. Cause and effect (corresponding to force and acceleration) are typically related to events, but candidates quantities in Sociophysics include objects, resources, processes, properties, variables, facts, rights, states of affairs. Contiguity, implied in causality, postulating that cause and effect must be in spatial contact or connected by a chain of intermediate things in contact, is frequently implied.

4.2.2. Proportionality. As a constitutional principle and as a general principle of administrative law, it requires that each

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decision and measure taken be based on a fair assessment and balancing of interests, as well as on a reasonable choice of means. This general meaning of the principle is valid for national law as well for European law, it playing a central role in the case-law of the European Court of Justice (ECJ). The ECJ requires that all administrative acts or decisions and all legislation be in conformity with the general principle of proportionality (like the acceleration and force in CM), whose application is to be tested. The wide range of application of the proportionality principle necessitates certain restrictions when describing its operation in law. In particular, differences in application are visible between proportionality in relation to penalties or financial burdens and proportionality in relation to discretionary policy choices. The general test of proportionality is subdivided in three different tests or requirements. To meet the requirement of proportionality, a measure or decision must constitute an effective means to realize the aims pursued by the measure or decision (test of effectiveness). Further, the measure or decision must be necessary to achieve the relevant aims, which means in particular that no alternative and less intrusive measures are available (test of necessity and subsidiarity). Finally, even if it is clear that a certain act or measure is an effective and necessary means to further legitimate government interests, an act, decision or measure can still be disproportionate if no reasonable or fair balance is struck between the aims pursued and the interests harmed (test of proportionality in the strict sense or proportionality *stricto sensu*).

When conditional equality is approached in Law, the similarity with the the IInd law is evident, f. e. "*On equal work with men, women shall get equal wages*", or "*No one shall be expropriated, except on grounds of public utility, established according to the law, against just compensation paid in advance.*"

4.2.3. Sometimes, in Law, there are limits to this II nd law, f. e. *"Justice shall be one, impartial, and equal for all"* [4, Art. 124.3]; no external force upon Justice is accepted.

4.3. In the IIIrd law, of action-reaction, **causality** is included.

4.3.1. *Karma* treated in Hindu, Jain, Buddhist and Sikh philosophies, means "deed" or "act" and more broadly, names the universal principle of cause and effect, action and reaction that governs all life. According to the Vedas, if one sows goodness, one will reap goodness; if one sows evil, one will reap evil. *Karma* refers to the totality of our actions and their concomitant reactions in this and previous lives, all of which determines our future. The conquest of *Karma* lies in intelligent action and dispassionate response.

4.3.2. Hegel's dialectic principle of unity and conflict of opposites (contraries) stated in his "Science of Logic", an other example of the validity of Physics action-reaction postulate, was seen by Hegel as the central feature of a dialectical understanding of things and originates from the ancient Ionian philosopher Heraclitus from Efes.

4.3.3. The general Hegelian principle of philosophy of history that is the development of the *thesis* into its *antithesis* which, by the *Aufhebung* ("*synthesis*"), may be also connected with this postulate of action-reaction. The *Aufhebung* conserves the thesis and the antithesis and transcends them both.

4.3.4. The law of demand and supply and many other laws in economics [5] are example of action-reaction type laws.

4.3.5. In the theories on Law, the rights are always accompanied and conditioned by obligations. The reverse allegation is also valid. The fraud on law is a standard doctrine in most jurisdictions. It reflects the need for governments to prevent their citizens from intentionally and improperly manipulating their behavior (using other law provisions) to prevent mandatory provisions in the law from applying to them, that means for using their rights to elude their obligations, that means to infringe the action-reaction postulate.

4.3.6. The observation of the action-reaction postulate is evident in the major part of provisions of the Constitution of Romania, for example: Art. 138.5 „*No budget expenditure shall be approved unless its financing source has been established*". Now, in EU, there is a tendency to include in

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national constitutions, provisions as to limit the State Budget Deficit to 3% of GNP, the national deficits continuously increasing in the last years because of non observance of action-reaction postulate.

4.3.7. A frequent example of breaking action-reaction law is offered by the requests of the representatives of some groups on behalf of those groups to gain financial and other gains without offering society nothing in return for their demands or at least by indicating where from to take the supplementary required resources. One could mention, f. e., some trade unions during strikes or political parties which, during electoral extended campaigns, to gain votes, demand uncovered budgetary future expenses, which, later on lead to future chronic State Budget Deficits.

5. Examples of modeling social behaviors by using basic Quantum Mechanics knowledge

The authors, considering that quantum correlations play an essential role in social life, tried to identify such possible models originating in QM, to explain to studens features of social world, some of them being shortly presented, in the following:

5.1. Probabilistic distributions are found in sentences given by different courts in quasi-similar situations, sentences which are variable in large limits or in the laws adopted in Parliament at short time intervals, which have different provisions on the same matter, based of change of appreciation or of the mood by the judges or respectively of the MP, not directly justified by the actual situation or evolution of things, representing observer's subjective knowledge of the social system. Each decider is to choose one from the many existing superposed possible solutions. Still, in actual experience, an observer never feels a superposition, but always feels that one of the outcomes has occurred with certainty. The reciprocal influence of the observer and the observed system is difficult to be evaluated in legal processes or when considering the contribution of lobbyists on the adoption of new laws in European and national Parliaments, for example. This may help corruption.

5.2. The action of the postulate based upon Heisenberg's uncertainty is evident when there are analyzed legal provisions on privileges (extended rights) and extended duties of public servants (policemen), magistrates (judges and prosecutors), of ministers and of members of the Parliament, when one consider those privileges and extended duties as deviations (errors) from the standard general human rights and obligations, accepted by the society. One may see, f. e., that larger be the independence and immunity and longer the period of irrevocability, smaller be the area for permission of engaging other activities, than the basic ones [4, Art. 144 and 145]. The major privileged groups are not subject to society direct controls. The judges are independent [4, Art. 124.3 "*Judges shall be independent and subject only to the law"*]. This independence even guaranteed for all justice is [4, Art. 133.1] is not valid for prosecutors [4, Art. 132.1], who are subjected to hierarchical control, under the authority of the Minister of Justice. The legislators are also protected when taken their decisions by the provision of Art. 72(1) „*No Deputy or Senator shall be held judicially accountable for the votes cast or the political opinions expressed while exercising their office*". They are under the political control of the people, at poles, once in 4 years. As regards the Government, it is under a political permanent control of the Parliament: Art. 109 (1) „*The Government is politically responsible for its entire activity only before Parliament. Each member of the Government is politically and jointly liable with the other members for the activity and acts of the Government*".

5.3. A wave–particle duality may be guessed when, in the decision on topics regarding an individual, the deciders act as like both that individual and themselves be implied in large networks of relationships and interests. In some privileged bodies the vote is secret ([see [4], Art. 133.3). The lobby activities are accepted by some parliaments (EP). When a loss for the society is produced by some decisions (discrete ones), usually, such a loss generated discretely is distributed continuously as a burden for all society (which may be regarded as a continuum).

5.4. The privileged bodies have a very small number of individual members and the absence even of one member may change the whole result of the vote, with important consequences for the society at large. The behavior of each decider is to be described by discrete approach not by a continuous one.

5.5. The privileged persons receive an "indemnity" even if they are not present at an activity (or active participant) supposed compulsory, absence which is not payed to laymen. (Energy at ground level in QM is different of zero!)

5.6. Measuring devices for the positions of groups of individuals who decide are essentially classical devices: the resultant published decision, measures only group behavior such as preference: for democracy or totalitarism, for more or less local autonomy a.s.o.

5.7. The quantum mechanical description of large systems will closely approximate the classical description, that may explain that the variations in content of laws on the same topics are smaller than the variations in the individual positions and votes of MP, that the national results at pulls are much less variable than the local results in electoral circumscriptions. Sometimes, special groups are reluctant in accepting statistical control of the society, for example the control of judges through the number of appeals accepted by a superior court, which could improve the judicial activity. Quantum Mechanics may be important for understanding how individual deciders combine to take decisions.

The groups in a society, which have larger rights (privileges) by also larger duties, generate in that society frictions when the society try to increase the control on those groups privileges and duties, the groups trying to increase there privileges and reduce their duties simultaneously. F. e. the magistrates in Romania, are mostly reluctant to accept many proposals of the Ministry of Justice (June 2011) to change the laws 303/2004 - regarding the privileges and duties of magistrates and 317/2004 - regulating the activity of Superior Council of Magistracy. One may see [12, 13] the opposite positions of magistrates which ask more privileges without new duties and of the society at large, to which they belong (through the Ministry of Justice and NGOs) which embraces an opposite intention.

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DECLINING INTEREST OF STUDENTS IN CAREERS IN SCIENCE AND ROLE OF SCIENCE COMMUNICATORS

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Abstract. *India has nearly 49 million graduates and about a quarter of these have a background of science. Most of the people think that science is all about derivations, equations and formulas and probably such a mentality is responsible for declining interest of science in young generations. Youngsters move in accordance with the changing trend. Business Process Outsourcing (B.P.O), Aviation, Radio stations, Management, Retail, Finance, Banking and Media has its place amongst trendiest career options whereas in comparison to all of them Science has taken a backseat. Even if students chose science for their higher studies, it is just to get a highly paying job in some multi-national company. Very few students plan to opt science with a mission to explore it and make researches in it. Inadequacies in the policies of the government, negligence of its importance by the political parties and social organizations etc. have accelerated the decline. This trend of non-science carrier prospects needs to be elucidated for growth of India by finding effective strategies for strengthening science education. Science must be given an attractive makeover so as to make it look worthy as a career option. Concept of career opportunities in the field of science must be made clear where science communicators, parents, teachers and government play a vital role. This paper work throws a light on how to cope up with this declining interest of science amongst student and the scope in science. It also discusses the root cause of declining interest in science, role of science communicators, parents, teacher, government to cultivate interest of science in children and creative ways to communicate science in rural areas.*

SIMPLE IMPLEMENTATION OF PARALLEL ALGORITHMS IN JAVA SIMULATIONS

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Abstract. *We describe how we have integrated the Parallel Java library (http://www.cs.rit.edu/~ark/pj.shtml) into the Easy Java Simulations modelling and authoring tool (http://www.um.es/fem/Ejs) in order to simplify the creation of parallel simulations in Java that run in shared memory multiprocessor desktop computers.*
We show examples of how the implementation of parallel algorithms in computational-intensive simulations is both easy and effective to speed up the programs.

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Abstract. *The Portuguese version of National Geographic magazine of August 2010 had on the chapter "Wide Angle" an article on "Science and Heritage". A short text referring to the art of fresco mural painting highlighted the scientific component which was associated.*
The Hands-on Science project called "Fresco Alkimiya" was developed in "Colégio Internato dos Carvalhos" with a multidisciplinary nature, with the participation of 33 students of Chemistry, Quality and Environment (13), Arts and Industrial Arts (7) and Heritage and Tourism (13).
The methodology used to start up the project included the research on the technique of fresco mural painting, original materials used in the execution of this artistic style and motivation / inspiration of the performer for its production in the past centuries.
In addition to the cognitive and social-emotional components, there was the body psychomotor component, opting for the production of a whole set of materials that allow the execution of art pieces painted on a panelwith the application of natural pigments on a panel built in hydraulic lime.
The release of this project had its main objective in the contribution to the knowledge of the activity of conservation and restoration of artistic heritage often called a "FRESCO". This project is mainly a demonstration of the ability of application. The importance lies in the scientific study of the pigments that were used at the time as well as construction and constitution of the materials that the walls and ceilings were made of, the same ones that would support the artist's inspiration and detail.
The frescos are included in the area of painting art known as mural painting. They've never lost an important social function, for it was through these records that some known biblical references were passed, indicationsabout the life and work of important personalities, characteristic economic activities of the people of the region where the fresco was produced or

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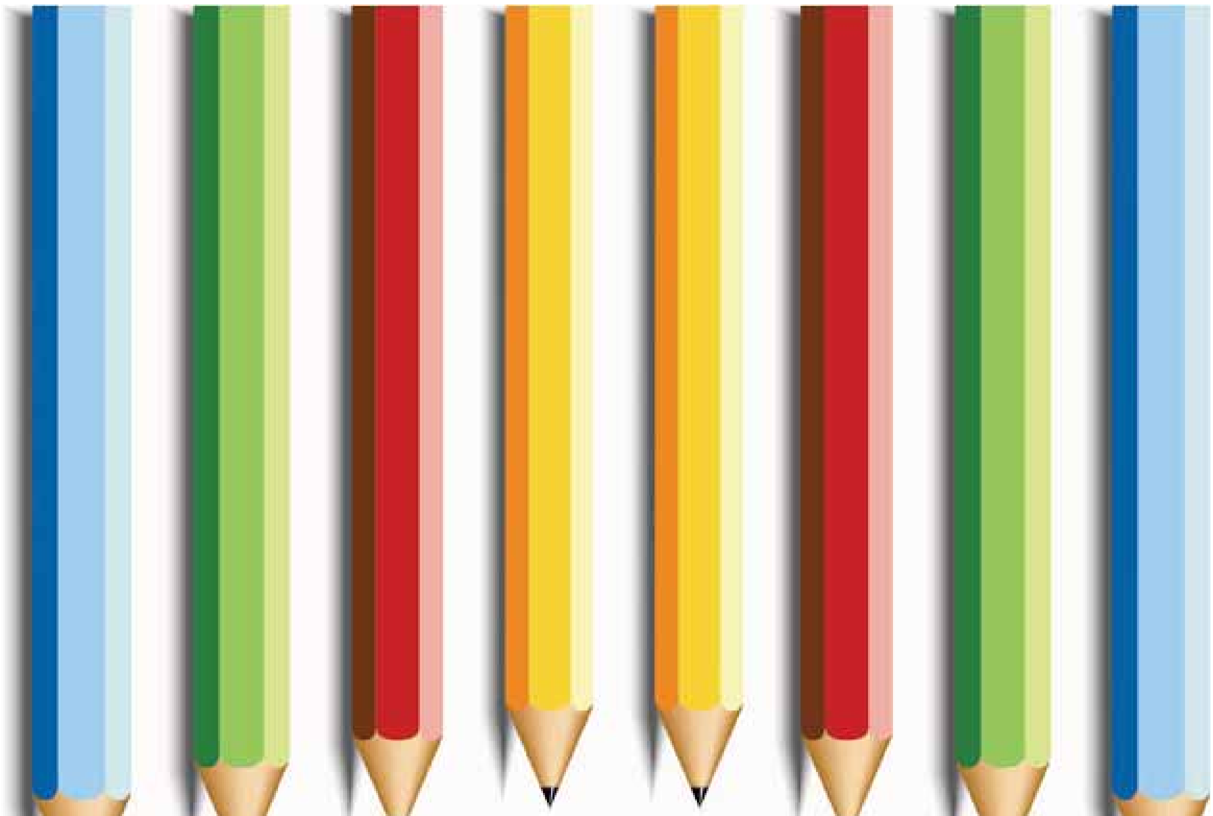
the graphic report of historical decisive battles that characterizedsome independent nations.

There are reports of frescos in Portugal for many centuries. They reflect well a golden period of the art of painting using natural elements - colored pigments made of minerals and rock sediment with which the artists of their time were able to deal so peculiarly to obtain authentic masterpieces. It is this rich heritage of fresco paintings and murals that needs to be preserved and to be published to all who visit us.

It is very common to hear "It's one thing to be an artist and another to be an art critic." Shall we then say: one thing is to be an artist another is be a researcher / scientist of art! We will say even more: a shared project is a participated project!

Science Teaching and Learning



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KIDS UNIVERSITY AND THE FAIR OF NATURAL SCIENCE IN OLOMOUC

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Abstract. *The experiment in physics teaching and learning is the most important medium and teaching subject. In our opinion students are motivated by curiosity and wonder during the lessons. A good understanding of the problems can be also a way how to motivate children for science. With untraditional and outdoor activities we can show that science can be fun and understandable. The fundamental way out is the students activity. Science programs cannot exist without hands-on beacause hands-on means learning by doing. The most popular activities at the Faculty of science in Olomouc will be presented –The Fair of Natural Sciences, The Kids University, and The Kaleidoscope of Physics.*

1. Introduction

The traditional school environment is not able to concern in science subjects such as physics, chemistry, technique. The content is comming of the students practical life and they cannot see the signification of knowledge acquired in school subjects. Developing a functional understanding of physics is one of the most difficult challeges faced by students. Many different studies have shown that there exist a lot of misleading conceptions about the nature and physics phenomena - misconceptions which many students have. Children develop their own ideas about the physical world, ideas that reflect their special perspectives. These misconceptions are extremely hard to change (Holubová 2007). These strong beliefs and intuitions about common physical phenomena are constituted by previous personal experiences and affect students' interpretations of the world. Research has shown that traditional instruction does very little to influence students' "common-sense" beliefs (see for example Driver, 1994, Holubová 2007) This is one of the reasons for changing the way of instruction in physics and science from the early childhood.

New trends for more attractive environment based on the own activity of students come into live – the constructivist approach. In a constructivist classroom students construct their knowledge on thein own.

It was found out that students are motivated by curiosity and wonder during the lessons. A good understanding of the problems can be also a way how to motivate children for the study. With untraditional and outdoor activities we can show that science can be fun and understandable. The aim is to bring the school environment and activities closer to students experience and the problems of practical life, technique, work, employment. It is necessary to show the application of knowledge in technique because technique, technology and physics are not the same but they cannot exist without each other. The fundamental way out is the students activity. It means not only asking and answering their own questions but the practical activities by taking the things in hand.

As it was mentioned above, hands-on learning is learning by doing. Our opinion is that this is the right way how students can directly observe and understand science. As students develop effective techniques of observing and testing everything around them, they learn the *what*, *how*, *when*, and *why* of things with which they interact (Heureka 2011). A hands-on approach requires students to become active participants instead of passive learners who listen to lectures or watch films – it is the most important outcome of the constructivist classroom. The term hands-on can be also related to the use of manipulative materials. The concept of hands-on science is predicated on the belief that a science program for elementary children should be based on the method children instinctively explore to make sense of the world around them. Science must be experienced to be understood. (Behrendt&Schlichting 2000).

Because further students´ learning in physics should include creating competences that contain skills developed in laboratory activities, hands on experiments will be important for physics education. They can help to create preconcepts for competences containing indoor so as outdoor experimental work. Students must construct their own understanding of physics ideas. This knowledge cannot be transmitted by the teacher, but must be developed by students in the interactions with nature and technique. The competences will be achieved when laboratory work, project and field work so as outside work are included and well integrated in learning and teaching physics.

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2. Hands on activities at the Faculty of Science in Olomouc

2.1. The Fair of Chemistry, Physics and Mathematics

This activity has been organized since 2000. At the beginning it was a part of the project called Bambiriada – a way how to point out The International childrens´ Day celebrated on June 1st. The fair was held on the main square of the town. The subtitle was „Motivation for Science with simple experiments for young and old". Nowadays the fair became very popular, one fair is held at the Faculty of Science in Olomouc, the other one that is organized by our department takes place in Uherske Hradiště,a town about 70 km far from Olomouc. Experiments are presented by various departments. In the morning a lot of school classes come to visit the fair and to play with the experiments. In the afternoon the fair is open for the public, everybody who comes can play - parents, grandparents, and friends. The trade fair is an inspiration for teachers and for students too. In the physics teacher programme at our department outdoor activities are included. Each student – pregraduate physics teacher - has to prepare experiments for the public within this framework.

The most popular experiments: soap bubbles, optical illusions, tornado in a bottle, Cartesian diver, experiments with candles and plastic bottles, angular momentum experiments – turning table and a bicycle wheel, experiments with coins, Bengal light, problems with sucking, paper in physics, simple experiments in acoustics, experiments with liquid nitrogen, chinese spouting bowl etc.

2.2. Kids University

This unique project started at our faculty four years ago. The idea was to promote public understanding of science – in this case of physics, chemistry, biology and mathematics. The originality of the project is the cooperation of the Moravian theatre in Olomouc. The main part of the presentations take place at the theatre, so that each lecture consists of the presentation of science problems, and the second part which is in the competency of the theatre. Kids are for example invited behind the scenes of the theatre. They can see how a performance must be prepared – from the sewing of theatrical costumes, manufacturing of properties, to the opportunity to see how a make-up room looks like etc. The kids are about 10 years old. The capability of the university class is about 100 children. The presentation on the stage in the theatre has some advantages – for example properties and costumes from the theatre can be used. The web-pages of the Kids University you can find at http://www.projektmedved.eu /udv.php.

The project is unique in the cooperation of the university and the theatre. Children have an opportunity to learn a lot about science and culture too. The university runs in a two semester period. The first semester consists of eight lectures, the second one is an on-line chat in mathematics, physics, biology and geography.

Figure 1. *From the trade fair*

Most popular presentations: physics in the kitchen, heart - the world´s champion, fairy tale about fire and water, bones can speak, the secrets of islands.

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2.3. The Kaleidoscope of Physics in Olomouc

The Kaleidoscope is a one day workshop for interested high school students. It consists of lectures, experiments and excursions into research laboratories of the Departments of Experimental Physics, Optics and the Nanotechnology centre. Lectures are focused for example on astronomy, metrology, quantum optics, nanotechnology, biophysics - plants and stress. One (very popular part) is the presentation of simple low-cost and high-tech physical experiments http://kaleidoskop.upol.cz/ the presentations and lectures are changed every year. The only part of the kaleidoscope that is held annualy are hands on experiments.

Figure 2. *Kids university – physics in the kitchen, heart – the champion*

Conclusion

Students' motivation plays a key part in innovations of educational strategies and methods. We can apply many motivational approaches during science teaching and cognitive motivational teaching methods have an important status among them. An application of school experiments, especially simple experiments, is one of the most important motivational method. An experiment has the principal function for research in experimental and theoretical science. Science experiment is an artificial natural phenomenon in controllable conditions with an objective to recognize a natural law, not discovered yet, what the natural phenomenon is followed by.

Students' activity during simple experimenting is the next basic characteristics of a simple experiment. Simple experiments should be realised and demonstrated by students themselves. From the view of constructivism, there is a need to use students' preconceptions, created by an independent spontaneous experimenting. Simple experiments therefore have to be easily feasible.

In physics teaching and learning various types of experiments can be used. The experiment has a central position in physics education. It can be a hands on experiment, a traditional experiment, a computer based experiment or a remote laboratory. Very useful seems to be computer based experiments with dataloggers that can be used in classrooms so as during outdoor activities. The importance of hands on experiments is based on our research and on our opionion. Hands on activities are the most important way to develop students handling skills, communication and cooperation competences. Learning by doing is effective and motivational. And as we can see hands on experiments are significant in science education at all school levels.

Figure 3. *Kaleidoscope*

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Modern-day and future science will increasingly demand on specialised proficiency from scientists, coupled with an ability to work with other scientists outside their own expertise. A natural consequence of this specialisation within interdisciplinary teams is that future scientists will have to rise to the challenge of explaining their science in ways that other scientists and non-scientists can understand. Chemists will have to engage with psychologists, molecular biologists with nanotechnologists, and neuroscientists with economists, until the edges between the disciplines are blurred. Even with the introduction of new technologies, communication and interpersonal skills will be more important than ever.
The scientist of the future will need to be equipped to ask the right questions and to find the right answers.
Our opinion is that the low level of positive attitude towards the science throughout society is why science education needs powerful innovations of strategies and teaching-learning technologies. Activities described above will help us to find the right way of innovation. Our projects and innovations in science education and new teaching strategies will help us to change and increase the impact of science.

Acnowledgements

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THE CASIMIR EFFECT: A MULTIMEDIA INTERACTIVE TUTORIAL

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Abstract. *In this work we describe a multimedia tutorial on the Casimir effect, integrating some freely available internet resources with originally developed interactive illustrations. The tutorial, appropriate for high school and university undergraduate students, provides them with a comprehensive overview on different aspects (historical, physical, technological) of the phenomenon. In particular, a qualitative explanation of the Casimir attraction force is given by interactively illustrating some classical analogs, such as the "attraction" between ships lying close together, or among beads strung on a vibrating wire. Furthermore, this tutorial permits to explore the relevance of Casimir effect both in technological (nano-machines) and in biological (e.g., red blood cells stacking) nano-world.*

1. Introduction

In 1948, at Philips in Eindhoven, researchers who studied the properties of colloidal solutions ran into some "anomalies" of the van der Waals forces.

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Examining this issue, Endrik Casimir realized that those experimental observations could be explained by a quantum electrodynamics property: quantum “vacuum” is not “empty”. On the basis of this intuition, Casimir worked out a detailed theoretical model of the behavior of two electrically neutral conductive plates placed very close each other, concluding that they should attract (Casimir 1948). Since the interaction force depends on the inverse fourth power of the distance between conducting surfaces, the Casimir effect becomes important only on very small scales: this is the reason why it didn’t have much practical significance for several decades. With the advent of nanotechnologies, however, the Casimir effect has assumed great importance, since on the nano-scale it becomes the leading interaction, giving rise to “sticking” phenomena which pose serious limitations to the feasibility of nano-machines.
A satisfactory quantitative treatment of the Casimir effect is far beyond the reach of secondary school students or undergraduates. Nevertheless, since this phenomenon is based on (quantum electrodynamics) wave’s properties, its main characteristics and practical implications can be well understood by starting from significant classical analogies involving wave systems, providing one assumes that quantum vacuum is filled with electromagnetic waves of various wavelengths depending on boundary conditions on the considered region of space. In this connection, we have developed an interactive tutorial on the Casimir effect, appropriate for secondary school or university undergraduate students, providing them with a comprehensive overview on different aspects (historical, physical, technological) of the phenomenon. In particular, a qualitative explanation of the Casimir attraction force is given by interactively illustrating some classical analogs, such as the “attraction” between ships lying close together, or among beads strung on a vibrating wire. Furthermore, this tutorial permits to explore the relevance of Casimir effect both in technological (nano-machines) and in biological (e.g., red blood cells stacking) nano-world.

2. The Casimir effect in a nutshell

"Ex nihilo nihil fit" is a Latin well-known motto dating back to Melisso (a disciple of Parmenides and Lucretius), among others taken from Shakespeare, who puts it in the mouth to the old King Lear.
"Nothing can come from nothing" ... Or at least it was so until the birth of quantum physics (and in particular, quantum electrodynamics). The picture of nature established in the last century envisages that the VOID (i.e., the classical – non-quantum - “nihil") is a noun that is not appropriate to itself in the form of an adjective: The vacuum is not empty! For quantum physics, in fact, it is full of very ephemeral particle/antiparticle pairs; the more ephemeral the higher their energy. The key to understanding the reasons for this phenomenon (which is so in contrast with the common sense developed in more than two millennia of Greek-Roman-Jewish-Christian thought) is the uncertainty principle, due as known to Heisenberg, at least in its original form. This law of nature puts a constraint on the possible values taken by particular couples of physical quantities. One of these pairs is constituted by energy and time, in which case the uncertainty principle essentially says that in the simultaneous measurement of these two variables we must have:

$$\Delta E \cdot \Delta t \geq \hbar/2 \qquad (1)$$

where the quantities on the left side are, respectively, the energy and time uncertainties, while the right side is half the reduced Planck constant – a very small number of the order of 10^{-34} in S.I. units. The practical meaning of previous formula, in the present context, is that a couple particle/antiparticle can come into existence from “nihilo” (i.e., from nothing), provided that it disappears before the time interval $\hbar/(2\Delta E)$ has expired.
The same applies to the creation of photons. In other words, the Heisenberg principle allows you to borrow energy from nothing, as long as it comes back soon. How soon? The sooner the greater the amount of energy from nothing, following eq. (1)! This means that it is possible that photons can be created from a vacuum (called "virtual photons") which immediately disappear in the "nothing". This phenomenon is not directly observable, however, it has many consequences that may be - and were - experimentally verified. These include the Casimir effect consisting, in its simplest version, to the fact that two conductive plates electrically neutral, placed parallel to face each other in a vacuum at a distance of the order of nanometers, mutually attract with a force inversely proportional to the fourth power of the distance between them.
Let us now consider such a system of plates (Fig.1). The space around and between the plates is swarming with ephemeral (“virtual”) photons. Due to the wave/particle complementarity principle of Quantum Mechanics (Feynman et al 1964) these photons can also be viewed as electromagnetic

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waves, which – as all kind of waves – are subject to limitations imposed by the presence of (conducting) border surfaces: the so called "boundary conditions". In particular, in the space between plates, only those waves can exist whose half-wavelength is a submultiple of the inter-plates distance; while outside the plates this limitation doesn't apply (Fig.1). In this way, the energy density of the electromagnetic field outside the plates is greater than that between the plates. The same way behaves the pressure, which is proportional to energy density. This unbalanced pressure results in a net force of attraction between plates: this is the Casimir Effect.

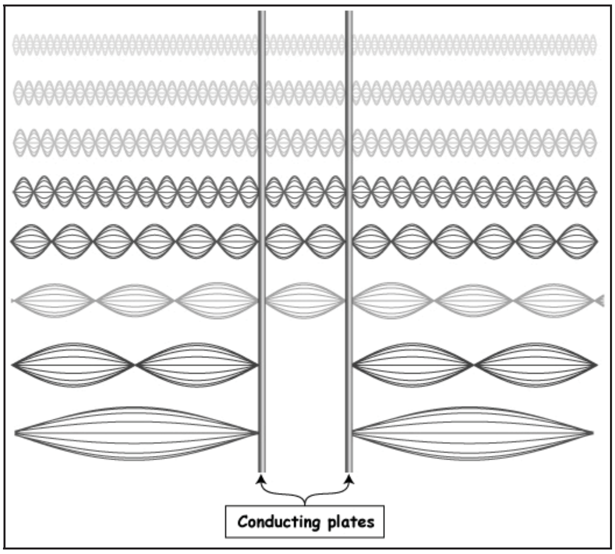

Figure 1. *The effects of the boundary conditions on the electromagnetic field in presence of two conducting plates. Between the plates only a fraction is allowed of electromagnetic waves existing outside. This gives rise to an unbalance in electromagnetic pressure, which is greater outside than inside: the plates seem to attract each other.*

3. The tutorial

The proposed multimedia tutorial[1] is designed to help people understanding the quality characteristics and origin of the Casimir effect, a phenomenon that almost of no practical interest to a couple of decades ago, is taking on a whole new importance with the development of nanotechnology. In fact, since Casimir force is *inversely proportional to the fourth power* of the distance between interacting objects, it becomes rapidly dominant as dimensions decrease.

The tutorial, developed using web-oriented technologies, may be used with any web browser and articulates in two main sections, each divided in turns in three sub-sections, all accessible from a main page (Fig.2).

The narrative form of the tutorial provides for a teacher guiding students through the learning path (Fig.3). The main sections correspond, respectively, to *physics* and *technology* of the Casimir effect, and their content is the following:

3.1. "Casimir effect": the physics section

The section consists of three subsections dealing with various aspects of the Casimir effect physics, at a level of difficulty suitable to undergraduate students:

- "PHENOMENON". A description of the basic phenomenology is given, together with a comparison of quantum and classical point of view regarding the Casimir effect.
- "HISTORY". The historical path, leading to the prediction of the phenomenon by Casimir, is illustrated in the context of research activities at Philips Research Laboratories in Eindhoven. The conceptual link with van der Waals forces is also outlined.
- "EXPLANATION". A qualitative interpretation of the Casimir effect is illustrated in terms of allowed oscillation modes for the electromagnetic field in presence of two conducting plates.

