Selected Papers on

Hands-on Science II

Editors

Manuel Filipe Pereira da Cunha Martins Costa
Universidade do Minho. Portugal

José Benito Vázquez Dorrío
Universidade de Vigo. Spain

Panagiotis Michaelides
University of Crete. Greece

Universidade do Minho

Universidade de Vigo

Associação Hands-on Science Network
Rua 1º de Maio, 2, 2º, 4730-734 Vila Verde, Portugal

©Hands-on Science Network 2017

ISBN: 978-84-8158-764-7
Legal Deposit: VG 801-2017

Printed by: Copissaurio Repro – Centro Imp. Unip. Lda. Campus de Gualtar, Reprografia Complexo II, 4710-057 Braga, Portugal
Edited by: Universidade de Vigo, Spain.
Number of copies: 500
First printing: December 2017
Distributed worldwide by Associação Hands-on Science Network, mfcosta@fisica.uminho.pt
Full text available online at http://www.hsci.info

Cover Design by Helena Martins http://www.helenamartinsdesign.com/

The papers published in this book compose the Proceedings of several International Conferences on Hands-on Science. Papers were selected by the Conference Committees to be presented in oral or poster format, and were subject to review by the editors and program committee. They are exclusive responsibility of the authors and are essentially published herein as submitted, in interest of timely dissemination.

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

Author (s). Title of Paper. Selected Papers on Hands-on Science II. Costa MF, Dorrío BV, and Michaelides P (Eds.); Associação Hands-on Science Network, Portugal. Page numbers, 20017.

The authors of this book and the Hands-on Science Network, none of them, accept any responsibility for any use of the information contained in this book.

All rights reserved.

Permission to use is granted if appropriate reference to this source is made, the use is for educational purposes and no fees or other income is charged.

PREFACE

The improvement in the levels of quality and effectiveness in Science Education our modern societies requires, can hardly be achieved without a strong investment and a change in the way Science Education is traditionally approached. The method that drives the pursuit of scientific knowledge should be the starting driving and guiding basis of all process of teaching/learning of Science. Leading the students to an active volunteer commitment in the learning process with an intensive and extended use of hands-on experimental activities; observing, defining, reasoning, analysing critically, deducing, discussing, experimenting...
This hands-on learning process is effective in all subjects of science, at all grades and age levels and contexts. The school plays a fundamental role not only in the learning of science but also it is, and should continue to be, of paramount importance to the healthy growth of our youngsters. Informal and non-formal learning contexts are also rather valuable especially if a hands-on investigative approach is used.
This second volume of the "Selected Papers on Hands-on Science" the Hands-on Science Network is publishing, reunites some of the most relevant works presented at the 2008, 2009, 2010 and 2011 editions of the annual International Conference on Hands-on Science. From pre-school science education to lifelong science learning and teacher training, in formal non-formal and informal contexts, the large diversified range of works that conforms this book surely renders it an important tool to schools and educators and all involved in science education and on the promotion of scientific literacy.
The Hands-on Science Network (www.hsci.info) exists to promote the development of science education and scientific literacy. It encourages a generalized use of innovative active hands-on experimental investigative approaches to science and technology education. In raising the profile and attractiveness of Science in Education, we aim to improve and generalize scientific literacy in our societies and also to increase the desirability of a career in Science for all.

Vila Verde, December 20, 2017

Manuel Filipe Pereira da Cunha Martins Costa

PREFACE

CONTENTS

Hands-on Sustainability: How Can We Contribute to the Construction of a Sustainable Future?

Vilches A, Dorrío BV and Gil-Pérez D

Introduction

Until the second half of the 20th century, our planet seemed huge, practically limitless, and the effects of human activity remained locally compartmentalised. These compartments, however, have begun to fade over recent decades and many problems have taken on a global character that has made "the world situation" a direct cause for concern. News on climate change, environmental deterioration, excessive, unchecked consumption of energy and raw materials with the subsequent exhaustion of resources and, in short, the serious situation of planetary emergency in which we are immersed [1-3], have all jumped to the front pages and opinion sections of the media. Calls by the international scientific community, NGOs and the UN itself, are multiplying.

At the same time, there are over twenty international agreements on environmental protection linked to the same number again of protocols putting them into practice [4-5]. And yet most citizens, including policy makers and educators, continue not to react in the face of serious threats of social collapse [6] and even the extinction of our species [7], which is in principle in contradiction to existing positive social interest, as seen in innumerable information resources regarding necessary respect for the environment [8-11].

It can be concluded, therefore, that there are serious obstacles which hinder necessary changes in attitude and behaviour and impede even a determined involvement of educators at all levels of formation for citizens who are aware of the situation of planetary emergency and its causes, and prepared to adopt the necessary measures to face up to the situation [12].

It is necessary, then, to keep up efforts to bring these obstacles to light and study how to overcome them. In this article we focus on one that most directly hinders finding a positive answer to the key question "How can each one of us contribute to building a sustainable future?" This is a reference to the widespread perception that individual actions are irrelevant. We will critically analyse this misconception and put forward some proposals for action to overcome it.

Are individual actions irrelevant?

Participants in courses and workshops on education for sustainability often express doubt about the effectiveness of individual actions, small changes in our habits or our lifestyles, that education can foster: The problems of exhausted energy resources and pollution – they usually state, for instance – are due, fundamentally, to big industry; what each one of us can do regarding this is, comparatively, insignificant.

Quite simple calculations that participants themselves can make with regard to everyday situations (Fig. 1) show, however, that individual commitment has a global repercussion. For example, although small reductions in energy consumption mean a small per capita saving, when this is multiplied by millions of people it can mean huge amounts of energy, with the subsequent reduction in pollution.

These calculations and estimations can be reinforced with hands-on activities [13-14] such as, for example, determining how much water is lost from a badly turned off dripping tap.

It should be stressed, therefore, that not only is it not true that our small actions are insignificant and irrelevant, but also that we are dealing with necessary, indispensable measures if we want to contribute in progressing towards a sustainable future and increased involvement of citizens.

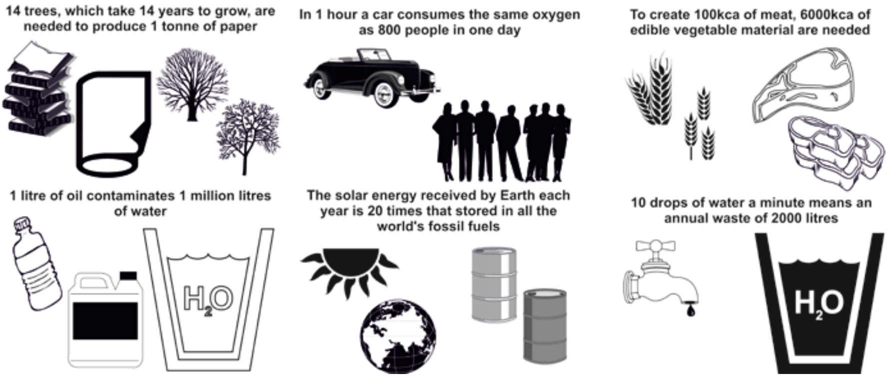


Figure 1. The Importance of individual actions

For the future is going to depend to a great extent upon the model of living we follow and, although attempts are made to impose this on us, the capacity we all have to change it should not be underestimated [11]. Agenda 21, fruit of the first Earth Summit, already indicated that participation by civil society is a vital element in the advance towards sustainability.

A systematic effort is therefore necessary to incorporate education for sustainability as a key objective in the formation of future citizens, and make the need understood for actions that contribute to a sustainable future in several spheres: responsible consumption, professional activity and action by citizens.

A careful follow up of these actions is also needed. Continued educational activities are therefore required that transform our conceptions, our habits, our perspectives… and that guide us in the actions to be taken.

But it is not enough to understand the importance of our actions and have a general view of the fields of action: we need to move into action. In the same way that scientific education calls for hands-on experiments, education for sustainability demands involvement in specific actions that need to be defined and transformed into a commitment to act.

Specific proposals

In different workshops imparted to secondary and university students and trainee and working teachers, we have been able to ascertain that collective work in small groups, followed by group sharing, gives rise to numerous proposals for concrete action that can become the basis for real commitment that can be (self) evaluated for the building of a sustainable future.
Together with the classic “3Rs” (*reduce, reuse* and *recycle*), that correspond to us as consumers and that can give rise to numerous specific proposals of interest, another three guideline principles arise that also respond to our roles as professionals and citizens:

- *Use technologies that respect* the environment and people
- *Contribute to the education of citizens* (we are all educators as we interact with each other)
- *Participate in socio-political actions* for sustainability

And it is equally understood that there is a need for continual evaluation of the effects of our actions that introduces, if needs be, *corrective offsets*.
They are proposals that occur again and again in the workshops, as the fruit of collective work, and they turn out to coincide essentially with what is collected in wide-ranging literature [18-22]. Below (Boxes C1 to C7) we outline the most frequently formulated specific proposals:

C1. Reduce (Do not waste resources) [26-30]

Reduce water consumption,* for hygiene, watering, swimming pools…** Short showers Turn off taps (whilst cleaning teeth, putting on soap, etc.) Drip feed watering ***Reduce energy use for lighting Use energy saving light bulbs Switch off unnecessary lights (beat inertia) Make the most of natural light ***Reduce energy consumption in heating and cooling*** Insulate housing adequately Do not programme very high temperatures (wear warmer clothing) or very low temperatures (ventilate better, use canopies…) Switch off unnecessary radiators or air conditioners
Reduce energy consumption in transport Use public transport Use a bicycle and/or go on foot

Organise shared transport
Reduce speed, drive efficiently
Avoid plane travel whenever possible
Avoid lifts whenever possible

Reduce energy consumption in other household appliances
Load washing machines, dishwashers, etc. appropriately
Turn off the TV, PC, etc completely when not in use
Defrost the freezer, check boilers and heaters, etc.

Reduce energy consumption in food, improving it at the same time
Eat more vegetables, pulses and fruit, and less meat
Respect closed seasons and do not eat small, young fish
Avoid exotic products that demand high cost transport
Eat products in season and produced organically

Reduce paper use
Avoid printing documents that can be read on screen
Write, photocopy and print on both sides of the paper
Do not leave excessive margins

Combat Consumerism
Analyse advertising critically
Mute commercials
Do not be pulled in by commercial campaigns around St Valentines, Festive season, etc.
Programme purchases with a needs list

C2. Reuse [23-24]

Print on the other side of already used paper

Collect sink and shower water for the WC

Also collect rain water for watering or WC

Do not use disposable objects
In particular, avoid plastic bags and wrappers, aluminium foil, paper cups, etc.
Substitute them with reusable ones, repair these when necessary for as long as possible

Use recycled and recyclable products **(paper, toner, etc)**

Encourage the reuse of computers, toys, clothes, etc.
Donate to charities that manage this

Rehabilitate housing
To make it more sustainable (better insulation, etc.) and avoid new construction

C3. Recycle [9,26,31]

Separate waste for selective collection

Take what cannot be left in the usual bin to "civil amenity sites":
Batteries, mobile phones, computers, oil, toxic chemicals, etc.

Do not pour waste down WCs or drains

C4. Avoid products that do not respect the environment and people [9,26,32]

Personally apply the precaution principal
Do not buy products without finding out how harmful they are: check the ingredients of foodstuffs, cleaning materials, clothes, etc., and avoid those that do not offer guarantees
Avoid sprays and aerosols (use hand sprays)
Apply safety norms at work, at home, etc.

Opt for renewable energies at home, in the car, etc.

Use efficient, low energy, low contamination (A++) household appliances

Reduce battery consumption and use rechargeable ones

C5. Contribute to civil education and action [33-38]

Get well informed and discuss the situation with others **(**family members, friends, co-workers, students, etc.) ***and, above all, what we can do***

Carry out dissemination and encouragement tasks:
Use the press, Internet, video, ecology fairs, schools materials, etc.
Help raise awareness of sustainability problems and those closely linked to consumerism, population growth, environmental decline, imbalance, etc.
Inform about actions we can take and encourage them to be put into practice, promoting campaigns such as the use of energy saving light bulbs, reforestation, responsible parenthood, forming associations, political work, etc.

Aid in conceiving measures for sustainability as an opportunity that guarantees the future of everyone and not as a limitation
Encourage social recognition of positive measures

Study and apply what one can do for sustainability as a professional
Research, innovate, teach…

Contribute to promoting the environment at work, in the neighbourhood and city where we live, etc.

C6. Participate in socio-political actions for sustainability [1,19,39]

Respect and help others respect legislation that protects the environment and biodiversity
Avoid adding to noise, light or visual pollution
Do not smoke where this might damage others, and never throw cigarette butts to the ground
Do not leave rubbish in the woods, on the beach, etc.
Avoid moving to housing that contributes to the destruction of ecosystems
Take care not to damage wildlife
Comply with traffic norms for the protection of people and the environment

Denounce continued growth policies that are incompatible with sustainability

Report ecological crimes:
Illegal tree felling, forest fires, waste dumping, predatory development planning, etc.

Respect and help respect Human Rights
Report any discrimination based on ethnic, social gender or other reasons

Collaborate actively and/or economically with associations that defend sustainability:
Aid programmes for the Third World, environmental defence, aid to people in difficulty, human rights promotion, etc.

Call for the application of the 0.7 aid for the Third World and contribute personally to this

Promote Fair Trade:
Reject products produced through predatory practices (such as tropical timber, animal pelts, over fishing, predatory tourism, etc.) or those are obtained using a workforce without labour rights, child labour
Support fair trade enterprises

Demand clear informative policies on all the problems

Defend the right for research without ideological censure

Demand the application of the precaution principle

Oppose unilateralism, wars and political predators:
Demand respect for international law
Promote democracy in world institutions (IMF, WTO, World Bank, etc.)
Respect and defend cultural diversity
Respect and defend language diversity
Respect and defend lore, customs and traditions (that do not contravene human rights)

Vote for parties with more favourable policies on sustainability

Work so that governments and political parties take on the defence of sustainability

Demand local, state and universal legislation for environmental protection

"Cyberactivism": Support solidarity and sustainability campaigns from the computer

C7. Evaluate and offset [40-41]

Carry out personal behaviour audits
At home, with transport, civil and professional action, etc.

Offset the negative repercussions of our acts (CO_2 emissions, use of contaminating products, etc.) ***through positive actions***
Contribute to reforestation, help NGOs, etc.

The educational role of the action

It is essential, without doubt, *to understand* the relevance our actions have – what we do or do not do – and construct a global view of the measures in which we can become involved. But educative action cannot be limited to achieving this understanding, taking for granted that this will lead to effective shifts in behaviour: a fundamental obstacle in obtaining the involvement of citizens in building a sustainable future is the reduction of educative action to conceptual study.

It is necessary, therefore, *to establish action commitments* in education centres, workplaces, neighbourhoods and in households themselves, in order to *put into practice* some of the measures [42] and carry out follow up of the results obtained. These actions, *properly evaluated*, become the best procedure for profound understanding of the challenges, and the impulse for new commitments. With this aim it is helpful to transform the specific proposals given above into a follow up or (self) evaluation network, starting with the acquisition of concrete commitments that can be evaluated periodically, such as can be seen in Fig. 2.

But before implementing this task in our courses and workshops, *it is necessary to create our own network of commitments that can be evaluated*, both in the realm of consumers and citizens (which allows us to aim better at those we work with, thanks to knowledge gained through our own experience), and with regards to our professional realm: In what way are we contributing, *as educators and researchers*, to the Decade of Education for Sustainable Development? What is our response to the call from the United Nations aimed at educators from all areas and levels for us to contribute to the formation of citizens prepared to contribute to the building of a sustainable future?

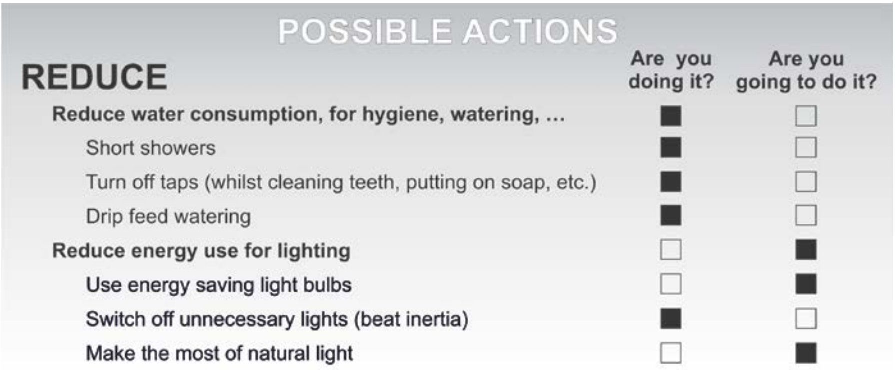


Figure 2. Network of concrete and (self) evaluation commitments

Conclusions

We end by remembering that we are at the start of a Decade that will be decisive for the future of humanity in one sense or another: sadly decisive if we cling to our inertia and do not become aware of the need to reverse a process of decay that constantly sends us unmistakable signs in the form of global warming, anti-natural catastrophes, loss of biological and cultural diversity, millions dying through starvation and war – the suicidal fruit of short term interests and fundamentalisms, of dramatic migrations, etc. Fortunately decisive if we are able to create a universal movement in favour of a sustainable future *that has to start today*. That is the objective that we can and must set ourselves, aware of the difficulties, but determined to contribute, as educators, as scientists and as citizens, to forging the conditions for a sustainable future.

Credits

This communication has been conceived as a contribution to the Decade of Education for Sustainable Development [43] instigated by the United Nations for the period 2005-2014.

References

[1] Vilches A and Gil-Pérez D, Construyamos un futuro sostenible. Diálogos de supervivencia, Madrid: Cambridge University Presss, 2003.