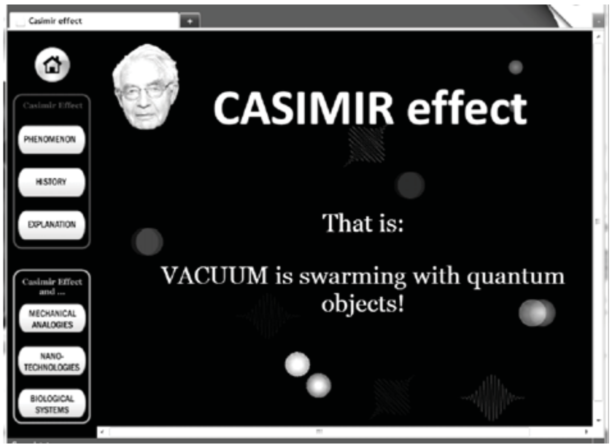

Figure 2. *The main page of the tutorial, from which one can navigate through the various sections using buttons on the left side of the window. In the black portion of the window under the title, a continuous animation illustrates pictorially the "swarming" of particles pairs and photons in the quantum vacuum.*

3.2. "Casimir effect and…": the technology section

This section also consists of three subsections dealing with technological relevance of the Casimir effect and its (classical) mechanical analogies. This

[1] Available at the URL: http://www.fis.unical.it/didattica/mptl16/casimir

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last topic, in particular, contributes to provide learners with further insights on the phenomenon understanding.

- "MECHANICAL ANALOGIES". In this subsection are interactively illustrated two classical mechanics analogies of the Casimir effect, such as the apparent "attraction" between: i) beads strung on a vibrating wire (Fig.4) (Griffiths 2001); ii) two ships lying parallel each other, close together on a wavy sea surface (Boersma 1996).
- "NANOTECHNOLOGIES". An overview is given on the relevance of the Casimir effect on the nano-world technological applications, with particular emphasis on "sticking" phenomena affecting nano-devices.
- "BIOLOGICAL SYSTEMS". An overview is given of the possible relevance of the Casimir effect on the nanoscale of biological systems, such as stacking phenomena among red blood cells.

Figure 3. *A virtual teacher guides the students through the tutorial learning path*

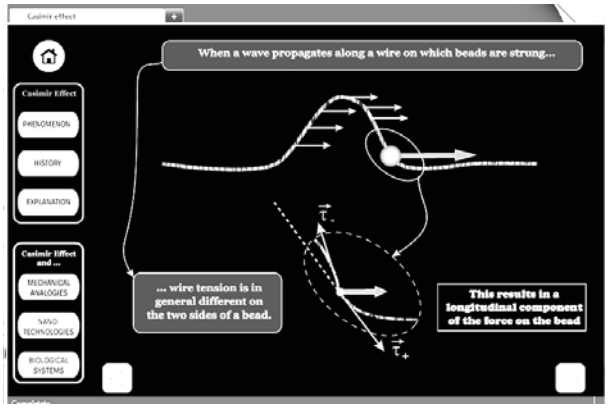

Figure 4. *Snapshot of the animation explaining a mechanical analog of the Casimir effect: beads strung on a vibrating wire seems to attract one another.*

4. Conclusions

In this paper we present an interactive multimedia tutorial, implemented by using web-oriented technologies, aimed to introduce the Casimir effect in a qualitative way suitable for high school and university undergraduate students. The tutorial gives a comprehensive overview of the phenomenon, at an elementary level, focusing on different aspects, such as historical, physical and technological. In particular, the interactive illustration of some classical mechanics analogs of the Casimir effect (the "attraction" between ships lying close together on a wavy sea surface, or among beads strung on a vibrating wire) helps learners to get a qualitative understanding of a phenomenon constituting a direct bridge between quantum field theory and the macroscopic world. A section of the multimedia is devoted to give an overlook on the technological applications and implications of the Casimir effect in the relevant field of nanotechnologies.

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OVERCLOCKING: A HANDS-ON EXPERIMENT IN INFORMATION TECHNOLOGY TEACHING

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Abstract. *This paper will discuss overclocking in broad educational context to find its niche in IT curriculum. The stability of a PC (CPU – Intel Core 2 Quad Q8300 2.5 GHz, motherboard – Abit iP35, RAM – DDR2-800) was explored in three different modes using benchmarks: 3DMark 2006, PCMark Vantage and 7-Zip. Commenting on overclocking results encourages students to learn more about PC architecture and benchmark software. Overcloking seems to be more than a thrilling pursuit for computer enthusiasts as it extends users' knowledge and provides a significant educational value for advanced students.*

1. Introduction

In general outline, overclocking is maximizing the performance of a computer through running its components in drastic modes, at a higher clock rate than they were designed for or was specified by the manufacturer. It can be done for processors, video cards, motherboard chipsets, RAM etc.
Several types of overclocking can be distinguished:

- *Quantitative overclocking* involves the increase of frequency, voltage etc;
- *Qualitative overclocking* results in new features of components that were not supported before (e.g. a new application can be run);
- *Physical modification* of a unit enables the parameters which are normally disabled by the manufacturer (e.g. the so-called volt-mod) that may cause harm to a computer if user's skills are not adequate;
- *Optimization* means the adjustment of the CPU multiplier, the motherboard's front side bus (FSB) clock rate, RAM timings and the like.

Different types of overclocking provide different performance benefits. Additionally, the overclocking potential depends on individual features of a specific CPU and other components of a computing system. Successful overclocking requires that a CPU has frequency reserve; a motherboard is designed so that to allow changing a bus frequency, voltages, memory timings and some other parameters. Moreover, a user should have good knowledge of computing systems and patience to plan and complete this time-taking process. Overclocking is an iterative procedure every step of which implies testing functional correctness and stability followed by measuring effects of overclocking and analyzing performance factors. All this definitely contributes in users' knowledge and skill, and overclocking is therefore worth the teacher's attention.

2. Experiment

An overclocking experiment was planned and performed by Pavlo Drevnytskyj, a 6-year student of the Ternopil National Technical University (Ternopil, Ukraine).

2.1. Hardware

The following hardware configuration was used in overclocking experiments:

- Motherboard - Abit iP35
- Processor - Intel® Core™2 Quad Processor Q8300 (4M Cache, 2.50 GHz, 1333 MHz FSB);
- Cooling - Scyte Ninja V2+ Cooler, 120 mm fan dimension;
- RAM - 4x1024 Patriot PDC22G6400LLK DDR2-800;
- Graphics Card - MSI NX 8800 (nVidia GeForce 8800 GT 512 MB);
- HDD - SAMSUNG HD501LJ;
- Power Supply Unit - Chieftec GPS-500-AB A.

2.2. Overclocking method and operating modes

The simplest way to overclock is manipulating the parameters of FSB, CPU and RAM through the BIOS setup menu. To avoid the CPU degradation, all clock rates and the CPU core voltage were interchangeably and independently incremented little by little until a maximum stable operating frequency is reached.
Finally, three operating modes were chosen:

1. Default Mode: CPU - 2500 MHz, FSB - 333.3 MHz, RAM – 800 MHz.
2. Overclocking Mode 1: CPU - 2800 MHz, FSB - 374 MHz, RAM – 748 MHz.
3. Overclocking Mode 2: CPU - 3100 MHz, FSB - 413 MHz, RAM – 826 MHz.

The CPU multiplier is 7.5 in all modes.

2.3. Software

Overclocked computers require to be tested to reveal limit values of characteristics which ensure operation stability and maximum performance enhancement. Pavlo Drevnytskyj used specialized benchmarking software to explore the stability of his PC and to measure the effects obtained in the course of overclocking.

Futuremark 3DMark 2006: 3DMark06 is a PC benchmark suite designed to test the performance of a graphics card. A 3DMark score characterizes the system's 3D gaming capabilities based on multiple real-time 3D graphics and processor tests (Futuremark 3DMark 2006).

Futuremark PCMark Vantage: PCMark Vantage is a PC benchmark suite which provides detailed testing. It runs a set of common tasks (viewing and editing photos, video, music and other media, gaming, communications etc.) to determine a PCMark score which is a measure of a computer's performance (Futuremark PCMark Vantage 2011).

7-Zip: It is a file archiver with a high compression ratio. While accomplishing compression/extraction the program stresses a PC that allows using it as a benchmark to estimate a computer's performance (7-Zip 2011).

3. Results and discussion

Benchmark		Operating Mode			Overclocking/Nominal Score Fractional Increase	
		Nom.	Ov. 1	Ov. 2	Ov. 1	Ov. 2
3DMark 2006	3D Marks	11530	12437	13284	8%	15%
	CPU Marks	3697	4019	4463	8.7%	20%
PCMark Vantage	PC Marks	5885	6290	6536	7%	11%
7-Zip	Compr.	2373	2602	2887	9.6%	21.6%
	Extrac.	8870	9866	10886	11%	22.7%

Table 1. *Benchmarking scores*

Performance enhancement is an ultimate goal of overclocking, however the measurement of performance is a very complicated task. Benchmarking scores are summarized in the Table 1.

Test results may be a destination point for an overclocker, but not for students who conduct such experiments within an IT-related course. Commenting on experimental results is very important educationally. In our case, we urge students to compare the values of performance increase achieved in each mode and measured with different benchmarks to take into account not only the effect of hardware parameters but the details of benchmarks' design as well. For example, any clock rate increment does not result in equal increase of 3DMark 2006 scores (12% versus 8% or 24% versus 15%) because this benchmark focuses on testing video subsystems, not a CPU only. PCMark Vantage shows a smaller Score Fractional Increase than 3DMark 2006 because, along with other PC units, it deals with HDD which remains outside overclocking. 7-Zip scores nearly proportionally grow with incrementing the clock rate because CPU and RAM are primary resources engaged in data compression and extraction; the value +9.6% will prompt that RAM frequency was set below a default in this mode for stability reasons.

4. Conclusions

Overclocking methods have been well presented in the literature and Internet resources in particular, so it was not our purpose to introduce a new one. Instead, we discuss overclocking in broad educational context to find its niche in IT curriculum. While many students are keen on this thrilling pursuit, it seems reasonable to think about how to make an instructional profit on this. A recommended strategy for students' experiments on overclocking can be formulated as "never do what you don't know". Further commenting on overclocking results will encourage students to learn more about PC architecture and benchmark software architecture. Thus, overcloking seems to be more than a thrilling pursuit for computer enthusiasts as it extends users' knowledge and provides a significant educational value for advanced students.

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7-Zip: http://www.7-zip.org, accesed 2011 June

PHOTOGRAPHING MIRAGES ABOVE THE SEA SURFACE

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Abstract. *This paper presents a series of photographs, attained by the authors in the Southern Bays of Galicia, Spain, in which inferior and superior mirages (fata Morganas, towering, and castles in the air) are captured. They are analyzed and classified, and the explanation of each one is given in a way easy to understand for a public without specific optical knowledge. The different ray paths distortions that lead to each photographed mirage are graphically shown, and the respective gradient index involved is described. The influence of the observer position when taking the pictures is also studied. All in order to expose the basic properties of the refraction law and of the gradient index media, both to motivate students, and to bring closer geometric optics to the general public. Different learning tools that can be used related with the phenomena is presented. In addition, and as an interdisciplinary scope, the temperature difference that causes each case is related to the successive oceanographic and climatic conditions that occur along the year in this coast. This allows establishing which mirages belong to the winter, when the water temperature use to be higher than that of the air, and which ones belong to the summer when, owed to the ocean upwelling phenomenon, the temperature difference is inverse.*

1. Introduction

Amongst the most appealing optical phenomena that can be observed in nature, are those of the mirages. In them, objects appear to be transformed in stunning, unreal-like and often beautiful ways. Photographing mirages and analyzing the pictures may be a good approach to learn about the light refraction and its properties, as well as the behavior of the gradient index media when transmitting light and optical images. The word mirage has been defined in different ways (see, for instance, web1 and web2), we will consider here that mirages are optical phenomena, in which images of objects are seen displaced and/or distorted respect their normal appearance, and whose cause is the bending of light rays passing through air layers with a continuous variation of their refraction index.

In the sea, the temperature difference between the water surface and the atmosphere can give rise, in stable weather conditions, to a vertical variation of the density in the lowest air layers. The gradient of the refraction index so established causes the bending of the light rays that, coming from an object, form its image in the observer's eye. This effect produces different kind of mirages, depending on the sense and intensity of this gradient. For instance, the Fig. 1 shows a rocky small island seen under a mirage of the kind called *Fata Morgana*, and Fig. 2 its normal appearance.

Figure 1. *The small island of Rúa seen under a Fata Morgana effect. The sail boat in the red frame appears duplicated with a superior and inverted image. It can be noticed also a vertical compression of the lighthouse*

Figure 2. *The same island of the Arosa Bay in its normal appearance*

The first documented description of a mirage is that of Aristotle in the *Meteorologica*, and is a sea mirage. He refers briefly how some promontories beyond the sea looked, when blowing certain wind, like floating above the sea, and of larger size. This philosopher followed a think-tradition that didn't split the physics from the physiology of the vision, and thought that the vision was emitted by the eyes. It is for this reason that he related the phenomenon to a supposed lighter air that would allow to be penetrated easier by the vision. More detailed descriptions, also in the Classical Antiquity, are given by Theophrastus, Agatharchides of Cnidus and Quintus Curtius, some of them relating the phenomenon with the temperature of the air, or that of the ground (a good account of the historical literature on the issue is that of web 3).

In modern age, and in the western countries, it can also be found several authors that mention or detailing describes mirages. In the eighteenth century, some of them even relate the phenomenon with the light refraction; but the first full scientific explanation of the inferior mirages (those of the dessert) was given by Gaspard Monge, who accompanied Napoleon Bonaparte in the Egypt campaign, in an article titled *Sur le phénomene d'optique, connu sous le nom de Mirage*.

Given the fact that the air temperature distributions to the observation of these phenomena are not very common, they are termed "unusual refraction", which does not mean that the normal refraction laws have any fail or singularity here. When these unusual images are displaced upwards they are called *superior mirages*, and when this displacement is downwards, *inferior mirages* (Berger 1990, Minnaert 1993: 59-74, Lynch 2001: 54-62, Vollmer 2009, web1).

The pictures here presented were taken by the authors in the Southern Bays of Galicia, some from boats and others from the shore, and under different oceanographic and weather conditions. Some of them were already included in a previous work (Blanco-García 2011); here we present the continuation of that work, in order to improve it as a teaching and divulgating tool. The aim of this article is to show how they can be used to explain the formation of the different kinds of mirages. Explanations are given for a public with only elemental optical knowledge (young students or the public that may visit science museums or exhibitions). The relationship between those oceanographic and weather conditions and the kind of mirage that they induce is discussed in this paper. This allows us to divulge also some interesting oceanographic phenomena that occur in the coast near our university.

2. Optical explanation and some learning tools

It is easy to expose how the refraction of light, something widely known by the public, can make to bend light rays. When a ray passes from a zone with a given refraction index to another with a different one, undertakes a change in its propagation direction. It is illustrated in Fig. 3, where the angle change is given by the Snell Law. If the index variation is continuous (i.e., a gradient index exists) the change of the propagation direction is also gradual and the ray path describes a curve. In order to connect the involved concepts in classroom with real-world experiences several tools can be employed. In this way, for example, web-based interactive simulations can engage students in

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educational activities that promote the self exploration of the bending of light between two different media according to Snell Law (web4, web5, web6).

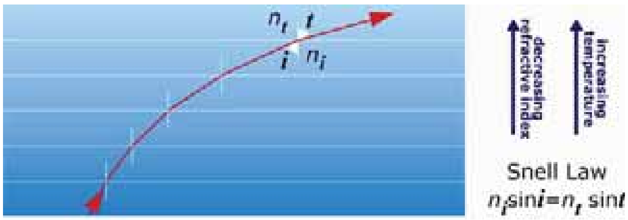

Figure 3. *Direction change of a ray that passes through decreasing refractive index layers*

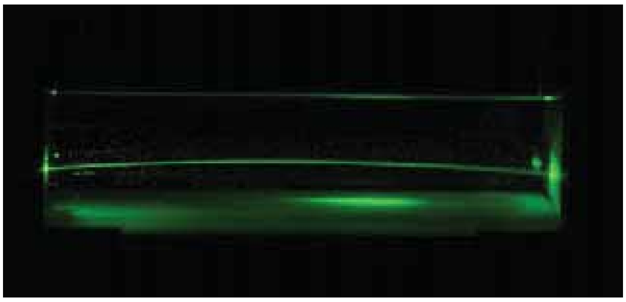

Figure 4. *A laser beam is bent downwards when passes through a variable-concentration dissolution (in this case, decreasing upwards)*

On the other side, hands-on activities related with experiences in the real world make learning significant (Resnick, 1987). There are reported several hands-on activities to show curved rays in classroom. In them, gradient index are induced by different methods: heating water in a tank from the surface (Barker 1989), heating and cooling simultaneously air (Richey 2006), generating a gradient-concentration dissolution (Strouse 1972, Vollmer 1998, Vollmer 2003, Gluck 2007, Lombardi 2010, Branca 2010), amongst others. For this article, we made to pass a laser beam (that of a laser pointer) through a variable concentration dissolution. In Fig. 4, a layer of sugar was deposited in the bottom of a transparent recipient and subsequently an amount of water was added without messing up the sugar layer (Mak 1993). As the sugar starts to dissolve in the water, a vertical variation in the concentration appears, such that it decreases with height. In optical terms, a gradient is established depending only on the height and in which the refraction index decreases with it (hence, horizontal planes of equal index). It is important to note in Fig. 4 that the laser beam bends towards the area where the index is higher, i.e., the concave side of the curve is facing to the increasing index, as it is shown also in the diagram of the Fig. 3.

3. Inferior mirages

Those where the refraction index increases with height and, hence, the rays are bent upwards, are termed inferior mirages. In them, the mirage image is seen under the real one. The widest known are those seen in the desert, and it is easy to observe one looking along a road in a hot sunny day (Vollmer 2009). In the sea they occur when the temperature of the water is higher than that of the air, so air layers close to the sea surface have lower refraction index than those away from it. This condition is typical of the autumn and winter season, when the air cools down quicker than sea water since this has a larger thermal inertia (Vollmer 1998, Vollmer 2009, Branca 2010).

Fig. 5 is a diagram where the ray paths are shown for this case. Rays coming directly from a couple of points in the object arrive to the observer, but other rays from the same points, with different initial directions, reach also the observer because they suffer a curvature in the gradient index area. This last ones form the mirage image, below the object.

If the bent rays do cross each other, the observer sees this image inverted, like reflected in a horizontal mirror (a mathematical analysis of the ray tracing in the mirages, taking into account if they cross or not can be read in: Fabri 1982; and a computer ray tracing in López-Arias 2009).

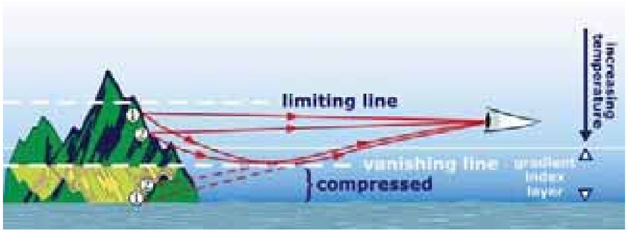

Figure 5. *Ray paths for an inferior sea mirage*

Nevertheless, this reflection is not perfect: the curved rays arrive with an angle between them slightly smaller than that of the direct ones and hence the inverted image appears compressed vertically. The vanishing line (*v.l.*) is the horizontal "mirror" plane, and below it no rays from the object reach the observer, so this part of it is not seen. The rays from points above the limiting line (*l.l.*) reach the observer position only directly and hence they are not affected by the mirage.

Figure 6. *The Port of Villagarcía seen under an inferior mirage in a calm winter day. The red line is the vanishing one*

Fig. 6 is a picture of a port seen under an inferior mirage, and the red line is the *v.l.* for this case. It was taken in a winter day with a weak breeze, when the water temperature was between 9 ºC and 10 ºC and that of the air was between 5 ºC and 6 ºC; the distance to the object was 8 km and the height of the camera over the sea surface was approximately 2 m. In Fig. 7, both the vanishing and the limiting lines are drawn. Inside the rectangular frame a curious effect can be seen: the rocks in this part seems to be on air above the water surface, something like a cantilever. It happens when the object's height is lower than that of the limiting line, then part of the sky over it is seen below and the object seems to float in the air. This effect is called *castle in the air* and is an *inferior mirage*.

Figure 7. *The Cies Island, in the Vigo Bay (autumn). The wider red line is the v.l., the narrower one is the l.l. and inside the red frame an effect of castle in the air is observed*

4. Superior mirages

When the sea water is colder than the atmosphere, the temperature in the air layers close the sea surface increases with height, that is, in higher planes it is higher than in lower ones. This temperature distribution is called a thermal inversion and, hence, the refraction index decreases with height, the same that happens in the dissolution of the Fig. 4. In this case, light rays from objects are curved like the laser beam in this picture, i.e., they are bending downward (Fig. 8), and the optical effects so originated are termed superior mirages (Baker 1989, Vollmer 1998, Vollmer 2009). A computer ray tracing for superior mirages can be seen also in Tape 2000.

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This temperature inversion is rather usual all along the summer in the Southern Galician Bays, and is caused by the upwelling phenomenon. In this season, the Azores High moves northeast and, given its clockwise rotation, causes northeast winds in the Spanish northwest coasts. These winds blow from land to sea in the Southern Bays. In this way, they drag the superficial water layers out of the bays, which are substituted by abyssal waters, since the continental shelf is not very wide here. The vertical stream so formed merges close to the bays, and in the case of the Arosa one, deeper than the others, inside it. This is the so called upwelling. These depth waters are very clear, have many minerals in dissolution (that feed the rich submarine ecosystems of the region) and are considerably cold (especially for swimming purposes). When the wind calms, a thermal inversion air layer is formed in contact to the sea surface, and this is the cause for the superior mirages that following are described (for a more detailed description of the upwelling phenomenon see Varela 2008: 14-18).

Fig. 1 is an example of a mirage of this kind: the water temperature was between 12 and 14 ºC, that of the air between 27 and 30 ºC, the distance to the object was 6 km and the camera was 2 m high over the sea surface. It was taken in a calm summer day. Probably the most curious effect here is that suffered by the small sail boat inside the red frame: it can be seen above it a second image of itself but inverted, like a reflection around a horizontal plane slightly above the boat.

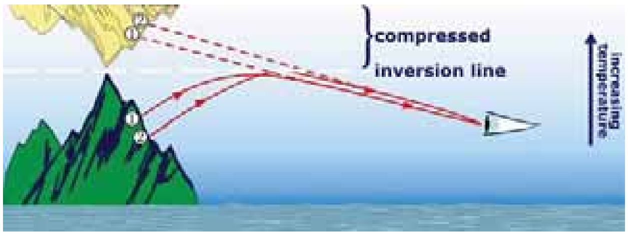

Figure 8. *Rays paths for a superior mirage*

This image-inversion effect, that can also affects rocks, island and other objects, is called sometimes *Fata Morgana*, since this is the traditional name for it in the Messina Strait, between the Italian Peninsula and the Sicilian Island, where it seems to be rather often. The explanation for it is given in the diagram of the Fig. 8. The abnormal curvature of the ray paths caused by the variation of the refraction index of the air, leads to the formation of an image above that of the real object and the inversion is due to the crossing of the rays coming from point at different heights as the figure shows. Moreover, these curved rays arrive to the observer with an angle between them lower than if they were direct, and this causes a vertical compression of the upper image, like it happens with the image of the lighthouse in Fig. 1. The inversion line (i.l.) is sometimes lower than the top of the object and, hence, the inverted image is seen overlapped partially over the real one.

Figure 9. Towering effect. Relatively low rocks seen as columns or towers. (Small island of Sagres, Arosa Bay, summer)

Another effect that can be seen in Fig. 1 and, even clearer, in Fig. 9 is that known as towering. It consists in that the image of an object is seen elongated, and also defocused, vertically. In Fig. 9 rocks no very prominent are seen like towers and walls, high over the sea surface (in fact, Galician sailors said that the coast was *castelled or walled*). Even many people interpreted this as remote and fantastic towns. The explanation is given in Fig. 10: a set of rays coming from the same point can arrive to the observer in directions slightly different, so forming virtual images displaced vertically.

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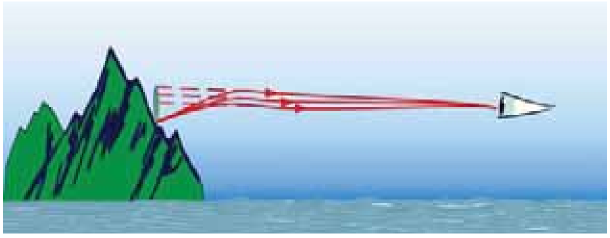
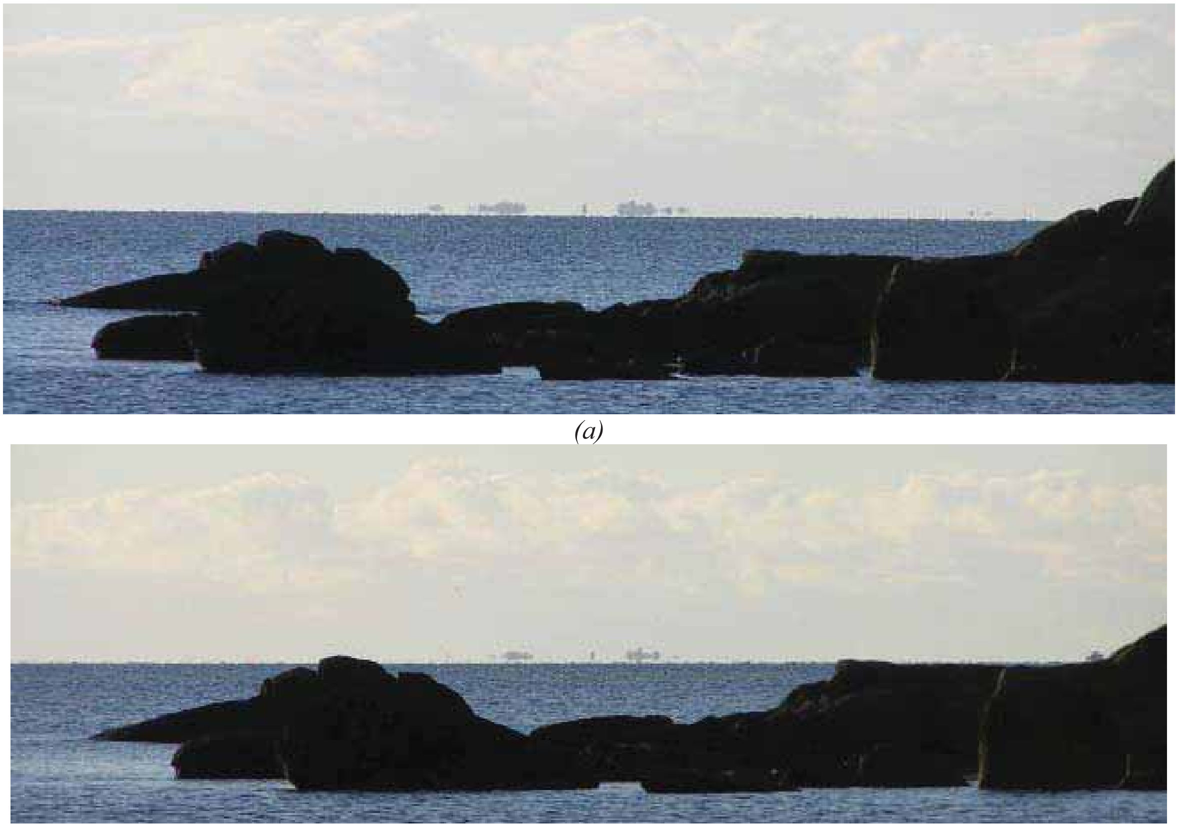


Figure 10. *Vertical elongation of a point: formation of towers or walls. The same can occur in inferior mirages but with the rays curved on contrary sense*

In fact, this effect can appear simultaneously with the former one, being both overlapped, as can be seen in Fig. 1. The same superposition is given in Fig. 11, that is the rock on the left hand side of Fig. 9: this rock is towered by vertical elongation and, at the same time, by the presence of a superior and inverted image of it.

Figure 11. *Superposition of the vertical elongating effect with the superior inversion one*

Really, this elongating or towering effect can appear also in inferior mirages, overlapped, for example, with a *castle in the air*.



(a)

(b)

Figure 12. *Some small islands seen as castles in the air, pictures taken in winter. The dark rocks are a reference to note the variation of the observer height. (a) Higher, (b) Lower*

5. Effect of the camera height

It is important to show how the appearance of a mirage is strongly dependent on the height of the observer over the sea surface. The authors of this article have observed that an intense effect of towering, seen standing on the beach, close to the water edge (eyes less than 2 m high), became very weak, and even disappear, when viewed from nearby rocks, about 4 m high. The index profile has a more pronounced variation in the bottom air layers, in such a way that an observer over them cannot be reached by any curved ray. It seemed, hence, that in our case the gradient index layer was pretty thin, less than 6m.

Figures 12 a) and b) are examples of a castle in the air taken the second with the camera a couple of meters lower than the first one. It can be noted that the effect of lowering the observer position is to raise the vanishing line, so a smaller portion of the object is seen "reflected" and hence it looks more thin and more "in the air". This effect is graphically explained in figure 13.

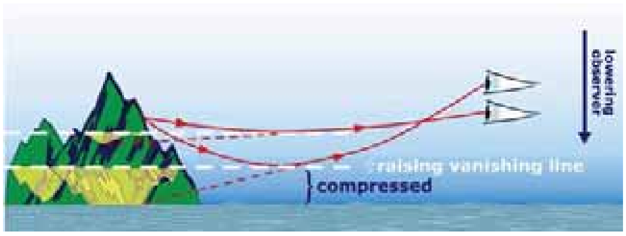


Figure 13. *Ray tracing for the effect of changing the observer height when photographing an inferior mirage*

6. Conclusions

Photographing mirages is shown here to be an appealing way for introducing students, and general public, to the Optics, especially to geometric ray tracing, and to gradient index media in particular. This paper describes different kind of mirages that can be seen in the sea. The explanation of each one is given in a way easy to understand for a public without specific optical knowledge. A set of pictures of mirages in the Southern Galician Bays is presented, and data about the conditions they were taken are provided. Each one is analyzed to identify the different optical effects that produce the respective image, since more than one effect can occur simultaneously. In addition, some of the different oceanographic and meteorological conditions that occur in this coast in each season of the year are described, and related to the temperature gradients that, in turn, produce each mirage. Different hands-on activities and web based simulations are referenced as learning tools for explaining the related concepts in classroom.

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HANDS-ON PHYSICS EXPERIMENTS FOR CLASSROOM

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Abstract. *Physics, as a fundamental science, is an essential part of most technological and scientific educational curricula. Amongst the many tools that can be used for making knowledge of Physics and its learning more attractive is that of Hands-on Physics Experiments (HPEs). In them, an understanding of many natural and technical processes is gained via direct observation and experience. Usually, HPEs can be found at interactive science museums, but an important effort is also being made in order to import them into the classroom. In this work, an updated view of HPEs resources (books, journals, events, projects, associations, mass media, companies, museums, etc.) is presented, as well as effective clues for an efficient search in practical situations. Finally, several strategies for using activities of this kind inside the classroom are shown.*

1. Introduction

Many studies have pointed out the fact that traditional instruction fails when it attempts to reach desired objectives regarding in-depth knowledge of theoretical concepts or positive attitudes towards science (Gunstone 1987, Viennot 1985, Hake 1997, Kim 2002). Different proposals are needed to favour interaction, motivation, and autonomy, and these should be alternatives to the traditional classroom (based essentially on exposition, examples and solving practical cases) where subject matter is usually presented as pieces of knowledge with no relation to the everyday setting. This means that students who can solve problems and practical cases successfully are not able to answer simple conceptual questions correctly (Roth 1997, Kim 2002, Powell 2003, Crouch 2004). These difficulties are similar in various countries, yet the speed at which the necessary changes are applied varies (Thacker 2003). This is the case even though the conditions for good learning (well structured basic fundamentals, adequate motivation, promotion of autonomous activity and interaction among peers) are sufficiently understood (Biggs 2005). This problem appears to worsen when student numbers are high. These changes are often rapidly driven by conditions outside the educational world. In particular, recent developments in Information and Communication Technologies (ICTs) lead one to think that they will be widely used in future learning for simulations, virtual tutoring, video games, on-line labs, etc.

Fortunately, the understanding of course contents for Physics can be improved by employing active/cooperative/collaborative approaches, where learners are involved in varied activities led by a teacher who is seen as a tutor or guide. Such supervision can become one of the most demanding, complex and sophisticated tasks and requires, therefore, that the teacher's role is given greater recognition (Brown 1988). There are strategies that enable this process to be carried out successfully by using interaction, experimentation and demonstration to increase the information retained, improve marks and eliminate negative attitudes towards disciplines. In particular Hands-on Physics Experiments (HPEs) influence the fact that the authority is the real world, and they have played an important role in curricula for scientific/technological subjects (Flick 1993, Dorrío 2004). Many projects have shown the benefits of their use to attain quality learning (NRC 1996, AAAS 1989). An HPE involves the use, both inside and outside the classroom, of any material, object, instrument or experimental setup used for learning a properly contextualized concept, principle, law or application (Dorrío 1994, Dorrío 2007). They contribute to the student's use of basic concepts and experimental skills to construct something new, and so give the pupil a chance to integrate theoretical and practical contents naturally, as indicated by current trends that have influenced the development of recent educational curricula (De Jong 1998).

In this work we present several ways of using HPEs based on our experience, taking into account the way in which people learn (Figure 1): considering their previous knowledge, using interaction among

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peers (solving problems in collaboration with others) and with real tasks, provoking cognitive conflict, and promoting conceptual change if needed. An updated view of resources will be shown, which assumes that teachers do not only need a methodological change in their teaching practice but also in their pedagogical beliefs and knowledge be achieved.

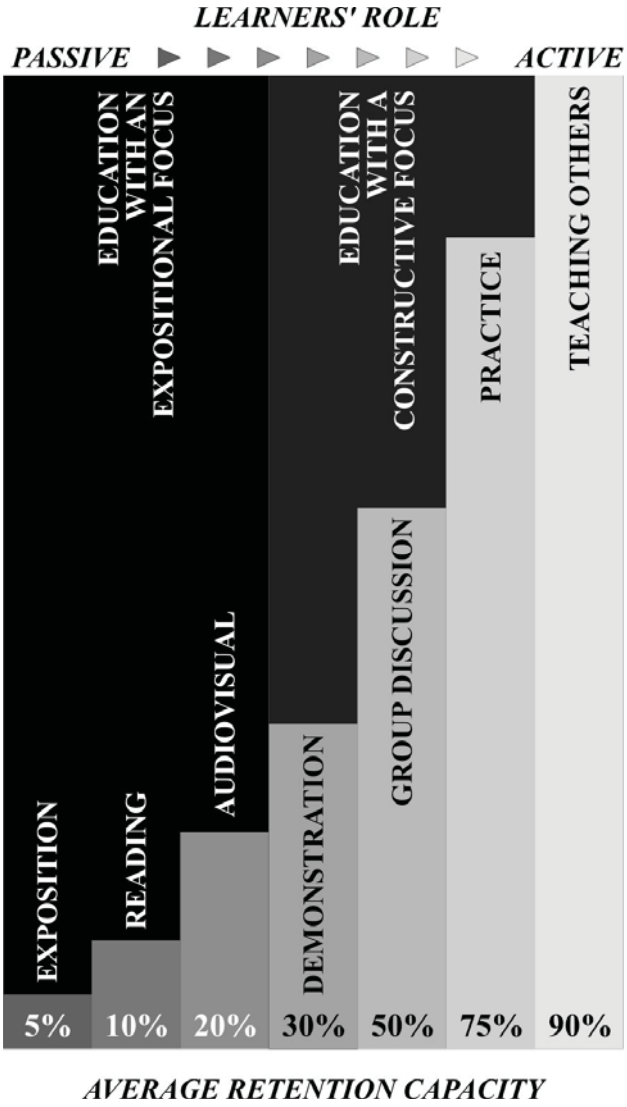

Figure 1. *Learning methodologies (Web 1)*

2. Resources

The use of ICTs has been a basic catalyst in the recent evolution of the educational sphere. At present they are generally used as either a source for support material or an on-line resource for conceptual learning. One of the tasks teachers have is to give training in how to make reliable searches using ICT. It is important to identify clearly which tools favour learning by introducing materials, methods and concepts into the classroom in terms of real situations the learners are familiar with. In this way the subject is made interesting and the learner's work and curiosity are stimulated. This does not mean teaching learning methods or techniques, but instead means fostering the use and development of these strategies by teachers in their daily practice. When it comes to implementing innovation of this type, teachers encounter a series of difficulties that have to be overcome: ignorance of the tools placed at their disposal by modern learning theories; strong resistance to change; lack of understanding of their integration in learning processes; or a lack of clear methodology for assessment. In the case of HPEs there are countless resources that can be used in the classroom (Table 1). The origin of present day HPEs possibly lays in the interactive centres that play an important role in informal learning contexts and offer, furthermore, a chance to update the public in general and build bridges between Science and Education (Oppenheimer 1972). Interactive centres offer the chance to connect theoretical and practical concepts, and show their contents by relating them to daily applications through the use of small-scale, semi-guided personal research. Much of the material developed in this context has successfully been exported to the educational world and has acted to drive the change taking place (Morris 1990, Johansson 1999).

BOOKS ⇨	(Ehrlich 1990, Cunningham 1994, Rathjen 2002)
SPECIALISED JOURNALS ⇨	(Web 2, Web 3, Web 4)
EVENTS ⇨	(Web 5, Web 6, Web 7)
PROJECTS ⇨	(Web 1, Web 8, Web 9)
ASSOCIATIONS ⇨	(Web 10, Web 11, Web 12)
WORLD WIDE WEB ⇨	(Web 13, Web 14, Web 15)
AUDIOVISUAL MATERIALS ⇨	(Web 16, Web 17, Web 18)
SUPPLIER OF EDUCATIVE EQUIPMENT ⇨	(Web 19, Web 20, Web 21)
INTERACTIVE MUSEUMS ⇨	(Web 22, Web 23, Web 24)

Table 1. *Available resources*

3. Strategies

HPEs can be employed for different learning modes that require different organizational structures: in master classes, in proposals for autonomous work, in small groups or in collective works. They are all oriented towards action and have the clear purpose of acquiring skills and increasing commitment to the

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subject. This diversity of strategies is the best way to respond to the various motivations and interests of the learners. Alone they do not contribute significantly to improved learning, and if they are to be effective, then there needs to be a clear definition of aims, interests and motivations. Only in correctly structured curricula do they contribute to success as one more piece in the puzzle. Here, we can at least document their use in the following modes (Figure 2):

a) Demonstrations. HPEs have traditionally been used in a demonstrative format during master classes, helping students to confirm or reject previous ideas, obtain useful information and venture new conclusions (Carpenter 1981, Freier 1981, Hilton 1981, Williams 1990, Di Stefano 1996). For the teacher, this requires limiting and organizing the material being presented and linking new and old knowledge, while avoiding the use of unnecessary terms or excessive detail that can lead to distractions. In many cases these are short demonstrations that do not interfere in the flow of the subject and provoke an increase in the learner's interaction as they introduce physical activity that often means standing up and moving a short distance. The contents thus take on a new dimension and become an opportunity to motivate and generate class discussion if they are complemented by thought-provoking questions. Among other things, such demonstrations allow pupils to observe activities that would not habitually be carried out in the lab because of their danger, cost or delicate nature: using apparatus that show simple concepts but that require complex handling, or the reproduction of historic experiments, for example.
b) Interactive demonstrations. The above demonstrations may be more effective in master classes if their interactivity is increased. In an interactive HPE (Sokoloff 1997, Meltzer 2002, Powell 2003, Crouch 2004, Sharma 2010) the teacher gives detailed explanations beforehand about the elements of the HPE and the steps to be taken, linking the scientific and technological concepts to be used if they have already been developed; learners are challenged to make predictions about the expected result; the teacher divides the activity into small steps, intersperses questions to maintain attention and check understanding, works to ensure the process is interactive for the learners, and encourages, if possible, the experiment itself. Once the interactive HPE is over the learners discuss what has happened with their nearest classmates and the teacher moderates the ensuing debate. This process promotes conceptual understanding by means of a combination of mental and hands on activities to produce information from the discussion amongst peers. Learners must fill out a sheet listing the expected results, using individual response cards or one of the commercially available electronic student response systems (Web 25, Web 26, Web 27).
c) Problem-based learning (PBL) mini-projects (Edelson 1999). Challenge HPEs, in which learners working in small groups are simply given a project title (usually from a list taken from a book (Ehrlich 1990) or webpage (Web 22)) that they must create, write up, (linking it to other contents and providing complementary information) and present the results for, once they have found and used the necessary resources. Much of this new teaching material should include images, sound, video, text and ICT elements. These include interactive web domains or online virtual simulation tools (Web 28, Web 29, Web 30). These complementary, virtual HPEs enable phenomena to be analyzed intuitively both graphically and numerically (which leads to more in-depth understanding). By using them, learners become familiar with computational tools in support activities that allow them to modify and explore parameters like those in the real HPE. The development of simulations can even be carried out by means of several ICT applications that can either be used by the teachers or the students (Web 31, Web 32). During these PBL format HPEs the learners, with teacher supervision: construct a model, measure, make hypotheses, estimate, discuss and suggest. This requires additional intellectual effort and offers a more creative and contextualized vision of the practical component than that offered by work in the lab. This latter type of work is often a mechanical labour directed towards

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obtaining, without reflection, expected results that have quantitative verification in the way of a response that completes a pre-designed and directed experiment (Domin 1999). Fortunately, such cases do not require costly or specialized equipment and in the case of Physics concepts there are a large number of well documented proposals to provide to learners, leaving them with the responsibility to design and create the final product independently.

d) Collective HPEs, Science Week. With the results of work undertaken by learners, a "cloning" of a small Science/Technology museum can be organized in the educational centre itself, in an activity that is both collective and cooperative and one in which learners are co-responsible for its definition, assembly and overseeing, within a framework of explanation by peers or equals (Campbell 1989, Bone 1992, Jones 1996, Esteves 2008, Williams 2008). Such design and interactivity work with learners is advantageous in attaining important learning goals related with the skills needed for activities of this type, and well as strengthening other basic competences used across the learning process: these could be instrumental (capacity for analysis and synthesis, problem solving, or organization and planning capacity, etc.), or personal (teamwork, interpersonal relationship skills, critical reasoning, etc.), or systemic (autonomous learning, creativity or initiative, and enterprise spirit, etc.) Each module is accompanied by a self-explanatory panel that, under an eye-catching heading, contains brief audiovisual information and a few provocative questions that attempt to lead participants to reconsider their mental models by seeking connections with the contents of the formal learning that are not obvious, as an essential step before recompiling the new information. Complex explanations, difficult instructions or highly sophisticated setups are avoided as they could inhibit potential participants from exploring unaided. The information provided is fun and attractive in order to increase and stimulate the visitors' attention, and it is related in some way to their previous experiences. More than learn, the visiting pupil is stimulated to delve deeper and develop a context for their own exploration in their own way, leading, if possible, to follow up activities done by themselves. Visitors are accompanied by the learners who act as guide or mediator and are provided with methodological models for communication with the visitors. They also promote alternatives to the spontaneous activities or make any adjustments that may be needed. The learners are given prior instruction so that they can give understandable scientific explanations (Dorrío 2006a, Dorrío 2006b, Rodríguez 2005, Villar 2005).

Figure 2. *Some examples of HPEs*

e) Corridor HPEs. Some of the HPEs designed by the teachers, or by the learners themselves, can later be set up throughout the centre's building during term time (Pinkerton 1991, Sampere 1999, Pizzo 1986). These selected modules will be a permanent exhibition that can facilitate the learner's voluntary interaction at any time. Incentives for their use can be given by organizing a competition among the centre's community, in which participants must solve simple challenges regarding the concepts that underlie the HPEs.

4. Conclusions

Hands-on Physics Experiments, (HPEs) in any of their possible usage modes, can be an additional tool

for facilitating learning of scientific and technological contents in any educational setting. Their main advantages are appropriate contextualization, flexibility and learner motivation. The learner is an interacting part of the process in which the monotony associated with the master class is broken. HPEs attempt to demonstrate that science and technology can be interesting, exciting, easy to understand, and subjects that are important in everyday life and also something that can be beneficial by putting the student in an active, critical learning position: experimenting, making hypotheses, interpreting, and reaching conclusions. They also attempt to convey scientific knowledge as basic for anyone in today's technological world. Of course, the contribution of HPEs is relevant when the learners themselves are the main participants in the process and the teacher is focused on proposing this learning environment and activating the learners.
Although there is a general lack of institutional support, time and teacher training in this type of learning strategies that deal with real subjects, an increase in their use has been observed because they increase the commitment of the agents involved, their capacity for learning to learn and the dynamics of the educational process. Using suitably organized and contextualized HPEs bridges the gap between theory and practice and leads to beneficial changes in the basis and the way that students learn. Involvement and participation in subjects is considerably increased according to opinions stated in several learner surveys, and likewise there is a contribution, without doubt, to the professional development of a teaching community who in most cases can escape, in this way, from the reproduction of models they suffered during their training.

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HANDS-ON EXPERIMENTAL ACTIVITIES IN INQUIRY- BASED SCIENCE EDUCATION

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Abstract. *Science experiments are to be organically included in certain teaching/learning methods. One of these methods is Inquiry-Based Science Education (IBSE), which has a strong motivational effect. Hands-on activities play a crucial role in all four levels of inquiry-based learning in science education: confirmation inquiry, structured inquiry, guided inquiry and open inquiry. These implementations of hands-on experiments develop students' knowledge and skills in a constructivist way. The principle of IBSE is presented on a particular example of hands-on activities in the frame of European research project PROFILES.*

1. Introduction

The Czech Republic and the entire European Union is struggling with declining interest of young people to study science. Some universities in Europe are reporting a halving in the number of students enrolled in physics since 1995. The way science is taught in schools is considered one of the main causes. In this context it is necessary to think how to change teaching methods and increase students´ motivation for science.

The science education community mostly agrees that one of the suitable possibilities is the IBSE. This teaching/learning way shows great promise according to the results of researches. IBSE has proved its efficacy in increasing students' interest and at the same time stimulating teacher motivation.

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IBSE is effective with all types of students from the weakest to the most able ones and supports the improvement of the gifted. Moreover, IBSE is beneficial to promoting girls' interest and participation in science activities.

2. Open learning

An important aspect of IBSE is the use of open learning. Open learning is described as a teaching method with no prescribed goals or outcomes students have to achieve. Many educators have dealt with the ideas of open learning. J. Deway is one of the most famous proponents of hands-on learning or experiential education. Dewey's ideas have influenced Project Based Learning (PBL) which allows students to perform the role of researchers. Open learning techniques were promoted by M. Wagenschein as well. He was one of precursors of modern teaching techniques such as constructivism, inquiry-based science, and inquiry learning. He emphasized that students should not be taught only facts, but should be made to understand and explain what they are learning. Open learning plays an important role especially in teaching through experimentation. Students do not only perform experiments like cooking according to recipes but they should understand what they do and how they do it.

3. Inquiry based science education

IBSE is an approach to teaching and learning science that comes from an understanding of how students learn the nature of science inquiry, and a focus on basic content to be learned (Narode 1987). Like any instruction, IBSE can also be divided into student activities and teacher activities. Therefore, it is possible to meet in literature the terms Inquiry Based Science Learning (IBSL) and Inquiry Based Science Teaching (IBT). The activities of teachers and students are close linked and Inquiry Based Science Education (IBSE) is broader term which connects the two activities.
IBSE engages students in the investigative nature of science, helps students put materials into a meaningful context, develops critical thinking and supports positive attitudes toward science (Kyle 1985; Rakow 1986). The emphasis is placed on teaching science as inquiry rather than on teaching science as the memorization of facts and terms. IBSE moves from a system that promotes science primarily as recall of factual information and rote computation to one that emphasizes conceptual understanding and logical process skills. The traditional methodology in which the teacher communicates information to the students should decrease in favour of hands-on activities in which students conduct investigations, discover principles, and practice applying those principles in a variety of situations. IBSE has a strong motivational effect which comes from intrinsic motivation relate to the satisfaction of having learned and understood something or relevance, meaningful of learning content, as considered by the students. Traditional instruction is usually based on the satisfaction of being rewarded - extrinsic motivation (Duschl 2007).
However, it is an erroneous assumption to require students to engage in inquiry oriented activities, like real scientists and doing it from scratch and completely independently. Most students, regardless of age, need extensive practice to develop their inquiry abilities and understandings to a point where they can conduct their own investigation from start to finish (Bell 2005; Herron 1971; Schwab 1962). H. Banchi and R. Bell define according to experience how much guidance (about procedure and expected results or guiding questions) is provided to students by teachers four levels of inquiry: confirmation, structured, guided and open Banchi 2008).

4. Hands-on activities in IBSE

Very important students´ activities in all four levels of inquiry-based science education are hands-on activities. Their implementation is necessary for inquiry. But they have to be organically included in certain teaching/learning methods, what is the main task for the teacher. It is not easy to transform science content into the form of IBSE. Just as students can not immediately switch from traditional methods of learning to inquiry based learning, teachers must also "learn" how to apply IBSE. It is important to use certain hands-on activities in corresponding inquiry levels. In the following text, we present characteristics of individual inquiry levels and examples of the implementation of hands-on activities.

4.1. Confirmation inquiry

In accordance with the name, confirmation inquiry, the outcome of this level is conformation the knowledge of principles, concepts and theories. The results of experiments are usually known in advance. Confirmation inquiry is useful in the beginning of IBSE when a teacher's goal is to develop students´ experimental and analytical skills. It is imperative that students have to gain practice and specific inquiry skills, such as collecting and recording data.

Example:

> *In the frame the curriculum content oxidation-reduction students confirm the sequence of metals in electrochemical series. They choose one of the metals and insert it into the different aqueous solutions of metal ions. They observe chemical reactions and changes with metals. They summarize all their observations in a table and analyze their results. On this base they make conclusions and compare them with theory.*

4.2. Structured inquiry

Also at this level the teacher has an influence on procedure and helps students in inquiry by asking appropriate questions. But students generate an explanation supported by the evidence they have collected. This lower-level inquiry is very important for development of student's abilities to conduct more open-ended inquiry. This kind of inquiry is very common in elementary science curricula as well as confirmation inquiry.

Example:

> *Students conduct the same experiments as in the first level but electrochemical series should not be told them ahead. The task for students is to determine which metal is less reactive using comparing reactivity of metals during oxidation-reduction experiments. The goals and rationale of this inquiry is to enable constructive building of the electrochemical series.*

4.3. Guided inquiry

At the third level, guided inquiry, the teacher is the "guide of inquiry". He encourages students using the research question and provides students with guidance about their investigation plans. Students are less supported than in the preceding levels. They design procedures to test their questions and the resulting explanations. The teacher provides students with guidance about their investigation plans. Students should to have experiences from confirmation and structured inquiry to be able designing their own procedures (Kirschner 2006). Outcomes of inquiry are better when students have had a lot of opportunities to learn and practice different ways to plan experiments.

Example:

> *To develop deeper understandings of metal oxidation-reduction reactions we ask students to predict on the base experiments which metals it is possible to use to metal plating and why.*

4.4 Open inquiry

Fourth and highest level, open inquiry, comes from experiences of preceding inquiries which implies that this level is the closest to "science inquiry". Students should be able to derive questions, design and carry out investigations, record and analyze data and draw conclusions from the evidence they have collected (Hofstein 2005). Because it requires a high level of scientific reasoning and cognitive demand from students it is suitable for development of gifted students.

Example:

> *During the previous explorations, students made conclusions on the base experiments which were planned by the teacher. In open inquiry students carry out their investigations so they have to suggest procedure of experiments, which metals and aqueous solutions of metal ions will be used. They need to include their focus question, a prediction, a detailed plan for how they will carry out their investigation, and the data table (if necessary) they are going to use.*

5. Project PROFILES as a support for teacher in IBSE

European research Project PROFILES (Professional Reflection-Oriented Focus on Inquiry-based Learning and Education through Science) deals with supporting teachers in application IBSE in instruction so that the open inquiry approaches are a major teaching target. PROFILES improves the teachers skills in developing creative, scientific problem-solving and socio-scientific related learning environments; learning environments which enhance students' intrinsic motivation to learn science and their individual competencies such as proper decision-making abilities and abilities in scientific inquiry. Project PROFILES is aiding a better understanding of the changing purpose of teaching science in schools. We present example of hands on activities from Project PROFILES which represent application IBSE in instruction. Here is an excerpt from one module, which is part of the materials used in the Project PROFILES. This module was developed by G. Tsaparlis and G. Papaphotis and it is based on the activity (Trantow 2002).

5.1. The excerpt of module: Brushing up on chemistry

(a) Phase: The teacher assign to students the task of going to a supermarket and buy a small selection of toothpastes, including toothpastes that have different purpose, for instance, whitening, with baking soda,

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for gingivitis. Following that they identify from the product packages the ingredients of each brand and under the teacher's guidance about a general reference to the composition of toothpastes they divide the ingredients into particular groups, depending on their action/functioning.

(b) Phase: Students carry out hands on activity preparing home-made toothpaste, using available at home materials. Subsequently they test the effect of homemade toothpaste by comparing with a commercial brand of toothpaste. The cleaning power of the both kinds of toothpastes is compared by testing their ability to remove food colouring from egg shells.

Making coloured eggs

1. Pour about 0.5 cup (120 ml) of boiling water into a glass. Stir in 1 teaspoon (5 ml) of vinegar and 20 drops of food colouring (red or blue recommended).

2. Immerse a hard-boiled egg in the food colouring solution until it is stained with colour (at least 5 minutes).

3. Remove the egg from the food colouring solution and place it on a paper towel to dry. Store the stained egg in a refrigerator if you will not be continuing the activity. Otherwise, go on to step 4.

Make and test toothpaste

4. Measure two teaspoons (10 ml) of baking soda and a quarter teaspoon (1.25 ml) of salt into a plastic cup. Stir until it is thoroughly mixed.

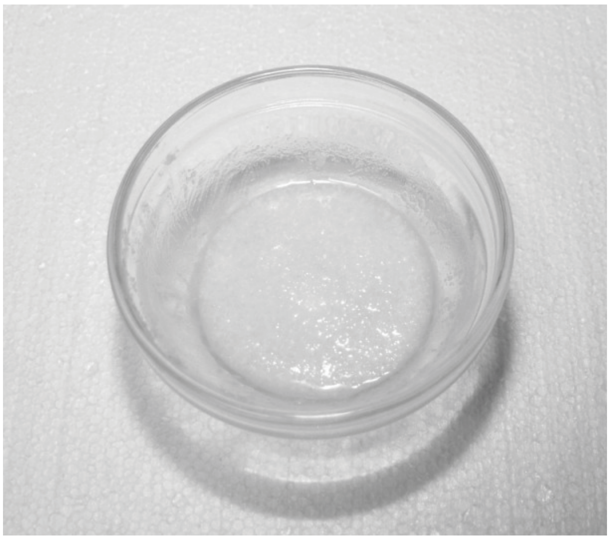

Figure 1. *Home-made toothpaste*

5. Add three-quarters of a teaspoon (3.75 ml) of glycerine to the baking soda/salt mixture. Stir it as thoroughly as possible. The mixture will be thick. Add water with a dropper while stirring until the mixture has about the same consistency as commercial toothpaste *(see Fig. 1).*

6. Rinse the coloured egg with water and scrub it with a toothbrush. What happens to the colour? Record your observations.

7. With a black permanent marker, draw a line on the eggshell, dividing its surface in half. Label one side C, for commercial toothpaste, and the other side H, for home-made toothpaste.

8. Put a pea-sized amount of commercial toothpaste on the toothbrush, then brush side C of the stained egg for five strokes (one stroke equals one complete back-and forth motion). Rinse the egg and toothbrush thoroughly with water. Then, put *a pea-sized amount of homemade toothpaste on the toothbrush and brush side H for five strokes. Rinse the egg and toothbrush with water again. Record your observations (see Fig. 2).*

Figure 2. *Comparison of abrasiveness*

9. Measure the pH of water, the commercial toothpaste, and the homemade toothpaste using paper. Record your observations.

10. Compare the abrasiveness of the homemade and commercial toothpastes by rubbing a pea-sized amount between your fingers, being sure to rinse thoroughly with water your fingers between examinations of samples. Record your observations.

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(c) Phase: The project is completed with an evaluation and recapitulation in class of the performed work. The following questions aim to test student's comprehension of problems related to the activity:

- Research the nine categories of ingredients in toothpastes. Give an example of each and explain its function. What is the purpose of each ingredient in your homemade toothpaste? What categories of ingredients are missing from the home-made toothpaste?
- Which toothpaste felt more abrasive to you in the touch test in step 10? Why is an abrasive useful in cleaning? Can an abrasive cause any problems in cleaning teeth?
- Compare the pH values of tap water, home-made toothpaste, and commercial toothpaste. How could pH affect the cleaning ability of toothpaste?
- How do plain water, homemade toothpaste, and commercial toothpaste compare in cleaning ability in steps 6 and 8?
- How does fluoride help to prevent cavities? Does it pose any risks to users? Would your home-made toothpaste help to prevent cavities? Does it pose any risks to users?
- If you wanted to make "whitening" toothpaste, what ingredient could you add to your mixture? Design an experiment to test your new toothpaste.

Through the study of the toothpaste, a common, well-known product of daily use, we aim to connect chemistry with everyday life, and increase students' interest in chemistry. In addition, through the toothpaste, we have the opportunity to refer to a large number of chemical substances and students can gain practice in experimenting. Apart from the hands on activity, which is shown in the previous text, there are many others in the full module. Students prepare solutions, measure pH; check reactions of ingredients with acids and hydroxides. Except science skills and knowledge students improve other competences. This activity offers the opportunity to discuss in class the importance of regular dental care for health of teeth and the general health.

6. Conclusions

IBSE is a way which may be taken to increase knowledge and skills of the students in science. Hands-on activities play a crucial role in IBSE because they are beneficial to promoting students´ interest and participation in science activities. These implementations of hands-on experiments develop students' knowledge and skills in constructivist way. PROFILES Project offers hands-on activities which were prepared by experts and verified in teaching by experienced teachers.

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A TEACHING – LEARNING SEQUENCE ON ELECTRICITY FOR PROSPECTIVE ELEMANTARY TEACHERS

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Abstract. *In this paper we describe the design and implementation of a teaching – learning sequence on electricity for prospective elementary teachers. The emphasis of this teaching – learning sequence is on the role of the electric field in the conducting wires, on qualitative experimental activities with inquiry and on the integration of activities that promote the development of the Pedagogical Content Knowledge of the learners. Although the scientific view of electricity has changed since it became a mature discipline in the end of the 19th century, this change has not yet became an integrated part of the curriculum which in many cases presents an out of date view of the subject so we tried to incorporate the most recent views on the subject.*

1. Introduction

Because the subject of electricity is part of the curriculum in all levels of education, the research on the teaching and learning of electricity is rich. In the context of constructivism, there have been published papers about the alternative ideas of the learners and teaching proposals to overcome them.

In the Tertiary Education level, three research lines inform our work: (a) The effort to reform the Physics Curriculum which has led to an emphasis on a small number of basic principles and the integrated approach of macro and micro worlds. (Chabay, 2006) (b) The modeling theory (Halloun, 2006). (c) The effort to reform Teacher Education, which has led educators to accept the notion of Pedagogical Content Knowledge suggested by Shulman (1986, 1987) as a theoretical construct whose cultivation will make student - teachers better.

In this paper, we will discuss our second attempt to design and implement a teaching – learning sequence (TLS) about electricity, suitable for prospective teachers of elementary school.

2. Connection with published research papers

McDermott & Shaffer (1992), proposed a teaching sequence that starts with the notion of the closed circuit, the introduction of current as a kind of flow and the brightness of the bulbs as a clue for the size of this flow, the introduction of resistance and equivalent resistance. Then, in a semi-qualitative description, they propose the introduction of ammeter as a better and more sensitive indicator for the quantity of current in a branch of a circuit and voltage as the voltmeter reading when it is connected to the edges of a circuit item. (Functional definition) In a following step, this teaching proposal introduces the fully quantitative description with measurements that confirm Kirchhoff's rules and the relation between voltage and current in Ohm's elements. In the last step, the notions of energy and power are introduced and the differences between ideal and real batteries are elucidated.

Eylon & Ganiel (1990), found that students cannot connect notions of electrostatics with electric current. Voltage, even when it is studied in electrostatics, stays vague and students cannot use it functionally in an electric circuit. Microscopic mechanisms that underlie the macroscopic phenomena are not understood and they cannot be used for giving explanations. The same researchers believe that the introduction of the notion of voltage early in a teaching sequence, as proposed by Psillos, Koumaras & Tiberghen (1988) is a successful practice because in this way, voltage acquires the role of a principal notion as it is the cause of the movement of charge in current carrying wires. They also propose the elucidation of the connection between macroscopic observations and microscopic explanations.

In their teaching sequence, Psillos, Koumaras & Tiberghien (1988) propose the introduction of voltage as a characteristic property of the battery. For the battery they introduce a model in which voltage is the result of the separation of charges in the poles of the battery. The chemical reactions that take place in every battery ensure that charge separation will remain even when the flow of charge (current) starts in a circuit. Depending on the circuit in which the battery is connected, the chemical reactions rate changes so as to ensure that charge separation remains constant independent of the rate of charge flow in the circuit. When the chemical energy that is stored in the battery is exhausted, charge separation cannot be kept steady and the voltage between the battery poles becomes (almost) zero.