[2] Delibes M and Delibes de Castro M, La Tierra herida. ¿Qué mundo heredarán nuestros hijos?, Barcelona: Destino, 2005.
[3] Duarte C, Cambio Global. Impacto de la actividad humana sobre el sistema Tierra. Madrid: CSIC, 2006.
[4] https://www.cbd.int/
[5] http://www.unece.org/
[6] Diamond J, Colapso, Barcelona: Debate, 2006.
[7] Broswimmer FJ, Ecocidio, Breve historia de la extinción en masa de las especies, Pamplona: Laetoli, 2005.
[8] http://ec.europa.eu/environment/index_en.htm
[9] http://www.wri.org/
[10] http://www.globalreporting.org/
[11] http://www.eyep.info/
[12] Gil-Pérez D and Vilches A, La atención al futuro en la educación ciudadana. Posibles obstáculos a superar para su inclusión en la enseñanza de las ciencias, Perspectivas Ciencia-Tecnología-Sociedade na Inovação da Educação em Ciência, Martins I, Paixao F and Marques R (Eds.), Aveiro: Universidade de Aveiro, 2004.
[13] UNESCO, 700 Science experiments for everyone, New York: Doubleday, 1962.
[14] Costa MFM, Dorrío BV, Michaelides P and Divjak S (Eds.), Selected Papers on Hands-on Science, Costa MF, Dorrío BV, Michaelides P and Divjak S (Eds.), Associação Hands-on Science Network, Portugal, 1-13, 2008.
[15] Comin P and Font B, Consumo sostenible. Preguntas con respuesta, Barcelona: Icaria, 1999.
[16] Brown LR, Salvar el planeta. Plan B: ecología para un mundo en peligro, Barcelona: Paidós, 2004.
[17] Calvo Roy A and Fernández Bayo I, Misión Verde: ¡Salva tu planeta!, Madrid: Ediciones SM, 2002.
[18] Gore A, Una verdad incómoda. La crisis planetaria del calentamiento global y cómo afrontarla, Barcelona: Gedisa, 2007.
[19] Laszlo E, Tú puedes cambiar el mundo. Manual del ciudadano global para lograr un planeta sostenible y sin violencia, Madrid: Nowtilus, 2004.
[20] Pessoa A and Cassasin A, Salvar la Tierra. Barcelona: Egedsa, 2007.
[21] Riba M, Mañana. Guía de desarrollo sostenible, Barcelona: Intermón Oxfam, 2003.
[22] The Earth Works Group, 50 cosas sencillas que tú puedes hacer para salvar la Tierra, Barcelona: Naturart, 2006.
[23] http://www.unesco.org/new/en/natural-sciences/environment/water/wwap/
[24] http://ecodes.org/archivo/proyectos/agua-dulce/index-2.html
[25] http://www.energy.eu/
[26] http://www.idae.es/
[27] http://www.eufic.org/
[28] http://europa.eu/pol/food/
[29] http://www.agroecologia.net
[30] http://www.consumehastamorir.com/

[31] http://www.recyclenow.org/
[32] http://ec.europa.eu/environment/ecolabel/
[33] http://www.enviroliteracy.org/
[34] http://www.setem.org
[35] http://www.actionfornature.org/
[36] http://www.cites.org/
[37] http://www.sellocomerciojusto.org
[38] http://www.ilo.org/
[39] Mayor Zaragoza F, Un mundo nuevo, Barcelona, UNESCO, Círculo de Lectores, 2000.
[40] http://www.greenpeace.org
[41] http://ecologistasenaccion.org
[42] Moreno JSM and Pedrosa A, Ecologic Sustainability and Individual and Collective Everyday Practices, Science and Environmental Education, Azeiteiro UM *et al* (Eds.), Frankfurt: Peter Lang, 2006.
[43] http://www.oei.es/decada/

Paper presented at the 5th International Conference on "Hands on Science. Formal and Informal Science Education",
Olinda-Recife, Brazil, October 13 to 17, 2008.

Solar-Recharged UPS as a Low Cost AC Power Supply for Electronics and Environmental Education

Diz-Bugarín J and Rodríguez-Paz M

Introduction

Uninterruptible Power Supplies (UPS) are a simple and inexpensive protection against mains failures for computers and many other electronic systems. These devices contain almost all the elements required (battery, charger and inverter) to make a portable mains supply that can be recharged by many sources like solar photovoltaic energy, wind energy or hydro-electric power. If any of these sources is not available, it could be removed and recharged with a car battery or an ordinary ac socket.

Figure 1. Complete solar kit with panel and ac socket (left). Mill and water channel-lead- (right)

Some external elements must be added, like a solar photovoltaic panel, a charge regulator and protection elements. The battery capacity can be increased adding a second element connected in parallel. This article describes all the changes that must be made and elements that have to be added. Fig. 1 (left) shows the system with external elements, cables and AC socket ready to use. This system was projected to light an old flour mill where we are planning to make an educational exhibition about traditional uses of renewable energies. Fig. 1 (right) shows the mill and surroundings with water channel or lead. In this application the system could be recharged by solar or hydraulic energy.

UPS description

A common UPS (Fig. 2) contains the following elements:

1) Power supply and battery charger that are connected to external ac mains and keep the 12V battery completely charged.
2) Battery (Fig. 3) of lead-acid type, 7-12 Ah. This capacity is enough to light one or two low consumption lamps for several hours.
3) Power inverter that receives 12V DC from the battery and provides an output of 230V AC.

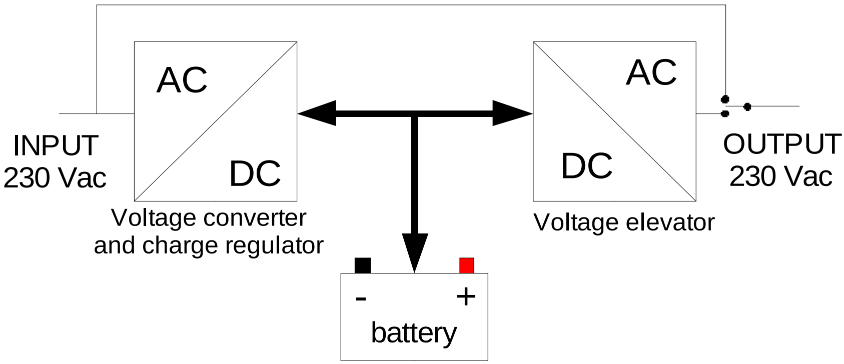


Figure 2. UPS internal schematic

These devices are typically connected to the mains all the time, and battery is always full. When there is a power failure UPS inverter starts generating power from the battery. In our application UPS is simply disconnected from the mains, and will continue generating power until battery is empty. If we can recharge the battery without reconnecting it to the mains we will get an independent power source that can be used anywhere.

UPS modifications

The following changes have been applied to allow solar recharging, as can be seen in schematic (Fig. 4):

- An external connector must be installed and connected to the battery to allow access and recharging (Fig. 5 and 6).
- A solar panel and external regulator must be connected directly to the battery. The solar panel should provide at least 14V and 10-20W of peak power [1]. The regulator can be a commercial type or a self-made one (see next section).

- A protection diode must be inserted between the battery and external regulator. This diode allows simultaneous working of external and internal recharging and avoids discharge of the battery through the solar panel.

Figure 3. UPS and battery housing

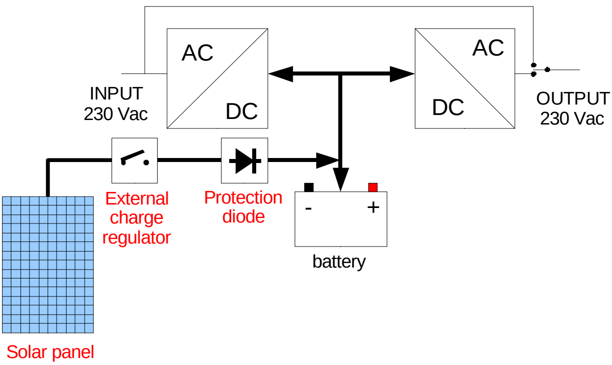


Figure 4. UPS modifications to allow solar recharging (external elements in red)

External regulator

UPS's have an internal charge regulator to avoid damage to battery. This regulator could be incorporated into the solar recharging system, but unfortunately manufacturers [3] do not provide enough information about internal circuits, so this option must be discarded. That's the reason we decided to develop our own regulator based in an integrated circuit of common use in electronics, the voltage regulator LM317 [2]. The circuit is adjusted to obtain an output of 14,5V. Fig. 7 shows the schematic of this circuit that can easily be assembled by electronics students in a typical school workshop. Fig. 8 shows a prototype of regulator inside an outdoor box.

Figure 5. External recharge connector

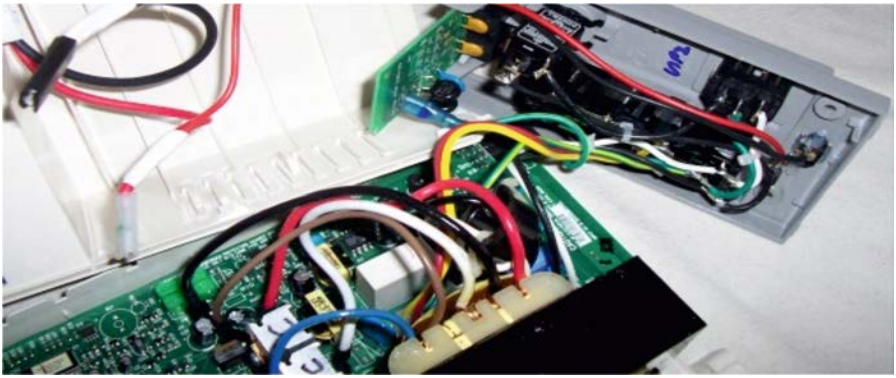


Figure 6. Detail of internal connections

Final assembly

To make the final assembly of the system the following steps must be followed:

1) Solar panel must be connected to the charge regulator input. It can be checked with a multimeter (under direct sunlight).
2) Regulator output must be connected to external battery connector in the UPS (Fig. 8).
3) UPS output must be connected to an electric appliance (like a low consumption light). A mains socket (schuko or similar) can be mounted at the UPS output to allow different charges to be easily connected and disconnected.

If everything is right the power supply will start generating electric power. If there is enough solar energy to partially recharge the battery every day the system will work indefinitely without any external contribution.

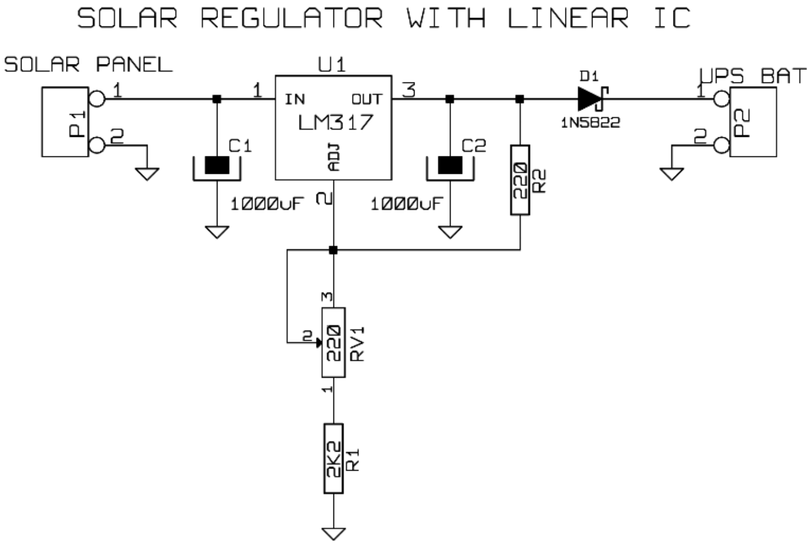


Figure 7. Charge regulator schematic

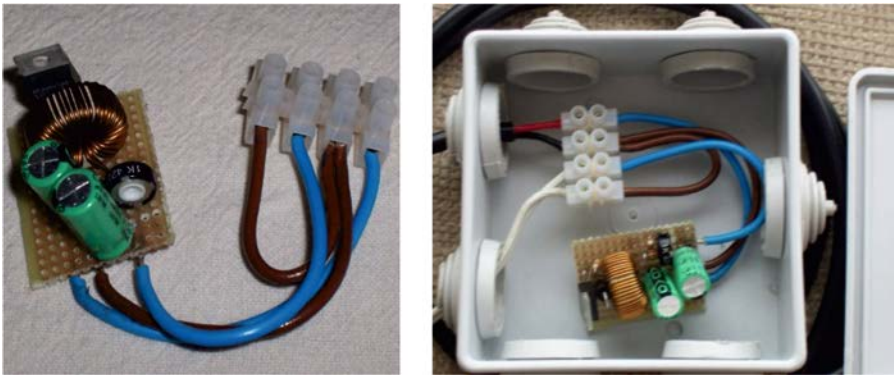


Figure 8. Charge regulator fully assembled

Applications

The system can be used wherever there is need for ac power with low consumption, like lighting in small isolated houses, camping, powering of small electronic devices like TV or radio transmitters, etc.

An important field of application is electronics students training, since these students can both make the system elements (like the regulator or connectors), and use them as a solar energy practice.

Students of other fields can also take advantage of this system due to its low cost, like in subjects related to environmental themes.
It can be used in exhibitions or science fairs about renewable energies, especially if other power sources are used for recharging instead of solar power (like a small wind generator, hydraulic generator, etc). As an example of this application, the kit was shown at "Encuentro Solar 2007" meeting in Granada, Spain.
Another interesting application is as a backup power source for laptops when used outdoors. A fully charged battery can provide 2-4 hours of use of computer.

References

[1] Kyocera Solar Panels technical information and datasheets. Available at http://www.kyocerasolar.eu
[2] National Semiconductor technical information and datasheets (LM317 circuit). Available at http://www.ti.com/lit/ds/symlink/lm317.pdf
[3] APC UPS technical information. http://www.apc.com
[4] Atersa 10W solar panel, http://www.atersa.com/

Paper presented at the 5th International Conference on “Hands on Science. Formal and Informal Science Education",
Olinda-Recife, Brazil, October 13 to 17, 2008.

Some Simple Experiments in Optics Using a Photo-Resistor

Dias Tavares A and Muramatsu M

Introduction

Nowadays, most countries are facing an increasing need for physicists and engineers since new technologies and their applications present an exponential growth. But, in general, most of those countries have not had a strong increase in the number of students looking for the so-called "hard sciences". In our university, the figures of the evasion from the four years undergraduate course of Physics are about seventy five percent. So, our teaching efficiency is quite low. Furthermore, there are still problems with those who succeeded on finishing their undergraduate courses: many of them do not have a good comprehension of practical or experimental problems. The knowledge transference from theory to day-to-day life problems is very scarce if there is any at all. We can attribute these difficulties also to a deficient laboratory teaching. One of the possible solutions would be a development of small and cheap laboratory experiments and their application to training and demonstration with students [1-2]. So the scope of this work is contributing with a cheap and easy way to do teaching experiments, in order to interest more students to persist and progress in Experimental Physics and, particularly, Optics. In Optics Laboratory teaching a recurrent problem is the measurement of light intensity. Several experiments depend on a fair evaluation of irradiances. We can cite a few among the most important: Point Source Irradiance Inverse Square Law; Malus' Law; Irradiance from a Cylindrical Lens. We named just these because they are among those most basic experiments in Optics Laboratory and the irradiances to be measured are quite high. Therefore we are just limiting the scope of this work to the experiments in which we can verify laws and behaviours with relatively high intensities. The scope of this work is to provide teaching laboratories with a cheap and powerful tool in order to proceed to experiments otherwise impossible to be made. Furthermore, mounting, calibrating and using this simple component, a photo-resistor, forces the students to learn important laboratory techniques and to develop the necessary patience and determination in order to obtain results with good level of accuracy. Two experiments are proposed in this work: Verification of the Point Source Irradiance Inverse Square and Malus' Laws. These experiments are basic in Optics teaching laboratory [3] and are fundamental for the scientific learning of the students. The scientific learning and the formation of a scientific spirit [4] is more important than only reproducing some experiments passing by them almost like scenery seen from a train window.

Methodology and Discussion

The experimental schemes for all of these experiments are well known, therefore due to this article space limitation we do not present them limiting ourselves to the results, which must be graphically presented.

Choice of an irradiance detector and its calibration procedures

The choice of a common photo-resistor was supported by a number of reasons: price, easiness to find them; it is practically foolproof; simple circuitry and a fairly good linearity (although over small regions). On the other hand they present some inconvenient aspects like: nonlinear dynamic range; slow response to intensities; nonlinear spectral response, which is much similar to that of human's eye. This scenario makes for a good place to start, setting the stage for building and understanding more complex experiments and procedures. The first question is how to conveniently mount the photo-resistor in order to detect intensity changes. The easiest way is simply measure changes in the photo-resistor internal resistance. One needs only an analogical or digital ohmmeter and measures the internal resistance variations of the photo-resistor. It is necessary to assume the ohmmeter scale is fair calibrated or execute its calibration. We think this step can be circumvented provide that students are warned about that. The electrical scheme of mounting can be seen in any good basic Physics book. The next step towards the Optics experiments is to calibrate the photo-detector response to incident intensity. The photo-resistor response also is opposed to the common sense of the students, that is, instrument readings are smaller for larger incident intensities. Therefore, the problem is to be sure the incident intensities vary linearly or with some well-known function, which can be fitted from experimental data. One can use some set of photographic neutral filters, or a graduated variable intensity filter, which, of course, are not easily available. A homemade solution is using a set of microscope slides. Each slide reflects about four percent of the incident light in the first surface and more four percent of remaining light. Therefore, one can plot the function of light intensity against number of microscope slides and use it to calibrate the photo-resistor against intensity. By the other hand, if one has a calibrated photo-detector like a silicon photodiode, he could use a much simpler mounting. Two polarizer filters can be used to grade incident intensities, which can be simultaneous (or not) monitored by the photo-detector. This is true for normal incidence and a 1.5 refraction index glass [3,5] and we assume the light absorption is quite small compared to the reflection in the dielectric boundaries. However, as we are interested only in the functional behaviour of our light "filter" and not in absolute values of intensities we can consider these values quite good for our experiment. An extension of this experiment would be to measure the refraction index of microscope slides and calculate the reflectance with measured value. Afterwards the students should calculate the mismatch between first figures and those from measured values. Surely, they will conclude that the errors the first procedure could introduce in the experiment are negligible. The conduction of the experiment will depend on the scope, time and available equipment. It can be conducted without leaving anything to chance or following to the verification of hereinabove named laws without the same strict regard to precision. In a laboratory with more resources a set of neutral filters with stepped intensities could be used or still a variable neutral density filter. A low cost car stoplight incandescent lamp was used for this calibration. The incandescent lamp has a spectral emission curve much like of a blackbody at the same temperature, therefore it couples quite well with the spectral sensibility curve of the CdS photo-resistor. Nevertheless, the great infrared emission of incandescent lamps will pose some problems in the verification of Malus' Law. An experimental curve of the spectral sensibility of CdS photo-resistor should be made, but a few more sophisticated equipment must be used in order to have a trustful result.

Verification of the inverse square law for the irradiance of a point source

Despite that this experiment is quite simple some attention must be paid to a few details in order to have experimental results consistent with theory. Correct alignment of all components is very important because detector will be displaced during the experiment. To a more precise experiment the light from a 300-watt lamp taken from an overhead projector is focused onto a variable diaphragm aperture and later strikes the photo-resistor. This is order to have enough light striking the detector still when the aperture of the diaphragm is very small and more similar to a real point source in the laboratory physical limits. Distances between diaphragm and photo-resistor are measured with a scale. A few attempts must be made in order to verify the amount of error introduced by increasing source diameter. One must consider whether the illumination system presents a focusing apparatus or not. If yes, this will distort the result as long as the wave front can have a negative convergence, a positive one or still no convergence at all. But, with a less demanding experiment an incandescent lamp of a car stoplight can be used with the advantage of low cost and low heat generation.

Verification of Malus' Law

This verification is a little simpler than the preceding ones. The polarisers are the usual ones used in photography and are mounted in a support with a goniometer. The polarizer are aligned in order to deliver the maximum irradiance, afterwards the direction of one is changed in five degrees steps from zero degrees to one hundred and eighty degrees. One can tabulate the results, calculate the cosine of those arcs, square them and make a graphic of intensity against square cosines. It is convenient to normalize the measured intensity values and trace a theoretical curve to compare with the experimental one. Another kind of graphics can be made to facilitate the comparisons, for instance, intensities versus square cosine and so on. In the measurement, special attention must be paid to the background infrared radiation since the normal polarisers do not act on infrared radiation. Once again, depending on the laboratory resources, a heat filter can be used or one can be improvised with water [6].

Results and discussion

Photo resistor calibration

Fig. 1 presents theoretical, experimental and an adjusted function curves for the light transmission against intensity. Experimental data were normalized for easiness. The theoretical curve was calculated using an estimated 4 percent transmission to each air/glass or glass/air boundary for normal incidence. The experimental curve was obtained using a calibrated photo-detector and one can see from the graphics that experimental data show good agreement with the theoretical ones. Therefore, microscope slides filter can be used safely to calibrate other detectors like a photo-resistor.

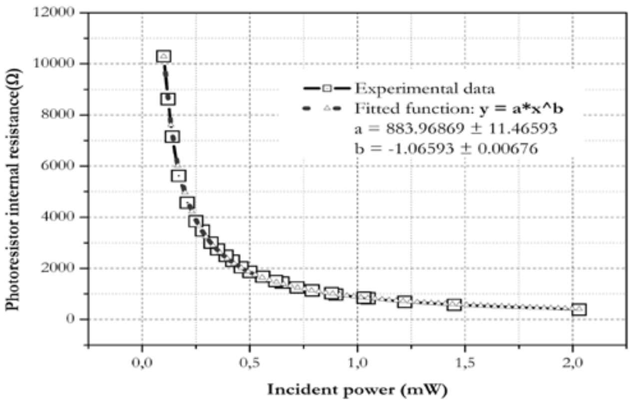


Figure 1. Transmittance x Number of added reflecting interfaces

The adjusting function $y=e^{-0.03835x}$ will provide a good help acting like a mathematical filter for the data obtained with the unknown photo-detector. Therefore, it is of the utmost importance to have a filter with a well-known transmission function. It will liberate one from the uncertainty about detector function response to intensity. But, it is important to remember that all this procedure will permit only qualitative measurements, not the quantitative ones, that is, it does not permit to obtain absolute values of incident power.

Fig. 2 shows the results using a more complex scheme with a power detector, polarizer filter set, power monitoring by a fixed (50/50) beam splitter and a silicon photo-diode.

The graphics has been elaborated using the *OriginPro*^{TM} 7.0 Server. As the photo-resistors present strong nonlinearities at both high and small incident power since they have a constant minimum internal resistance and that evolves almost exponentially with very low incident power we limited the operational range of our photo-resistor to 0.1 to 2.0 mW of incident power. In spite of that, it is clear that the photo-resistor have a good linear response only in the range of about one to two mW of incident power.

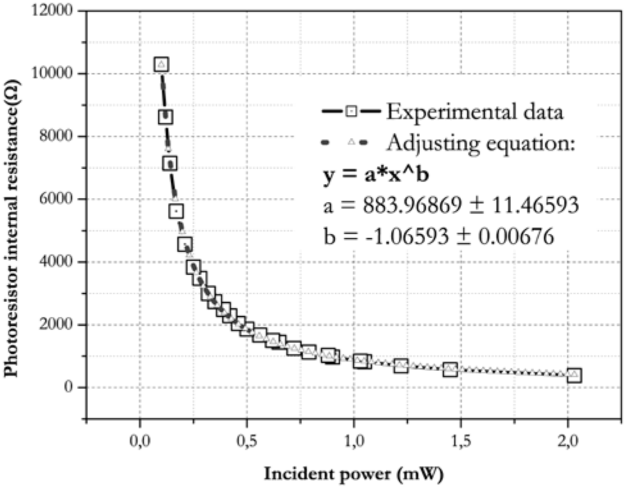


Figure 2. Photo-resistor internal resistance x Incident power (Reduced range)

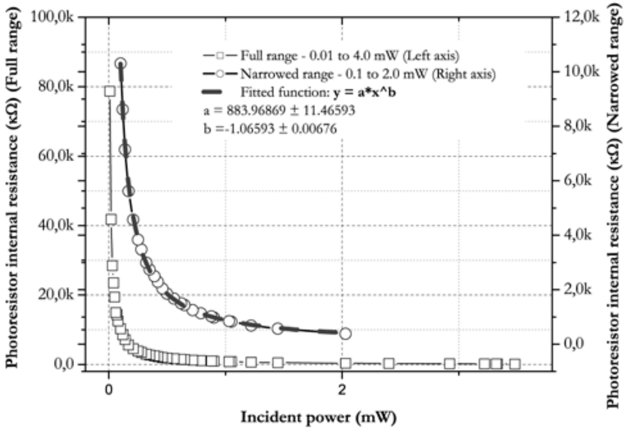


Figure 3. Photo-resistor internal resistance x Incident power (Full and reduced ranges)

Nevertheless, one can divide in small sectors and in each of them the photo-resistor will present a quite linear behaviour. Besides that, the adjusting function $y=884\ x^{-1.07}$ can be used to correct the measurements made with this photo-resistor in the presented range. With this curve the student can transform his/her measured values in power figures. So, absolute measurements can be performed using the graphics presented in Fig. 2. In order to get a better comprehension of the problem, Fig. 3 presents the photo-resistor full range measurements comparing it with the smaller portion we have assumed for better accuracy. One can observe the quasi divergence of the photo-resistor internal resistance at low (< 0.1 mW, typically) and a flat behaviour at large powers (> 2.0 mW).

Verification of the Inverse Square Law for the irradiance of a point source

Fig. 4 shows the result of photo-resistor application in the determination of the behaviour of a near punctual light source with the distance. The point source used was a common car stoplight lamp. We have preferred to use this one because of its friendliness: it is cheap, easy to find, easy to mount and turn on. We did not worry to focus the lamp light in an iris diaphragm in order to obtain a much more punctual source and the reason for that is the small power of the this lamp. In spite of these unforgivable imprecisions in the experiment assembly, the result is quite consistent with the theory.

That can be seen from the fitting function for the experimental data, $y=0.0067\ x^{-2.15}$, which has a good agreement with the real dependence $y \sim x^{-2}$. A larger number of experimental points would be better for a more precise reproduction of intensity behaviour at small distances to the source, that is, in the interval between 0.1 and 0.3 meters. This discrepancy at smaller distances can also be attributed to the real dimensions of the source, which is minimized at larger distances.

Verification of Malus' Law

Fig. 5 presents the results obtained for the Malus' Law. In this experiment, two photo-resistors were used and also a selenium photocell, which delivers a few mA current when illuminated.

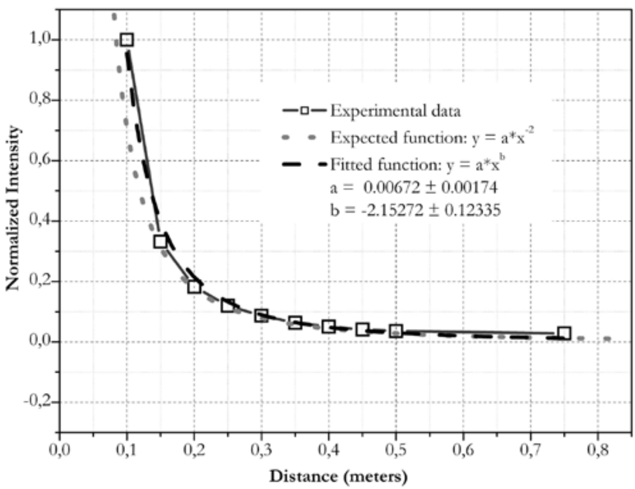


Figure 4. Inverse Square Law verification

This last one was used only as an additional reference. One can see from the graphics that the best result is obtained with the 5 mm diameter photo-resistor. As expected, the best agreement between theoretical and experimental curves occurs in the regions in which the incident power is larger, that is, there is a discrepancy in those curves when the incident power values tend to zero. Surprisingly enough, both photo-resistors present more accurate results than those of the selenium photocell. We believe with a little more effort these results can be still enhanced but the clear dependence of experimental data with the theoretical curve is noticeable and the fitting function below confirms that.

$$y = A\{\sin[\pi(x - x_c)/w]\}^2; \text{ with}$$

$$x_c = 89.55408 \pm 0.68404;$$

$$w = 180 \pm 0 \text{ and } A = 1.02834 \pm 0.01323$$

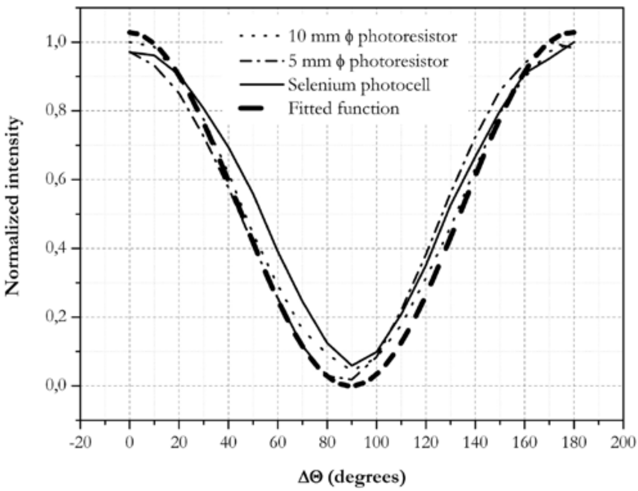


Figure 5. Malus' Law verification

Conclusions

We have shown how a few interesting and involved experiments with light can be performed using cheap, easy to find components. Furthermore, these experiments can be tailored to the audience, in accordance to the students' general level of knowledge. There is still room for other experiments looking for improving the results and figures presented in this article, but not only that. Experiments to determine the photo-resistor internal resistance dependence with incident light spectrum are very promising and can lead to other interesting experiments and so on. Effectively, there is no dead end for the experimentalist. For the college students work to enhance the results and pursue a better data treatment using some convenient software can be very rewarding. Nowadays we have also to develop the student skills in dealing with informatics but not only that! Our vision is that the best way is to ally laboratory work with data treatment and simulation.

Acknowledgements

To FAPERJ for the grants, those have supported this work.

References

[1] Dias Tavares Jr. A, da Fonseca RJM, Sosman LP and da Mota LACP, Proceedings of SPIE, 5622, 1522-1526, 2004.
[2] Dias Tavares Jr. A, da Mota LACP and Vieira GJ, Mechanical Oscillation Superposition and Lissajous´ Figures, Proceedings of the 4th International Conference on Hands-on Science. Development, Diversity and Inclusion in Science Education, Costa MF, Dorrío BV and Reis R (Eds.), Açores, 202, 2007.
[3] Hecht E and Zajac A, Optics, Menlo Park/California, USA: Addison-Wesley Publishing Co, 225-226, 1979.
[4] Bachelard G, La formation de l'sprit scientifique: contribution à une psychanalyse de la connaissance, Paris: Librairie Philosophique J. Vrin, 1938.
[5] Jenkins FA and White HE, Fundamentals of Optics, McGraw-Hill Kogakusha, International Student Edition, 4th edition, Tokyo/Japan, 503-504, 1976.
[6] Strong JD, Modern Physical Laboratory Practice, New York: Prentice-Hall, Inc., 369-371, 1938.

Paper presented at the 5th International Conference on "Hands on Science. Formal and Informal Science Education",
Olinda-Recife, Brazil, October 13 to 17, 2008.

Research Interpretation in University

Dorrío BV

Introduction

The currently accepted paradigm for learning scientific-technological subjects requires, among other things, the use of collaborative strategies such as group work and critical thinking, and skills for practical problem solving, which, in addition, take the subjects closer to an individual's social, cultural and personal concerns [1,2]. The use of hands-on activities can contribute to such objectives as yet another tool to make learners active participants in the process: constructing in order to learn and learning in order to construct [3]. A hands-on activity in a knowledge acquisition context means the use, whether in a formal learning environment or not, of any real material or object employed with the intention of learn a properly contextualised concept, principle, law or application [4]. These are well-known methods for presentation and communication regularly employed in interactive centres or science museums, where the message being transmitted appears in an informal, fun context [5-7]. In this case the interpretation is chosen for revealing meanings and relationships by using original objects, direct personal implications and illustrative means instead of mere audiovisual communication of the facts [8-10], in an inclusive experience in which personal, social and physical contexts of participants intervene to a unique, individual experience [11].

There are innumerable examples of such resources being imported into the educational sphere [12-15] backed up by the use of everyday items, videos, simulations, models and demonstration teaching material or instruments themselves from research laboratories [4,16]. Thus, the teacher can integrate [17-18] them into traditional, large group, master classes as subject area experiences [4,16], propose to learners the creation of a hands-on experimental module in the form of a challenge activity undertaken individually or in small groups [19-20] or even suggest the cloning of a science and technology museum within the educational environment, a collective and cooperative activity in which learners are co-responsible for its definition, set up and monitoring [21-24].

Within the framework of Science Week 2007, organised by the General Direction for Research, Design and Innovation (R&D&i) of the Xunta de Galicia Regional Authority [25], the above strategy of using hands-on activities as a link between learning and popularisation was used to carry out an interpretive experience related directly to research undertaken in the Higher School of Mining Engineering (Escola Técnica Superior de Enxeñeiros de Minas or ETSEM) at the University of Vigo [26].

Photo 1. Key ideas for the ETSEM activity: its installations and research

The main aim was to show the relationship between this research and energy, new materials and the environment (Photo 1), in a similar way to a science and technology museum, but run by student monitors and employing real hands-on activities backed up by tailor-made audiovisuals, with representative photos, videos and simple, clear, direct, easy-, and quick-to-read texts that in all events transmitted the correct message to create "places of informal fun learning" within the ETSEM itself. This activity fitted within the aims of the Social Communication and Awareness Programme of the Galician R&D&i Plan inasmuch as it attempted to create an experience in educational innovation at the university by trying, amongst other things, to promote greater social recognition of its research activities, make potential students aware of these or even promote the ETSEM's participation in science and technology experiences by means of contextualised hands-on activities.

The educational innovation experience was centred on work with a small group of selected students from the ETSEM who were involved in a process in which part of the teaching staff carried out corresponding tasks in a coordinated, collective and cooperative way. The students worked as guides, interpreters, intermediaries, monitors or mediators with the visitors for whom a two-hour guided tour was designed: science and technology pupils from nearby secondary and high schools (14-18 year olds), usually accompanied by two or three teachers (Photo 2).

Context and methodology

Mining Engineering studies, with a long tradition and great prestige in the EU, started in Spain in 1777 and were the first Civil Engineering qualification to be created there. Its name originally comes from the traditional location of mineral and energy sources. Nowadays the versatility of qualifications means it can be adapted directly to new technologies. Mining engineers are essentially responsible managers of the Earth's natural resources and contrary to popular opinion, most of them do not work in mining exploitations, as the fields for work are numerous and, at the same time, unknown to the public, such as, for example: energy and fuels, metallurgy, the iron and steel industry, resource and environmental management, geology, civil works and construction, business management, explosives or safety and risk prevention in the workplace.

The studies were established at the University of Vigo in the 1992-1993 academic year. ETSEM is now one of five offering higher level qualifications in Spain and the only one in Galicia.
The recently built installations made it possible to unify the technology area of the University Campus at Lagoas-Marcosende (Vigo), given the fact that the ETSEM occupies a space in the centre, with corridors going out from it to the three Higher Engineering Schools of the Vigo Campus. Sixteen years on from its start up in Galicia, the scientific and technological activities related to the ETSEM are in part unknown by the general public and for this reason the theoretical proposal for this activity was aimed essentially at showing close up and explaining the work going on in the labs, showing the great range of career possibilities available to future graduates and what is on offer in terms of education and services from the ETSEM, and, furthermore raising awareness of participants with regard the importance of preserving the Earth's natural resources (energy and materials) and the environment, with the specific objectives of:

1) Increasing interest for scientific and technological aspects developed at the ETSEM.
2) Bringing the ETSEM's scientific and technological research to the public.
3) Showing scientific technological applications at the ETSEM in a fun, interactive way.
4) Making society aware of the importance of preserving the Environment and our Heritage.
5) Showing the scientific technological work at the ETSEM as an interdisciplinary task.

Photo 2. The public during the activity

In order to achieve these objectives an educational innovation experience was drawn up under the general, eye-catching title of "Energy, materials and environment: this qualification is a mine", which consisted of a guided visit designed to take visitors around the ETSEM facilities whilst everyday teaching and research activities were going on. Within this architectural framework, which in itself warrants a guided tour, the monitor work (Photo 3) was essentially carried out by final-year students from the ETSEM, in a context of explanation among peers or equals. The teaching staff worked together to establish the contents, the corporative image of the audiovisual presentations and the protocols for interpretive presentation. It was understood that the media could not offer more than someone had thought, prepared or represented, and should therefore be complemented by the direct personal contact of the interpreter [10]. Likewise the students worked on their own to prepare the material for providing more or less support depending on the case, which was then unified with all the modules.