Chabay & Sherwood (2006), have proposed a new treatment of electricity that insists on a unified treatment of electrostatics and circuits initially in terms of charge and field and later in terms of potential and current. It also tries to connect macroscopic phenomena with microscopic mechanisms and it studies the transient before the steady state. This treatment is quite different from the traditional one where there is little or no connection to electrostatics, circuits are studied solely in terms of potential and current on the macroscopic level and steady state only. Their teaching proposal is developed on their textbook "Matter & Interactions II Electric and Magnetic Interactions" (1995 & 2007) and it is addressed to students of Science and Engineering. Our effort to develop a teaching – learning sequence tries to keep much of the conceptual structure but remains at a qualitative level with almost no calculations.

Barbas (2005), has proposed a teaching – learning sequence that uses a series of microscopic models, qualitative and semi-quantitative, based on the Coulomb interaction that help the learners to understand the evolution of the phenomena with the use of simulations on PC's and simple experiments. The emphasis of this sequence is on the evolution of the temporary states of electric circuits till the establishment of the steady state and in the bridging of the gap between the typical "homogenous" explanations of the theory and the causal reasoning of the learners.

In a previous paper (Kountouriotis & Michas 2010), we have described the design of our teaching – learning sequence (TLS) for its first implementation. In this paper we will describe the redesigned TLS after its first implementation.

3. The needs of prospective elementary teachers

The design of a teaching and learning sequence must take into account the needs of the population that it is addressed to, in our case the prospective elementary teachers. Concerning Physics, these needs are defined by the conceptual understanding of the phenomena and the ability to give qualitative forecasts or explanations. The solving of calculation exercises does not guarantee understanding (McDermott & Shaffer, 1992) and is a skill that is cultivated in Science Schools and Polytechnics.

In the subject of Electricity, we believe that it is necessary for the learners to understand the electrostatic interactions, that is the construction of the model of the Coulomb force between point charges, the introduction of the electric field model for the explanation of the Coulomb interaction, the models of the behavior of conductors and insulators inside an electric field, the model of the feedback for the returning to electrostatic equilibrium after every disturbance in a conductor. The understanding of the function of simple circuits includes the model for the closed circuit voltage – current – transferred energy in the circuit items and it is a linear causal relation. It also includes the model of feedback that drives a circuit in its steady state, the model of the battery and the model of the capacitor.

Another important need for the prospective teachers is to know how to make the content teachable. As Sulman (1986, 1987) first claimed, successful teachers have strong Pedagogical Content Knowledge (PCK). So it is important to develop the PCK of prospective teachers. In order to develop the PCK of our prospective teachers, we used Content Representations (CoRes) as developed by Loughran, Mulhall, & Berry (2004). A CoRes represents a conceptualization of the collective PCK of expert teachers around a specific science topic, including "the key content ideas, known alternative conceptions, insightful ways of testing for understanding, known areas of confusion, and ways of framing ideas to support student learning" Loughran et al. (2008). Using scaffolding, we helped our student teachers develop their own CoRes for the subject, as a way of developing their topic specific PCK.

To those who have dealt with the further education and professional training of elementary school teachers in Greece, it is widely accepted that there is anxiety and insecurity to the teachers about the use of experiments in their teaching. This is of course a result of the minimal experimental activity they were engaged to when studying at University or at the previous Educational Levels. Our TLS is focused on experimental activities and we hope to help in lessening any negative attitudes about using experiments in teaching.

4. Conceptual models of electricity

As conceptual models of electricity we define the models that the scientific community of physicists accepts and uses for the explanation and the forecast of electric phenomena. These models are compared with the mental models of the learners which are products of their interaction with their environment and their apprenticeship in formal environments such as the school. The mental models are or include alternative ideas with the meaning that has been given to the term by Driver (1985)

There are three bodies of knowledge which are related to Science Education, Scientific Knowledge, School Science and Children's ideas. (Koulaidis, 1994) The relationship between them is shown in Figure 1.

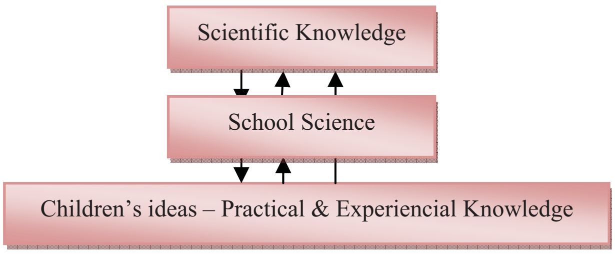

Figure 1 *Relationship between the bodies of knowledge of Science Education (Koulaidis, 1994)*

Scientific Knowledge is the product of the work of scientists or researchers and it constitutes the authoritative body of knowledge used as a reference (for every era or period) and it includes the conceptual models that have been developed for every subject. In the subject of electricity, the historical evolution of the conceptual models starts with the model of the one fluid or the two fluids (attributed to Gilbert and Du Fay respectively) then the model of the elastic fluid of Franklin follows or the improved model of the two fluids that was suggested by Symmer. The revolution of course belongs to Faraday who introduced the field model in 1850 which then was improved by Maxwell and in the beginning of the 20th century, after the development of the microscopic model, it was enriched with microscopic explanations. (Stocklmayer & Treagust, 1994) This was our reference model. Trying to find the description of this model in classical University Textbooks, we found out that the electric field inside a current carrying wire is not studied. There were no references to the causes of this field which are the surface charges. (Preyer, 2000) On the contrary, textbooks that are considered reformatory, as the textbook Matter & Interactions II of Chabay & Sherwood (1995, 2007) describe in detail this microscopic model based on the surface charges.

5. The suggested didactical transposition

We will now describe the basic principles of our didactical transposition. The first is the importance of the microcosm for the electric phenomena and the ability that it has for explaining macroscopic behavior. The second is that Physics is a Science based on a small number of principles that can explain a large number of phenomena. The third is the importance of building models that follow the observed behavior of systems and using them productively in describing, explaining and predicting phenomena.

Following these principles, we will discuss the microscopic level inside a current carrying wire, we will use the charge and energy conservation principles to help us infer the state of circuits and we will explicitly discuss the "consensus" models of the science of electricity.

The models we want the learners to construct include the Coulomb interaction between point charges, the description of electric interaction with the electric field, the microscopic structure of insulators and conductors, the behavior of insulators and conductors inside the electric field and the mechanism that brings conductors to electrostatic equilibrium. A simplified model for the battery without any reference to the chemical reactions that take place inside the battery, a model for the electric current inside the current carrying wires that describes the electric field and the sources of this field, the feedback mechanism that drives any circuit in the steady state every time a disturbance occurs. A model that describes the transient from the time of turning on the switch of a circuit till the establishment of the steady state. Voltage is introduced initially with a functional definition as the voltmeter reading and later it is connected to the work of the electric forces per unit charge. We avoid defining and using potential deference and electromotive force. To complete the picture for conductivity we need a model for the electric current in the electrolytic solutions and ionized gases. Finally, a model is introduced for the microscopic explanations of the behavior of capacitors in circuits of direct current.

6. The development of the teaching and learning sequence

In Table 1, you can see the content of each meeting with the learners. Student teachers worked in the Laboratory in groups of 2 so as to have satisfactory interaction with the materials. They used adhesive tapes, sticks from ivory, glass, PVC, electroscopes, batteries, wires, lamps, compasses, multimeters and capacitors of very large capacitance. The capacitors with the very large capacitance have been used in very few TLS. (Steinberg, 1985) These capacitors when connected with common lamps give charging (or discharging) times of the order of tens of seconds. The learners can observe the gradual

dimming of the lamps (clue for the decrease of the current) and measure charging and discharging times. These activities can lead to discussions about the microscopic level in circuits.
The student teachers work in the Lab, in groups of two, in order to have satisfactory interaction with the materials and the appliances. We used adhesive tapes, bars from ebonite and glass, PVC, electroscopes, batteries, wires, lamps, compasses multimeters and capacitors of very high capacitance. Most of the above mentioned materials and appliances have been used in electricity teaching and learning sequences extensively. The capacitors of very high capacitance have been used in only a few TLS that are mentioned in published research. (Steinberg, 1985) These capacitors when combined with common lamps have charging and discharging times of the order of tens of seconds. This allows the learners to observe the gradual dimming of the lamps and measure charging and discharging times. In our view, but also in the view of Eylon & Ganiel (1990), these activities are ideal for the introduction of a microscopic model for electricity and the connection with macroscopic phenomena.
The capacitors we used have a capacitance of 1F and they are surprisingly small for their capacitance. They are electrolytic but there is no danger of explosion in case of inverse connection. Perhaps, the only disadvantage they have is that they have a maximum voltage of only 5V. We overcome this problem by using as voltage sources batteries of 4.5V.

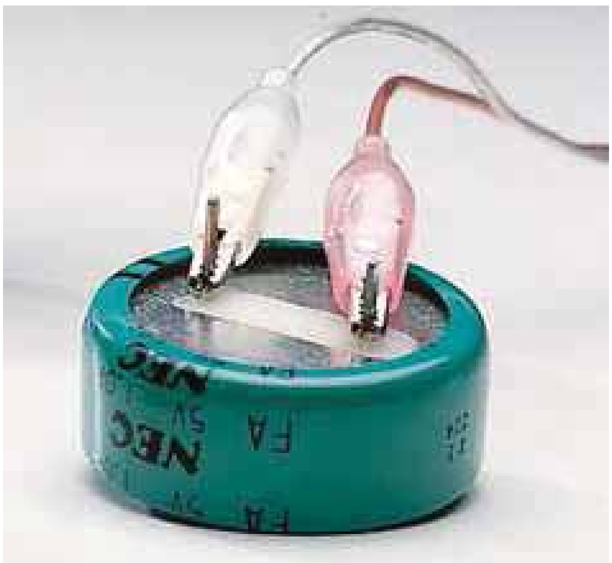

Figure 1. *Capacitor of very high capacitance*

	Subject	**Activities**	**Microscopic Level**
1st Meeting	Electrostatic interactions I	1. Electric Attraction & Repulsion with adhesive tapes. 2. Interaction with atom simulations.	Coulomb interaction of point charges
2nd Meeting	Electrostatic interactions II	1. With the use of electroscopes charging by induction and inquiry about the differences between conductors and insulators. 2. Interaction with simulations of electric fields. 3. Simulations of the behavior of insulators and conductors in an electric field.	Behavior of atoms inside the electric field – Polarization Behavior of insulators and conductors inside the electric field
3rd Meeting	CoRes in Electrostatics - Connection between electrostatics & dynamic electricity – Conductivity of ionized gases.	1. Fluorescent lamp lights near an electrostatic generator. 2. Observation of current in a circuit with an electrostatic generator in the role of a battery. 3. Observation of electric discharging	Microscopic explanations. How to ionize a gas
4th Meeting	The need for a closed circuit – Voltage (more precisely emf) as a characteristic of the battery and cause of current.	1. Closed circuit – Battery –Lamp 2. Heating of current carrying wires. 3. Influence of current carrying wires on a compass.	Electric current in conductors in microscopic level.
5th Meeting	Initial transient in a circuit – Conductivity of electrolytes.	Designing the electric field inside conductors. – Circuit with electrolytic solution.	Electric field inside conductors. – Electric current with one and two mobile charge carriers.
6th Meeting	CoRes for the electric current.- Transients in circuits with capacitors	1. Capacitor – Charging and discharging – Use of capacitors of very high capacitance. 2. Inquiry of the factors that influence the duration of charging and discharging	Microscopic description of charging and discharging of a capacitor.
7th Meeting	Circuits with lamps and capacitors – Energy study	Forecasts and explanations in circuits.	Microscopic explanations for the illumination of lamps.
8th Meeting	Connections of lamps in series and parallel. The principles of charge and energy conservation in circuits.	1. Circuits with lamps in series. 2. Circuits with lamps in parallel.	Explanation of Kirchhoff's rules with the principles of charge and energy conservation.

Table 1. *The Content of the TLS*

The activities we designed follow the structure Forecast – Observation – Explanation. There are also some activities that are of the inquiry type where the learners are asked to design an experimental activity in order to corroborate or refute a hypothesis. The learners have to write down their forecasts, observations and explanations in special forms. After the end of each activity on all groups, a discussion follows with the whole class.. In this part of the lesson, the researcher had the chance to examine the conclusions that the learners came to and scaffold the effort to reach the target conceptual model. We always ask the learners to compare their naïve ideas with their scientific counterparts. We also emphasize the fact that both science and the learners use models. After each lesson, the learners had to do a set of activities as homework by using their PC. The homework activities included the use of simulations about the microscopic level and the electric circuits.

7. Conclusions

Prospective teachers need sound scientific knowledge in the subjects of the Curriculum, practice in the use of simple experiments in teaching and topic specific PCK to help them become qualified professionals. Our design of a TLS tried to integrate all these in a single and autonomous learning unit. We think it is possible to organize at least some parts of the Science Education we offer in prospective elementary teachers in this way and we hope that our results from the implementation of such a TLS will justify that it is worth doing it.

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HIGH-TECHNOLOGY MATERIALS FOR HANDS-ON ACTIVITIES IN CLASSROOM

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Abstract. *The present work is a proposal of different hand-on activities to develop in the classroom. The objective is to strengthen the concepts acquired in lectures using direct demonstrations in classroom. Specifically, this work proposes a set of hand-on activities with technical materials, which covers diverse aspects of materials science topics: memory shape materials, viscoelastic materials, photoelastic sheets, thermochromic materials, ….*

1. Introduction

The adaption of the European Higher Education Area (EHEA) represents a review of the methodologies used that make the students, familiar with the New Information and Communication Technologies (NICT), an active actor in the process (Benito 2005, Anderson 2002). For the teachers the new learning framework implies an opportunity for reflection about their role in teaching and what can be improved. In particular, some of the new roles of teachers, respect to the master class as the dominant and passive practice, include the search of tools those adapt to the new contents, interests and skills, promoting learning and self-managed by students and their active participation in the classroom. In the university context are even more necessary the motivations that lead students to the pursuit of knowledge and enable them to a career in continuous transformation (Thorne 2008). On the other hand it is well known that in the scientific-technological field, the practical aspects are a necessary complement to the learning theory in so far as they promote the applied features of the subjects. One way to increase this practical component is to create a reflective and motivating atmosphere that allows achieving the proposed objectives, and the introduction of manipulative activities that require the use contextualized of any material, object, instrument or any experimental setup used for learning a concept, principle, law or application (Vázquez 1994, Costa 2010). Its origin is found in science museums or museums interactive (web 1) and it was used successfully in numerous subjects, since some time ago (Dorrío 2007, Dorrío 2008).

The present paper shows a set of hand-on activities aimed to support the educational changes that allow a more imaginative approach to improving academic performance and facilitate the activities that students will do in your professional near future. On the other hand, these activities would also be used to compensate the "blind faith" in NICT tools (computing, multimedia, …): the real world is complex and imperfect.

2. A set of hand-on activities.

A set of hands-on activities related to polymeric materials is proposed to develop in the master sessions, which reinforce the learning of specific skills and knowledge of the subject and help to illustrate the concepts explained in the classroom. Any of them can be combined with on-line resources. A lot of evidences suggest that education utilizing only hands-on activities as standard demos results in relatively small improvements in most students' understanding of basics contents. Of course, without the chance to predict and discuss the hands-on activity's outcome, students having seen the hands-on activity had no better comprehension of it than those who never observed it (Sokoloff 1997, Mazur 2004, Loverude 2009).

2.1. Activity I: Types of polymers (thermoplastics and thermosetting).

Structural differences between the two great families of plastics, together with the bases of recycling technology, can be illustrated by comparing of a thermoplastic as the policaprolactona (web 2) which has a melting point relatively low (60 ºC) that makes easy its softening while the known Araldit® or silicones of two components can be an example of thermosetting plastics (Liff 200). Thus, the introduction of the policaprolactona pellets in boiling water get a transparent malleable mass which becomes opaque when it getting cold and retains shape. A new immersion reverses the process and facilitates the re-shaping base of recycling of thermoplastics. On the other hand, the rigid thermosetting plastic obtaining by mixing the two component of silicones or known Araldit® leads to an irreversible and non-recyclable moulding process and so, when they are heated they are burned rather than softening or melting.

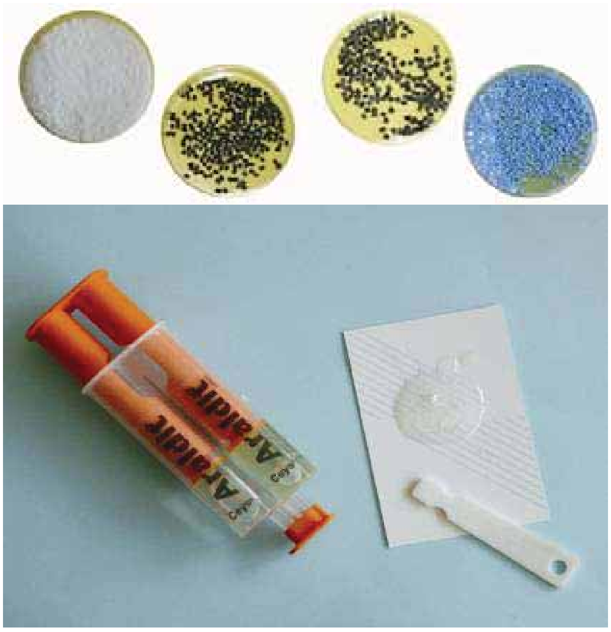

Figure 1. *Examples of different types of termoplastics under pellets shape (up) and a commercial themosetting (Araldit®) made by two precursors (down).*

2.2. Activity II: Types of crystallinity in polymers (observation through optical microscope.

Crystallinity has a great influence on the behaviour of thermoplastics. It can check the presence of crystals and the different tendencies to crystallize for example comparing Low Density Polyethylene (LDPE) and polypropylene (PP) (Mills 2005). For that, you can put a polarizing sheet on microscope USB PCE-MM 200 simultaneously connected to a computer and projector, making visible the whole process to the classroom. A second polarizing sheet allows the observation of the spherullite structure and the different crystallinity degree depending on the type of polymers (LDPE or PP). Using an overhead projector, it is possible to observe the crystallinity evolution when a piece of PP is stretching. To do that, the blade must be placed between polarizing sheets.

Figure 2. *Picture of spherulite crystals of PP (up). Microscope model USB PCE-MM 200, which allows the observation of the previous structure (centre), and view through polarizing sheets of large crystals obtained by stretching of PP sheets (down).*

2.3. Activity III: Effects of the crystallinity (loss of transparency)

The loss of transparency is one of the most striking and unknown feature of plastics outside the educational frame. The opacity is associated with the crystals formation, which act as areas of light dispersion, mainly in the grain boundary. The practice can also show the resistance increase in the opaque/crystallize zone. By introducing a thread of a PET bottle in boiling water for a few minutes or by applying heat with a dryer (it will be necessary to ensure a temperature above 90 º C) it takes place a transformation towards the opacity. A complementary expertise can be performed with high density polyethylene (HDPE). This is an opaque material due to its highly crystalline character, but with increasing temperature (T ≈ 140 °C) this melts and becomes transparent. This activity can be a simple proposition of self-employment.

Figure 3. *Thread of PET before (transparent) and after the introduction into boiling water (up). Opacity generated in PP when it is stretched (centre). HDPE transparent obtained when it is heated above 140ºC (down).*

2.4. Activity IV: Glass transition temperature (stiffness and brittleness)

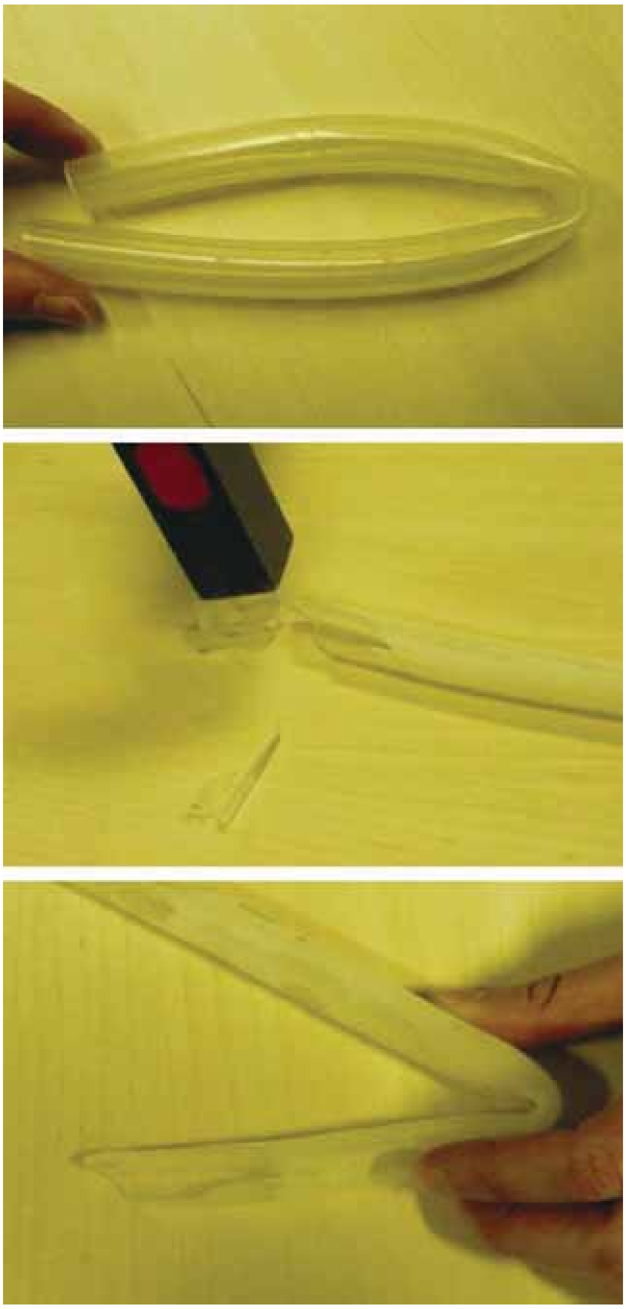

Figure 4. *Rubber hose bent at room temperature (up). Brittle behaviour when it is being hit by a hemmer, after the introduction into liquid nitrogen (centre). Recovery of the flexible behaviour after a few minutes at room temperature (down).*

To illustrate the concept of glass transition in amorphous materials can be used a piece of rubber hose, a typical flexible material that becomes rigid and brittle (vitreous) below its glass transition temperature (web 3). After the introduction of this elastomer into liquid nitrogen, this is “frozen” adopting a rigid and brittle consistency, as it can be

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checked by beaten with a hammer. After a few minutes, after the introduction of this elastomer into liquid nitrogen, this is "frozen", and its consistency is rigid and brittle, as it can checked by beaten with a hammer. After a few minutes, the hose recovers its original flexible behaviour. There are numerous on line videos with similar activities.

2.5. Activity V: Viscoelasticity

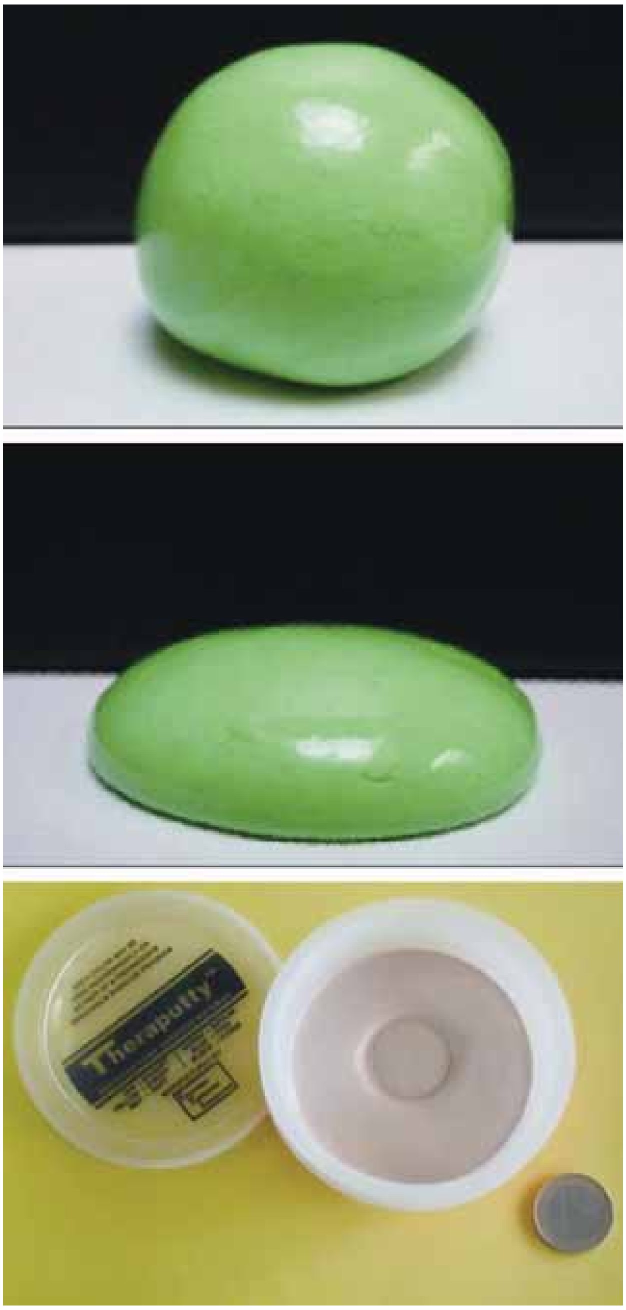

Figure 5. *Illustration of the viscous behaviour of the Silly Putty®: ball (up) that is spilled on a flat surface (centre) and disappearance of the bas-relief of a coin with time (down).*

The important concepts related to the viscoelasticity of polymers can be illustrated using Silly Putty® (Astin 2002, web 4), a material with several uses in fields as diverse as toys or medicine. The experience is to observe its elastic bounce like a rubber when it is thrown, and its viscous behaviour by spilling it on a flat surface, like a fluid.

2.6. Activity VI: Memory shape

Figure 6. *Shrink PE before and after submitting to heat source (up). Recovering of the original shape (a sheet) of yogurt glass made with PS (centre). Tendency to recover the original shape (cylinders or perform) of PET bottles (down).*

Some materials tend to return to its original shape when they are subjected to specific conditions. The shape memory phenomenon appears in shrinking materials, such as polyethylene (PE) and the polystyrene (PS) (Chanda 1987, Papalexopoulos 2002, web 5). By applying heat with a soldering iron or with a flame to a piece of PE, it can observe a significant decrease in its size and its diameter. Other example is the introduction of a yogurt glass made with PS in an oven (T≈120 °C), we will see that returns to its original flat shape. The same can be observed in a PET bottle during the heating at temperatures above 90 ºC.

2.7. Activity VII: Chemical properties of polymers.

Figure 7. *Different type of commercial products covered with plastics soluble in water (up-left) and illustration of the plastic dissolution when the tablet is immersed in warm water.*

The absorption properties of nonpolar substances, such as oils or petroleum products, can illustrate by using a commercial hydrophobic styrenic polymer: IMBIBER® (web 6), which is immiscible with polar substances like water. If we introduced some IMBIBER® beds in a basin with water and coloured diesel, they will absorbed totally the diesel in few minutes. This activity shows an application of polymers in environmental sector and establishes the relationship between Science-Technology-Society-Environment. On the opposite side, there are examples of water soluble polymers, the best known are based on polyvinyl alcohol (PVA) are widely used in important sectors such as hospitals or at home (web 7). The solubility can be verified easily by introducing a dishwasher detergent tablet covered with this type of plastic in a glass of warm water. The plastic will dissolve quickly.

2.8. Activity VIII: Manufacturing of polyurethane (PU) foam

One of the main developments in the world of polymers is the production of cellular materials (foams), formed by the reaction between two chemical components, for example, a polyol and an isocyanate. The end product is a pore network with a high porosity. This structure is the responsible of the characteristic properties as high lightness and damping capacity, as well as provides a sense of comfort in product like car seats, pillows or sportive shoes.

Figure 8. *Different stages of the manufacturing process of a foam.*

3. Conclusion

The foundations of the European Higher Education Area (EHEA) imply new teaching methodologies, the promotion of a continuous evaluation and more practical classes. Keeping in mind this outline, this paper documents a series of hand-on activities to perform in master classes. These reinforce and complement the practical contents. On the other hand, they act as a complement to the field activities, which facilitate the contact of the students with companies and technology centres that can relate to their professional future. Hand-on activities thus becomes a complement of their interest, and leads them to work in a practical and experimental way about a particular concept. Something that students may not acquire only reading books or notes or by on-line consultations.

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PROJECT BASED COMPETITIVE LEARNING IN HIGH SCHOOL

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Abstract. *The goal of this paper is to present how we may improve education of high school students and to provide them with environment that will help them with adaptation towards their future career. In this paper we present a study that aims on using project base learning and capture addition education aspects that supplement students' knowledge and positively motivate them to learn new things more effectively. The methodology used in the study involves not only project based learning but also competitive learning research, where used methodology are results from our teaching at university experience.*

1. Introduction

The traditional education provides good overview of techniques and technology, but does not focus on related aspects that are essential for university study. In this paper we present a study that aims to using project base learning and capture addition education aspects that supplement students' knowledge and positively motivate them to learn new things more effectively. The methodology used in the study involves not only project based learning but also competitive learning.

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The students engaged in this study were students of high school Gymnasium Arabska in Prague. There were 54 students in the study but only girls. This fact will need some other study, because this is common trend in all such a type of study program and in engineering education at technical universities, but we did not pay any attention to this in the study.

2. Background

Gymnasium Arabska is public high school, where is always one class with educational program Information Technologies. Students have in each year one of main subjects programming and informatics. They have each year at least 4 hours per week of those special subjects and they do final exam (maturita) from this subject as well. The students in those classes are very oriented on programming and they are very experienced in the field. This needs special teachers and also special methodology. Teachers are recruited from university teachers of Charles University, Faculty of mathematics in Prague and Czech Technical University in Prague. In fact this is advantage for both sites, students receive the best possible education and teachers has opportunity to prepare very good students for study at their schools, because the most of students study one of those two universities. In this study we used results from Gymnasium Arabska using our experience which we received from our teaching at Czech Technical University in Prague.

Similar approaches used in our study were already applied in many study disciplines. Project based learning is well known for a long time. In project based learning (PBL), students have to solve complex problems with many questions they have to find answers on them. Project has to be carefully planned, managed, and assessed and the students learn skills as collaboration, communication, critical thinking, and development and evaluation of created products, how to write documentation and how to do presentation of the project. The project, which is solved during one year of education, is one of possibilities how education may be improved. There are many types of projects which are used by teachers in education. We will present here projects, where students are analyzing, designing and implementing software projects.

Another goal of our methodology is Competitive learning. Projects can allow students to present their work to audience in some competition which is also motivation for them to learn.

The definition of term competition is given as (Coakley, 1997) – “*A social process that occurs when rewards are given to people on the basis of how their performances compare with the performances of others doing the same task or participating in the same event.”*

A competition is evident throughout our society, so usage of it in education brings benefits to the students whose outcomes often exceed content-driven and application-based objectives that prepare them better for the professional career. Informatics is an area that matches with its professional expectation to this type of learning.