Photo 3. Some students as guides, interpreters, intermediaries, monitors or mediators

Some of the activities required additional training or preparation of the students by the teaching staff, so that they could handle instruments easily and with confidence. This design and interactivity work with the students was completed by their presence every day in the modules, verbally presenting the contents, carrying out hands-on activities and generally dealing with the visitors. This all resulted in them achieving important learning goals regarding the particular abilities for this type of activity, and the strengthening of several linked competences: some instrumental (ability to analyse and sum up, problem solving or organisation and planning skills, etc.), some personal (teamwork, interpersonal relationship skills, critical reasoning, etc.), and some systemic (autonomous learning, creativity, initiative, enterprise spirit, etc.).

The two-hour visits are distributed sequentially and in parallel in several of the ETSEM's spaces and with various timings, which were maintained to a greater or lesser extent. Two morning sessions were scheduled and were used for most of the five days that the activity lasted. On most occasions the visitor groups needed to be split into smaller groups for ease of work, enjoyment and to take better advantage of the visit. After a general reception in the ETSEM's main lobby by two people from management who introduced themselves, the ETSEM, and its facilities, the support material for the visit was handed out in the form of a leaflet together with general information about the education on offer and services at the University of Vigo, and material provided by the General Direction for R&D&i.

Also in the main lobby, two monitors ran activities dealing with energy, aided by audiovisual material projected onto a portable screen. Later, one of the monitors took a group to the upper floor to be shown some of the ETSEM services: photocopying, academic administration and the library. Later, on the upper floor, the visitors were received in the degree hall by a teacher who gave an informative talk on the qualification and the visit. This was finished by forming small groups of visitors who were circulated independently around the rest of the interactive themed modules (new materials and environment) located at various areas within the facilities, all of which were backed up with the corresponding audiovisual presentation. At the end of the visit all of the visitors converged once again in the lobby as a meeting point and received a souvenir gift of their visit to ETSEM and an individual evaluation questionnaire to take back to their centres for later return. After the event they received further support documentation about what they had seen and a photo report made during their visit, which included, for example, 2D thermal images or 3D scans of themselves.

Contents and undertaking

The hands-on modules attempted to relate the contents with the participants' own experience, employing whenever possible some everyday elements to link the unknown to the familiar. They were focussed on a specific research topic, around which the general context and applications were shown at the same time (Photos 1 and 4). Thus the visitors could:

a) attend a handling demonstration of different explosives (a specific Mining Engineering function) provided by the former "Spanish Explosives Union", now MAXAM, together with explanations of tasks and procedures that mining engineers carry out in underground civil works (tunnels, car parks, etc.) and quarries; or individualised demonstrations of rock compression resistance testing;

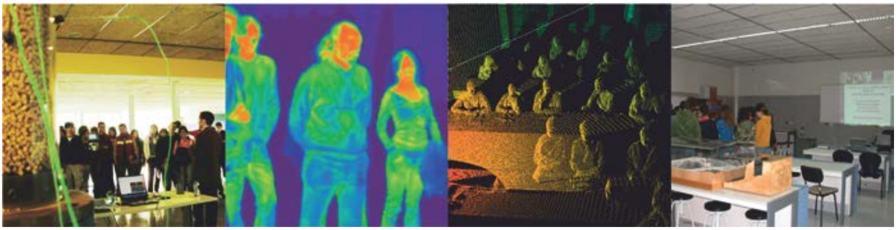


Photo 4. Some examples of the hands on activities developed

b) take part in fieldwork demonstrations undertaken at the ETSEM with actual technology from the research labs, such as 3D scanning of part of a building or different structures by using high precision 3D laser scans of the area, such as those used by Mining Engineers to analyse bridges, heritage sites, etc. Here, data collection was taken of the group itself for them to see afterwards on the screen used to project the accompanying audiovisual;

c) get to know the possibilities of alternative energies in general and biomass in particular, by watching the operation of a real research model, moved from the lab into the lobby, in which detailed study is made of the combustion process for this type of renewable energy; or the features and properties of the most representative materials in industry (ceramics, metals, hybrids and polymers), explaining, for instance, how a PET mineral water bottle or a toothpaste tube is manufactured by using injection, or, with the help of the student monitors, the creation of polyurethane, or carrying out nickel plating as an example of corrosion protection or;

d) participate in taking non-destructive 2D thermal images with a thermal camera such as those employed in heat efficiency studies on buildings. Here, visitors saw different applications and participated in small experiments such as viewing the thermal contours in a small piece of PVC tubing which was subjected to internal sedimentation with silicon, or even the observation of their own body temperature, in which case, once the activity was over, a thermal image was taken of the group as a souvenir.

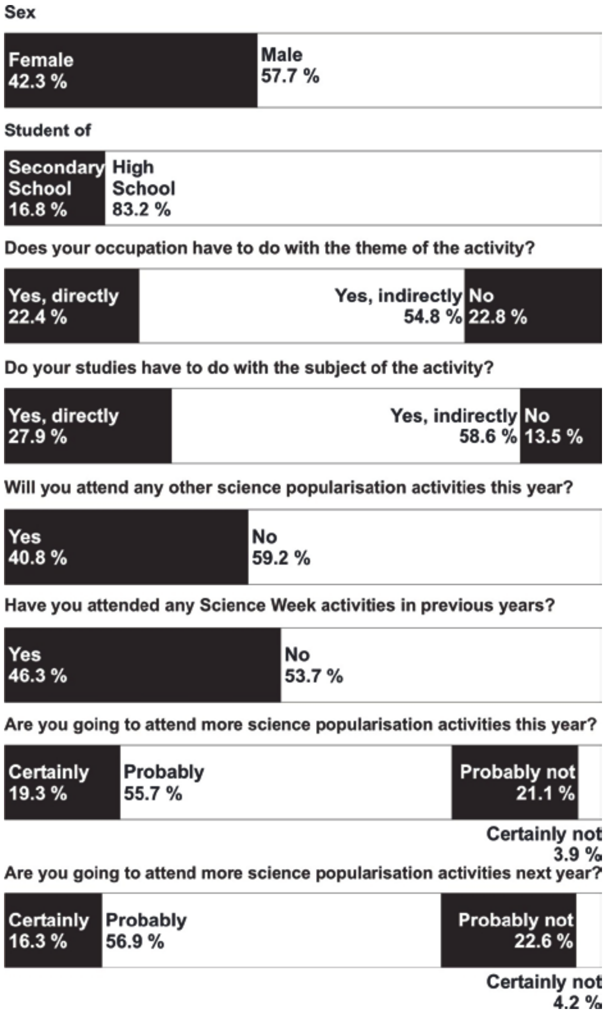


Figure 1. Evaluation: characteristics of the sample with regard to their origin and experience in popularisation activities

The teaching staff and students involved took responsibility for general organisation and coordination of activities, planning and design of work, and the compilation of graphic and bibliographic documents for the interpretative audiovisuals, poster and leaflet. They were also involved in defining the guided tour of the ETSEM, in design and creation of the audiovisual presentation material, in acquiring material and booking the equipment and instruments for demonstration, and the teaching staff were involved in the training of the student monitor guides.

A plan for diffusion, follow up and evaluation was drawn up. A section of the ETSEM webpage was prepared, where general information on the activity along with downloadable PDFs of the poster and leaflet were published beforehand together with preparatory background reading for accompanying teachers aimed at gaining a more useful educational experience. When each daily session was over, a selection of photos was sent to the Xunta de Galicia General Direction for R&D&i [25] and five galleries were published. The activities undertaken were also diffused in the media (press, radio, web and TV) thanks in good measure to the work of the University of Vigo Press Office [27]. All this meant a significant increase in the ETSEM's external visibility during the days of activity.

Evaluation

The questionnaires employed for evaluation of the activity were designed by the General Direction for R&D&i of the Xunta de Galicia for Science Week 2007. The questionnaires of around 250 participants were analysed. The main results, in the form of percentages reached for each of the possibilities, can be seen in Fig. 1-3, where general information on the origin and membership is given for the visitors who were essentially a captive audience, obliged to attend the activity during school hours, exposed to an optional learning activity and without the possibility of free choice about participating, which is an important factor to take into account. There is also information about their knowledge of other similar activities and experiences, whether part of the Science Week organised by our government or of a different origin. With regard to evaluation of activity undertaken at the ETSEM, it appears that they far exceeded the participants' expectations. Predictably, lack of initial knowledge was great, whereas after the visit there was a palpable perception that it had helped in the acquisition of new knowledge, increasing interest in the contents presented. Also of note was that the majority of the participants felt that the contents were suitable for their degree of knowledge, which means there has been relative success in the process of adapting and presenting the contents in a way that is understandable to the layperson, an idea supported by the high average overall rating obtained (7.6 out of 10). Finally, and also very high, was the rating for the work of the monitors, the material and the organisation.

Conclusions

This work presents the methodology for planning, organisation and coordination together with the most noteworthy results gained during an educational innovation experience related to the creation of an interactive museum and a guided tour of the ETSEM facilities at the University of Vigo as part of Science Week 2007, organised as a learning activity aimed at acquiring essentially transversal competences, knowledge and skills by means of autonomous work carried out by a small number of selected students, oriented by teaching staff acting as coordinators.

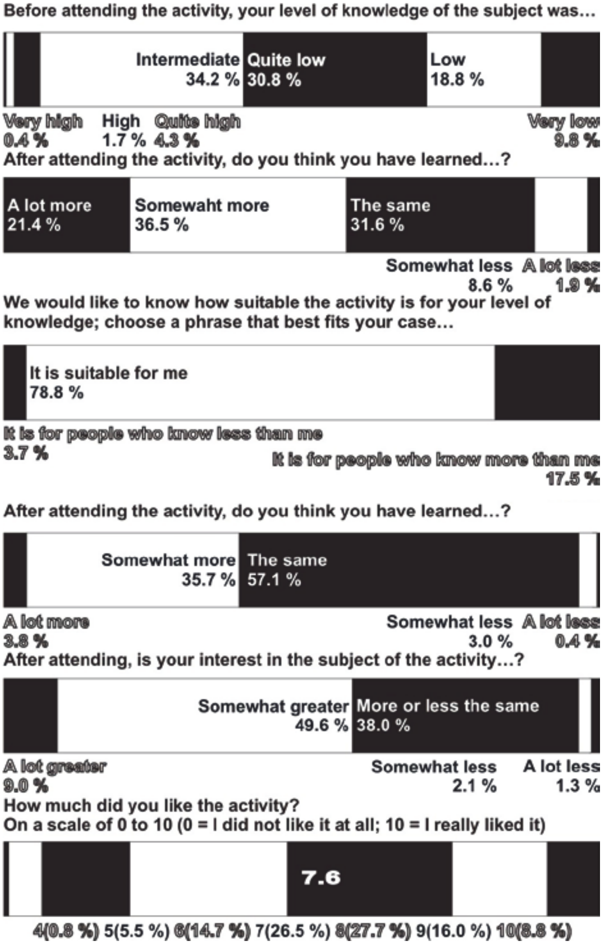


Figure 2. Evaluation: degree of suitability, knowledge, learning, satisfaction

The activity attempted to engage participants with research going on at the ETSEM, recreating it technologically and increasing empathy towards it by employing interpretive resources for demonstration and participation. It is understood that the questionnaires reveal a high degree of satisfaction among participants, who consider it to have been a special and novel experience that was important to them. The activity, fun, enjoyable and motivating, appears to have awoken their interest in the contents presented and shifted in the majority of cases, the ignorance and ideas previously held. The participants thought that the experience was a fount of useful information and that is was possible to learn new things from it.

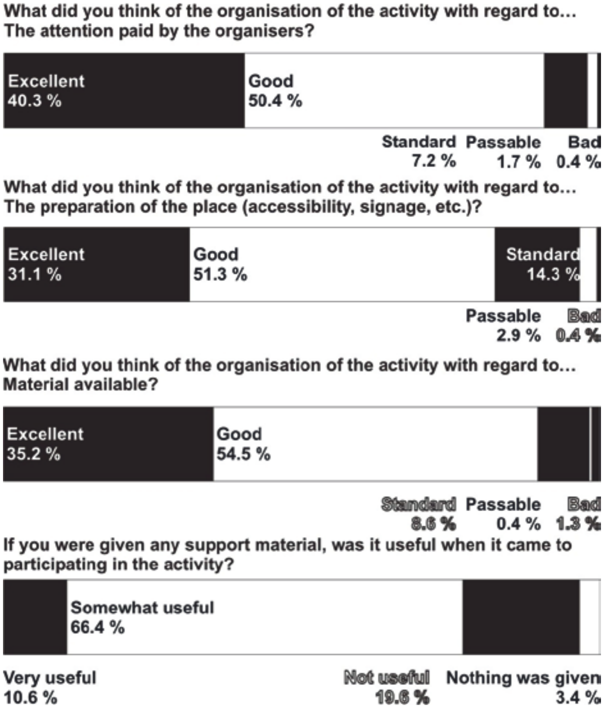


Figure 3. Evaluation: attention paid, material and organisation

A large part of the success achieved must be put down to the student monitors who, with clear and straightforward messages offered a general broad-ranging idea of their modules within the context of the ETSEM, including details with their own personal impressions, awakening the interest and desire to see new things, becoming the vital medium to aid in understanding and help enjoy these facts. The enthusiasm seen by participants during the activity also constitutes an important achievement. Finally, it is important to also mention that in general the rest of the teaching staff and students of the ETSEM not directly involved in the activity also felt highly satisfied with the experience, as did most of the accompanying teachers from the visiting schools.

Acknowledgments

Thanks go to the General Direction for R&D&i of the Xunta de Galicia for funding as part of the Science Week 2007 programme. Thanks also go for the logistic support of the OTRI (Arístides Huerga and Javier González) at the University of Vigo, the diffusion tasks to the media by the University of Vigo Press Office and the demonstration material provided by MAXAM. Finally, thanks go to the teachers, students and support and service staff of the ETSEM who participated by giving their help, particularly to: Pedro Arias, Natalia Caparrini, Enrique Granada, Carmen Pérez, Fernado Cerdeira, Enrique Orche, Javier Taboada, Fernando García, Pedro Merino, Marta Cabeza, Ramón Nóvoa, Iria Rodríguez, Jaime Martínez, Diego Copena, Antonio Soliño, Carmen Moreira, María Rodríguez and Karolina Biskup.

References

[1] Hodson D, In search of a meaningful relationship: an exploration of some issues relating to integration in science and science education, International Journal of Science Education, 14: 541-566, 1992.
[2] Barab SA and Karns D, Rethinking methodology in the learning sciences, Journal of the Learning Sciences, 10: 5-15, 2001.
[3] Flick LB, The meanings of hands-on science, Journal of Science Teacher Education, 4: 1-8, 1993.
[4] Dorrío BV, García Parada E and González P, Introducción de demostraciones prácticas para la enseñanza de la Física en las aulas universitarias, Enseñanza de las ciencias, 12: 62-64, 1994.
[5] McManus PM, Topics in museums and science education, Studies in Science Education, 20: 157-82, 1992.
[6] Maxwell LE and Evans GW, Museums as learning settings: The importance of the physical environment, Journal of Museum Education, 27: 3-7, 2002.
[7] Allen S, Designs for learning: studying science museum exhibits that do more than entertain, Science Education, 88: 16-33, 2004.
[8] Beck L and Cable T, The meaning of interpretation, Journal of interpretation research, 7: 7-10, 2002.
[9] Lee C and Brown A, Bibliography of interpretative resources, Journal of interpretation research, 8, 2003.
[10] Tilden F, La interpretación de nuestro patrimonio, Pamplona: AIP, 2006.
[11] Falk JH and Dierking LD, Publics institutions for personal learning. Washington: TISAAM, 1995.
[12] Morris C, Importing “hands-on” science into schools: the Light Works van programme, Physics Education, 25: 263-267, 1990.
[13] Boone WJ and Roth MK, Organizing school science shows, The Physics Teacher, 30: 348-50, 1992.
[14] Johansson KE and Nilsson Ch, Stockholm Science Laboratory for schools: a complement to the traditional education system, Physics Education, 34: 345-350, 1999.
[15] Rodríguez S, Fernández J, Asín JA, Lago A and Dorrío BV, An informal interactive science and technology centre, Proceedings of the 2nd International Conference on Hands-on Science. Science in a changing education, Michaelides PG and Margetousaki A (Eds.), Rethymno: University of Crete, 190-195, 2005.
[16] Dorrío BV and Vieites AR, Actividades manipulativas para el aprendizaje de la Física. Revista Iberoamericana de Educación, 42/7, 1-15, 2007.

[17] Dorrío BV, Museos interactivos na escola. Revista Galega de Educación, 35: 20- 22, 2006.
[18] Dorrío BV, As actividades manipulativas como ferramenta de aprendizaxe científico-tecnolóxica, Experiencias de Innovación Educativa na Universidade. Ourense: Tórculo Artes Gráficas, Universidade de Vigo, 11-16, 2006.
[19] Dorrío BV, Hands-on Physics activities with the overhead projector, Proceedings of the 4th International Conference on Hands-on Science. Development, Diversity and Inclusion in Science Education. Costa MF, Dorrío BV and Reis R (Eds.), Ponta Delgada: Universidade das Açores, 199-200, 2007.
[20] Dorrío BV, 101 Hands-on electromagnetic induction activities, Proceedings of the 4th International Conference on Hands-on Science. Development, Diversity and Inclusion in Science Education. Costa MF, Dorrío BV and Reis R (Eds.), Ponta Delgada: Universidade das Açores, 201-202, 2007.
[21] Dorrío BV and Villar R, Indoor interactive science museums in school, Proceedinds of the 3rd International Conference on Hands-on Science. Science Education and Sustainable Development, Costa MFM and Dorrío BV (Eds.), Braga: Gráfica Vilaverdense, 623-628, 2006.
[22] Dorrío BV, Rodríguez J, Fernández J, Ansín JA, and Lago A, Ciencias en las manos: aprendizaje informal, Alambique, 51: 107-116, 2007.
[23] Villar R and Dorrío BV, Aproximación a la arqueología: un ejemplo de interpretación del hecho científico, Íber, 48: 115-125, 2006.
[24] Villar R and Dorrío BV, Science interpretation in high school, Proceedings of the 2nd International Conference on Hands-on Science. Science in a changing education, Michaelides PG and Margetousaki A (Eds.), Rethymno: University of Crete, 184-189, 2005.
[25] http://www.xunta.gal/
[26] http://etseminas.uvigo.es/
[27] http://www.duvi.uvigo.es/

Paper presented at the 5th International Conference on “Hands on Science.
Formal and Informal Science Education",
Olinda-Recife, Brazil, October 13 to 17, 2008.

Itinerant Museum of History Chemistry – Soap

Mesquita Contarini J and Ruggeri Waldman W

Introduction

According to an international evaluation of quality in science teaching to 15 years old students performed by Programme for International Student Assessment (PISA), Brazil is in one of the last positions in comparison with more developed countries. This fact might be explained by Brazil's great socioeconomic inequality. Nevertheless, this situation is particularly concerning when considering countries of the same region and economic reality, e.g. Argentina, Uruguay and Chile [1]. Brazil's ranking in PISA 2007 is a result of the lack of investments in science teaching in addition to the lack of adequate structure for science laboratories in educational institutions.
Another research was promoted by the Ministry of Science and Technology (MCT in Portuguese) in 2007 [1]. This study also involved the Brazilian Academy of Science, FIOCRUZ Museum of Life, FAPESP and Unicamp's Laboratory of Advanced Studies in Journalism. The study showed preoccupying results regarding the public perception of science:

[1] 58% of the interviewees have little or no interest in science and technology (37% of them said this was mainly due to the fact that they do not understand it);
[2] 73% of the search little or no information on science and technology (32% of them said this was mainly due to the fact that they do not understand it);
[3] only 4% of the interviewees visited a museum of science in the last year;
[4] from the 96% that did not visit museums of science in the last year, 47% said this was mainly due to the museums' location (35% declared there were no museums of science in their area and 12% declared that the museums are very far).

Nowadays, museums and centres of sciences are not recognized as a place of scientific production anymore [2]. Instead, they are a place of representation of science and a link between society and scientific production [3].
Some authors have been emphasizing the importance of visits to spaces of science as a means to develop a more critical perception of the world. "Museums of science and technology enable visitors to look at the world in a different way after the visit.

They see things that they have never seen and, eventually, make things that they have never made because they thought they were not able. The Centres and Museums of Science's goals [4] are raising awareness to scientific culture; avoiding possible "anti-scientific" resistance and encouraging attitudes and processes of science, especially curiosity and critical thinking."
Aiming to help the reversion of science education's current situation and to establish interactions between society and science, the Itinerant Museum of Chemistry History was created in the North Fluminense region, promoting strategies of improvement in Chemistry teaching.
Based on MCT research's results, we decided for the museum's mobility in order to assist the several North Fluminense regions and to minimize the problem of museums' distance.
Another objective of the project is to improve students and teachers' knowledge on History of Sciences by developing specific activities on the topic. The activities for teachers will be trainings that are being implemented at the Regional Coordination of Education of North Fluminense Region. The training's aim is the actual application of Science History in the teaching of sciences. The activities for students will be presentations of experiments related to the History of Chemistry, focusing on technologies that are part of students' everyday life. Some research has been made on this area, namely the application of History of Science when teaching Electrochemistry topics (e.g. pile) presented positive results favouring the learning and increasing students' interest during classes [5].
The Itinerant Museum of Chemistry History nowadays works with four topics that are related to classic experiments in the History of Science and Technology. These topics are part of students' everyday life and offer the possibility of approaching current Chemistry topics in high school. The topics are: candle, beer, soap and food conservation. The four topics were presented in Scientiarum Historia - 1st Congress of History of Sciences and Techniques and Epistemology.

Soap

In this study, the topic soap will be developed with experiments based on its history. The preparation of experiments will require materials such as ashes and soda. Support texts will be made to explain the chemistry involved. These texts will be used by students and by high school teachers who do not hold a Bachelor degree in Chemistry (in Brazil, only 13% of public school Chemistry teachers have Bachelor's degree in Chemistry) [6].
Soap is a common topic in Chemistry lectures as it is approached several times in high school's curriculum, i.e. organic chemistry, carbon chain's nature, saponification reactions and intermolecular interactions.
In this article, experiments will be developed in order to help discussions regarding water superficial tension, formation of surfactant monolayer on water's surface and emulsion agents.

Soap in health

Soap has a simple production process, which has happened since ancient times. It is worth to remark that changes in soap production contributed to human being's

evolution in a direct way. Today it is practically impossible to imagine life without soap or similar products. When somebody from a tropical country does not take a shower one day, it is easily noticed by our sense of smell. It is important to remind that that bad smell that we feel is human being's characteristic smell (that we hide with perfumes of soap and of deodorant that we use every day).
Baths as hygiene practice and health of the body only happened in the 19th century, when science identified a series of diseases [7].

Reactions

In the most primitive way of making soap, the basic reagents were animal fat (for instance, ox tallow) and plant ashes. In animal fat there are several glycerides that, in alkaline environment, can be decomposed in glycerol and soap. The abundant alkaline environment in antiquity was found in plant ashes, i.e. the sodium and potassium carbonates (Fig. 1).

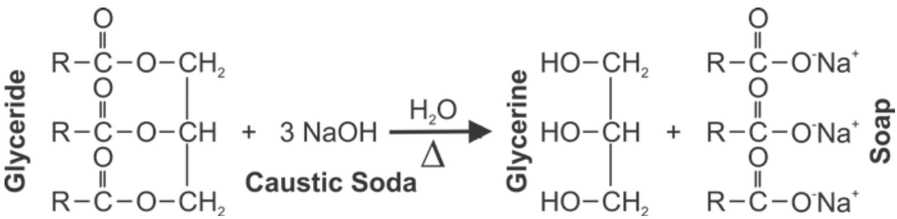


Figure 1. Representation of saponification reaction

The alkaline hydrolysis of glycerides is called saponification reaction. Depending on the alkali used in this production, different types of soaps are obtained. When the reaction involves sodium hydroxide, or sodium carbonate, harder soaps are produced. If the reaction involves potassium hydroxide or potassium carbonate, the resulting soap is softer.

Soap chemical structure and properties

Soap has two different characteristics in their molecular structure: great apolar hydrocarbonic groups and a polar extremity (Fig. 2). The polar extremity can interact with water (also polar) and the hydrocarbonic chain interacts with the fat (also apolar).

Soap as a cleaning agent

Water surface behaves as an elastic film. This property of liquids is called superficial tension, and it happens due to the attracting forces among the internal molecules of a liquid and the molecules of the surface. Soap reduces the water's superficial tension, which is why soap is called a surfactant agent. Soap has the property of concentrating oil particles in micelles, i.e. microscopic droplets of fat involved by soap molecules. Micelles are self-organized systems of soap molecules, or surfactants, and they have the following shape (Fig. 3).

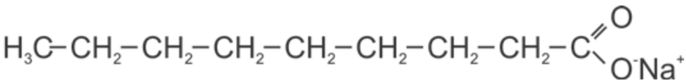


Figure 2. Representation of a soap molecule

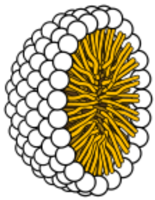


Figure 3. Representation of a micelle system

In a micellar structure, the apolar part of soap molecules is guided to the interior of the micelle (interacting with the fat), and the polar part is guided outside the micelle, interacting with water, as shown on Fig. 3. The micelles stay dispersed in water generating an oil emulsion. This happens because their coagulation is avoided by electronic repulsion.

Potash

The delay in industrial and scientific development in Brazil during colonial period was mainly due to D. Maria I, who prohibited manufacture activities in the colony in 1785. In 1808, the Portuguese royalty migrated to Brazil and finally some actions to stimulate technology, labour education and, consequently, scientific thought were undertaken. In the 18th century, during the period when modern Chemistry appeared, Frei Jose Mariano de Conceição Veloso translated some books about industrial activities to Portuguese. Veloso was devoted to Botany, leading the first botanical expedition (1779-1790) through the interior of Rio de Janeiro state, being considered one of the main names of science and technology of the Portuguese empire in the end of the 18th century and beginning of the 19th century. Veloso wrote books that helped the beginning industry, agriculture and natural history in Brazil. Veloso also described around four hundred new species of Brazilian plants.

In Brazil, one of the first written registrations related to soap was a book written by Veloso in 1798. The book's main subject was large-scale production of potash, one of the main ingredients of soap. The book "Alographia dos álcalis fixos vegetais ou potassa, mineral ou soda e dos seus nitratos, segundo as melhores memórias estrangeiras, Que se tem escripto a este assunto parte primeira" described the species of Brazilian plants which are rich in potassium.Veloso had the assignment of promoting potash industry in Brazil. Potash was very significant for the beginning industry because it was used in the production of several products, such as fabrics, glass, paper, sugar, medicines and dyes. On Veloso's book, there are illustrations indicating plans for the construction of potash factories that, when in operation, would yield profits for Portugal. The book also gives instructions to those who decided to set up potash factories in Brazil. Until half of the 19th century, potash and soda were obtained from combustion of certain types of plants. After that, the practice disappeared with the exploration of Stassfurt's mineral deposits in Germany in 1861. With Leblanc's process, industrial production of sodium carbonate in the beginning of the 19th century [8].

Experiments

Soap preparation varying the fat type

Soap preparation was tested with varying types of fat, which showed that several different products can be obtained depending on the type of fat used as a reagent.
The different fat types were obtained in different ways. Some were bought in trades, such as ox tallow from slaughterhouses and soy oil from supermarkets. Others were extracted during the preparation of meals, such as chicken fat, obtained by separating the skin from the fat during its cleaning, and rib fat, obtained after the rib cooking.

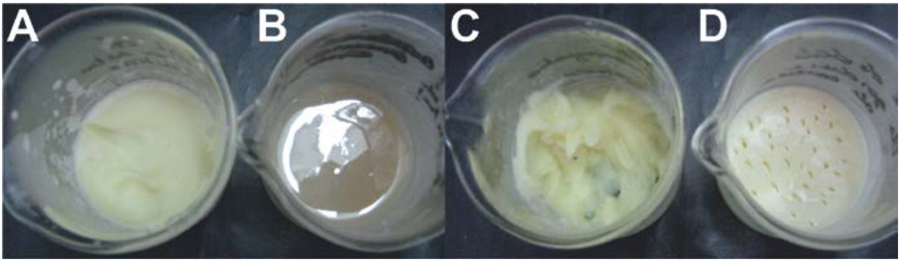


Figure 4. Soap made from several kinds of fat. A) ox tallow; B) soy oil; C) chicken and D) ox rib

To guarantee that all fats were in the same conditions, the reaction began with warm fat so that all of them were in liquid state (at room temperature, rib fat and ox tallow are in the solid state). In a beaker, twenty millilitres of warm fat were added. Afterwards, five grams of soda (bought at a construction store) were added. The mixture was slowly stirred for thirty minutes in a heating plate, at 100 C. After the soap cooling, three different products were obtained (Fig. 4).
The resulting soap presented different properties. The order of hardness was (from the hardest to the least hard): ox tallow, rib fat, chicken fat and soy oil. This practice demonstrates that the various kinds of fat's different properties (i.e. insaturation level, glycerine concentration and chain size) influence the final product's physical properties. It is also possible to obtain soaps with intermediate characteristics, mixing different fat types.
With the aim of characterizing the foaming capacity of each piece of soap obtained, we made a quantitative comparison with water in test tubes: 0,1 gram of different pieces of soap was mixed in 5 ml of water. The resulting foam formed on the different pieces of soap is shown on Fig. 5.
It is possible to observe that there is no significant difference in the amount of foam on different soap types. After one hour of rest, different stabilities of foam were observed (Fig. 5). The foam from soy oil soap is less stable than the others. This kind of practice, where reagent can be varied using materials from everyday life (i.e. the several fat types and different types of vegetable oils) and where the different

products obtained are predictable and verifiable, stimulates the raising of students' scientific curiosity.

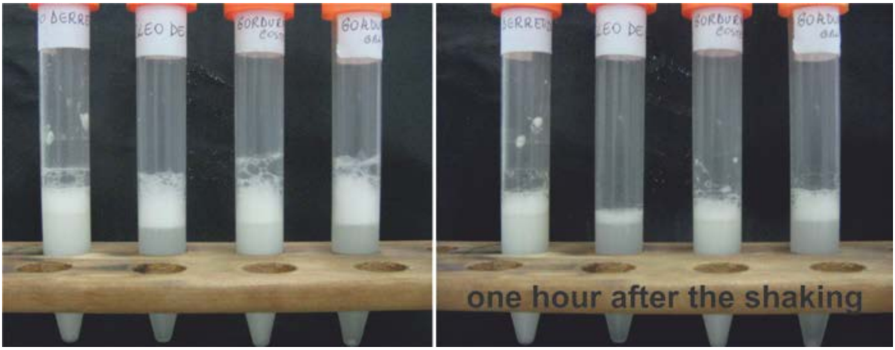


Figure 5. Samples of soap foam from different kinds of soap, just shaken. From left to right: ox tallow, soy oil, ox rib fat and chicken fat

Influence of water hardness in efficiency of the soap

This experiment was developed to approach the influence of metallic cations, namely calcium and magnesium in soap's action. Different samples containing hard water and soap were analyzed, observing the variation in the amount of foam in function of Ca^{2+} concentration. Water's hardness is defined in function of calcium and magnesium concentration. Hard water prevents foam formation when soap is used [9]. Water hardness is a regional factor, because the calcium and magnesium ions concentration depends on the type of rock, e.g. calcareous rocks [10]. This kind of effect occurs because Ca^{2+} and Mg^{2+} ions interact with soap's carboxilate, generating an insoluble substance before foam formation. A common problem involving hard water is the formation of insoluble deposits in water pipes and kettles [11]. In the hard water experiment, whitewash (used in constructions), plastic bottles, commercial detergent and coffee filter were used. Thirty grams of whitewash were added to 500 millilitres of water. This mixture was stirred and left to rest, decanting. In order to remove suspended impurities, the mixture was filtered twice using paper filter. The saturated and filtered solution was diluted several times in the following way: 250 ml of saturated solution was mixed with the same amount of water, diluting the solution's concentration in 50%. 250 ml of this solution was separated for the experiment and the other 250 ml were diluted again in 250 ml of water. This procedure was repeated 7 times, producing solutions with Ca^{2+} concentrations of around 0,8% of the original solution (all solutions have 20 drops of detergent):

[1] Saturated solution
[2] 50,0% of saturated solution
[3] 25,0% of saturated solution
[4] 12,5% of saturated solution
[5] 6,3% of saturated solution

[6] 3,2% of saturated solution
[7] 1,6% of saturated solution
[8] 0,8% of saturated solution
[9] Water

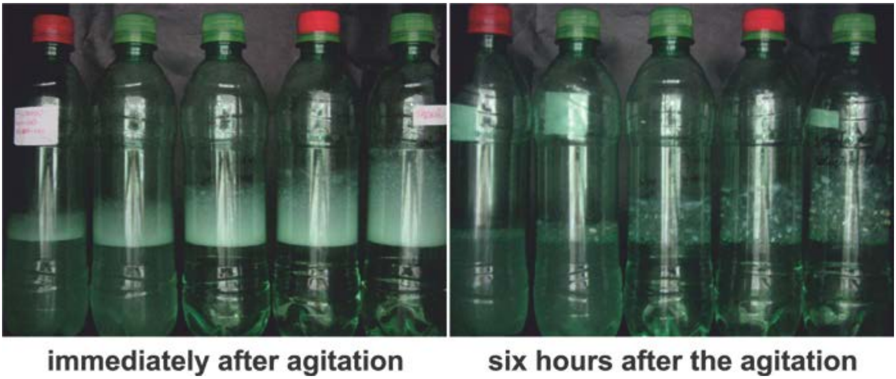


Figure 6. Picture of solutions 1, 2, 7, 8 and 9 immediately after agitation

Results and Discussion

By reducing the concentration of whitewash, an increase in the foam column was observed, as illustrated on Figure 6. Six hours after agitation, two facts could be observed: 1) all foam formations are stable and 2) less foam is generated in function of Ca^{2+} concentration (7).The metallic ions responsible for water hardness react with soap, precipitating the carboxilates that consume the soap (Figure 7).

$$Ca^{2+} + 2\ CH_3(CH_2)_{16}COO^- \rightarrow Ca(C_{18}H_{35}O_2)_{2(s)}$$

Figure 7. Representation of the formation of $Ca(HCO_3)_2$

Lava Lamp

A mixture of water and oil was used in a proportion of 1:3 (water: oil). An effervescent pill was added to generate an ascending effect and thus, the visual effect is similar to a lava lamp. A double of this system was made and, having the two bottles in front of students, we added soap to the aqueous environment in only one of the two bottles. The result illustrates, with interesting visual appeal, the influence of detergent in emulsion formation.

The materials utilized in the experiment were kitchen oil, potassium permanganate, 600ml plastic bottles, effervescent antacid, water and a syringe adapted with a hose. The solution contains a tip of spatula of $KMnO_4$ in 200 millilitres of water. It is important to remark that permanganate is only used in this experiment due to its appealing colour. Another coloured substance could be used, if more easily available. One hundred millilitres of the permanganate solution was added in each bottle. Afterwards, 300 millilitres of oil were added to each. In one of the bottles, some millimetres of a solution of detergent (15 ml in 85 ml of water), was added in aqueous phase with a syringe coupled to a fine hose. Finally, a tablet of effervescent antacid was simultaneously added to both bottles, and the differences between the two bottles could be analysed.