3. Experiment

The study presented in this paper is based on 3 years experience with using projects and competitive learning in teaching programming and informatics at high school Gymnasium Arabska. During last year of study students have to submit individual project, which is solving some problem by their request which may be any type. Within project they have to do specification of problem, find some solution, design, and implement SW application and present results. This is little specific, that result is SW, but all processes which has to be realize during projects are the same as any other project There were 16 - 20 students each year of age 18 years in programming seminar in this study.

Projects start at the begging of school year with problem submission and students work for the projects whole year. Every month there was a control day, when each student presents his work and there was evaluation of his work, which is done not only by teacher, but also by other students in the group. At the end of the school year there was final presentation, where is committee of teachers to evaluate results. Again there was evaluation also by students.

Development of the projects consisted of several parts. The students were asked to report to the teacher at deadlines (every month) their progress on completing specific parts of the project.

The first part of the project we call ‘kick off’. This part covered organizational issues and project section. We decided not to force the students to select the project suggested by teacher but to let them propose their own project.

The following part of the project wee calls ‘project analyses. Students analyzed the problem and wrote the detailed specification of the project. Within this activities students had to look for similar project and the application and they had to do some evaluation of them.

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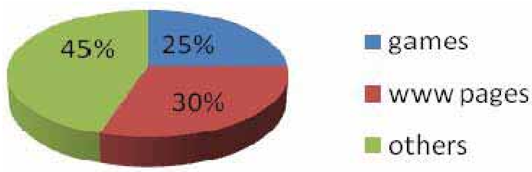
After this there is a 'design' of application. This is finding the best programming tool and environment and also decision which programming language and operating system will be used for implementation.
Next part was 'implementation and testing'. The design solution was coded in programming language. The parts were tested and integrated. Finally, students perform the acceptance testing and usability testing. This was done in cooperation with other students.

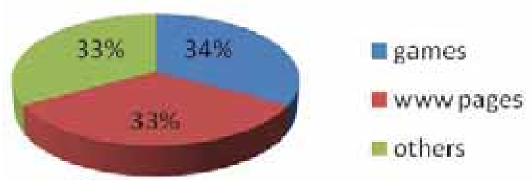
School year 2008/09

games	5
www pages and technologies	6
other	8



School year 2009/10

games	6
www pages and technologies	6
other	6



School year 2010/11

Games	5
www pages and technologies	7
Other	4

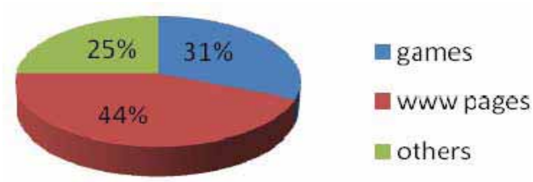


Table 1

The last but not least part of the project was documentation. Students create web page of their project, documentation how to use program.
There was interesting what topics for their projects student chosen. We divided all topics into # groups: games, www pages and www technologies and other. In group of 'other' were such topics as educational programs, robots, computer graphics, system utilities, database etc. It was interesting that the best project were always from group 'other'.

List of main group of topics by years is in following Table 1. From the table one we can see that within 3 years more and more students were interested in www technologies. This is evident, because they are using more and more those technologies and there are more frameworks which allowed doing very nice application not demanding lot of work.
How we did evaluation of projects? At the beginning we put down criteria for evaluation. There are 4 different parts of evaluation, each with different significance.

- Application implementation 50%
  - Choice of programming language
  - Quality of code
  - Used algorithms
  - Application area
  - Review of similar application
  - Specific value
- Documentation20%
  - Content
  - Logical structure
  - Typographic
  - Correct spelling and grammar
  - Citation
  - User handbook
- Presentation 20%
  - Structure of presentation
  - Quality of presentation tools
  - Oral presentation
  - Answers on questions
- WWW page 10%
  - WWW page existence
  - Reach ability of web page
  - Content
  - Used technologies
  - Graphical design

4. Competitive learning

The best of the projects (approximately 50 % each year) participate in High school research contest. In the last 3 years some of students from this study always won whole national competition. Some of them were very successful in international contest.

Some of them are studying on prestige's' schools in Europe and in USA.

If we look on topics of projects there are always more than 30 % of computer games and more than 30 % of creation WWW pages. Other topics are very various: there are robots, educational programs, computer graphics or some system programs. Winners of Students contest are always from this last group 'other topics'.

The key question might be what motivates students to attend the competition? They have high motivation to compare their results with other students, and also to be best. This helps them in CV for University application. Our feeling from the teachers' perspective that the students were positively motivated by the announcement of the change winners on the lecture and also by applause for their presentation in all levels.

5. Conclusion

Student projects at high school showed to be positive as they played a role for both project learning and competitive learning. It confirms that complex problem solving is very strong educational tools and the most of students like it.

What we teach in this approach? We teach student to write technical document, to develop SW project in correct way, to do presentation of their work, to work by timetable of the project (Control days) and to do evaluation of other students' projects.

We describe here study that applies project based and competitive learning in teaching. We teach by this approach also problem solving, which is something what is very important especial for good students. This methodology stimulates student's interest and motivation. From feedback from students we found, that this was taken by them finally as very valuable and interesting.

Acknowledgment

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REMOTE EXPERIMENTATION AT PRIMARY SCHOOLS

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Abstract. *The development of new information technologies enables remote experimentation suitable for primary schools science education. The paper presents the results of a pilot pedagogical experiment using remote experiments (RE) from the field of Temperature carried on five Slovak primary schools. For this purpose the Project-based learning with the support of RE was used with the main goal to study the durability of the gained knowledge. The achieved questioner score was compared with the score of pupils of reference group. The gained results show teaching with RE supports increased durability of knowledge compared to traditional teaching methods and arises interest in the subject matter.*

1. Introduction

New Education Act was passed in Slovakia on the 1st September 2008, and the Slovak State Educational Programme (SSEP 2009) entered into force in 2009. It covers primary as well as secondary schools and sets down the changes in the field of curricula, number of teaching hours for individual subjects and requirements on teachers and students. Teachers have to cope with the new structure of curriculum and implement interdisciplinary approaches to teaching and learning with the main objective: to prepare pupils/students for the knowledge society and further development of their key competencies.

One of the mainstreams in the documents is the introduction of Information and Communication Technologies (ICT) into teaching with the main stress on the modern interactive methods and strategies in teaching and learning. One of the novelties in ICT, occurring very recently, is remote experimentation. And we elucidate the role remote experimentation can play on primary school pupils.

Remote experiment (RE) is a hardware and software system that enables pupils/students from his/her PC to use real experiments physically located in a university or any other laboratory. In this way, students can access real experiments with the support of live webcam view 24 hours a day, 7 days a week anywhere with access to the Internet. Implementation of REs into education was a novelty in Europe at the turn of the third millennium. REs are more often used at the university level than at the secondary level. To our knowledge the remote experiments have not been used for primary school teaching yet. The reasons could be teachers´ not knowing about the existence of remote experimentation and/or lack of suitable REs for primary schools.

One of the advantages of RE is the possibility to bring a new way of experimentation to classes – via REs accessible in e-laboratories. The second is the possibility to increase students' motivation and interest in science, get young children excited about problems of the real word phenomena and to enhance pupil/student science understanding of real world phenomena. Such involved students feel no difference between RE and hands-on experiment in a class. On the contrary, they are curious about the new way of mediating information, similar to their experience with computer games.

In this paper we address the role of the e-laboratory in modern education process, specifically at testing the possibility of using RE at the Slovak primary schools. The contribution describes a practical application of REs from three open e-laboratories in Trnava (http://kf.truni.sk/remotelab), in Prague (http:// www.ises.info), and in Porto (http://experimenta.fe.up.pt). Specifically, we are, using the RE and project based learning, concentrating on the teaching topic "Temperature", looking for the answer "How many goals set up in the Slovak State Educational Programme (SSEP 2009) for the second grade of primary school can be fulfilled with remote experimentation?

2. Project "Measuring Air Temperature in Different EU Countries"

In our pedagogical research we concentrated on the following questions - *How to implement REs to primary school education?, - What will be the benefit of REs for the educational process and the pupils' knowledge gained?*

One possibility to implement REs into education, often used at university level (Schauer 2009), is by means of project education. We've designed a set of project-based learning units with support of RE for topic "*Energy in nature, technology and society*" (Gerhátová 2008).

For the research we choose the unit "Temperature measurement" to be found in the 7th grade curriculum of physics. For this unit we compiled the assignment "*Measuring Air Temperature in Different EU Countries*" based on the simultaneous temperature measurements using three Res. Specifically, we used RE in e-laboratories located at the University of Trnava in Trnava, Slovakia,

Charles University in Prague, Czech Republic and University of Porto, Portugal.
The requirements for the project designing was to fulfil the demands defined by the State Education Programme for primary schools ISCED 2 (see http://www.statpedu.sk) where we can find the following demands on the pupils' activities, taken into consideration:

- Observations and measurements;
- Search for proper information, its processing and storing,
- Organization and planning of work,
- Analysis of graphs, its explanation and interpretation;
- Comparison of two or more graphs and identification their common and different features;
- Using a computer to make a graph;
- Elaboration of the transferred meteorological data and design of a corresponding table;
- Data and results presentation.

These demands were implemented into project activities based on work with meteorological stations with url addresses http://remotelab1.truni.sk, http://kdt-16.karlov.mff.cuni.cz/en/mereni.htm lhttp://experimenta.fe.up.pt/estacaometeorologica/index.php?lang=pt (Fig. 1).
The summary of our activities in the pedagogical experiment (PE) is shown in Tab. 1. As can be seen, we worked with two groups – experimental and reference. The reference group was educated in a traditional way, without RE. The experimental group was educated via project-based learning and RE. At the end of the project work pupils completed the questionnaire. Six months later we checked the persistence of knowledge gained during the project and the results are discussed.

	1st step: Education process	2nd step: Questionnaire	3rd step: Didactic test
Experimental group	Project-based learning with the support of RE	yes	yes
Reference group	Traditional learning	no	yes

Table 1. Steps in the pedagogical experiment (PE)

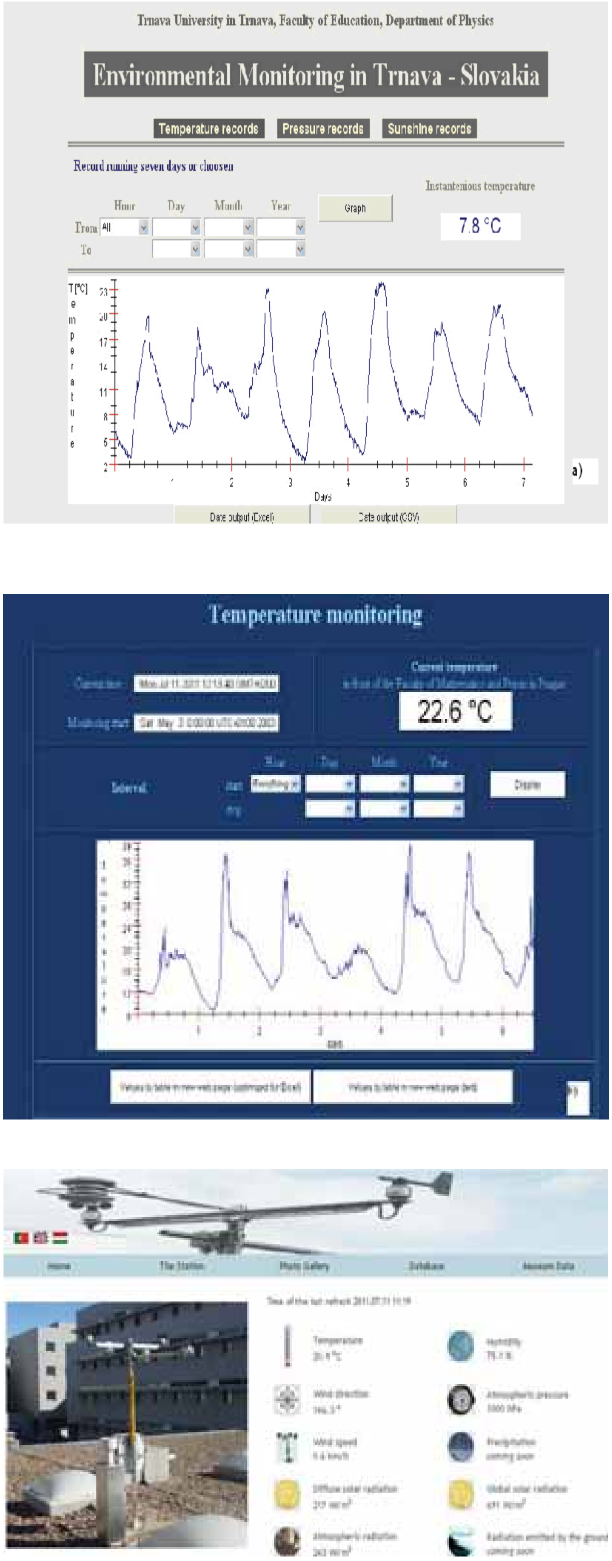

Figure 1. *Remote meteorological stations: Trnava, Slovakia (a), Prague, Czech Republic (b), Porto, Portugal (c)*

2.1. Project steps

Before the first step of the PE the project was tested on a small testing group of 9 pupils at a private primary school in Levice. The aim was to verify the

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functionality of the existing RE for primary school level. We needed to identify the weak spots of the project and to remedy them. Then the project was realized during October and November 2010 at four state primary schools in Trnava district. Pupils could choose the work with one of three offered meteorological stations. Within the project pupils worked with the following assignment:

- To choose the period of two weeks´ for data collection;
- To collect the data on the air temperature (with the appropriate sampling period – e.g. every six hours) and gained data arrange in a table;
- To plot the corresponding time dependence of the air temperature;
- To explore the changes in the temperature and to identify the maxima and minima;
- To calculate the average value of the temperature; to identify the greatest difference between the maximum and minimum of the day temperature;
- To show the independent and dependent quantities;
- To denote the average value of the temperature in the graph;
- To show the particular country from the point of view of its temperature changes;
- To compare the data obtained with the data of other groups;
- To explore the relation between the temperature and the latitude; to draw conclusions from this comparisons.

Pupils have three weeks for their work on the project – record and evaluation of data, search of information about particular country and city and preparation of the report. Then they presented their results. In evaluating the quality of both the report and the presentation the following factors were evaluated: the quality of the project, the relevance of sources, the overall design, and presentation of his/her results. Two examples of the pupils' project presentation in the form of a poster can be seen in Fig. 2. But 68 % of pupils preferred to produce the computer presentation.

2.2 *Questionnaire*

The second step: Before the end of the project work pupils of the experimental group completed the questionnaire consisting of 15 questionnaire items. These were aimed at exploring pupils' relation to the Internet, their way of realization of the project and the benefits of the project. They were encouraged to express their attitudes towards REs, and advantages and disadvantages to work with them.

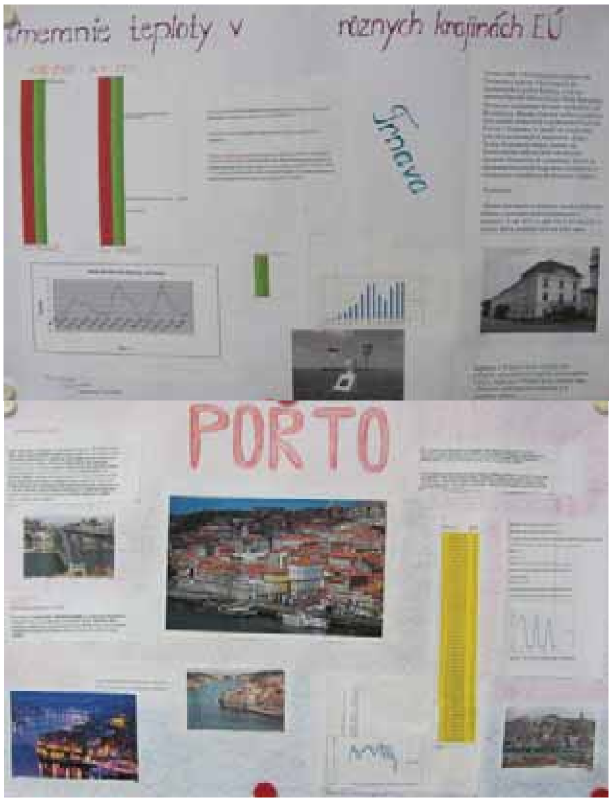

Figure 2. *Examples of the pupil's project*

Let us to present some results of the questionnaire. The total number of respondents was 47. The analysis showed that 89 % of pupils of the 7th class have the possibility to use the Internet at home. We were also interested for which purpose pupils use Internet. Pupils use the Internet predominantly for chat with friends (85 %) and for searching of information for school assignments (81 %) (very encouraging information), the games playing (70 %) and 53 % use the Internet for searching information from the area of his/her interest. The gained results confirmed our assumption that project with RE, closely connected to ICT and Internet, will be motivating for pupils. Another interesting questionnaire item was the question: "What did you like most from the project?" The most often answers were: "*I could cooperate with pupils in my group*, *I liked making the graph*, *The project was very interesting, I learned something new, I refined my ability to make the presentation on a computer.*" Our further interest was directed on the pupil´s total benefit of the project via questions: "What have you improved?", and "What have caused the most

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problems?" The most often answers are shown in Fig. 3a. Three most frequent answers were: for the first question: *work with graphs; search information; make a table,* and for the second question: *work with graphs; make a table; the average value of the quantities.*

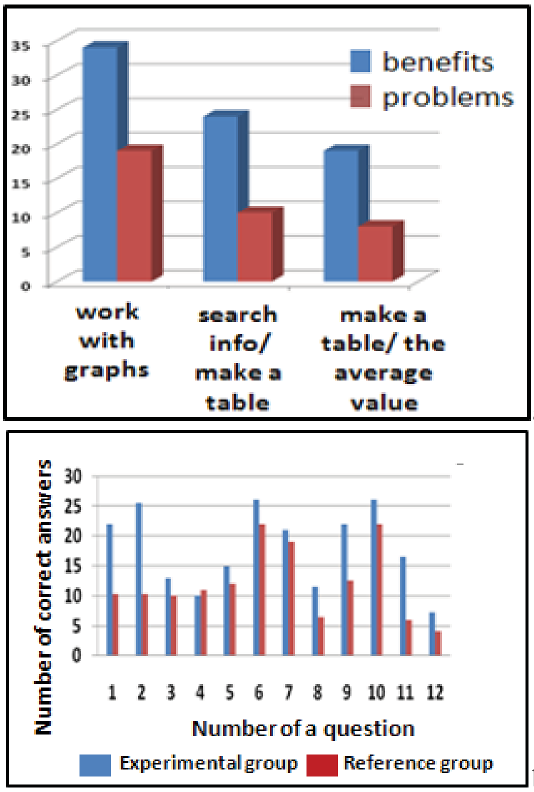

Figure 3. *Evaluation of the questions: (a) about the benefits of the project and problems during the work on the project, (c) of the didactic test*

Finally we wanted to know if the pupils liked the activities of the project and if they would like to make another project using REs. Results showed: 66 % of respondents liked the work on the project and 38 % would like to do another one. Taking into account the dislike for Physics (declared by many researches – see e.g. Wieman 2005), we can consider these scores as high. We would like to end the evaluation of the questionnaire with the quotation of one of the pupils: "*Now I'm having more fun in Physics and experiments.*"

2.3. Didactic test

In the third step pupils from both, experimental as well as reference groups, made the didactic test. Our goal was to determine whether teaching with the support of remote experiments positively affects the level and durability of pupil's knowledge. During the time of this step the number of pupils of experimental group was reduced. The reason was the interruption of communication with one school. Each group for the didactic test consisted of 31 pupils. The test had 12 items and the maximum score was 21 points. It was focused on various abilities needful for pupils, e.g.:

- To read a graph;
- To identify the dependent and independent quantities;
- To calculate the average value of the temperature.

Evaluation of individual questions of the test is presented in diagrams in Fig. 3b. The overall result of the test presents Table 2. As Fig. 3c shows, both groups reached higher score on questions No. 6, 7 and 10 – these were aimed at identification of maximum and minimum value of the temperature and instantaneous temperature. Both groups had also problems with questions No. 8 and 12 – to calculate the difference between maximum and minimum temperature. Experimental group had much better score on questions No. 1, 2 and 11 – to describe axis, identify minimum and maximum scale in the graph, and to calculate the average value of the temperature. There was only one question were better score was reached by reference group – No. 4 – to identify the independent quantity.

	Experimental group Test-maximum points 21	**Reference group Test–maximum points 21**
Number	31	31
Score achieved	362	216
Average score of the test [points / %]	12 / **56**	7 / **33**

Table 2. *Analysis of the results from the test*

The simple analysis of the results (Tab. 2) clearly demonstrates the effectiveness of the education with the support of RE. The average score in the experimental group (expressed as a percentage) was S_E = 56 %. To compare, the average score in the reference group was S_R = 33 % that is significantly less than in the experimental group (ΔS = 23 %). It is obvious that our research question was confirmed and we can say teaching with the support of remote experiments positively affects the durability of knowledge of pupils.

3. Conclusions

Among teachers of Physics exists the prevailing opinion for the necessity of the change of the

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teaching strategy. By using the new teaching tools educators can move pupils/students from mindless memorization to understanding and appreciation. In the previous section we have presented the use of the remote experiments in teaching with the first experiment aimed at testing the possibility of using RE in primary school education. By the project-based learning supported by RE we presented the use of REs into the non-traditional form of education of the unit "Temperature". The pedagogical research via questionnaire and didactic test has been performed at five Slovak primary schools. The main conclusions of the results gained may be drawn as follows:

- The project "Measuring Air Temperature in Different EU Countries" was designed and implemented into the education process at four Slovak primary schools in compliance with the demands of national curriculum.
- The results showed the positive attitude of pupils to remote experimentation.
- The test, aimed at the durability of pupils' knowledge, confirmed the active approach to knowledge acquisition via RE is more effective and causes better durability of knowledge.
- Preliminary results indicate that both teachers and pupils find the remote e-labs to be good learning tool for developing experimental skills.
- The exploitation of three meteorological stations from different EU countries enabled the integration of knowledge and enhanced pupils' key competences from Physics, Math, ICT, Slovak and English language, Geography, and Environmental education.
- We recognized that our project-based learning with remote experimentation fulfils the goals of education in four out of eight fields of learning of the Slovak State Educational Programme for the second grade of primary school: Language and Communication, Mathematics and Work with Information, Man and Nature, Man and Society.
- The remote experiments support the idea of globalization.

Positive results encourage continuing with the presented project as well as with prepared interactive projects at primary schools via remote experimentation during next school year.

Acknowledgment

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THE CINEMA AS STRATEGY OF TEACHING FOR THE COMPRENSION OF SCIENCE AND THE SCIENTIFIC CONTENT IN SECONDARY EDUCATION: THEORIES OF DARWIN AND THE FILM "CREATIÓN"

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Abstract. *At XXI society science teaching play an essential role and the science teachers' comprehension about scientific and technology development is fundamental. The cinema achieved an important and unquestionable social role. Recent studies considerate the cinema can be an effective science teaching strategy. The study it centered to determine biopics Creation impact to improve a secondary student learning about Darwins' Theory and better understanding about science.*

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Qualitative analysis content of fifteen students answer at structured questionnaire about Darwin's theory and movie evolution exposed a positive integration of knowledge scientific between teacher and movie content of evolution.

1. Problem

The Scientific Literacy emphizes about alls majority of citizenship have access to scientific education whit a narrow idea about science and technologic knowledge (Bybee, 1997; Reed y Hodson, 1989). According with a diverse investigation and international documents it´s science education should be centered in enhanced scientific and technological knowledge near to citizenship and student everyday life. For example, diverse problems of health and survival issues agree with the complex relationships between science and society. Science as part of the culture of our time (Furió y Vilches, 1997). In this sense, the comprehension of the nature of science and its relevance to improving the scientific knowledge that is part of the curriculum science it´s fundamental.
On the other hand, cinematographic genres include elements of scientific activities and about nature of science. It can be seen recognize cinema as one of the biggest mass media in information transmission (García, 2005; Gutierrez, Camargo & Guerrero, 2004). Gutierrez *et als*. (2004) say cinema as an audiovisual mediate line can promote the visual alphabetization making the students improve they different abilities, they have particularly can have an important impact in the thinking and creative development. In this sense, this work is centered in find opportunities to science teachers use more creative and significant strategies to promote better understanding about scientific content and with a specifics context related with epistemological, historical, sociological aspect of science.

1.1 Investigation issues

Traditionally, science curricula have been focused in conceptual contents that one need by the inner logic of science. In many senses had forgotten the creation of science itself, about: What science means; How it works; How knowledge is created and developed. Methods used to validate this knowledge; Values involved in the scientific activities; Nature of scientific community; Bounds with technology; Relationship with the society. All dimensions of science must be present in everyday science classrooms. Science teaching through decades has been centered in spread the strict epistemological vision about the scientific activity (Manassero, Vásquez & Acevedo, 2004; Vázquez, Martin, Oliva, Acevedo, Paixao, & Manassero, 2005).
The relevance of cinema to improve the science teaching it present in recent investigation (e.g. Arroio, 2007; Danhoni, Cardoso, Sakai, Veroneze, Bernabé, & Bernabé, 2000; García, 2009, 2010). In many cases the cinema communicates ideas about scientific activity and science non directed by specialist (García, 2010). The problem is the visions of science present in many movies. Recently, García (2009) affirm the vision of science in the movies it´s incorrect. In this stage is essential role to improve in the idea of cinema to a useful resource to improve science strategies to a better comprehension of science in classroom and all the society.

1.2 Aim of study

We investigate the impact of cinema as a teaching strategy to improve the comprehension of nature of science and grade of relation students establish between the content of evolution given in the biology classroom with the issues about evolution in the film "Creation" (Bio-pics, directed by Jon Amiel, based on the book by Randal Keynes in 2009).

2. Methodology

The study used qualitative approach. Data collected with nine questions in structured questionnaire related with content of theories of evolution and aspect about nature of science dimensions. The sample was fifteen students from third grade of secondary school worked in nine groups. Analysis included the content of students answer an each question organized in a semantic net.

3. Result and Discussion

The figure 1 show the semantic net built with most constant concept founded in the students answer.
The semantic net gives important elements that facilitate the visualization of many perspectives of the content learned about Darwin theories and its nature of science dimension. According with a great number of investigations emphasizes the presence of concepts involved with science as a group of processes that make a characterization of the empiric and inductive models. (e.g. Fernández, Gil, Carrascosa, Cachapuz, & Praia, 2002; Abd- El Khalick y Lederman, 2000). However, it has been detected ideas about science closer to constructivist of the scientific activity. Students had some notion of the nature of science but these notions are limited

to a traditional vision of science. The extent numbers of concepts of scientific content and context of discovery with the movie creation showed cinema it's good strategy to use to improve the student learning and with a complete and correct vision of science. Semantic net indicate students achieved an adequate understanding of Darwinian evolution and their social, historical, politic, geographic context and the personal context of Darwin's life. Finally, the study proved the critical role of science teacher to guide student by the best learning of science.

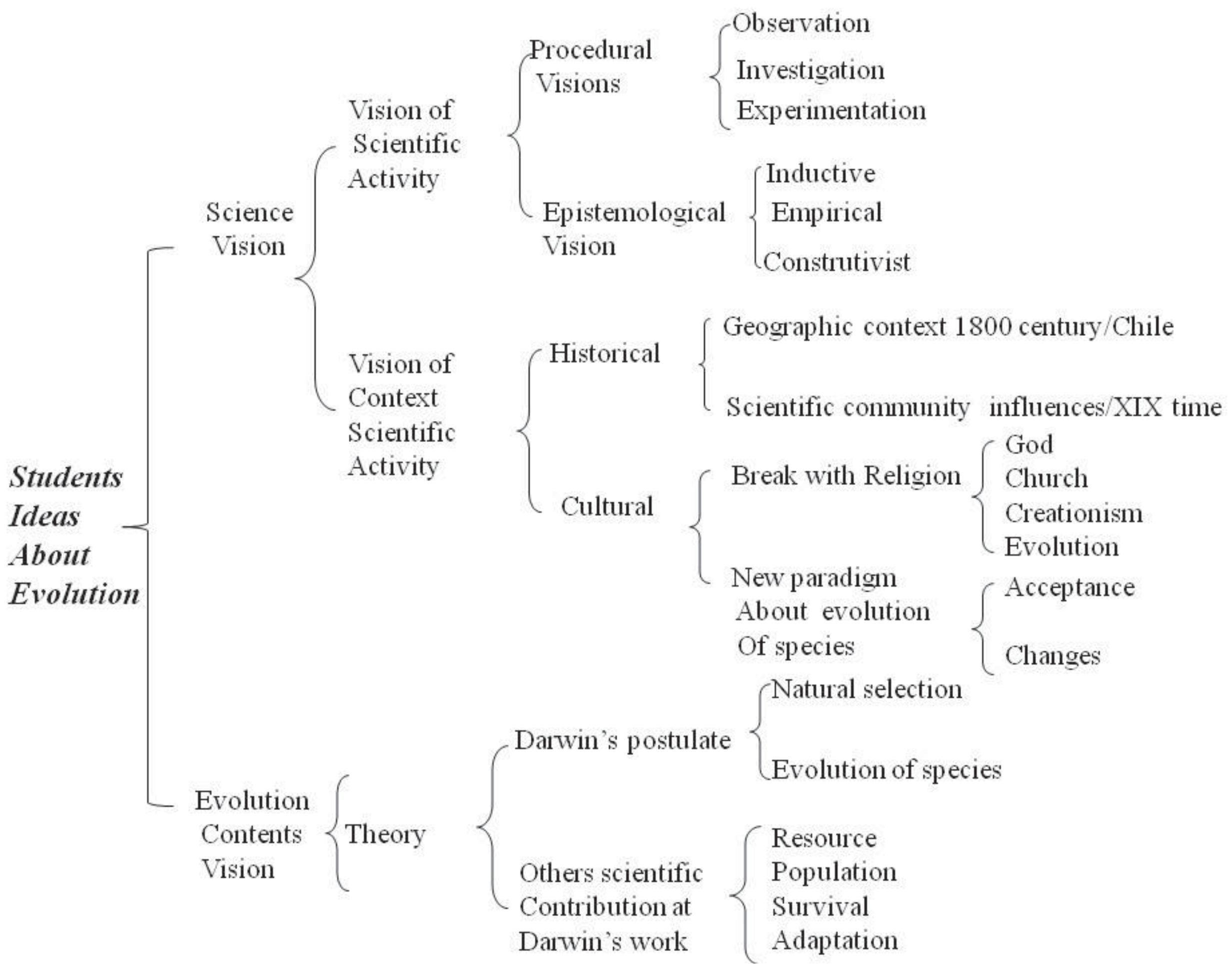

Figure 1. *Semantic net with a different categories and concept students learning about Darwins' Theory and of nature of science*

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NEW MATERIALS: LIQUID CRYSTALS – WHAT TO LEARN ABOUT THEM?

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Abstract. *This contribution discusses possibilities and advantages of introduction of liquid crystals to education as a topic which allows for introduction of a current research topic having a context as liquid crystals are met in everyday life in lap-tops, cellular phones etc. Discussed are physics concepts that are prerequisites for understanding the physics of liquid crystals. Further, physics concepts, which could be better comprehended or illustrated by liquid crystals, are presented. The physics of liquid crystals is interesting as a teaching topic also by itself. Therefore some experiments that can easily be performed in school are presented.*

1. Introduction

Liquid crystals are materials which are seen every day everywhere. Young and old people spend hours in front of computer, cellular phone or TV screen every day, not being aware of the material which allows for the colors, sharpness of the picture (Collings, 2001), etc.

On the other hand, the developed part of the world as a whole is confronting a decreasing interest in science and technological studies (Rocard Report, 2009). There are various reasons pointed out by experts. One of them is a detachment of topics taught in school in time and place with respect to young people's lives. Most of the science topics were discovered long ago and are old from the perspective of a student. They are usually also of no serious relevance to anything in their lives (Bulte, 2004).

Liquid crystals are modern materials, present everywhere and are also a topic in current research. Therefore they are good candidates for being interesting and motivating. They have very special properties; therefore they can be included in organic chemistry, in optics and in thermodynamics as illustrations of various phenomena. In addition, some phenomena can be shown also to very young children as a motivation for science and to increase their curiosity. Liquid crystals are more than welcome in undergraduate physics and chemistry programs as they help to the introduction of difficult concepts like order parameters, phase transitions or dynamical properties. Last but not least, interdisciplinarity in science and in education is nowadays "hot". Liquid crystals fit perfectly as they

exist due to the "symbiosis" between chemistry and physics.
In this contribution we discuss the concepts in physics which are important for understanding liquid crystals and their properties and also vice versa, and we discuss the concepts in physics which could be nicely illustrated and supported by liquid crystals (Pavlin, 2011). Most of them are found in optics and thermodynamics, but there are several other fields in physics as well, where the knowledge about liquid crystals can be used straightforwardly or with a little modification. One of them is also classical mechanics (Bobnar, 2011). The contribution is related to the contribution of (Pečar, 2011) in this proceedings, where some of possible accompanying experiments are discussed in more details.

2. What should students know about liquid crystals?

As scientists we are aware that there are several interesting concepts that the scholar should understand in order to enter the research in the field of soft matter with the emphasis on liquid crystals. However, in this contribution we want to open a different question. What should a student or, if you like, a generally educated citizen know about liquid crystals? From the physicist's point of view, the list is long and it is well known that researchers - specialists are not the best reference when the general knowledge involved in their field is discussed. They tend to exaggerate severely. But, let us try anyway. According to my opinion five different concepts should be recognized by a general audience.

(a) *They are found in all displays that are marked as LCD.* The technology used in visual communications with computers, mobile phones etc. is usually based on liquid crystals. As an interesting fact it is also worth to mention that membranes in our cells can also be considered as liquid crystals, materials forming spider threads are a sort of liquid crystals as well, etc. The message to students is they are everywhere, so it might be interesting to know more about them.

(b) *Liquid crystals are materials in which a special state of matter, a liquid crystalline state is found.*

Usually students are aware of only three states of matter: solid, liquid and a gaseous. They are familiar with the three states for water, for other materials they tend to associate the state of matter at the room temperature with the general material property. A proper choice of sample material which exhibits the liquid crystalline phase at the room temperature, the isotropic phase close to the room temperature accessible by simple means as by heating the cell with the hairdryer and the crystalline state slightly below the room temperature, accessible by cooling the material with crushed ice, allows for students getting acquainted with as a novel phase in addition to the well known ones. Such materials are for example MBBA or 5 CB.

(c) *Liquid crystals have properties of crystals (birefringence) and properties of liquid (they flow).* While the second is trivial, the birefringence as a concept is usually not introduced within a high school curriculum. However, by the help of liquid crystals, the concept may be introduced as an interesting and a motivating one and as it is important for the technology on which LCD displays are based, it could be added to a general knowledge.

(d) *Why are liquid crystals birefringent?* The birefringence and anisotropy of liquid crystals is a consequence of their ordered structure. The concept of the order is also the concept important for understanding the phases and phase transitions. Therefore few types of order in few types of liquid crystals are worth to be presented. One has to bear in mind, that analysis of order, the consequences of the order and how they are used for the structure recognition results from a plethora of various intertwined phenomena.

(e) *Properties of liquid crystals can be manipulated by external field.* Another concept on which the technology is based, are influences of the external electric field on the order and the properties, especially the birefringence, on the liquid crystals, consequently.

The concepts mentioned above will be discussed in the continuation.

3. Which concepts before liquid crystals?

There are several physics concepts that can be simply used when the material properties and the reasons for them are discussed. For example: Snell's law of refraction can be extended to birefringent materials, concepts related to latent heats can be used straightforwardly. There are others that are poorly developed during the teaching in the high school and even at the university level many students manage to escape without deep understanding. Examples of such concepts are: The polarization of light, a general concept of interference as an addition of different electromagnetic waves, etc. However, there are some concepts, which are usually not explained but are necessary to be introduced before speaking about liquid crystals or along with them. They are, according to my opinion: The anisotropy and its relation to different speeds of light in an anisotropic material, the spectrum of light related to its color, and also the polarization of light itself. How can we help students to acquire the understanding or to apply and further develop their existing knowledge? It is hardly believed that liquid crystals would become an obligatory topic at the pre-university level, but they will probably be used to increase the students' motivation for physics and as a topic which supports the development of other scientific skills as the application of a scientific method. Therefore in teaching the prerequisite topics one should use active learning methods, where students are actively involved in experimentations, trying to find experimental answers to "research" questions and to construct the understanding of phenomena with the help of their teacher. Let us briefly discuss few experiments which can be either shown as a demonstration or, even better can be used an active learning problem or an experiment during laboratory activities at least.

(a) *Anisotropy* is a property of material that depends on direction. As directions are usually connected to vectors, such property can easily be shown by some simple examples. Comparison of different knitting patterns (Fig.1) introduces the anisotropy itself and also shows its relation to the material structure. As an example let us compare three different patterns: the rice pattern (Fig.1 – left), the knit stitches (Fig. 1 – middle) and the 2 knit 2 purls stitches (Fig. 1 – right).

Figure 1. *(left) Rice pattern: 4,4 lines/cm and 2,5 stitches/cm; (middle) knit stitches: 5,5 lines/cm and 2,7 stitches/cm; (right) 2 knits 2purls: 3,53 lines/cm and 3,57 stitches/cm.*

The three squares were made by the same number of stitches. One can easily see that they vary in width significantly. Also the number of lines differs. For formation of the square it is extremely difficult to find the pattern for which the number of lines would be equal to the number of stitches in a square. Therefore a comparison of the number of stitches per cm and the number of lines per cm can give the student a basic illustration for the concept of anysotropic structure. Next step is an introduction of anisotropic properties. If one measures the elastic constant i.e. the ratio $\Delta F/\ \Delta x$ of the pattern in two different directions – parallel to the lines and perpendicular to the lines, they differ significantly (Pečar, 2011).

After introduction of the basic concept – the anisotropy, it is easily recognized that the wood should have anisotropic properties. The wood is especially appropriate for building the first conceptual understanding of different states of polarized light. During the teaching, the linear polarization is usually mentioned; however various other types of polarization, especially details with respect to elliptic polarizations are often presented simply by equations. Transmission of microwaves having different directions of linear polarizations with respect to the wood fiber direction, allows for a detailed study of the properties of elliptically polarized light and to deduce the value of difference between the two refraction indexes (Ziherl, 2010, 2011).

Extending the knowledge from microwaves, which are monochromatic, to the light, which has many components, one can use simple materials like tape or transparencies, which are birefringent in the optical region. In the teaching sequence we first show that the transparent tape becomes colored, when it is observed between crossed or parallel polarizers. The experiment where the thickness is varied by changing the number of tape layers is shown. The thickness obviously influences the color. Finally one measures the light spectrum, which clearly indicates absence of some light wavelengths. For known birefringence data students can easily calculate that for these well defined wavelengths the tape presents either $(2k+1)\pi$ retardation of one polarization with respect to the other or for parallel polarizers or $2k\pi$ retardation for perpendicular polarizers. They can also estimate the difference in refraction indexes if the data is not known [6,9]. The same method is later used for observation of liquid crystals textures.

4. Which concepts by liquid crystals?

It is interesting for students, if they synthesize materials themselves within chemistry laboratory. Afterwards they use "their" material for studying their physical properties within physics laboratory. Some of the procedures were already reported, they are simple enough that the synthesis in successful and demands only one laboratory session of approximately 90 minutes (Pavlin, 2011).

The quality of the synthesized liquid crystal is verified by two different methods. The two transition temperatures are measured in the oil bath (Pavlin, 2011). The measurement is also used for introduction of the new phase. Students are often not aware of the fact that the phase transition occurs at a certain temperature. For a physicist the absence of such an idea is hard to understand, but students meet ice in (glasses of) water that is far from zero degrees, they know that the snow exists also when air temperatures are above zero degrees; the exact measurements of ice temperature are extremely rare in their personal experience, especially out of the school. Therefore the cloudy appearance of the liquid crystalline phase can easily be misinterpreted as a mixture of the crystal and an isotropic liquid. The teacher has to point out that the cloudy appearance is present in a wider temperature region and for a comparison performs also measurement of the ice temperature during the heating.

Liquid crystalline cell are prepared by very simple means. Using clean rubbed object and cover glasses usually used for microscopy, students fill with liquid crystals, observe the colors under crossed polarizers under the usual microscope used in biology classes. They heat the cell with a hair dryer and induce a phase transition to the isotropic phase. The instantaneous disappearance of colors indicating the sudden change of optical properties at the phase transition is clearly observed [4]. Finally, they can measure the two different refractive indexes by measuring the light laser beam deflection on the wedge cell or by observation of the conoscopic images (Pavlin 2011, Pečar 2011).

The properties mentioned above can be used as motivating experiments as well. For example, color of a liquid crystal under crossed polarizers can be used as a motivation to understand the effect of the birefringent material on the polarized light.

5. Conclusions

The paper discusses possible roles of liquid crystals in education. Several physics concepts are needed to understand the physics of liquid crystals. However several phenomena, typical for liquid crystals can be used for introduction of these phenomena. As liquid crystals are materials on which several daily used modern devices are based, they present the interdisciplinary topic in physics, chemistry and technology, which is not old with respect to active research and which is also relevant for every day. Such topics are rather rare but they should increase students' motivation for science.

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PARADOXICAL QUANTUM EFFECTS AS MOTIVATING TOOLS FOR INTRODUCTORY QUANTUM MECHANICAL COURSE

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Abstract. *Quantum physics is difficult and its basic ideas are very far even from the university students. Principles governing the quantum realm and the macroscopic classical world differ significantly not only in their mathematical formulations, but also in their fundamental concepts and philosophical consequences. Quantum effects cannot be interpreted in the frame of classical physics due to the probabilistic character of quantum physics. Discussion of real and thought experiments which lead to paradoxical result according to classical physics can provide a motivating starting point for the introduction of the most important principles and methods of quantum mechanics.*

Interaction-free measurements are those ones in quantum mechanics where the position or state of an object should be detected without the occurrence of any interaction between the object and the measuring device. One of the best example of the interaction-free measurement is the Elitzur–Vaidman bomb-testing problem: consider a collection of bombs, some of which are dud. Suppose that usable bombs have a photon-triggered sensor as a detonator. If the sensor absorbs a photon the bomb explodes.

The detonator of the dud bombs does not work. The problem is: how a usable bomb can be chosen without its explosion. Without quantum mechanics the solution of the problem is impossible because the only possibility of testing a bomb is to try to detonate it. An actual bomb-tester was constructed and successfully tried by Zeilinger at al. in 1994.

The description of this quantum effect is relatively difficult. In this paper a simplified version of the Zeilinger method is shown. This version of the measurement can be represented in 2-dimensional Hilbert-space with Schrödinger-picture and with the use of simple mathematics (the most advanced mathematical operation is the product of 2x2 matrices). For helping students, an interactive computer-based material is also presented.

Another good example is the quantum version of the well-know Monty Hall game which is discussed also in this lecture.

AN INTERACTIVE COMPUTER-BASED MATERIAL FOR RANDOM-WALK PHENOMENA

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Abstract. *Random walk has proved to be a useful model in a wide field of scientific disciplines for the description of natural processes. With the application of this model students can obtain a deep insight of the governing mechanism of some natural phenomena. Therefore the knowledge and understanding of the model is very important for the students of technical universities too.*

In this work an interactive, computer-based material is presented which has been applied for teaching modern physics at Faculty of Mechanical Engineering and Automation of Kecskemét College. (It was created by Peter Nagy who is one of the authors of this presentation.) The level, style, and content were fitted to the knowledge of college level student.

In the material, with the use of videos and computer simulations a lot of example is shown for application of the random walk process. (For example the Brown motion, the percolation, the diffusion limited aggregation, the self avoiding random walk and the PageRank algorithm of the goggle search engine are discussed.) Material provides possibility for interactive measurement, students can measure the fractal dimension of the random walk and also for the self avoiding random walk. The mathematical description of the fractals is also discussed in a detailed manner and illustrated with spectacular examples. Simulations based on the independent particle model of ideal gases give the illustration of the equipartition theorem and the barometric pressure formula. The different character of the two and three dimensional random walk, namely the 2d motion is recurrent (it returns to its starting point), while the 3d one is transient (after some time walk does not return to the starting point) is also enlightened. Finally, there is a possibility for students to try some simulations which illustrate the behaviour of chaotic system.

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EXPERIMENTING FROM A DISTANCE IN CASE OF (OPTICAL) FOURIER-TRANSFORMATION

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Abstract. *One of the aims to use multimedia in physics teaching and learning is to visualize mathematical relations or complex phenomena, e. g. Fourier-Transformation (FT). It is well known that if light is diffracted by objects the intensity distribution in Point P on a screen is the Fourier transformed of the diaphragm described by a suited function. Therefore it is obvious to use an optical set up to teach and model the FT experimentally.*
We built a Remotely Controlled Laboratory (RCL) to study optical FT. The set up is standard, but the objects are produced by electron beam lithography for high quality diffraction patterns. The remote user has to switch on the laser, has to choose a diffracting object, has to analyse the respective intensity pattern and has to develop his own research program depending on the richness of diffracting objects or matter of interest.
We will perform the RCL with diffracting objects like circular, quadratic or triangular diaphragms (single forms), like different arrangements of single forms and "infinit" or finit quadratic grids. One aim is to visualize the basic laws of FT (scaling, linearity, separation, convolution, symmetries) and to support their learning. The other aim ist to understand the structure of two-dimensional diffraction pattern.kM11

NANOMATERIALS SCIENCE LEARNING RESOURCE FOR SECONDARY SCHOOLS

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Abstract. *The aim of this work is development of electronic learning resource on Nanomaterials Science Basis for pupils of secondary school. This resource is a component of electronic educational complex "Physics of nanomaterials" ("PhNM"), which was developed for support of the course "PhNM" for students of Karelian State Pedagogical Academy.*
Using this resource pupils get first knowledge on nanomaterials science. All themes are divided in four sections: "What is nano?", "What is nanomaterial?", "What is nanotechnology?" and "Applications of nanotechnologies". Materials are presented as brief illustrated texts and video materials, as well as games, crosswords, puzzles and different practices. Tests collection with multiple choices is intended for the knowledge control. Also there are such important sections as "Dictionary", "Library" and "Materials for Teacher" in developed resource.
For the development of learning resource language HTML, Sothink SWF Quicker, Macromedia Flash and Adobe Premiere were used. Programming language Java Script was used for tests processing.
The testing of developed learning resource on Nanomaterials Science Basis among school students will begin in September 2011.

THE IMPACT OF LEARNING MARINE BIODIVERSITY "BY DOING", IN 8TH SCHOOL YEAR STUDENTS

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Abstract. *For Students from the 8th school year of the Portuguese educational system, Natural Sciences and Project Area units are mandatory. With the objective of learning marine biodiversity "by doing", an activity involving both units was implemented during 6 months. Firstly students were given a conference by external experts. Secondly students worked in the field (intertidal platform - protect Biophysics of Avencas) collecting animals and registering the biodiversity. Thirdly, in the lab, they tried to identify the species collected. Finally, at the classroom, students prepared different types of works: models, posters, films, PowerPoint's, etc. The best works were submitted to the national contest KIT MAR. To evaluate the impact on students, surveys were implemented before and after. Results demonstrated that students appreciated the methodology and knowledge has improved.*

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A REASEARCH BASED E-LEARNING PROCESS FOR TEACHER FORMATION ON QUANTUM MECHANICS

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Abstract. *A deep reflection in the reconstruction of the basic concepts is crucial for teachers when a conceptual change in the way of thinking about phenomena is involved, as in the case of Quantum Mechanics (QM). Metacultural, Experiencial and Situated integrated modalities were implemented in the last years in a e-learning Master module on QM for personal involvement of teachers in building Pedagogical Content Knowledge (PCK). Different learning path in the construction of CK and PCK on QM emerge in the conceptual discussion of the virtual community of in-service teachers of different areas in Italy.*

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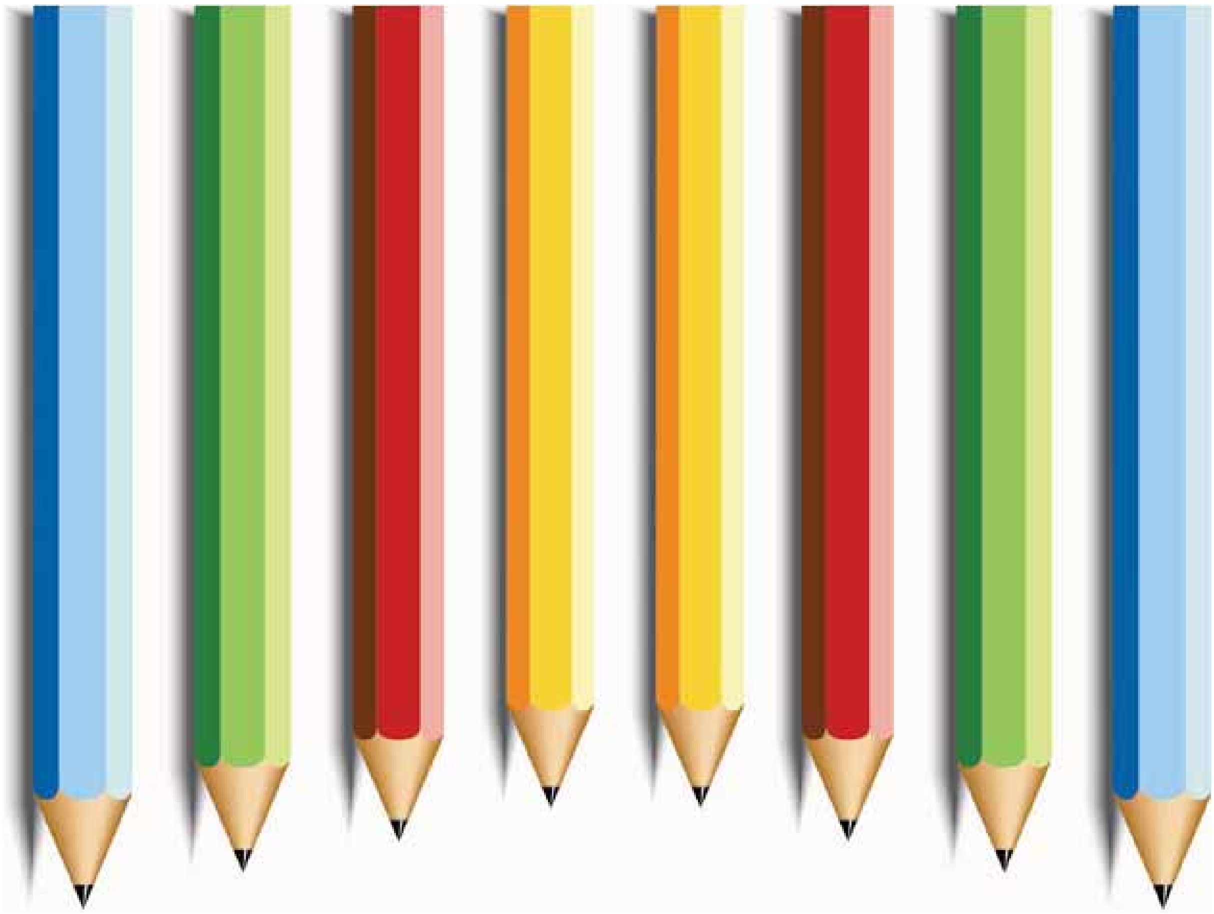
Science and Society



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DESIGN AND CONSTRUCTION OF SOLAR OVENS: A PRACTICAL APPROACH TO THE GREENHOUSE EFFECT AND CLIMATE CHANGE

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Abstract. *This article describes the use of solar ovens as a practical way of understanding how the greenhouse effect can cause warming of any object or the earth's surface, a phenomenon known as global warming. The design and construction of solar ovens requires a basic knowledge of the physical effects of solar radiation, the forms of heat transfer and its relation to the temperature of objects, but there is no need of complicated formulas or mathematical calculations. The article also shows several activities with elementary students (8-12 years) who were able to perform the construction and use of solar ovens with excellent results. The activities were carried out in two schools of Barrantes (Tomiño) and Gondomar, and IES Valadares (Vigo), all of them in Galicia, Spain.*

1. Introduction

In XVIII century swiss scientist Horace de Saussure cooked some fruits and vegetables in a triple glass box insulated with wool. It was one of the first documented experiences of solar ovens construction and solar cooking.
From these early experiences a major research effort has been carried out in the field of solar energy for both thermal and electrical applications.
In recent years growing concern about climate change and global warming recommended to make extensive work teaching on these issues to increase knowledge of the general public and promote searching of possible solutions.
The construction of a solar oven concentrates on a single experience all the scientific principles involved in the global warming phenomenon, which can be verified and measured on a small scale. In addition it is a fun experience and with the help of a little sun the result can be tasted in the form of a delicious cake or dessert that students will not forget.

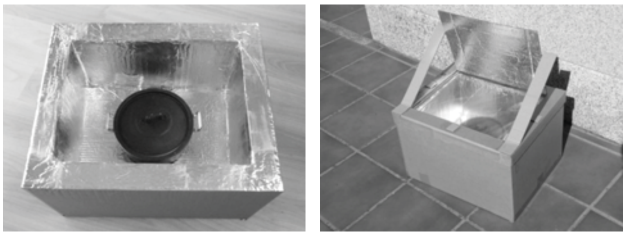

Figure 1. *Solar oven without cover (left) and with cover and reflector (right)*

2. Solar cookers in practice

Modern history of solar cooking box-type oven begins in the 70's with Barbara Kerr and Sherry Cole, two of the founders of Solar Cookers International. Their design, made of cardboard and foil, is a model of simplicity and efficiency.
The use of solar ovens is not limited to food preparation, but is the basis for numerous industrial and energy applications. In Odeillo, in the French Pyrenees, has been operating for several decades an oven (which really is a concentrator) for the metallurgical testing, and the Plataforma Solar de Almería (Spain) has also a similar system.
From a technological point of view a solar cooker is a solar thermal collector designed specifically for heating solids such as food (although it can also be used for liquids stored in pots or bottles).
The determining parameter of cooked foods is the temperature, so that the design of a solar cooker is oriented to achieve a rapid increase of the temperature of the food and keep it the time required for proper processing.
There are two ways to achieve the temperature rise in a solar kitchen: capturing the maximum possible solar radiation by concentration or the accumulation of heat in an insulated box ("heat trap").
The principle of heat accumulation present in the solar ovens can be observed in many real cases, as in automobiles, homes and in the atmosphere (greenhouse gases also cause warming on the earth surface). In all cases there is a transparent window and an enclosure that accumulates the heat.

Figure 2. *Barbara Kerr and Sherry Coke (left) and solar oven at PSA (right)*

3. Solar ovens design

Solar ovens design and construction involves a careful study and application of principles of energy and heat transmission by conduction, convection and radiation. These principles will be revised in the next paragraphs.

3.1. Radiation

Solar energy reaches a solar oven by radiation. Visible, ultraviolet and near infrared radiation get into the oven and get absorbed by a black pot and lid that works as a black body. White or reflecting pots don´t work the same way and reject sun radiation. Glass or plastic window in the upper part of the oven must allow this type of radiation get into the oven.

On the other hand, lower radiation frequencies like far infrared should not be allowed to escape from the oven, so window must reflect them inside. This effect (known as the 'greenhouse effect') leads to a net storage of heat inside the oven and raising of inner temperature.

Some techniques to achieve the maximum amount of radiation inside the oven:

- proper orientation of the oven (south at midday).
- use of reflectors to increase the collector area (plans, parabolic).
- transparent surfaces of glass or plastic to maximize the radiation transmission.
- reflective surfaces for internal radiation reflection.

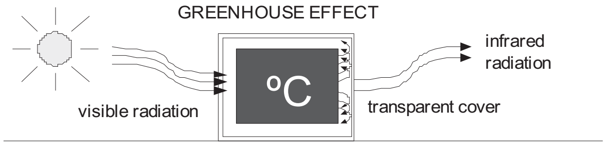

Figure 3. *Solar radiation and greenhouse effect*

3.2. Conduction and Convection

Heat stored in the oven escapes by conduction throws solid walls of the oven and convection of air trapped inside. The hot pot generates infrared radiation, so it must be surrounded by surfaces that reflect the radiation (mirror, glass, some types of plastic like polypropylene, poliester, methacrylate). Any hot area must be separated from the outside elements and surrounded by insulation or air. Wood, cardboard and paper are good low cost insulations. Hot air surrounding the pot can transfer heat to the upper cover and walls. For the cover, it can be avoided with a double layer of transparent glass or plastic. It must be noted that in solar cookers the upper part is warmer than lower (as opposed to the traditional cuisine).

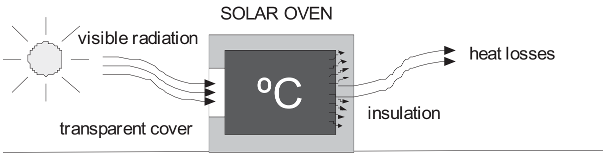

Figure 4. *Heat losses in a solar oven*

4. Solar oven construction

We have chosen the original solar oven model developed by Barbara Kerr and Sherry Cole. A detailed description of the construction process can be found in (Solar Cookers International 2004).

The activities were carried out in CEIP Barrantes (Tomiño, Spain), CEIP Chano Piñeiro (Gondomar, Spain) and IES Valadares (Vigo) with several groups of students of different ages. The activities took two days, the first for the construction of the solar ovens and the second to use them. It is recommended to leave at least one night to completely dry all the glued parts of the ovens.

The first day there was a presentation about solar energy types and devices and how can contribute to sustainable development and stop climate change. In second place there was an explanation of the construction steps of the solar ovens and after that students started to make their own ovens.

The second day was dedicated to food preparation and different activities like games and basic scientific experiences about solar energy.

Figure 5. *Explanation and first construction steps (CEIP Barrantes)*

Figure 6. *Covering with aluminium foil (CEIP Barrantes)*

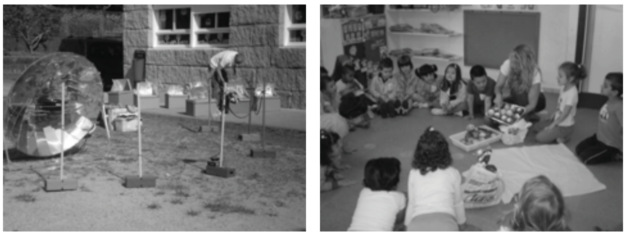

Figure 7. *Solar ovens ready to cook and the delicious result (CEIP Barrantes)*

5. Complementary activities

Use of solar ovens means waiting a long time before food is ready, specially for children. To “fill the gap” several activities were made, like construction of water pasteurizers, solar games, using of parabolic cookers to boil water, etc.

Figure 8. *Exhibition of solar devices and presentation (CEIP Barrantes)*

Figure 9. *Sunflowers painting workshop and boiling water with the parabolic cooker (CEIP Barrantes)*

Figure 10. *Solar pasteurization workshop (CEIP Chano Piñeiro)*

Figure 11. *Solar activities and games (CEIP Chano Piñeiro)*

Figure 12. *Solar oven workshop at IES Valadares (Vigo)*

Acknowledgements

The authors wish to thank Prof. Maria Lemos, Prof. Begoña Martinez and all the students and staff at CEIP Barrantes, CEIP Chano Piñeiro, IES Valadares and Mr. Thierry Soto of Terinex LTD for their cooperation to the success of these activities.

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LEARNING THE IMPORTANCE OF THE SUN AS AN IMPORTANT ENERGY SOURCE BY BUILDING "SOLAR CARS"

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Abstract. *It is important that public opinion becomes aware of the consequences of using pollutant energy sources, so that they can act as a pressure group to change the world's energy paradigm. To achieve this goal, we are presenting to children, 10 to 15 years old, the opportunity to get in touch with photovoltaic energy production, its basic working principles and applications, by enrolling them in building "Solar Cars". Children can understand the benefits of this clean renewable energy in a very exciting way byputting their "hands-on-science". This experimental learning process is capable of producing meaningful and long lasting knowledge, important to improve science teaching in our schools.*

1. Introduction

Due to the increasing demand onenergyand the need to replacefossil fuel, responsible for significant pollution problems, and the increase in global warming due to high emissions of CO_2 to the atmosphere, there is a growing interest is producing energy directly from renewable green sources, namely producing electricity directly from the sun.

Photovoltaic cells are the answer to this goal. Although the photovoltaic effect was discovered in 1839 by the French Physicist Edmond Becquerel, only in 20th century (1954)the first inorganic modern solar cell was announced by the Bell laboratories(Partain 2010).Since then, lots of progresses were made. The efficiency of the inorganic photovoltaic cells was improved and nowadays there are standard solar cells with efficiencies around 15%. Due to the development of different materials and production techniques, the price of these devices as also had a significant decrease (Partain 2010),making them more competitive for energy production. In parallel with the inorganic materials, the development of organic and polymer based photovoltaic elements introduced the possibility of commercializing flexible, low weight and low cost cells to produce energy from light (Sariciftci1992, Spangaard 2004).

At first,solar cells were used in space applications such as space stations and satellites,small objects, like calculators and toys, and other minor uses. Nowadays solar cells are commonly used in power plants to produce electricity in a large scale and in remote places. More recently solar cells were integrated in buildings' roofs and walls, as a part of glasses, roof tiles and wall coatings (Miles 2007).In the next few years, with the decrease of their price and the increase of their efficiency, solar cells may further gain a significant importance in the world's energy production (Partain 2010).

It is important that young people get in touch with this technology, understanding the basic physics concepts involved, rather important in physics andscience teaching, and all its benefits for the environment. To do so we implemented a very simple approach to the study of solar energy, allowing young students to create and develop solar car models by their own.Just the basic information is provided about the world's energetic situation, energy resources and in particular solar cells basic working principles, basic electricity concepts and, only when necessary, helping them in some construction problems that they may face.

Because thissolar cars project is designed to target young students, the best place for itsimplementationis at school. To achieve thisit is important to motivate school teachers to theproject, because they will have the leading role on its development. To do so, we provide theminitial training courses were we present the objectives of the project, all the necessary theoretical information andalso an application guide for classrooms.