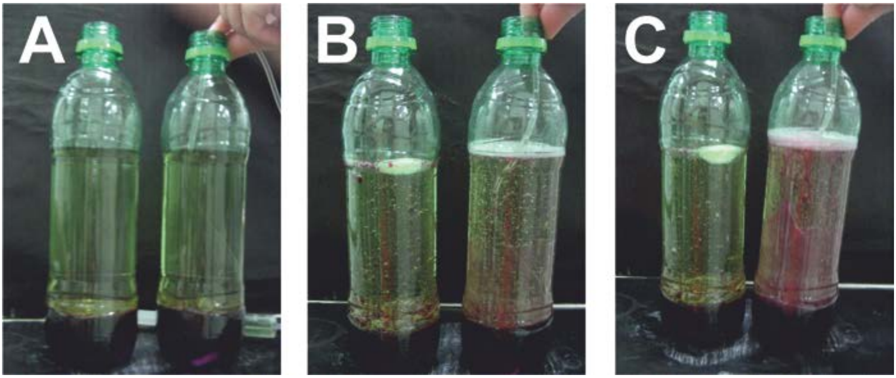


Figure 8. The bottles in different moments of the experiment. A) Before the addition of the effervescent tablet; B) just after its addition; and C) after the emulsion formation

The effervescent tablet is mainly made of sodium bicarbonate, which reacts with water to form sodium hydroxide and carbonic acid, (an unstable acid that easily decomposes to H_2O and CO_2). In both bottles, the formation of CO_2 bubbles was observed due to the effervescent tablet's addition. In the bottle without surfactant, the CO_2 bubbles carried the permanganate solution. After coming to the oil's surface, the permanganate solution went down due to its higher density. This ascending-descending movement resembles the functioning of a lava lamp.

In the bottle where detergent had been added in the aqueous phase, there was an emulsion formation of the system permanganate-oil, and foam formation during reaction. Both effects are due to the ascension of CO_2 bubbles carrying portions of water. After the reaction, the foam remained on surface.

The ascension of water bubbles in the bottle without detergent was still observed after the end of effervescence. An interesting activity is to visually follow one of these water bubbles coupled with remaining bubbles of gas. Halfway to the surface, some gas bubbles are detached from the water bubbles. The interruption in the ascending motion and the fact that they go down illustrate the density concept.

Conclusion

From the experience with high school visits of the Itinerant Museum of Chemistry History, we learn that dynamic experiments, i.e. the lava lamp, have an immediate impact on students' reaction. Moreover, experiments such as soap preparation and hard water encourage students to reproduce them due to their flexibility and easy execution. Thus, the students are encouraged to try them more than once, with variations in the conditions. All experiments described here stimulate students' interest in experimental practice and promote the association of everyday life experiences with scientific concepts approached in classes.

Acknowledgements
The authors thank UENF for Juliana Contarini's fellowship and Prof. Fernando Luna for the access to papers related to the subjects approached in this study. The authors are also thankful to Roberta Gregoli for the help with translation.

References
[1] http://www.estadao.com.br/ext/especiais/2007/11/oecd.pdf
[2] http://www.mct.gov.br/
[3] Lopes MM, O Brazil Descobre a Pesquisa Científica: os museus e as ciências naturais do século XIX, HUCITEC, São Paulo, 1997.
[4] Rodari P and Merzagora M, The role of science centres and museums in the dialogue between science and society, Journal of Science Communication, 6: 2, 1-2, 2007.
[5] Gil FB and Lourenço CM, Que ganhamos hoje em levar os nossos alunos a um museu, Comunicar Ciência, 3, 4-5, 1999.
[6] 46 Congresso Brazileiro de Química http://www.abq.org.br/cbq/2006/trabalhos2006/6/335-503-6-T1.htm
[7] Ruiz AI, Ramos MN and Hingel M, Escassez de Professores no Ensino Médio: Soluções Emergenciais e Estruturais. http://portal.mec.gov.br/cne/arquivos/pdf/escassez1.pdf
[8] Le Couteur P and Burreson J, Os botões de Napoleão: as 17 moléculas que mudaram a história, Rio de Janeiro: Editora Jorge Zahar, 2006.
[9] Luna F, The production of Potash from plants in colonial Brazil as described in Fray Conceição Veloso's Alographia dos Alkalis, Química Nova, 31: 8, 2214-2220, 2008.
[10] Lee JD, Quimica Inorgânica não tão Concisa, Editora Edgard Blücher, 2000.
[11] Mol GS, Barbosa AB and Silva RR, Água Dura em Sabão mole. Química Nova na Escola, 2: 32-33, 1995.

Paper presented at the 5th International Conference on "Hands on Science. Formal and Informal Science Education",
Olinda-Recife, Brazil, October 13 to 17, 2008.

Nanotechnology Education on a Local Scale

Berchenko N and Berezovska I

Introduction

Nanotechnology is a too complicated phenomenon to have a single definition. The simplest one defines nanotechnology as the engineering with anything smaller than 100 nanometres with novel properties. It integrates multiple disciplines, technologies, materials, and processes to enable the creation, assembly, measurement, or manipulation of materials, devices and integrated systems at the nano and molecular scales with great potential. Further progress in this field depends on availability of well educated specialists.

The fields of nanoscience and nanotechnology are broad and still exploratory, with connections to almost all disciplines and areas of relevance. Thus the most important matter to be taken into consideration while developing educational materials in nanotechnology is an exponential growth of new information and an accelerated transition from generating new ideas to implementing those ideas in industry.

In this communication we examine the training in the nanotechnology, which derives from microelectronics, surface and interface science, and focuses on fabrication of structures in silicon, carbon and other inorganic materials that will be, as we expect, one of the main direction of the evolution for the nanoelectronics.

Current issues in nanoscience education

While planning educational initiatives for nanoscience and nanotechnology, it is very useful to have estimates of how many specialists are needed, because “training people is a key component for long-term success” [1].

According to M.C. Roco, Senior Advisor for Nanotechnology of the National Science Foundation, a need for a multidisciplinary trained nanotechnology workforce in the years 2010-2015 is of 900 000 in the USA, 400 000 in Europe, and about 2 million persons in total [1].

There is an interesting estimate for a proportion of staff with different qualification levels: “experts have estimated that future demands will require 15 trained technicians for each scientist in a nanotechnology manufacturing business” [2].

International initiatives in nano-education

The response from European higher education institutions to the existing need for nano-education focuses mainly on Masters courses, but other forms of education including short courses, formal PhD programs and undergraduate education, and vocational training courses are also being discussed and developed. European or international standards for good quality education in nanosciences and nanotechnology should be developed and initiatives taken for sharing best practices between professors and vocational trainers. The EU can stimulate this under the People programme in FP7 for university graduates funded by DG Research and the new Lifelong Learning programme funded by DG Education (2007-2013) [3].

A five-year goal of the U.S. National Nanotechnology Initiative (NNI) is ensuring access to the full range of nanoscale research facilities to 50% of US research institutions' faculty and students, while students' access to education in nanoscale science and engineering is enabled in at least 25% of the research universities [1].

The European Materials Research Society (E-MRS) is planning an "European Whitebook on Nano-Science Education" with contributions from scientists of diverse backgrounds and disciplines presenting an overview of the state of the art in this existing fields from European and global (by the International Union of Materials Society - IUMRS) international perspectives [4].

Four leading research and educational institutions in Europe (Chalmers Tekniska Hцgskola, Sweden; Technische Universiteit Delft & Universiteit Leiden, the Netherlands; Technische Universitдt Dresden Germany and Katholieke Universiteit Leuven, Belgium) have proposed a joint Erasmus Mundus Master Course entitled "Nanoscience and nanotechnology". This is an integrated program, with a strong research basis and an international outreach. The objective of this course is to provide top quality multidisciplinary education in nanoscience and nanotechnology [5].

The Nanotechnology Centre at Rzeszow University

However this does not mean that less known educational institutions are not able to train specialists for this field. E-learning is just right to ensure a high quality of education.

At Rzeszow University this problem is of an increased importance because the Nanotechnology Centre currently being under construction will be launched in 2010. To meet the forthcoming demand for nanotechnologists, we have to develop and implement relevant teaching strategies here and now. The Nanotechnology Centre will become a technology and research base in the southern-eastern Poland for BA, MA and PhD degree courses as well as for research projects concerning the growth, characterization and application of nanostructures based on II-VI semiconductor materials. This decides which methods we pay special attention, however students will be given an overview of basic instrumentation and metrology needs across all nanoscience and nanotechnology. Everybody goes his/her own way to the nanoscience guided by previous research experience and a way we choose decides what we will do in a new field. We have been kept to the straight and narrow path leading from microelectronics to nanoelectronics - low dimensional structures, such as: quantum wells, quantum dots and super-lattices grown by MBE-technology.

E-learning in nanotechnology

Combination of multiple time-limiting factors in nanotechnology makes e-learning the most efficient teaching strategy. We have used the e-learning potential to compile a laboratory course on nanostructure characterization. This is a very important component of a curriculum for nanoscience education because a proper measurement of nanostructure parameters critical to realizing its underlying physical ideas is as challenging as the development of nanostructure technology because even classic methods become specific when applying to nanostructures.
Presently a central problem is not how to locate a proper material in the Internet, but how to implement it in a right way. There are both general-purpose and specialized resources. The first to be referred to among general-purpose resources is NanoEd Resource Portal launched by National Centre for Learning and Teaching in Nanoscale Science and Engineering, available at http://www.nanoed.org/. The site is designed to both gather and disseminate information on nano-education related topics, including education research, nanoconcepts, teaching materials, seminars, and degree programs. The NCLT is the first national centre for learning and teaching of nanoscale science and engineering education in the United States. The centre was created in October 2004, through a National Science Foundation award of $15 million for five years. The mission of NCLT is to develop the next generation of leaders in nanoscale science and engineering teaching and learning. Its educational materials are addressed to science teachers and students in grades 7-12, college and university students and faculty, researchers, and post doc students. Additionally the National Science Foundation provided a five-year $20 million grant to the Nanoscale Informal Science Education (NISE) Network (http://qt: Exploratorium.edu/nise-resources/) to bring researchers and informal science educators together to inform the public about nanoscience and technology.
However extensive materials relevant to our goal, i.e. teaching the nanostructure characterization, are developed by many university laboratories and analytical equipment producers. Some examples of their web sites are discussed below.

Characterization and imaging methods in the nanotechnology curriculum

Advances in fundamental nanoscience, design of new nano-materials, and ultimately manufacturing of new nanoscale products will all depend to a great degree on the capability to accurately and reproducibly measure properties and performance characteristics at the nanoscale. The revolution in nanoscale science and technology requires instrumentation for observation and metrology, otherwise we are not able to see and measure what we build. Though Richard Feynman challenged the scientific community to explore the "space at the bottom" since 1959, nanoscale R&D activities have been initiated on a full-scale only few years after Gerd Binnig and Heinrich Rohrer have invented the scanning tunnelling microscope for seeing and touching nanostructures on surfaces in 1981. Instrumentation and metrology have been identified by the U. S. National

Nanotechnology Initiative (NNI) as one of critical nanotechnology areas as they are both vital to the success and commercialization of nanotechnology.

Characterization techniques

However a number of methods used in nanostructures research have turned a hundred. Additionally, they are being improved and updated according to specific research goals. Therefore it is a primary task to select the most relevant methods and explain students why they answer the purposes of research. Over the past 30 to 40 years a wide range of surface and microanalytical techniques found an application in nanotechnology have evolved. Each technique has its own unique capabilities that are related to the particular physical interaction involved with that technique. With the exception of SPM/AFM, all of the techniques involve the interaction of some type of particle (electron, ion, or photon) with the sample material. The physics of each particular interaction affect the limits of lateral resolution, depth resolution, and detection sensitivity for each technique. Understanding these interactions, and more importantly the limitations they impose on a technique, can be crucial when selecting an analytical technique for specific problems to be solved. The main parameters characterizing technique - the required spatial resolution and the sensitivity (detection limits) are strictly interconnected.

Students study many of surface analysis techniques being used today: AES -Auger Electron Spectroscopy; XPS / ESCA - X-Ray Photoelectron Spectroscopy / Electron Spectroscopy for Chemical Analysis; SIMS - Secondary Ion Mass Spectrometry; TOF-SIMS - Time-of-Flight Secondary Ion Mass Spectrometry; Raman Spectroscopy.

All these techniques are the “classical” methods developed to surface analyses, however recently their main parameters have been substantially improved to keep pace with nanotechnology increase resolution.

Nanoscale imaging

Because nano-devices can operate on the level of a few molecules, or even a few atoms, accurate atomic-scale imaging is important. The sphere of nanoscale imaging belongs largely to electron microscopy and scanning-probe microscopy. Electron microscopy relies on the fact that electrons have much shorter wavelengths than visible-range photons and can thus resolve much finer details while maintaining a large depth of focus. Electron microscopy is now the most universal and *de facto* obligatory technique for atomic-scale structural characterization.

It is divided into two very different techniques: scanning electron microscopy (SEM), and transmission electron microscopy (TEM). In SEM, a focused electron beam is scanned across a conductive surface, releasing secondary electrons that are collected by a detector placed above the object at an angle that determines the perspective view. Magnification is changed by adjusting the size of the scanning area. Resolution ranges down to a couple of nanometres for the most-advanced tools-not fine enough to resolve atomic detail. Transmission electron microscopy

takes a different approach: electrons are passed through the specimen, producing a shadow that is magnified by magnetic lenses and projected onto a sensing screen.
In scanning transmission electron microscopy (STEM), a variation of TEM, an electron spot is raster-scanned across the specimen and the secondary transmitted electrons detected. Magnification ranges up to 1 million, allowing the imaging of atomic lattices. High-resolution aberration-corrected electron microscopes (both TEM and STEM) already today can provide valuable measurements at the sub-Engstrom level. In general, resolution is accepted as the ability to determine if an image feature represents two objects rather than one. In high-resolution electron microscopy these objects are atoms.
Scanning probe microscopy (SPM) is a branch of microscopy that forms images of surfaces using a physical probe that scans the specimen. An image of the surface is obtained by mechanically moving the probe in a raster scan of the specimen, line by line, and recording the probe-surface interaction as a function of position. By using such a probe, researchers are no longer restrained by the wavelength of light or electrons. The resolution obtainable with this technique can resolve atoms.
Scanning Probe Microscopy is a general term, used to describe a growing number of techniques that use a sharp probe to scan over a surface and measure some property of that surface. Some examples are STM (scanning tunnelling microscopy), AFM (atomic force microscopy), and NSOM (Near-Field Scanning Optical Microscopy). Many scanning probe microscopes can image several interactions simultaneously. The manner of using these interactions to obtain an image is generally called a mode.

Web-base resources

A useful list of excellent surface science courses, from introductory to graduate levels, each emphasizing different aspects of the subject is available on the UK Surface Analysis Forum (http://www.uksaf.org/).
Evans Analytical Group has collected and presented on its web site (www.eag.com) materials on most known methods of surface characterization, their practical use and the interpretation of measurement results.
Interesting materials on specific techniques are posted on web-sites supported by producing companies, e.g. Kratos (http://www.kratos.com) provides materials on XPS, and Jeol (http://www.jeol.co.jp/en/) – on SEM and TEM.
Though in comparison with other methods SPM is a fairly new one, nevertheless there are extensive e-collections related to different aspects of those methods. We would like to emphasize some of them. First of all – the James Madison University SPM Education website (https://www.jmu.edu/coe/) - the clearinghouse for SPM experiments, techniques, labs and ideas that have been published in the scientific educational literature or developed by educators to be used primarily for educational purposes.
As to SPM producing companies, NT-MDT Co. should be mentioned first and foremost (http://www.ntmdt.com).
Nanoscience Instruments publishes the Nanoadvisor educational newsletter, which offers reviews on nanoscience programs, funding, resources, and nano-teaching information (http://www.nanoscience.com/).

Literature-based study of imaging and characterization methods

Research publications, both printed and electronic, provide information on the most current accomplishments which is indispensable to successful learning any subject. In nanotechnology, however, they also somehow compensate a lack of expensive equipment which many educational institutions cannot afford.

Formats of research publications

Published research generally follows an established format. It is important that students understand each part of the research paper. Typically it includes the following parts [6]:

- **Abstract** "serves to briefly answer the basic questions about what was studied, how it was done, and the results. Its primary purpose is to allow readers to make an initial evaluation of whether a study is of interest without having to read the complete paper". Structured abstracts make it easier for readers to select appropriate articles. The introduction, methods, results, and discussion (IMRAD) format [7] is well known and widely adopted for structured abstracts in original articles.
- **Introduction "**explains *why* the study will be conducted... It also expands a little more on *how* the research will be conducted. The introduction can be divided into two major parts: the Background section and the Purpose section. *Background* …should reflect a comprehensive knowledge of the body of research on the subject and should brief the reader on both the previous studies that support the concepts or theories of the current study and those that do not…*Purpose* … dictates how a study will be conducted: the research design, the variables that will be measured, how information will be collected and analyzed, and what conclusions may be drawn".
- **Methodology** "…explains how the research was conducted and should give information in enough detail for the reader to evaluate the study. It should also enable the reader to understand to whom or what the study results apply".
- **Results** section provides the data and its analyses.
- **Discussion** section "gives the reader some insight into the study subject area and often sheds new light on the results and their meaning. Alternative explanations for the results and the implications of the research may also be presented". Sometimes conclusions may be not adequately supported by the data for many reasons (collection of insufficient or inadequate data, overgeneralization of results, methodological problems, or inherent limitations of the study design). This is why it is important to review the methodology section.
- **References** always can tell experts "if key research has been omitted from the reference list…Also, a reference list that includes both older and newer relevant research can reassure the reader that the author has thoroughly reviewed the entire body of research for background and has not just considered the last few or first few studies conducted on the topic".

Reading strategy to study techniques applied in nanotechnology

A workshop which involves a thorough consideration of research articles is the final stage of learning characterization and imaging methods. These articles are selected by teachers according to their instructional utility and are analyzed by students according to the following 7-step strategy:

[1] Students' reading is controlled in a step-by-step manner when they are offered all parts of an article one after another.
[2] An object of studies is analyzed, e.g. a method of fabrication, possible application, methods providing the most complete characterization. Students suggest a set of methods, the research purpose is discussed.
[3] Methods used by authors are considered; specific equipment used in experiments is discussed with a focus on its potentials and limits; user manuals available from a producer or on a Web site are read. Students make assumptions regarding an outcome to be achieved if the selected methods are applied.
[4] Sample preparation for the investigation methods are considered (e.g. ion beam milling, angle lap etc.). This stage is not always paid a proper attention. However it is this point that ensures correct findings, especially for nanostructures.
[5] Results achieved with each specific method are analyzed with a focus on their completeness, reliability and informative capacity.
[6] All results are considered as whole; authors' conclusions are discussed.
[7] Directions of further studies are suggested. Two options are possible depending on a purpose of the research under discussion:

- a purpose was to characterize a structure. Possible continuation may be additional studies with an extended set of methods,
- a purpose was to study a particular phenomenon. Then the question is whether this structure is optimum to observe that phenomenon and, if it is not, which structure would be better. Answering the latter question requires not only the knowledge of research methods and nanostructure physics, but basic experience in materials science and technology as well.