In order to introduce students to the project, whenever possible, they should visit an electricity solar plant or, in alternative, another "green"electric plant.After an initial theoretical briefing,students are encouraged to use all kind of materials and everyday objects that we can found at our homes and that otherwise will be considered as trash, recycling them, to build their solar cars. The only non recycled materials will be the solar panels and the electric motor (that can also be foundin an old toy car, for instance).

2. Implementation

In the next paragraphs we will show an example of how a class ofnineteen students, with 13 years old,engineered solar cars.

Before the physical construction of the car, we divided our class of students in small groups (a maximum of 3 individuals is advisable). Then, each group has to create a solar carproject, making the entire task planning,identifying the materials needed and estimating the time needed to complete the project. This is important for students because they have opportunity to think autonomously, and to

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develop their skills in abstract thinking and group dynamics.

The choice of the car chassis is a first very important step in its construction process because it has to be resistant,sinceall other components will be assembled there, but at the same time very light due to the relatively low power generated by the solar cells. Our goal is to have the students using everyday materials that otherwise will be considered as trash.Thusthe chassis can be a simple plastic bottle, a juice or milk pack, styrofoam from any appliance, or other material that has the desirable lightness and robustness characteristics. Below we describe the solar car building of a group of students that chose a milk pack as chassis, the material used (Figure 1.), and all its construction steps.

Figure1. *Materials used by a group of students to build a solar car.*

After choosing the chassis it is important now to choose the car wheels and axis. Students chose plastic bottle caps perforated in the middle in a way that they can use wood sticks, used in barbecues, as axis. The transmission has also to be included in the wheels axis. It can be a smaller cap, or cork, sandwiched between two larger caps, serving also as wheels (Figure 2.). The students chose this type of transmission because they will use a small elastic rubber band to transfer the rotation movement from the electric motorto the wheels axis.

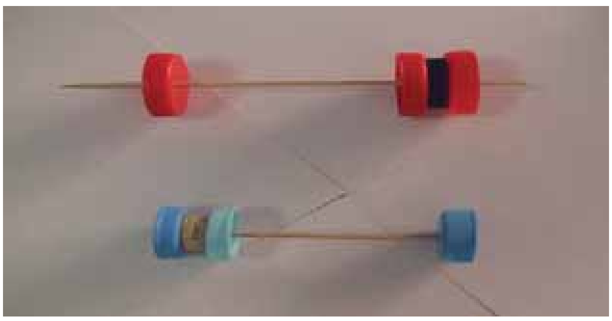

Figure 2. *Two different solar car transmission axis.*

Figure 3. *Solar car chassis with drilled holesforaxis support.*

After washing the milk pack the students drilled holes on it to introduce the car axis. It is important that the holes are perfectly aligned, so that the front and back wheels and axis are parallel to each other. To reduce the friction between the wood axis and the milk pack a strawwas introduced in the front and back holes with enoughdiameter to allow the wood stick to rotate freely (Figure.3.).

The first part of the car construction was completed and thereafterit was necessary to build the electrical part. In this case, the studentsused 3 small solar panels (each one generating 0.2 watt) connected in series. It is possible to use just one panel if it is capable of generating a higher power, oreven more than 3 panels. Nevertheless it is important to balance the panels power with their weight.The panels were connected to the electric motor using small diameter wires.

The last step of the construction process is to place the solar panels and the electric motor in the chassis. It is very important that the transmission and the electric motor rotating axis are perfectly aligned. The distance between these two components has to be set in a way that the small elastic rubber band, responsible for the movement transmission, gets the correct tension. The electric motor wasattached to the chassis using a plastic clamp and solar panels were attached using double-sided adhesive tape.The construction was now completed and the carwas tested to make the necessary improvements or adjustments (Figure 4.).At this point it is possible to use the solar cars to explore some physical concepts. For example, students can be induced to understand the effects of using different diameter caps on wheels or transmission,introducing important physics concepts like velocity or acceleration.

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Figure 4. *Assembled solar car.*

After this construction stage it is important that student's don´t forget their cars! Teachers and students should organize solar car races(in their school and with other schools), so that they can see the result of their creations, and its applicability. This willhelp them to assess the quality of theircar and to come up with improvements to its characteristics, adoptinga critical attitude and encouraging them to think autonomously. All these aspects are very important to help them develop a scientific thought.

3. Conclusion

Our experience shows that children that participated in this project improved their capacity of problem solving and their self critic. At the same time their interest for scientific disciplines, and for school itself, was boosted and consequently their grades improved, especially in scientific areas. In the above mentionedclass,with 19 students, the number of negative grades in physics and chemistry was reduced to zero(from aninitialnumber of three), and the number of higher grades improved66 %, in comparison with the previous year. This was achieved by letting the studentsput their "*hands-on science*"!

4. Future developments

From the success with basic school students we are now starting to present the "solar cars project" to older students (secondary school grades). Although the goals are basically the same, working with older students opens the possibility of more daring projects. In future we will communicate more details of its implementationand the results obtained.

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MODULAR MULTIFUNCTIONAL SKYLIGHT

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Abstract .*The city of Porto, World Cultural Heritage since 1996, presents in its historical center, a large number of skylights in secular buildings that are a hallmark of its brownish tone.*
The need for natural light inside buildings due to the absence of electricity might have been the reason for the appearance of these historical structures in the city, along with the fact that this region is prone to periods of overcast by clouds or fog.
The rooftops of the buildings that allowed for natural light gains were pure masterpieces adjusted to the available space, the taste of the iron and glass craftsmen or by the taste of the master builder. The skylights were well differentiated and executed one by one, adapted to the roof of the building.
With the introduction of electricity in the city, the construction of skylights was somehow demoted as a Plan B, to be set up in place by convenience or by tradition and conviction of energy savings.
The rationalization of energy is now a key objective in order, to be a part of philosophy geared towards sustainability as a way of ensuring quality of life standards for future generations.
The current construction of skylights in the built environment reveals itself as almost inexistent or so aesthetically appealing and sometimes causing an inadequate environmental impact in its architectural value.
The project hereby presented, in a commitment to sustainable design, is challenging in its conception, development and implementation. We are aware that the sun is our source of natural light.
The design of the structure in study will serve as a model for a possible application of glass in the pieces but always taking into account other bold proposals such as

the use of colored glasses. Imagination is the line that connects creativity to innovation!
The idea of sustainability in design aims to contribute to the improvement of quality of life and is always seeking to find a balance between the functional, aesthetic, economic, social and cultural global development.
The materials used, glass and aluminum, were cut, manufactured and applied in the construction of surfaces for different experimental models of pyramidal skylights. This new structure has a prismatic shape with equilateral triangles with side 30 cm and 8 cm in height to be applied in outdoor spaces on top of buildings.
In this school project we promote modular construction of skylights, showing that it is possible to get an effective energy saving in buildings associated with the elimination of the corresponding carbon dioxide emissions into the atmosphere from burning fossil fuels.

Keywords. *Solar Energy. Sustainable Architecture. Hands-on Teaching. Urban Design.*

1. Introduction

When we visit the historic center of Porto few are the opportunities to enjoy the typical secular skylights due to their rooftop positioning, but the ones with a keen observer eye areal ways able to contemplate. Lost in the pedestrian sidewalks, between roads and streets, we do not realize the true masterpieces that are these architectural elements. Skylights back to the time when there was no electric light inside buildings and they were only lit by natural light during the day and even at night with the moonlight. In fact, there are some top places that let you see the top of the houses. Strategic viewpoints such as the Cathedral Square (Sé) in Porto, or "Serra do Pilar", in Vila Nova de Gaia, can serve as observation posts.

Figure 1. *Historic Center of Porto*

With the implementation of electric light, new constructions relegated to a secondary concern the construction and preservation of skylights. Likewise, the cost of manpower and shortage of skylight's craftsmen contributed to the reduction of construction of these masterpieces. In 2007, a master's thesis presented at FEUP - Faculty of Engineering of Porto University, studied and promoted intervention techniques for maintenance and restoration of old skylights in the city of Porto.

2. Project Methodology Applied

We can describe the methodology used based on the tasks that were followed in every step.

- Photographic exhibition about the skylights in the historical downtown of Porto;
- Documentary research on annual average hours of sunshine in the city of Porto;
- Planning, design and production of a model piece for testing outdoors;
- Preparation and assembly of a structure (equilateral face) in aluminum bracket to support the pieces together;
- Study of the integration and assembly of the faces in pyramidal structures with an innovative urban design;
- Installation of different pyramids outdoors for testing with experimental data collection;
- Analysis of final results and reflection on future prospects.

The authors, high school students attending the Scientific-Technological Course of Chemistry, Environment and Quality of "Colégio Internato dos Carvalhos", developed this extracurricular project.

3. Hands-on MMS Project

3.1. History

Throughout history sunlight has always represented a subject of study by all of those who devoted all their attention to scientific observation. The first scholars of optical and geometrical physics contributed significantly to the parallel construction of scientific knowledge between physics and mathematics. Nowadays, the assembly and installation of skylights for natural light gains, within public and private buildings, often turn out to be inadequate in terms of its architecture. The visual impact does not take advantage of the architectural value of buildings and so, a valuable asset is lost in the urban environment.

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Take advantage of natural light provided by the sun, from the perspective of sustainable design, was for us, the great challenge that led to the design, development and implementation of this project.
The option of resorting to the use of common raw materials such as glass plates [4] and plate aluminium, demonstrates well our intention to combine the design of simple parts, which together allow the construction of handmade skylights.
Practically this school project developed in *hands-on* environment stands out for its ability to minimize energy consumption in buildings with environmental implications associated with the corresponding reduction of CO2 emissions and a saving in the consumption of natural fossil fuels.

3.2. Design and construction of the model number

The model structure, PIN, was produced and tested for its ability to use the sun by refraction and reflection of light [7]. The structure is constructed in the form of an equilateral triangular prism with a height of 80 mm and sides 300 x 300 x 300 mm. This was built by connecting units of equilateral triangular and rectangular glass with colorless silicone.
Presented below are sequential images of the PIN model.

Figure. 2. *PIN glass units*

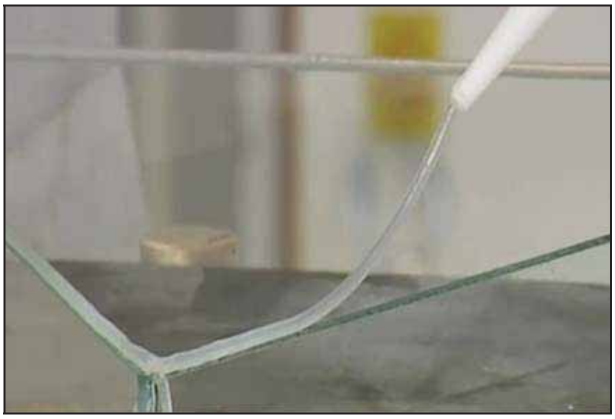

Figure 3. *PIN structure assembly*

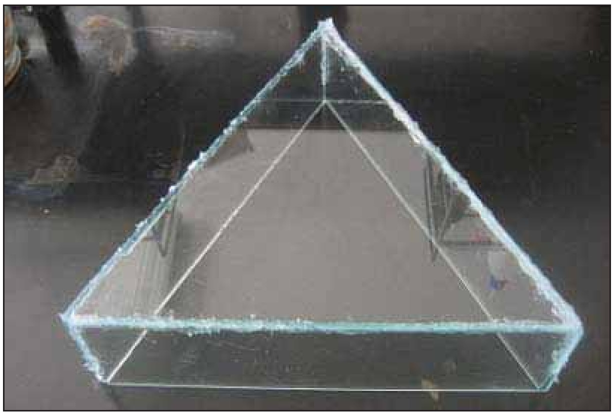

Figure 4. *PIN structure*

3.3. Design and construction of aluminum-sided bracket

We used a coated aluminum bracket with 30 mm flap and 1 m in length. Rivets join the cutted pieces and two parallel brackets form the equilateral triangle, in order to support the parts in each section. Then we present the images of the structure of the support layer built in white-coated aluminum.

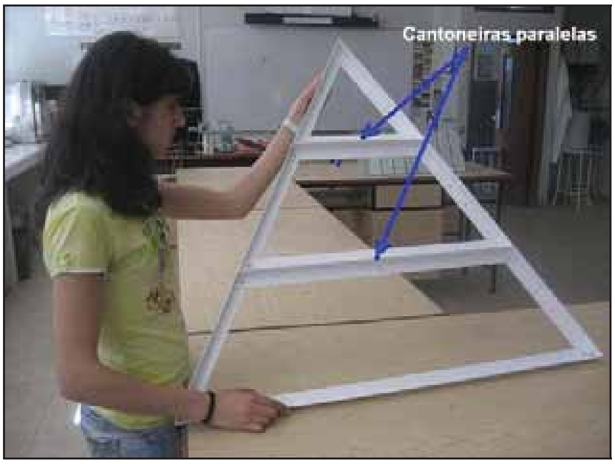

Figure 5. *9 PIN face structure*

In this structure of the layer we've proceeded to the implementation of the PIN parts, with the result presented in the following image:

Figure 6. *Pyramid face*

3.4. Construction of the adjustable pyramidal skylights

Based on the scientific knowledge about the relationship of equality between the side of a hexagon inscribed in a circle and its radius and also the division of a hexagon into six equal equilateral triangles, we find that six PIN pieces are on the same flat face. If we removed one piece corresponding to one side we would get a pentagonal pyramid, by removing two we would have a square pyramid and removing three pieces would get use triangular pyramid. The relationship between the heights of the pyramids and the side of the formed equilateral triangle will be as follows:

Unidade / PIN										
Peças com 30 cm de lado	1	4	9	16	25	36	49	64	81	100
Largura do lado do triângulo / cm	30	60	90	120	150	180	210	240	270	300
Área da base / cm2										
triângulo	390	1.559	3.507	6.235	9.743	14.030	19.096	24.942	31.567	38.971
quadrado	900	3.600	8.100	14.400	22.500	32.400	44.100	57.600	72.900	90.000
pentágono	1.548	6.194	13.936	24.775	38.711	55.744	75.875	99.100	125.425	154.845
hexágono	2.338	9.353	21.044	37.412	58.457	84.178	114.575	149.649	189.400	233.827
Altura da pirâmide / cm										
triângular	24	49	73	98	122	147	171	196	220	245
quadrangular	21	42	64	85	106	127	148	170	191	212
pentagonal	16	32	47	63	79	95	110	126	142	158
hexagonal	0	0	0	0	0	0	0	0	0	0
Relação (Área/Altura)										
triângulo	16	32	48	64	80	95	111	127	143	159
quadrado	42	85	127	170	212	255	297	339	382	424
pentágono	148	297	445	593	741	890	1.038	1.186	1.334	1.483
Factor de progressão da área										
triângulo	-	2,00	3,00	4,00	5,00	6,00	7,00	8,00	9,00	10,00
quadrado	-	2,00	3,00	4,00	5,00	6,00	7,00	8,00	9,00	10,00
pentágono	-	2,00	3,00	4,00	5,00	6,00	7,00	8,00	9,00	10,00

Quadro 1 – Relação área/altura

Table 1. *Relationship Between Heights Pyramid And Face Numbers*

The images below show a top view for all possible combinations of parts. Sequentially all the images from the plan model to the tetrahedron.

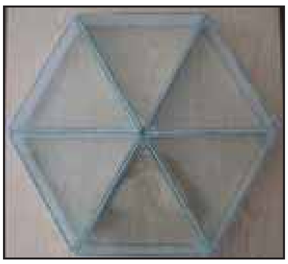

Figure 7. *Six PIN (flat surface)*

Figure 8. *Pentagonal pyramid*

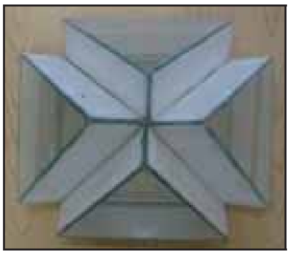

Figure 9. *Square pyramid*

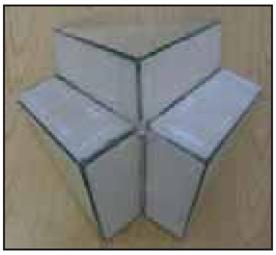

Figure 10. *Triangular pyramid*

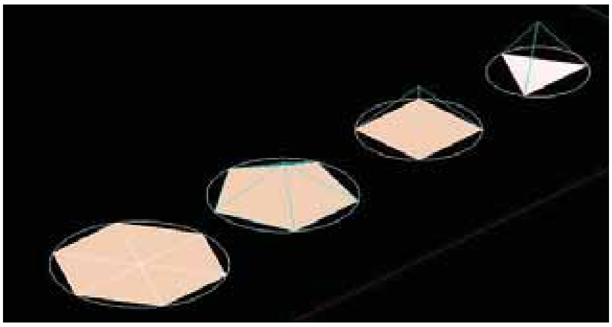

Figure 11. *Geometrical representation of all the possibilities*

The construction of the structures of the skylights was conducted in the laboratory from which we have some of the sequential images of the assembly:

Figure 12. *Skylight models*

Figure 13. *Skylight structure assembly*

4. Experimental Results Obtained

The experimental results presented below were obtained on days when there was high solar radiation: 2800 Lux, in open sky.

The tests were conducted on a single PIN structure and on three different pyramidal skylights shapes with their faces all the same. The piece where the sensors were installed in the skylight was facing south in all pyramidal configurations.

The photos below were taken from a 4 meters high spot and they represent the three different skylight configurations submitted for testing.

Figure 14. *PIN test*

PIN		17 ABR 2011 (céu aberto)				
tempo/min	Temp. Amb./ºC	Temp. face exposta ao sol/ºC	Temp. interior da peça/ºC	Temp. face interior/ºC	Temp. Amb. interior/ºC	HORA
0	20	24	[illegible]	26	[illegible]	10:35
15	20	24	[illegible]	29	[illegible]	10:50
30	20	25	[illegible]	31	[illegible]	11:05
45	21	25	[illegible]	34	[illegible]	11:20
60	21	28	[illegible]	37	[illegible]	11:35
75	22	28	[illegible]	39	[illegible]	11:50
90	23	31	[illegible]	42	[illegible]	12:05
105	22	31	[illegible]	43	[illegible]	12:20
120	22	31	[illegible]	45	[illegible]	12:35
135	23	32	[illegible]	47	[illegible]	12:50
150	23	33	[illegible]	49	[illegible]	13:05
190	23	33	[illegible]	49	[illegible]	13:35
205	26	34	[illegible]	53	[illegible]	14:00
220	28	35	[illegible]	48	[illegible]	14:15
235	25	36	[illegible]	52	[illegible]	14:30
265	25	35	[illegible]	47	[illegible]	15:00
295	25	33	[illegible]	48	[illegible]	15:30

Figure 14.B. *PIN tests results*

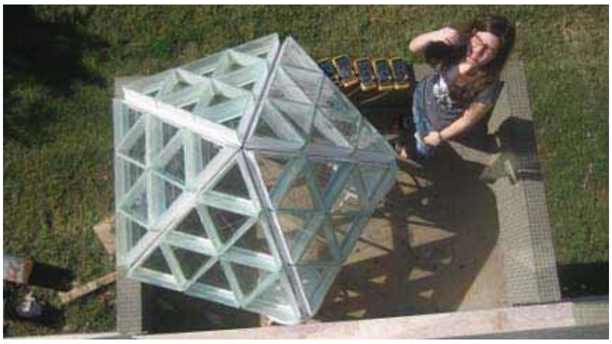

Figure 15.A. *Pentagonal pyramid Skylight*

Pirâmide Pentagonal			13 Abril 2011 (céu aberto)			
tempo/min	Temp. Amb. /ºC	Temp. face exposta ao sol/ºC	Temp. interior da peça/ºC	Temp. face interior/ºC	Temp. Amb. interior/ºC	HORA
0	19	24	30	25	19	10:00
30	20	26	33	30	23	10:30
60	21	32	39	35	22	11:00
90	24	35	40	38	23	11:30
120	24	37	43	41	25	12:00
150	28	39	46	43	30	12:30
210	24	34	41	38	28	13:30
240	23	33	38	37	28	14:00
270	25	32	38	37	25	14:30
300	22	31	35	37	25	15:00
330	22	31	35	37	25	15:30
360	24	31	33	34	27	16:00

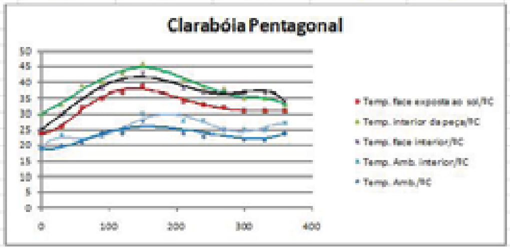

Figure 15.B. *Pentagonal pyramid Skylight tests result*

Figure 16.A. *Square pyramid Skylight*

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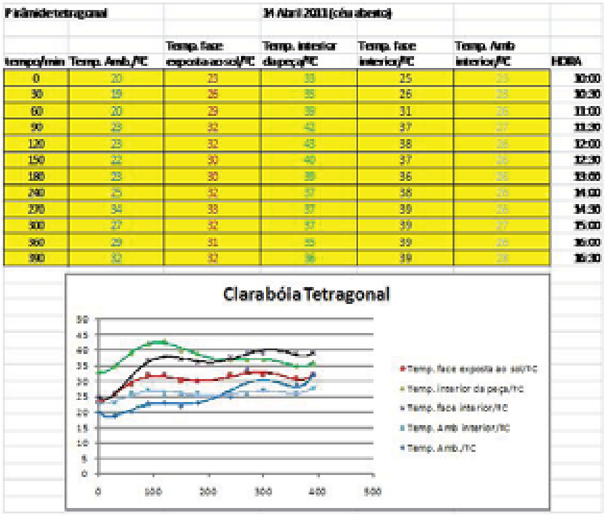


Pirâmide tetragonal			14 Abril 2011 (céu aberto)			
tempo/min	Temp. Amb./°C	Temp. face exposta ao sol/°C	Temp. interior da peça/°C	Temp. face interior/°C	Temp. Amb interior/°C	HORA
0	20	23	33	25	23	10:00
30	19	26	35	26	23	10:30
60	20	29	39	31	26	11:00
90	23	32	42	37	27	11:30
120	23	32	43	38	26	12:00
150	22	30	40	37	26	12:30
180	23	30	39	36	26	13:00
240	25	32	37	38	26	14:00
270	34	33	37	39	26	14:30
300	27	32	37	39	27	15:00
360	29	31	35	39	26	16:00
390	32	32	36	39	28	16:30

Figure 16.B. *Square pyramid Skylight tests result*

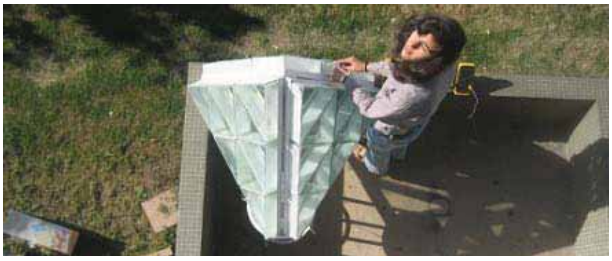
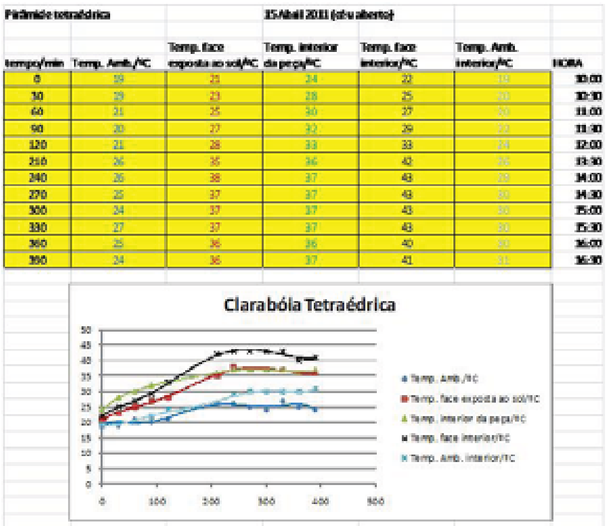


Figure 17.A. *Triangular pyramid Skylight test*



Pirâmide tetraédrica			15 Abril 2011 (céu aberto)			
tempo/min	Temp. Amb./°C	Temp. face exposta ao sol/°C	Temp. interior da peça/°C	Temp. face interior/°C	Temp. Amb. interior/°C	HORA
0	19	21	24	22	19	10:00
30	19	23	28	25	20	10:30
60	21	25	30	27	20	11:00
90	20	27	32	29	22	11:30
120	21	28	33	33	24	12:00
210	26	35	36	42	26	13:30
240	26	38	37	43	29	14:00
270	25	37	37	43	30	14:30
300	24	37	37	43	30	15:00
330	27	37	37	43	30	15:30
360	25	36	36	40	30	16:00
390	24	36	37	41	31	16:30

Figure 17.B. *Triangular pyramid Skylight test results*

5. Reflection on Future Prospects

The results offer some discussion aspects we do not want to run away from.

5.1. Natural Light

From the readings taken by the light meter,it is easy to conclude that in the days where there has been testing there were optimal conditions outdoors, with values of 2800 Lux. Inside the skylights, illumination was 2700 lux from which we can infer that this slight light attenuation is attributed to phenomena of reflection and refraction of light in the PIN.

5.2. Natural Temperature

Temperatures inside the skylight were almost every time greater than the outdoors temperature. Clearly the skylight built on the PIN protects indoors from winds and / or breezes, which allows a concentration of heat inside. The PIN works like authentic thermal boxes that become an interior insulator in the skylight.

5.3. Solar journey

It should be remembered that we analyze the results of studies on certain days of the year. The solar journey, as we know, is only equal in two days of the year and these differ in six months time. Skylights are static architectural elements and can provide different values because environmental conditions are always different. There aren't two equal days!

5.4. Modular skylights

The modular design of skylights reveals as an alternative to consider, especially as there are in many urban buildings and other interior lighting solutions that do not allow the quality use of natural light and force to use electric lighting, when this could be avoided!

Acknowledgements

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ROBOWIKI: RESOURCES FOR EDUCATIONAL ROBOTICS

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Abstract. *This work presents a new web portal, the RoboWiki site whose primary aim is to make available a set of important resources in Educational Robotics (ER). Indeed, although ER has become a recognized alternative to traditional pedagogical approaches, the universe of resources available to the community is still limited to achieve an effective implementation of ER in the classrooms. This situation even gets worse when one considers only resources in the Portuguese language.*

This work aims to contribute to fill this gap in Portugal and Portuguese speaking countries, by presenting the RoboWiki web site, an ER portal in Portuguese language where some important resources are made available, namely: a basic course regarding the introduction to ER; lesson plans to approach curricular subjects using ER; plans of multidisciplinary projects; documentation (in Portuguese) about programming robots. All the previous materials are oriented to the use of Lego Mindstorms kits although in the future other platforms can be considered. Currently, the site includes resources developed by the authors as part of previous and current research. However, the whole ER community is invited to contribute to this effort to make it truly relevant.

Keywords. *Educational Robotics, Constructionism, Early Education, Curricular Integration, Sharing Pedagogical Resources*

1. Introduction

Educational Robotics (ER) has emerged in recent years as a tool with an immense pedagogical potential for a range of subjects and skills in different levels of education. Indeed, there are projects developed by children, youngsters and adults at elementary, secondary schools and colleges.

Robotics is present in classes mainly in three different perspectives: (*i*) Robotics as a technological discipline, which by itself deserves to be addressed separately; (*ii*) Robotics as a means of teaching/learning programming concepts; (*iii*) Robotics employed as a pedagogical resource to stimulate the learning of varied contents and skills at different levels of education (Oliveira, 2004).

The perspectives indicated in (i) and (ii) will probably be important in some contexts of a more technological nature, usually at more advanced levels (high school or university education) and especially for Electronics, Automation and Informatics classes. In this work, we are going to focus on the ER vision as presented in (iii). We will thus look at ER as a vast set of resources, which may be used at different levels of education and as a means to teach varied contents well integrated in education in the constructivist perspective (Ribeiro, 2006).

ER proposes a number of benefits to support transversality by propagating the integration of concepts from multiple disciplines such as: Mathematics, Physics, Electronics, Mechanics, Architecture, History, Geography, Arts and Literature. This tool allows to conduct multidisciplinary activities in a practical manner, while also developing skills and aspects related to the planning and organisation of work. Thus, it motivates students to learn about existing mechanisms and machines stimulating creativity, both when building models or prototypes of robots, when using manipulative materials and when developing reasoning and logic in the construction and programming of the respective mechanisms (Bacaroglo, 2005).

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Creating and implementing projects based on Robotics, we may obtain a number of benefits. The fundamental advantages of this technological tool are the integration of various areas of knowledge, the possibility to manually operate tools, the enhancement of the transition from the concrete to the abstract and the possibility conferred to students of mastering graphical languages as if they were Mathematical ones, with a synchronous control of the different variables. Moreover, ER allows students to develop systems thinking, to form and test their own knowledge acquisition strategies in an innovative learning environment (Quevedo et al, 2008).

Robotics is understood as an environment capable of providing knowledge and learning through practice, experience and challenges. For Robotics to be perceived as practical education, it is not only necessary that students build extraordinary robots, but even more so that essential significance be given to knowledge management and cognitive development of students as designers of their own knowledge. ER requires a range of skills from a number of disciplines and it is understood as an environment, which ensures the process of education by means of practice, experience and multiple challenges to address.

It is generally known that school plays an increasingly greater role in education, upbringing and preparing young people for their integration in the society. In this way, the school builds the right atmosphere for students to develop skills which are necessary for their suitable education; for students to be active and participate in a society distinguished by rapid changes enhanced by technological developments taking place over recent years. Children as individuals and members of the community undergoing transformation should have the possibility to learn to use the tools that support this transformation.

Robotics is becoming the right means to decentralise teaching and replace it with the possibility for the child to create, recreate and construct their own knowledge in a collaborative manner, which would enable collaboration of different agents of the educational process (Badilla-Saxe, 2007). Technologies in general, and Robotics in particular, should be utilised so that students examine knowledge through play with a possibility to experiment with the new tools, to design, to construct or to invent systems, which would help them resolve real challenges and problems. By means of these tools, students may get more extensive knowledge in a more creative manner.

For the entire potential of Robotics to be utilised, it is necessary that students develop technological fluency or acquire knowledge and skills to communicate with the robot, learning its language so that the two could cooperate. The student should know how to use the tool and how to create meaningful things with the tool for their learning to be meaningful too (Resnick, 2006). For the learner to have Robotics fluency, it is necessary to develop the following strategies:

- **Learn to plan** – the student should be able to design a prototype to build later on in order to resolve specific tasks or challenges.
- **Learn to program** – programming the robot, students develop programs based on simple commands, which could be used in complex activities. The student learns to construct and structure their knowledge.
- **Learn to combine** – acquiring new knowledge, the student should be able to combine it with the previous knowledge. On the other hand, by means of the programming language, which in this case is an iconic model, they should also combine symbols with words, learning the meaning of every symbol to be able to communicate with the machine.