Students' efficient work during the workshop is supported through continuous referring to different resources including not only common electronic tutorials developed at our university but mostly web-based resources, both research and industrial. The quality of students' learning depends on how accurate is teacher's selection of materials to be used at workshops. This requires that a teacher should make a great deal of pre-workshop literature research.

Conclusions

Nanotechnology poses new challenges to education in many ways because existing paradigms are evolving – new physical ideas are being discovered and then some technologies are revolutionary transformed, other ones are getting out-of-date, or completely new approaches are introduced to solve the problems which seem to have been solved.

E-learning allows a timely response to new trends regarding the fundamentals of nanotechnology methods and provides application examples to explain students which method or combination of methods is good for a particular experiment, how to plan an experiment, and how to interpret its results.

References

[1] Roco MC, International Strategy for Nanotechnology Research and Development, J. of Nanoparticle Research, 3, 353-360, 2001.

[2] Lighteather J, Nanoscience Education, challenges and opportunities, Presentation at the Expert Group Meeting “North-South Dialogue on Nanotechnology, Challenges and Opportunities”, 10-12 February, Trieste, 2005.

[3] Ineke M, Nano-education from a European perspective, Journal of Physics: Conference Series, 100, 1-7, 2008.

[4] Glasow PA, How should the Higher Education in Materials Sciences and Technology be performed in Europe, 2007.

[5] Erasmus Mundus Master Nanoscience and Nanotechnology, 2008. http://www.emm-nano.org

[6] How to Understand and Interpret Food and Health-Related Scientific Studies, Review from the International Food Information Council Foundation.

[7] Nakayama T, Hirai N, Yamazaki S and Naito M, Adoption of structured abstracts by general medical journals and format for a structured abstract, J. Med. Libr. Assoc., 93: 2, 237–242, 2005.

Paper presented at the 5th International Conference on “Hands on Science. Formal and Informal Science Education",
Olinda-Recife, Brazil, October 13 to 17, 2008.

Hands-on Activity as a Source of Motivational Effectiveness of Learning Tasks in Science Education

Trna J

Introduction

The learning task is a specific requirement set to students during learning/teaching. Learning tasks have specific form from the elementary tasks demanding only memory reproduction of knowledge to the complicated tasks demanding creative thinking. Learning tasks fulfil various functions, primarily based in the teaching phase (motivation, exposition, fixation, diagnostics and application).

One of the main science educational objectives is creation and development of skills necessary for problem solution. Not only memory knowledge is needed to understand natural phenomena and patterns but also its application during meeting with problem situation which has to be completed successfully by a student. Teachers can evoke problem situations by means of learning tasks, especially the problem ones. The significance of the learning tasks solution is emphasized by Talyzinova ([3], p. 76): "…without problems, without tasks, neither skills nor knowledge can be acquired".

Analogously to other factors of education, there is needed to assure effectiveness of application of learning tasks during teaching. Quality of learning tasks is therefore an important research topic to which is paid attention [2]. Our research into physics education in lower secondary schools with use of video-study brought conclusions that teachers solve the learning tasks most frequently in interactions with students, most of the learning tasks require verbal solution and experimental learning tasks are rare [7].

Low frequency of learning tasks based on experiments leads to low students' motivation [6]. The finding that some teachers did not even use any experimental tasks is alarming. Therefore we tried to use hands-on activity as a source of motivational effectiveness of learning tasks in physics (science) education.

Learning tasks based on hands-on activities

Learning tasks sorting can be based on various sorting criteria, primarily on: educational objectives, difficultness of cognitive operations needed for task solution, level of calculations use during task solution, form of task setting and solution and especially teaching phases.

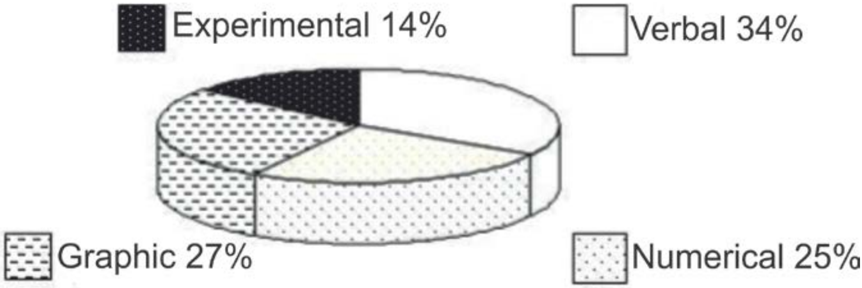


Figure 1. Frequency of types of learning tasks (form of setting and solution)

Students make psycho-motor activity during the learning task solution and that's why the task serves primarily for skills acquirement. Hands-on activity in learning tasks is useful mainly during fulfilment of educational objectives in the form of skills. Elementary partial skills, so as reading with understanding of the task text, graphs drawing, modification of algebraic expressions, etc., are being developed during learning task solution. Partial skills form complex skill of learning task solution as a problem. Hands-on activity itself can serve as an educational objective or tool for acquirement of other educational objectives.
Tollingerova [4] classified learning tasks on the basis of Bloom taxonomy into five basic categories based on difficultness of cognitive operations needed for learning task solution:

1. learning tasks demanding memory reproduction of knowledge when students use memory operations,
2. learning tasks demanding simple mental operations with knowledge so as analysis, synthesis, comparison, categorization,
3. learning tasks demanding complicated mental operations with knowledge so as induction, deduction, interpretation, transformation, verification,
4. learning tasks demanding knowledge interpretation when students interpret not only the results of their own solution but also its progress, conditions and phases,
5. learning tasks demanding creative thinking based on the previous operations, ability to combine these operations into wider complexes and come to new solutions.

Hands-on activities can occur in all these groups of learning tasks but their importance grows from the first to the last one.
Learning tasks are classified as qualitative and quantitative according to the level of calculations during task solution. Hands-on activities belong mainly to the group of the qualitative learning tasks demanding a minimum of calculations. Appropriately

connected with measurements and ICT, they can also be a part of the group of the quantitative learning tasks when an output is a numerical value of the wanted physics quantity.
According to the form of setting and solution, learning tasks can be classified as verbal, numerical, graphic, experimental, etc. Hands-on activities are primarily the part of the experimental learning tasks.
According to the teaching phase, learning tasks can be classified as motivational, expositional, fixation, diagnostics and application. Hands-on activities can occur in all these groups of learning tasks but they play the most important motivational role in the motivational tasks.
As we mentioned above, hands-on activities can be included in various types of learning tasks and they can play various roles. We focus especially on motivational effectiveness of hands-on activities in learning tasks.

Motivation of hands-on activities

Hands-on activities are strongly motivational activities [5]. Students are motivated mainly by the fact that hands-on activities are incentives exciting students' cognitive needs. Hands-on activities are therefore considered to be motivational education techniques [6]. The basic feature of motivational education technique is its incentive and/or impulse effect on some of students´ needs, which are excited in education.
Every suitably chosen hands-on activity has motivational effect. This activity, mostly in the form of experiments, has strong motivational effect because the hands-on experiment becomes an incentive activating several cognitive needs at the same time. It concerns particularly the following cognitive needs [6]:

- problem solution
- senses and muscular activity
- modelling of natural phenomena

Hands-on activity could be a complex incentive in activating all these cognitive needs. This simultaneous activation of some cognitive needs can result in strong motivation of students in physics (science) education. An evidence of motivational effectiveness of hands-on experiments is also in their commercial use in form of toys both for children and adults (yo-yo, click-clack, some wooden toys etc.).

Motivational learning tasks based on hands-on activities

According to the above mentioned classification of learning tasks based on hands-on activities, there is a need to form these learning tasks for their application during teaching. Thus the students can be more motivated in physics and science lessons. We use our applied research to form these motivational learning tasks and divide them into groups. Concrete examples of these learning task groups follow:

Problem learning tasks

The problem based teaching is the significant innovation of science education. Psychological substances of problems determine the taxonomy of learning tasks. Motivational effectiveness of problem learning tasks based on hands-on experiments results from increasing students' cognitive needs and their consequent satisfying by way of students' active cognitive working. Psychological base of increasing cognitive needs is "perception and conceptual conflict" [1]. This conflict becomes an incentive which causes strong motivation and thus students become active which heads towards conflict elimination and satisfaction of the need. An induction of that conflict has several variants [1], namely surprise, paradox, doubt, uncertainty and difficulty.

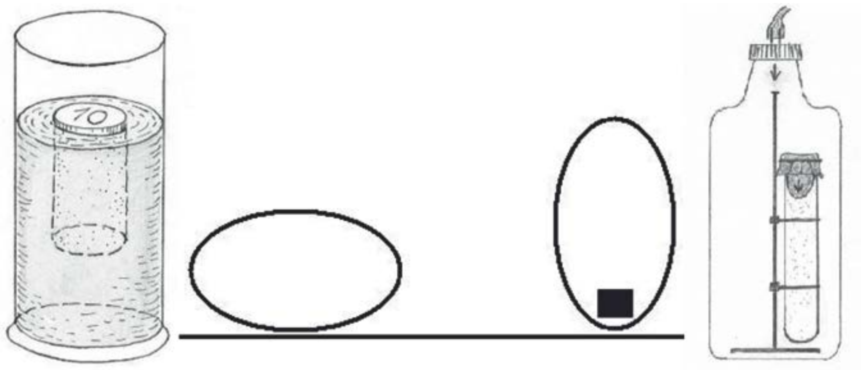


Figure 2. Problem cylinder, balance and overpressure

An example of problem learning task based on hands-on experiment follows:

Problem cylinder
We glue a coin on the base of a polystyrene cylinder. The coin has the same diameter as the cylinder. Height of the polystyrene cylinder will be adapted so that only the coin extends from the surface of the water. We turn the cylinder coin down and place it in the water again. How deep will the cylinder with the coin dip?

a) the height of an extending polystyrene is the same as the height of the coin
b) polystyrene will not extend from the surface since the coin pulls it to the bottom
c) the higher part of polystyrene than the coin will extend from the surface

Correct learning task solution: This is about Archimedes' principle application. Weight of the cylinder does not change during turning and therefore buoyant force and volume of the sunken part of the cylinder will be the same.

Play learning tasks

We define a toy as an object which displays a feature that is remarkably emphasized (elasticity, colour, distinctive behaviour etc.). The toy in the role of hands-on activity stimulates the needs to have sense and muscle activities. The relaxation function of the play is also remarkable. There are many toys

manufactured commercially but students can create their own. We can form the play learning task based on hands-on activity and apply it in education.
An example of play learning task based on hands-on experiment follows:

Balance
The objects with a lower centre of mass do not capsize. It is recommended to use the commercial toys, oval covers or polystyrene eggs. Explain the base of the demonstrated phenomenon.

Correct learning task solution: The phenomenon to understand is the balance of the objects. The centre of gravity of the object is so low that it cannot be overturned.

Modification learning tasks
Strong motivation and support of creativity development is brought by learning tasks which contain creation of hands-on activities modifications. Students are familiarized with a hands-on experiment and their learning task is to create similar hands-on experiment or, on the contrary, an experiment with additional physics phenomenon. These learning tasks are appropriate especially for gifted students.
As an example of modification learning tasks based on hands-on experiment follows the learning task aimed at demonstration of an additional phenomenon:

Underpressure and overpressure:
Behaviour of an apparatus in an underpressure chamber is often demonstrated. An experiment with membrane flex in an underpressure container is well-known. Make an apparatus for demonstration of the inverse phenomenon in an overpressure chamber. How does this phenomenon appear on human body?

Correct learning task solution: Test tube covered by rubber membrane arches by overpressure in the plastic bottle. The rubber membrane simulates behaviour of ear-drum during swimming, bathing and diving. Water in ear canal pushes on ear-drum at this time. The result is deflection of the ear-drum.

Conclusions
Learning tasks based on hands-on activities are an important part of physics and science education. They are a source of significant motivation because they excite and satisfy primarily students' cognitive needs. Learning tasks sorting should be done according to educational objectives, difficultness of cognitive operations needed for task solution, level of calculations use during task solution, form of task setting and solution and especially teaching phase. Because of the quick increase of physics and science education efficiency, information about learning tasks based on hands-on activities should be inserted into both pre-service and in-service teacher training.

Acknowledgements
The paper was created and supported within the project projects “Special Needs of Pupils in Context with Framework Educational Program for Primary Education” (MSM0021622443).

References
[1] Berlyne DE, Notes on Intrinsic Motivation and Intrinsic Reward in Relation to Instruction, Contemporary Issues in Educational Psychology, Clarizio HF, Craig RC and Hebrens WA (Eds.), London, 1977.
[2] Leutner D, Fischer HE, Kauertz A, Schabram N and Fleischer J, Instruktion-spychologische und fachdidaktische Aspekte der Qualität von Lernaufgaben und Testaufgaben im Physikunterricht, Aufgaben als Katalysator von Lernprozessen, Thonhauser J (Ed.), Berlin: Waxmann, 169-181, 2008.
[3] Talyzinova NF, Utvareni poznavacich cinnosti zaku, Praha: SPN, 1988.
[4] Tolingerova D, Uvod do teorie a praxe programovane vyuky a vycviku, Odborna vychova, 21: 77-78, 1970/1971.
[5] Trna J, Motivation and Hands-on Experiments, Proceedings of the 2nd International Conference on Hands-on Science. Science in a changing education, Michaelides PG and Margetousaki A (Eds.), Rethymno: University of Crete, 169-174, 2005.
[6] Trna J and Trnova E, Cognitive Motivation in Science Teacher Training, Science and Technology Education for a Diverse Word, Lublin, Poland: M. Curie-Sklodovska University Press, 491-498, 2006.
[7] Vaculova I, Trna J and Janik T, Ucebni ulohy ve vyuce fyziky na 2. stupni zakladni skoly: vybrané vysledky CPV videostudie fyziky, Pedagogicka orientace, 18: 4, 34-55, 2008.

Paper presented at the 5th International Conference on “Hands on Science.
Formal and Informal Science Education",
Olinda-Recife, Brazil, October 13 to 17, 2008.

The Brazil Chemistry Discovery. Itinerant Museum of the History of Chemistry - Approaching on “Food Conservation”

Morais de Sousa A and Ruggeri Waldman W

Introduction

The concern with a historical approach in the experiments of sciences is already known for some time. In the end of the 19th century, the Austrian physicist and philosopher Ernst Mach was a defender of this practice [1]. In the beginning of the 20th century, also touched with the problems faced by the teaching of sciences, Pierre Durheim also took the theme to the discussion, seeking to introduce the history of the science in the teaching of sciences [2].

A recent research of international assessment of the teaching of sciences quality, accomplished by PISA (Programme for International Student Assessment) with 15 year-old youths, showed discouraging results for Brazil that was in the last positions. In comparison with countries of similar economic situation and within the same region, like Argentina, Uruguay and Chile [3], Brazil still keeps the worst places: a solid evidence that the situation of the teaching in Brazil lacks improvements.

The result of this research, in the authors' interpretation, presents direct relationship with the lack of interest about sciences. The national research promoted by MCT in 2007, involving the Brazilian Academy of Sciences, the Museum of Life (FIOCRUZ), FAPESP and Labjor (UNICAMP) demonstrates this lack of interest [4]. The research found that, among all interviewees, 58% have little or any interest in science and technology and 73% have little or any knowledge on science and technology. The main reason answered by the interviewees in the two cases was not to understand about sciences (respectively 37% and 32%). In the same research only 4% of the interviewees visited a museum of science in the last year and of the 96% that didn't visit museums of science, 47% declared problems of location of the museums for not visiting, such as: 35% said there were no museums of science in his/her area and 12% said that the museums were very far.

Museums and science centres changed historically from a place of scientific production [5], to a place of representation of the science and finally to a mediation environment between the society and the scientific production [6]. Today a science centre or museum of sciences has as function to offer a meeting atmosphere between the scientific development and the social instances and of exhibition of the scientific accomplishments and their implications for society. Some authors have been highlighting the visit to spaces of science as valuable in the teaching of sciences and in the perception of the world, as it can be noticed in the following text:

> "*the Museums of science and technology help the visitors for, after the visit, look at the world in a different way, see things that they had never seen and, eventually, make things that they had never done because they thought they were not capable. This is the environment of the Centres and Museums of Science: the sensitization for the scientific culture, the removal of eventual "anti-scientific" blockades and the incentive of the attitudes and of the processes of the science, specifically the curiosity and the critical spirit.*" [7]

Itinerant Museum of the History of Chemistry

The Itinerant Museum of the History of Chemistry was created as an extension activity to contribute for the reversion of this situation in the Rio de Janeiro State North region, concerning chemistry teaching. Complementary to the situation presented above, regarding the public perception of science, other two factors guided the implementation of this project:

a) Poor chemistry teachers' qualification, mainly among those without specific background, resulting from the lack of chemistry teachers in the high-school [6]. In addition to the insufficient use of science history in the teaching of sciences, a powerful instrument for this purpose [8-9], this problem motivated the creation of courses of educational improvement starting from the historical approach of chemistry concepts studied in the high school, currently under implementation with the help of Regional Coordination of Rio de Janeiro State North Teaching I.
b) Museums of sciences with chemical approach have some problems that avoid its wide use, as development cost and maintenance of the modules, safety and management of the residues. [10] The Itinerant Museum of the History of Chemistry works four themes, present in the life of people that make possible the approach of scientific concepts in the high school. The themes approached by the museum are:

    - **Candle:** Reproduction of the experiments of the book "the chemical history of a candle" of Michel Faraday, approaching the evolution from the raw material of the fat to the paraffin and production of didactic texts for understanding of chemical concepts,
    - **Beer:** Experiments based on the history of the beer and production of didactic texts for understanding of the chemical concepts,
    - **Soap:** Experiments based on the history of soap. Preparation of soap from ashes and soda and development of attractive experiments involving surfactants action. Production of didactic text for understanding of the chemical concepts.