As a new technological tool, ER offers excellent advantages, including:

- **Motivation and enthusiasm** – there are numerous studies referring to the motivational role of ER towards students. All students who can work with this tool manifest great enthusiasm, interest and commitment to tasks that employ this technological resource. Students who are inattentive in class typically become exceptionally involved in performing tasks with robots (Rogers and Portsmore, 2004).
- **Transversality** – ER makes it possible to establish bonds among multiple fields of education, allowing for the expansion of transversal projects that are quite impressive from the cognitive point of view (Gura, 2007).
- **Problem-solving based learning** - activities with Robotics involve facing a number of problems and challenges and aim at unravelling and overcoming them. From the very beginning to the very end of the project students come across many

problems and aspire to resolve and overcome them [Teixeira, 2005].

- **Project-based learning** - through ER, students develop technological problems with a huge educational potential. By means of this tool, students enhance their social, cognitive and technological skills. Robotic events make students enthusiastic and committed to the development of projects to win important positions and awards (Gura, 2007)
- **Joint work and communication skills** – sharing knowledge and skills is growing more and more important. Students need to have, accept and share knowledge and skills with others to offer and receive help. ER enables students to work in groups, to collaborate with each other to attain a final product with a contribution from everyone. For group work to be successful, it is essential that on the one hand everybody shares their ideas with others and on the other that everybody listens to others and maintains a critical thinking. Group work should be conducted consistently and result from the combination of forces from different directions so as to achieve meaningful effects.
- **Imagination and creativity** - as ER projects progress, students develop their imagination and creativity. To carry out any ER project, students have to design and construct a robotic prototype, to achieve an assigned goal. Previous to the construction and programming of robots, students are invited to make innovations in the case-resolving process (Torre, 1998).
- **Development of logical reasoning and abstract thinking –** the processes of planning, constructing and programming the robot all concern abstract-level skills. To build a robotic prototype, a student needs the capability to plan and design accounting for all the qualities which make it able to perform appropriate functions (Lau et al., 1999, quoted by Teixeira, 2006). The fact that the programming language is symbolic and visual enforces the student to control the physical behaviour of the robot and obliges the student to predict the robot's behaviour based on abstract symbols included in programming (Ribeiro, 2006).
- **Learning autonomy** – working with the technological tool, the student is responsible for constructing their own knowledge, i.e. the student is responsible for demanding knowledge indispensable to develop the project as has been decided before.

The above-mentioned qualities of ER strengthen its enhanced pedagogical potential in multiple disciplines. In addition, from the integration of the tool, we learn that it is not easy to attain this goal. This situation is due to the novelty of pedagogical efforts, but may also be related to the technological nature of the field, which makes even committed teachers anxious.

Incidentally, more important than the previous factors may be the lack of pedagogical materials drawing upon different didactic areas (e.g. manuals, tutorials) and the lack of opportunities for training teachers as key aspects for the appreciation of ER.

The work presented in this article aims to contribute to fill the known lack of pedagogical materials based on ER for use in classrooms. So, the main objective is to provide an ER portal in the Portuguese language intended for early education, where the teacher may find all the necessary materials for their own initial training and for their students in the field of Robotics, as well as a set of materials to enable linking ER with multiple pedagogical disciplines. The proposed material is oriented at using the ER Lego Mindstorms platform, which becomes an appropriate alternative for the age group in question and which is available at affordable prices.

The structure of the article is as follows: the next chapter concerns the organisation of the RoboWiki site and its content. It ends with a discussion and conclusions from the work.

2. RoboWiki site

The Wiki concept was created in 1995 by Ward Cunningham to develop a website which would be an open shared space. The term became popular when Wikipedia appeared (http://www.wikipedia.org), a site that expands its database through contributions and participation of experts in multiple fields of knowledge. Wiki is based on Web 2.0 technologies - promising because of the implementation of techniques of collaboration within a virtual group. Wiki is a site or a collection of sites which are usually developed by many authors and which are related to each other but do not have a hierarchical structure defined *a priori*. This way, a Wiki enables one to make content and tools available on Internet websites (Ferreira et al, 2009). Its construction allows for adding, editing and deleting content created by other authors.

A Wiki has an interface to propagate the exchange and construction of information and knowledge among people who share the same interests and knowledge. The fact that they have common interests establishes relationships among co-authors as members of the same community where they may share knowledge and collaborate (Carvalho, 2008).

Santamaria (2006) and Schwartz (2004) believe that Wiki offers the following possibilities:

- It enables dynamic cooperation of the participants;
- It enables the exchange of thoughts, development of various applications and proposal of activity schemes to achieve pre-defined aims;
- It makes it possible to draw up glossaries, textbooks, manuals and other related documents;
- It enables the visualisation of the whole revision history;
- It enables the establishment and launch of shared knowledge structures based on cooperation, facilitating the formation of the educational community.

2.1. Global structure of the website

The objective of this paper is to develop and dynamise a wiki site to the ER community. This is freely available in the URL: http://darwin.di.uminho.pt/robotica. The objective of this Wiki-based portal is to compile a repository on ER so that other relevant experts, besides the authors, could make a contribution. The main problem is to develop materials, which would benefit from the qualities of ER, at the level of the most transversal abilities defined in literature (e.g. interdisciplinarity, motivation and enthusiasm aroused in students) but also the possibility to work upon specific skills in particular areas of knowledge in early education.

The global structure of the site includes typical areas of a Wiki site such as the navigation area and tool area. At the same time the portal contains all the areas of pedagogical resources and documentation more closely related to the ER subject matter. There are pedagogical resources for use in ER by teachers and students and auxiliary documentation of a more technical nature related to the *Lego Mindstorms*platform there respectively.

The area of pedagogical resources includes the most important resources in the site, in the pedagogical perspective, namely:

- **Robotics introductory course** - a set of materials intended for running a course to teach the basic concepts of ER at the level of constructing and programming robots;
- **Didactic sessions** - a set of modules oriented at different didactic subjects, which may have various configurations depending on the fields and relevant skills (this area is still under construction);
- **Multidisciplinary projects** - concepts and experience from multidisciplinary projects concerning Robotics (e.g. dance, contests, historical dramas and other projects suggested by teachers, inspired by educational projects etc.).

2.2. Robotics introductory course

This area contains a set of lesson plans to teach basic concepts and skills related to the construction and programming of robots using *Lego Mindstorms,* kits, as well as indispensable auxiliary material (presentations, videos, work charts, observation tables, tests etc.).

The proposed sessions are structured as follows:

1. **Introduction to Robotics:** concerns the basic concepts of ER: what a robot is; comments on robots and robotics; group discussion on those concepts, sharing relevant videos.
2. **Construction of robots** using *Lego Mindstorms* kits - concerns a presentation of components of robots, available parts and rules for constructing robots; it proposes construction exercises for students to work on.
3. **Programming of a robot** – explains the programming accessible in the robot itself; it proposes simple exercises in programming (see examples in Figure 1).

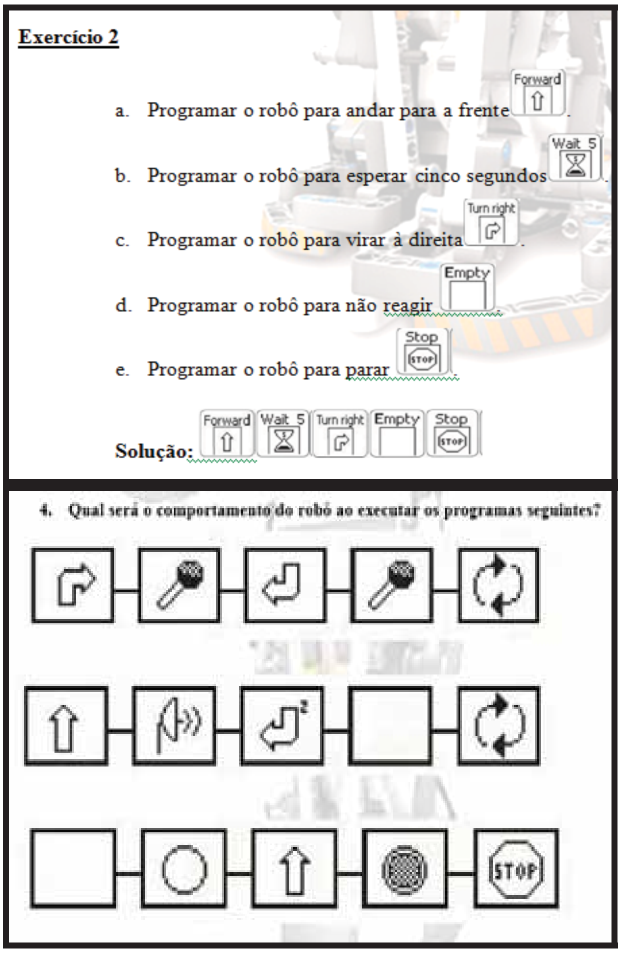

Figure 1. *Exercises in the programming of robots*

4. **Programming with NXT software** – explains different programming blocks and possible functionalities of available software; there are proposals of exercises in programming and learning programming blocks (see sample exercises in Figures 2 and 3).

Exercise 15
a. Program the robot to move backwards.
b. Program the robot to respond to the sound sensor switching on.
c. Program the robot to turn right.
d. Program the robot to stop when the touch sensor is enabled.
e. Program the robot to move forward with 4 revolutions.
f. Insert a loop (put the whole program in the loop function).

Figure 2. *Exercises in the blocks of programming the robot*

Exercise 16
a) Program the robot to move forward (motor speed - 50).
b) Program the robot to respond to the sound sensor switching on.
c) Program the robot to move forward (motor speed - 100).
d) Insert a *loop* (put the whole program in the *loop* function).

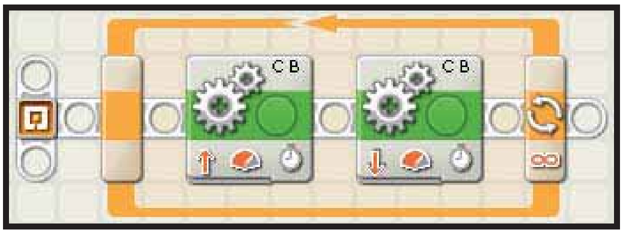

Figure 3. *Exercises in the blocks of programming the robot*

5. **Programming the robot using sensors** – presents a number of sessions to program the robot using the different sensors the robot has; many exercises are provided in programming using various sensors and software (see example in Figure 4);

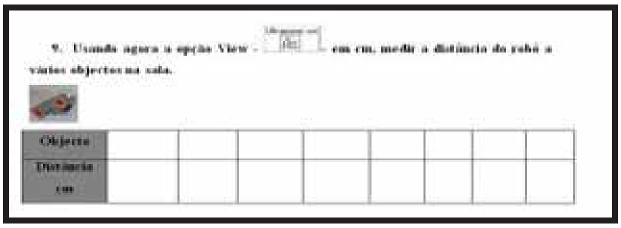

Figure 4. *Exercise - with the ultrasound sensor to measure the distance of objects*

2.3. Didactic sessions

This section of the website will be devoted to the proposal of different sessions intended to address distinct contents within basic school curricula by means of ER, in different disciplines and age groups. This area is still under construction; it may include suggestions from the authors only or from all researchers or teachers interested.

At this stage, as proof for the concept, there is a module available designed for work upon skills and contents for 3rd and 4th grades in Mathematics, and particularly in the area of solving problems related to the arithmetic operations of multiplication and division. (Figure 5).

The objective of this module is to focus on examining the content of the "Numbers and operations" block, while working mostly upon skills related to solving problems with arithmetic operations. Indeed, the similarity of robot programming to the operations of multiplication and

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division is confirmed due to the countless proportionality ratios used in the programming of the robot's movement, related to time and space, to the programming of the number and degrees of rotation of the robot's wheel, etc. The examination of those concepts in a set of exercises constitutes a basis for this thematic module, which encourages students to discover those relations through experimentation, to predict robots' behaviour by means of interpolation and extrapolation and to verify their assumptions in practice. Exercises combine the programming of robots with multiple calculations. Also, a set of games is proposed to consolidate the acquired relations through play.

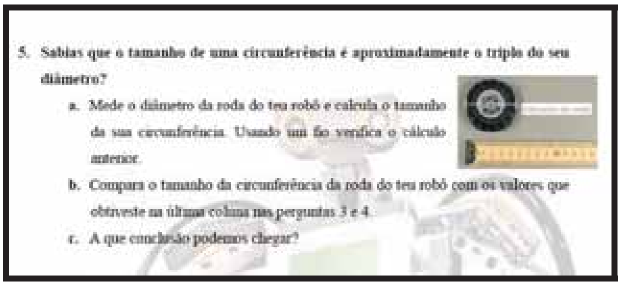

Figure 5. *Exercise – solving with the robot´s wheels*

2.4. Multidisciplinary projects

At last, the third pedagogical area of the website is oriented at teaching transversal skills. To that effect, it will contain projects of a more "playful" nature, where the configuration may be different and adapted to the characteristics of students and the nature of the intended use in class. This includes proposals such as theatrical performances of popular folk tales, programming of robotics dance shows or the participation of students in robotic contests.

At present, one may find here several previous experiences of the authors as an example:

- Theatrical performances of folk tales (e.g. *Carochinha*, *Little Red Riding Hood*, *Three Little Pigs*, Princesa Gualtar, etc)- (Figure 6)
- Participation in robotic contests (e.g. RoboParty, national Robotics shows etc.), including robotics soccer, search and rescue, dances etc.;
- Fashion shows, dance performances and so on;
- Activities related to class projects or projects conducted at school (e.g. Firefighter-Robots etc.).

Figure 6. *Storytelling – "A Princesa Gualtar"*

2.5. Documentation

This section of the site contains a set of manuals written in Portuguese for programming Lego Mindstorms robots. These texts are adaptations of the documentation of the software written originally in English These resources offer important assistance to all those who begin to use the kits.

3. Conclusions and work in the future

This article proposes and describes a wiki web site to disseminate ER and to provide resources and tools which may be used in classrooms and when developing educational projects. The purpose of this wiki is to establish a shared space where experts in this branch can insert their materials of interest making those available to the entire robotics community. An important advaantage is the fact that it is written in Portuguese as there are few materials on this subject in this language.

The portal presented offers a set of materials to develop the software for robots and many proposals to work using ER disseminating its use by teachers of early education. In addition, we believe that the site can contribute a lot to the training of all those interested in the field, thus helping to patch up the gap in ER training.

Although it is a significant contribution already, the authors are aware that the portal is still being constructed and at present is based on the initial phase of the authors' work. In the immediate future, we expect the portal to gather contributions from more researchers and teachers interested in the subject. Still, resources of this type will never be complete, as new resources will be introduced on a continuous basis.

A major limitation of the portal is its restriction of activities to the Lego Mindstorms kits and requirement of access to the material by interested teachers. Despite the relatively low prices of the material, it is still not available for everybody. We hope that in the future the site will be supplemented with sessions based on other robotic materials.

The authors have several ideas concerning possible other sections useful to the portal, such as a repository of articles and other essential publications, tools for the validation of the materials, videos of ER classes and a discussion forum.

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SCIENCE ON STAGE ACTIVITIES AS AN INSPIRATION FOR INQUIRY BASED SCIENCE EDUCATION

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Abstract. *The Science on Stage (SoS) activities offers European teachers the chance to exchange successful and innovative teaching methods and materials. The project SoS addresses the content and format of science teaching in European schools, seeking to improve the quality of teaching and to find new ways to stimulate students to take an interest in science. SoS aims to facilitate the exchange of good practice and innovative ideas among Europe's science teachers and to provide a forum for a broad debate among educators, administrators and policy-makers about the key problems in science education today. The impetus for all SoS activities is the international Science on Stage festival. The activities include workshops, teacher-training courses, travel scholarships for teacher exchange programmes, online and social media activities, publications and collaborative projects with industry. The bases for all these activities resulting in an international Science on Stage festival are in national activities that are carried out in each participating country. The poster introduces the Slovak national festival named Creative physics teacher that is an opportunity for physics teachers across Slovakia to exchange their ideas with their colleagues and other people working in the field of physics education. The recent festivals were dominantly devoted to new methods of inquiry-based education in physics since this is the key point of the educational reform in science education that teachers are currently involved in. The poster presents several ideas from the national festivals, e.g. sets of physical problems, where students are guided from examination, through questioning, exploring, experimentation and measurements towards understanding, interpretation and conclusions. The examples of presented inquiry problems include the examination of rising water in Archimedes screw, chain falling into the palm, magnet falling in a metal tube, magnetic oscillations, measurement of air density inside a football, Coanda effect and a set of problems that can arise from experimentation with things we can find in the kitchen or bathroom.*

1. Introduction

Science education is an important component of education. It does not only comprise cognitive aspects, but also an interest in science, the scientific way of thinking and a scientific orientation, what we call scientific literacy. By collecting experiences from daily situations children have formed their own preconceptions concerning science phenomena, even before they get into school. They are self motivated to predict or explain whatever happens around them even though most of the times these ideas are far from the scientifically correct model.

In teaching science, teachers have to stimulate the learners' interests and change preconceptions about science topics. It is widely known that students learn best when they are allowed to work out explanations for themselves over time through a variety of learning experiences. The learners add their own knowledge to these experiences and subsequently link new information with their previous knowledge. To help them make the connections between what they already know and new information, we have to follow five different stages — Engage, Explore, Explain, Elaborate and Evaluate (Welz, 2006).

Firstly, the learners have to engage with a question mentally. This starting point captures their interest and provides an opportunity for them to express what they know about the concept. They can articulate their own ideas/preconceptions about the topic. During the exploration, the learners carry out hands-on activities that allow them to explore their concept of the topic. They grapple with the problem and describe it in their own words. If they had misconceptions on the topic, this step tends to prove to them that their own ideas cannot explain a particular phenomenon. After exploration, explanations and terms to describe what they have experienced must be provided. The significant aspect of this stage is that explanation follows experience and is not provided by teacher. The explanation follows the experience, yet the learners try to reach conclusions on their own. The elaboration stage provides opportunities for the learners to apply what they have learnt to new situations and so develop a deeper understanding. It is important for them to discuss and compare their ideas with each other. PEER instruction method is well usable. The final part (evaluation) has a dual purpose: learners continue to develop their understanding, and they evaluate what they know at the same time.

There are many modern didactic approaches, which we would like to increase the learners scientific literacy. Our main orientation is focused on non-formal scientific education activities, as science festivals are, which can also have an useful outputs into classroom practice.

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2. The international Science on Stage festival

Science on Stage is a European initiative to foster and share innovative science teaching. It evolved from the Physics On Stage programme, which was initiated in 1999 by representatives of the CERN, ESA and ESO Outreach Departments, in response to the European Commission's Call for Proposals for the European Science and Technology Week 2000. The key objectives of that programme were to draw attention to the low level of scientific literacy among European citizens; to propose innovative and practical solutions to this problem and to establish a network of experts on physics teaching and popularisation from all over Europe. Science on Stage activities aimed at stimulating innovative approaches to science teaching in Europe's schools through the active participation of science educators and by:

- fostering the exchange of 'good practice' examples/methods between teachers and curriculum developers,
- supporting the dialogue between teachers and education policy makers,
- enabling Europe's primary- and secondary-school teachers to explore modern scientific knowledge by bringing together teachers and active scientists, notably at Europe's leading research facilities.

The ultimate goal of strengthening the quality and attractiveness of science teaching is to permit students to achieve success in scientific and technological endeavours for the future.

Science on Stage (www.scien-on-stage.eu) is organised in a bottom up structure. The basis is the Science on Stage community in the participating countries. Each country has a national steering committee (NSC). The NSCs get together in the Science on Stage assembly and elect the executive board. The board is supported by invited experts and by the Science on Stage Europe office, which is temporarily hosted by the Science on Stage Germany office in Berlin. The Science on Stage international festivals take place every two years, as the culmination of all the national Science on Stage activities. The festivals are organised jointly by a European festival programme committee and a national organising committee. The programme Science on Stage festival consists of:

- Fair - exhibition where all participants present their projects.
- On-stage activities - plenary presentations on a big stage. Performances, keynote speaks and other spectacular presentations.
- Workshops - the participants develop teaching materials, recommendations and discuss pedagogical issues. Topics will be organised in relation to project themes.
- Master classes - master classes are all about sharing good practice. Teaching methods and concepts are shared in small, informal presentations.
- Forum - public and private enterprises, organisations, foundations and publishers exhibit.
- Social events - grand opening, event dinner, prize awards, closing event etc.

27 European countries are involved in Science on Stage Europe. A network of national steering committees provides the interface to the national science teaching communities. They organise national activities for teachers and select the teachers who represent each country at the European Science on Stage Festivals. Creative physics teacher is Slovak national Science on Stage festival.

3. Creative physics teacher - Slovak national festival

More than 60 participants, mainly basic and secondary school physics teachers and university teachers working in the field of physics education attend the national festival organized by Slovak physical Society and Faculty of Science Šafárik University in Košice under the financial support of Slovak research and development agency. The festival take place on Smolenice Castle, Slovak Academy of Science conference centre. Four day programme is set up from lectures, workshops, fair and social programme for participants. All materials are published in print and web available proceedings of the meeting. The festival is an opportunity for physics teachers across Slovakia to exchange their ideas with their colleagues and other people working in the field of physics education. The festival is dominantly devoted to new methods of inquiry-based education in physics since this is the key point of the educational reform in science education that teachers are currently involved in. A lot of successful projects, ideas and example of good teacher practice were presented.

3.1. Good practice examples for innovative physics teaching

The selected set of idea involves a series of experiments aimed at some physical phenomena, where student is guided from observation, through questioning, investigation and exploration to exact measurement towards understanding and his own interpretation of physical phenomena. The observation and examining of rising water in Archimedes screw, falling chain, motion of rotating CDs, energy transmission of inductance cooker could excite students' interest and stimulate and enhance asking their own questions. A prepared set of conceptual questions at different level of understanding can be asked by teacher. The investigation and exploration of magnets falling through a metal tube influenced by eddy currents, self starting siphon, discharges in a candle flame, Coanda effect, can be a challenge for students to think, analyse and discuss with their peers. The exact measurement of air density inside a ball, the height reached by a simple rocket model can bring a more detailed insight into these phenomena providing new knowledge and understanding and developing students´ competences and experimental skills. The designed activities can be used in a class or as a student home assignment or a project to be solved. They can also be realized within afterclass activities for talented students and within non-formal education. Some examples are shortly described.

Archimedes screw can be made from rubber tube wrapped around a rod, fastening it down with tape or glue. When the lower end of the tube is placed in a basin of water and rotated around the longitudinal axis, the water will travel up the tube to flow out the upper end.

Measuring air density can be done by weighing the ball on a sensitive scale. Blow the air into the ball by the cycle pump. Volume of the air from one pump movement could be determined by cylinder inserted into the water bottom up. Repeat this procedure after each pumping (e.g. 10 times). Plot the ball mass vs. pumping air volume graph. The graph slope means the air density.

A very flexible uniform chain is suspended from one end so that it hangs vertically with the lower end just touching the surface of the scale. The upper end is suddenly released so that the chain falls onto the scale. The force sensor (or digital scale) is connected to the computer through CoachLab II interface. Time graph could be analyze in details.

When the tube with magnet is placed on a scale, the total weight is 132,89 g (with our equipment) . If the magnet is falling down inside the metal tube, in part with constant speed, the scale reading is exactly 132,89 g. The magnet falling through the metal tube is slowed by an induced magnetic force due to Lenz`s law. The action-reaction pair is generated by the two forces: weight of the magnet and magnetic force.

4. Conclusion

Active participation on international Science on stage activities with strong national background could be inspiration for inquiry based science education for large scale of physics teachers. Fair, workshops, on stage performances, enthusiastic teachers and scientists meetings and exchanging of good science education practice can produce a lot of new themes for innovative teaching.

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SUPERSTRINGS PERFORMANCE: "PARTICLES OR STRINGS? UNIVERSE AND ITS HIDDEN ENERGY"

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Abstract. *"Superstring performance" is a complex work, including an initial interactive installation, from which the performance derives, and a performative part in which performers, generative music and video projections come together.*

It is intended to present the idea of string theory to a large portion of the public, through an outreach activity (in which public is invited to participate actively). It can be easily transported and reproduced at will (as installation) and the perfomance requires the presence of a couple of actresses (or a video showing their performance on screen).

Superstrings was recently presented at the Museum of Cinema of Torino and shown on RAI National TV. It is an interactive performance, in which the public actively participates, inspired the Theory of Superstrings. The so-

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called "Standard Model" is the currently established theory of Particle Physics. A framework has been proposed in Theoretical Physics, which tries to replace standard particles with so-called "strings" and "superstrings". These are "extended objects" having one dimension, like real tiny elastic ropes which fill infinitesimally small portions of space. Strings continuously vibrate in SpaceTime generating observable excitations of the physical fields. The Performance is an exquisite mix of "Art & Science": "Virtual" strings fill the space, a creative process in which the public entangles never ending patterns using elastic ropes, creating a vibrating universe. Generative music is produced, while multicolour lights let strings glow into the dark as laser rays. Performers act within the installation, using corporal mime and dance, and give a final poetic explanation. The language of emotion suspends disbelief. A well-known physicist gives explanations about our universe and current scientific theories made understandable by the installation itself.

INDIVIDUAL AND SOCIO-CULTURAL INFLUENCES ON FEMALES' CAREER CHOICE FOR STEM

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Abstract. *The under representation of females is one of the main challenges for professions in science, technology, engineering, and mathematics (STEM). Current statistics show that in Germany just 18.8% of the professional workforce in the field of computer sciences is female; this percentage is even lower for mechanical engineering with just 6.2%.*

To get deeper insights in influencing factors, the paper focuses on the process of career choice. The theoretical background relies on the models of Dick and Rallis and Dickhäuse. Dick and Rallis emphasize the importance of the socio-cultural environment as facilitator and obstacle for career choices while Dickhäuser et al. specify this in more detail and focus on socializing persons, e. g. parents. These socialization factors are in interaction with individual factors, e.g. aptitudes, motivations, and also the perceived value of taking up a specific career. Thus, when looking on the issue of facilitating females' choice for STEM careers, one has to take up a multi-dimensional approach that is not only focused on the individual itself, but also considers the socio-cultural environment.

Based on these aspects, the paper presents three case studies on facilitators and obstacles for career choices in the field of software engineering. It relates these case studies to the theoretical models and particularly investigates factors important for female and male career choices—from an individual as well as from a socio-cultural perspective. For these case studies, three individuals, two females and one male, were interviewed by semi-structured interviews. The interviews were transcribed and analyzed according to grounded theory.

Results of the case studies show that the female subjects had a high personal interest in the subject of computer science and were therefore choosing a career in this field. However, they also reported that their socio-cultural environment was "science-affine", even if they didn't name this as direct factor. Yet, according to socio-cultural theory, such a "science-affine" environment is an important background for opening the mind for a science career and for developing personal interests.

These results have consequences for STEM education. Approaches just focusing on the individual are not enough for facilitating a career choice for STEM. Furthermore, the socio-cultural environment has either to support such career choice or, if not, the individual has to overcome the socio-cultural obstacle on her own. Thus, aiming at enhancing females' career choices for STEM, one has to look beyond the individual and also target the socio-cultural environment, e.g. by parental support, the provision of role models, or an appropriate design of school books.

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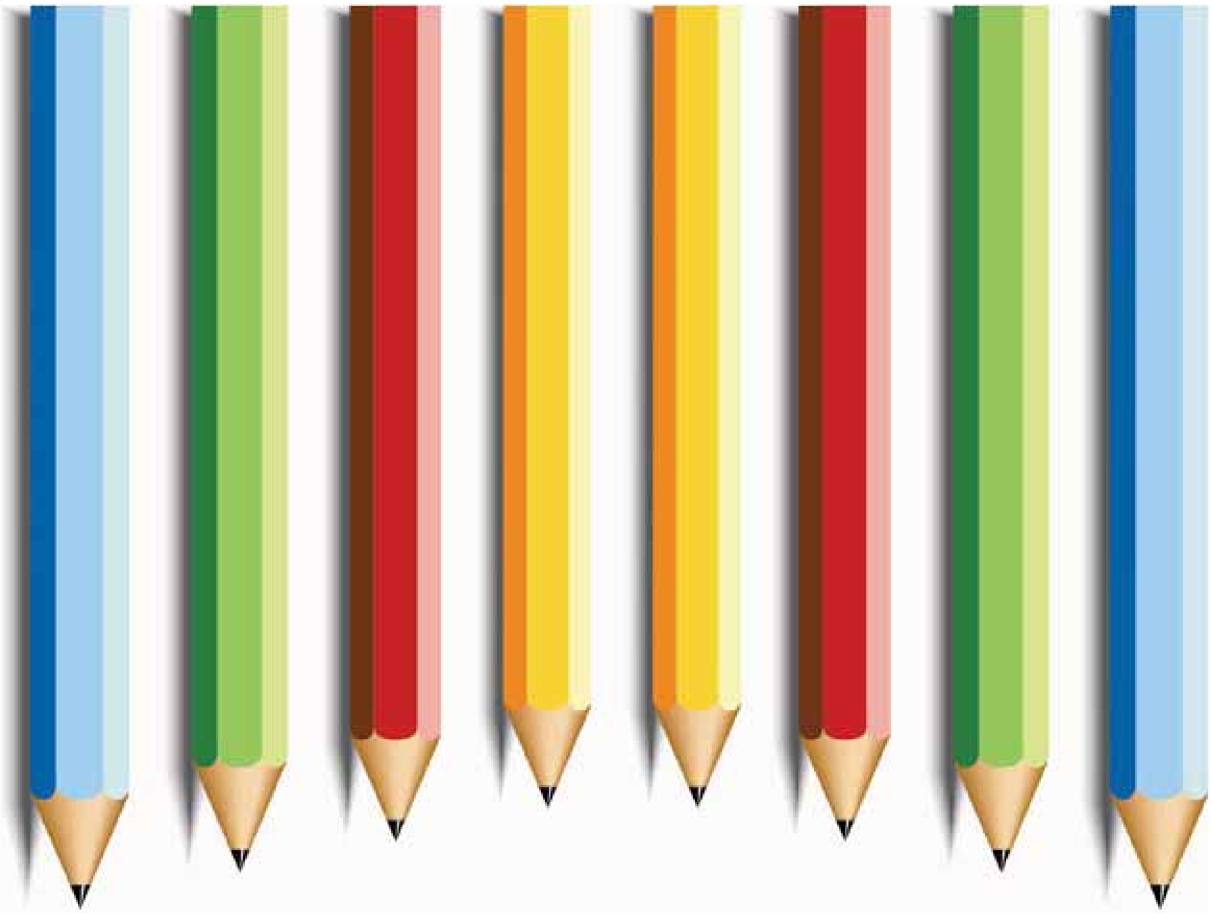

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International Organizing Institutions

European Physical Society (EPS) – Physics Education Division
http://education.epsdivisions.org/

Multimedia in Physics Teaching and Learning Group
http://www.mptl.eu/

Hands-on Science Network
http://www.hsci.info/

Collaborating Scientific Institutions

Group International de Research in Physics Education (GIREP)
http://www.girep.org/

International Commission on Physics Education (ICPE)
http://web.phys.ksu.edu/icpe/

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