- **Conservation of foods:** Techniques of conservation of foods. Development of easy-to-make experiments with spices, salt and smoking, and production of didactic texts for understanding of the chemical concepts.

The great concern of the museum is to develop low cost experiments, with little or no danger and of easy handling to make possible the replication at home or at the schools, and to help in the understanding of science history in practice.

Conservation of foods

At this paper we will describe the work based on the theme Conservation of foods.

Historical context

Traditionally, the word "spice" didn't designate, specifically, any seasoning used at the kitchen, but just the exotic products, mainly, from India. These products were marketed intensely, therefore they were to disguise odours of the foods in rotting, they gave a pleasant flavour and they still symbolized status. Besides, the spices were so valuable that a pound of dry pepper (approximately 454 grams), for instance, was enough to buy a servant's freedom [11].

Between the centuries XI and XIV, during the feudal system, the farmers' exploration was remarkable. Problems such as climatic alterations and terrible crops resulted in low agricultural productivity and high prices of the products. The exhaustion of precious stones also generated economical difficulties. This picture had as consequence revolts, escapes and farmers' protests [12].

In addition to these problems, the epidemic of black plague killed about 1/3 of the European population. The pains were very strong, and death could happen within five days after the manifestation of the first symptoms. Everything that left the body of the patient, breath, perspiration, blood of the lungs, had very bad smell. Exotic medicines were prescribed by the doctors as serpent minced meat, myrrh, saffron, pearls or triturated emeralds, powder of gold and mainly mixing done with rare spices. It was already demonstrated at that time that some patient estimated the therapeutic value of the medicine for its cost [13].

The physicians used spices (Fig. 1) as prevention against the plague, because it was believed that the propagation of the disease was through "humours" emitted by the patients and the bodies in decomposition. The "humours", according to the faith of the time, would be the transmitters of the disease, hence the use of spices to filter them [14].

The social, economic and health crisis were the starting point to understand the transition process from Feudalism to Capitalism. The servants, that then were "free workers", possessed neither machines nor other goods, so they were soon forced to sell their workforce in exchange of money. It was in that context that the Europeans rushed to the marine discoveries. The trade of the spices and consequently the flavour, the smell and the properties of the molecules in them contained, they were one of the motors of the Discoveries Age.

The several seasonings were used traditionally to stimulate appetite, to increase digestion, to relieve the tension and to give more energy. Spices are known for a long time to possess preservative properties, as antimicrobial and anti-oxidizers. Recent studies showed that clove, cinnamon and oregano suppress the growth of Escherichia coli, present in raw meats [15].

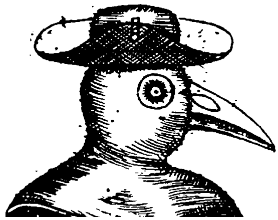


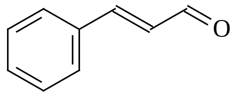
Figure 1. Representation of the physician prepared to have contact with the sick people. The beak at the mask was filled with spices

Chemical composition

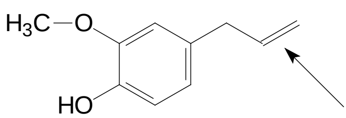
The spices are dry, aromatic or spicy parts of the plants. They contain a volatile oil (also known as essential oil) and they are used mainly as seasonings, and do not like food. Although the chemical constitution of the volatile oils is much differentiated, they have characteristic odours in common and, normally, they are immiscible in water, but they are soluble in ether, alcohol and in the most part of the organic solvents.

The essential oils of some seasonings have inhibits the growing of microorganisms in meats, sausages, breads and juices, but in order to have this kind of effect, they would be necessary very big amounts of spices in the food, what would result in an unpleasant flavour.

Cinnamon



cinnamaldehyde



eugenol

Figure 2. Picture of cinnamon - Cinnamomum zeylanicum [16] and representations of the molecular structures of Eugenol, and cinnamaldehyde

Cinnamon (Fig. 2) is derived of the dried inner bark of a tree that belongs to the laurel family. The tree is native of Asia (Sri Lanka), and, therefore, cinnamon was an article in the trade of spice from East to the West. Cinnamon was valuable for Egyptians for embalming and for culinary purposes. Cinnamon was described as magic, being used in love potions and also in medicines, a drink prescribed for colds by a Roman doctor - hot liqueur and cinnamon - it is still in use today. Formerly the cinnamon was more precious than gold. Cinnamon was a long time an essential ingredient in the Moroccan and Greek chicken and beef serves, and in Middle East it is usually used with meats, especially lamb [16].

Cinnamon is a spice since ancient times in the History, and its use is told since the biblical times as in Exodus 30:23, "*Take also for yourself the finest of spices: of flowing myrrh five hundred shekels, and of fragrant cinnamon half as much, two hundred and fifty, and of fragrant cane two hundred and fifty*" or in Proverbs 7:17, "*I have sprinkled my bed With myrrh, aloes and cinnamon*".

They possess pleasant smell, sweetened flavour and they are slightly spicy. They come commercially in peels or powdered. The cinnamon has an essential oil of the leaf, rich in eugenol and the one of the peel, rich in cinnamaledehyde.

Studies were accomplished with cinnamon for the combat to the effects of the diabetes melitus type 2. It was verified the improvement in the cholesterol tax and significant reduction of sugar in the blood with the ingestion of around 3 grams of extract of cinnamon daily. It is not known for sure if the consumption of cinnamon is effective in the combat to the arterial hypertension. There are three studies in process monitoring the subject of the effect in the blood pressure. [17]

Cloves

Figure 3. Picture of cloves: Syzygium aromaticum [19]

Figure 4. Picture of pepper: Capsicum annuum [20]

Cloves (Fig. 3) the dried buds of trees originated in the Moluccas Islands in Indonesia, during a long time called also as Spice Islands. Centuries before the birthday of Jesus Christ, cloves were used by the Chinese, Egyptians, Greeks, and Romans. The name "clove" comes from the Latin word clavus, which means "nail" and describes its appearance. The Portuguese were the first from the West to reach the Spice Islands and create a monopoly on the clove trade [18].

The main fragrant substance present in its volatile oil is the eugenol. Plants produce strong aromas to protect from insects and herbivore animals that suck its sap or eat their leaves, the eugenol besides contributing with its pleasant smell, still acts in the combat to the natural enemies.

Pepper

There are different colours, sizes and forms of peppers that are present in the several species of the gender Capsicum. The capsaicine ($C_{18}H_{27}O_3N$) and the piperine ($C_{17}H_{19}O_3N$) they are the responsible active ingredients for the spicy sensation when we ingested it (Fig. 5).

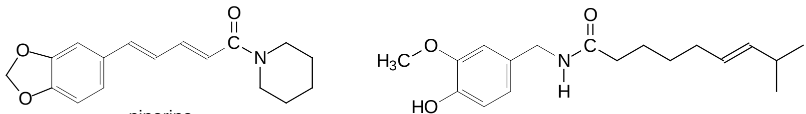


Figure 5. Representations of the molecular structures of piperine, and capsaicine

Some peppers present more piperine in its composition, as for instance the pimenta-do-reino, as it is called in Brazil, has more piperine while the chilli pepper has more capsaicine. However, both are quite burning, what can be explained by the similarity of their molecules.

Each pepper has characteristics of different flavour. The essential oil gives the flavour, while their piperine molecules and capsaicin give the pungency. Peppers contain potassium, calcium, sodium, magnesium and iron.

Good chemical reasons explain why we ate and we liked pepper. After we ingest a spicy meal, the brain produces as natural answer to the pain, endorphin that satisfies us of pleasure. The larger the amount of responsible capsaicin for the pungency of the pepper, the larger the pain, in other words, the larger the amount of produced endorphin and the larger the final pleasure.

Besides, the chilli peppers had a lot of therapeutic use and a lot of folkloric importance. The Inca considered them as sacred plants and they used them in offers to the gods, they also used to repel sorceries. Before Columbus, Indians mixed pepper with other ingredients for sore throat, coughs, arthritis, acid indigestion, ear pains, to improve the vision and to facilitate the childbirth.

In India and China, pepper is used thoroughly to improve circulation and to improve hypersensitivity to catch a cold, coughs, asthma, kidney inflammations, and muscle and committee pains.

Experimental Part

Chemistry teaching is a great challenge in the public schools, taking into account the lack of structure for practical lectures. In this work we propose an interdisciplinary experiment, easy, low cost and low risks, in order to involve and to motivate the student on the discussed subject. The experiment is based on the adaptation of a popular plate of the Brazilian cookery, the rice pudding, “*arroz-doce*” in native language, added of some spices and left out of the refrigerator to deteriorate. The comparison of the time for the emergence of signs of microorganisms was the parameter of the antimicrobial efficiency of the spices.

Figure 6. Samples preparation step, with and without spices

Figure 7. Efficiency of clove in the rice pudding conservation, observed after four days (below) and five days (above)

2 g of recently-grated cinnamon were used, 2 g of clove, 2 g of powdered cinnamon, 350ml of solution of sugar of concentration of 40g.L^{-1}, beakers of 100ml, heating plate, plastic pots and 140g of rice.
Was added in each beaker, 50ml of sugar solution and they were heated to the boiling. After the boiling, 20g of rice and 1 gram of spice were added in each beaker, except for the standard sample, cooked without spices (Figure 6). The prepared samples were the following ones:

a) Standard Rice pudding, without spices.
b) Rice pudding cooked with recently-grated cinnamon.
c) Rice pudding cooked with expired powdered cinnamon.
d) Rice pudding cooked with cloves
e) Rice pudding just added of expired powdered cinnamon at the surface after the preparation of the rice pudding.
f) Rice pudding just added of cinnamon recently-grated after the preparation of the rice pudding
g) Rice pudding just added of cloves at the surface after the preparation of the rice pudding.

The rice was cooking during 30 minutes. After the cooking, the samples were cooled to room temperature, and transferred for plastic pots, covered with plastic film. It is important to emphasize the flexibility of the experiment, because the cooking can be done in stove and the spices or seasonings can be chosen as a function of the habits of the students' region.

Results and discussion

Recommendations

All the experiments had as comparison parameter the presence of visible microorganisms in the samples of rice pudding. The absence of visible microorganisms at the surface of the sample does not mean that the sample is safe to eat, because there is the possibility of non-visible microbial forms, therefore the material used in the experiment is not to eaten. For the correct discard of the experiment, cook the used material with the microorganisms in a pressure cooker until boiling.

Spices effects

In this stage we compared the emergence of visible microorganisms at the surface of the cooked samples with and without the cloves and cinnamon.
Comparative experiments with samples of rice pudding left out of the refrigerator showed great difference in the formation of microorganisms, after five days to room temperature. As it can be observed in the Fig. 7, while it is not more possible to visualize the rice for the development of the microorganisms at the surface, in the rice pudding cooked with the cloves there is still no sign of microorganisms.
About this experiment it is important to observe that in the standard rice pudding of the Fig. 7, as well as in the prepared repetitions during the works of development of this experiment, different microorganisms are developed in each replicate. These differences happen due to the heterogeneity of the microbial population of the air that infects the samples during the cooling after the cooking. Therefore replicates done in different moments can have different results, however always with larger efficiency of the cooked samples with the clove and the cinnamon, tested in this work.

Volatility effect

Some spices are sold already grated to save the effort of their processing, as the cinnamon. Some cooks dissuade this practice due to the loss of the volatile components of these spices, preferring their grinding just before use. To test this statement with the experiments that we propose in this article, we compared a cooked sample with cinnamon just-grated with a cooked sample with cinnamon already grated and expired, to increase the contrast and the discussion with the students on the importance of the information of expiration at the foods.
As it can be observed, the cooked sample with powdered cinnamon, after expiration (Fig. 8) presented larger development of microorganisms than the cooked sample with just-grated cinnamon (Fig. 8).
This result can be explained by the largest superficial area of the grated samples that it can take to the loss of volatile substances with antimicrobial activities, as the essential oils. Another possibility is the largest superficial area of the grated spices to allow larger access of the air oxygen to the substances with antimicrobial activities, allowing its oxidation.

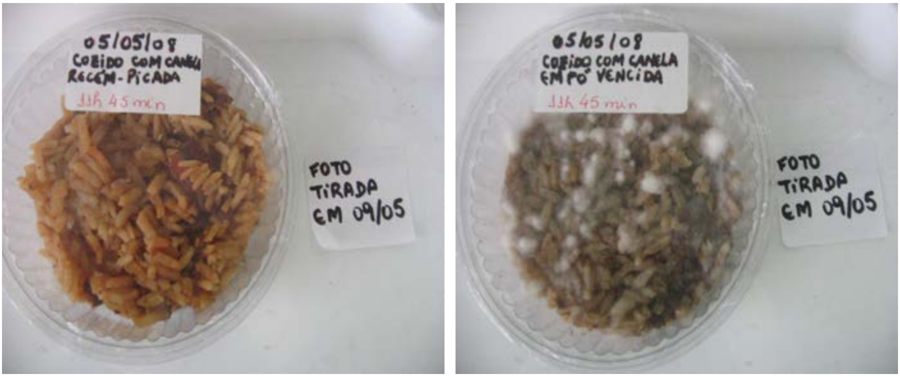


Figure 8. Evidence of the loss of active components for volatilization comparing cooked rice pudding with cinnamon just-grated with rice pudding cooked out with expired powder of cinnamon after 4 days of out of the refrigerator

Kinds of addition

It is usual cover the surface of the rice pudding with a fine layer of powder of cinnamon before being served, because of the arrangement of flavours. With the experiment proposed in this article, it can be tested if the simple presence of the spice without cooking together of the rice has antimicrobial activities.

The weight of the spices used in the cooking and on the surface of the rice pudding was the same to allow comparison. We observed that the cooked samples with cinnamon just-grated (Fig. 9, left) present smaller development of microorganisms than the cinnamon just-grated added on the rice pudding after the cooking (Fig. 9 right).

The samples with cloves just added after the cooking presented the same performance as the cooked sample with the rice pudding, with no significant effects of antimicrobial activity.

With these results, it is possible to argue with the students about concepts like extraction with the boiling water in order to have the antimicrobial activity of the cinnamon. The cloves, without the extraction with the boiling water, presented antimicrobial activity, showing the same results as the sample of rice pudding cooked with cloves.

Conclusion

The comparative experiment of rice pudding with and without spices has excellent receptivity with the students of the high school, for its easy execution, and for the visual appeal of the samples deteriorated by the microorganisms. In the visits done at the public schools, the students have been manifesting the intention of repeating the experiments with other spices or seasonings and suggesting the attempt with teas and other ingredients, demonstrating the effectiveness of the experiment in the awakening of the interest for the science and their methods.

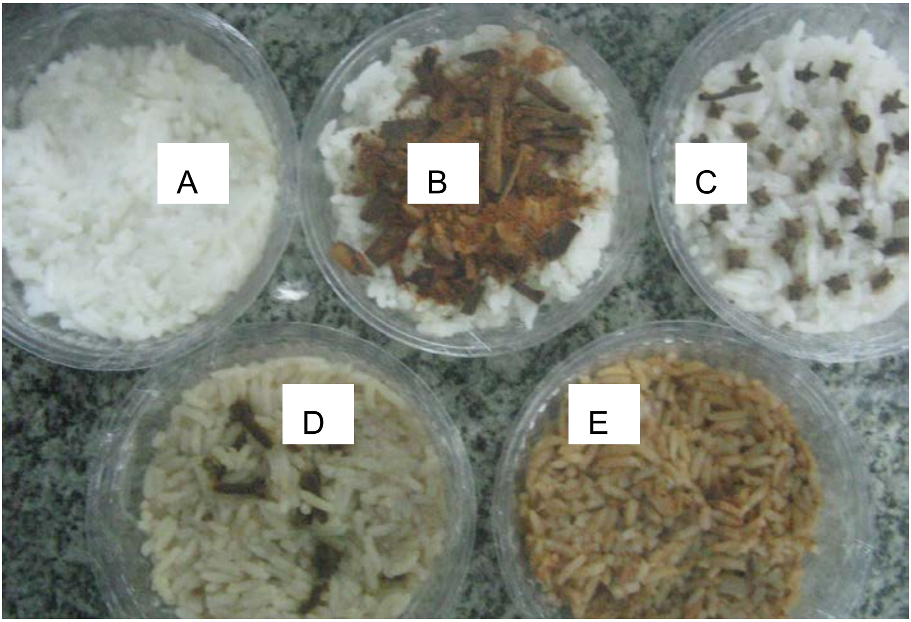


Figure 9. Prepared samples for comparison among kinds of addition. A) Standard without spices; B) rice pudding added on the surface of just-grated cinnamon; C) rice pudding just added of clove; D) rice pudding cooked with clove; E) rice pudding cooked with just-grated cinnamon

Figure 10. Cooked samples of rice pudding with cinnamon (left) and cooked samples just added of cinnamon over the rice pudding after the cooking (right)

Acknowledgements

The authors thanks to UENF for Anne’s fellowship. We also thank to Antonio Carlos Pavão for his provocative phrase that “Brazil was discovered due to the chemistry of food preservation”.

References

[1] Ernst M, Popular Scientific Lectures. Open Court Publishing, 1910.

[2] Ronaldo César de Oliveira P, Master Dissertation, O uso de experimentos históricos no ensino de física: um resgate da dimensão histórica da ciência a partir da experimentação, Universidade Federal de Brasília, 2006.

[3] http://www.estadao.com.br/ext/especiais/2007/11/oecd.pdf

[4] http://www.mct.gov.br/

[5] Lopes MM, O Brazil Descobre a Pesquisa Científica: os museus e as ciências naturais do século XIX, São Paulo: HUCITEC, 1997.

[6] Rodari P and Merzagora M, The role of science centres and museums in the dialogue between science and society, Journal of Science Communication, 6: 2, 1-2, 2007.

[7] Gil FB and Lourenço CM, Que ganhamos hoje em levar os nossos alunos a um museu, Comunicar Ciência, 3, 4-5, 1999.

[8] Hottecke D, How and what can we learn from replicating historical experiments? A case study, Science and Education, 9, 343-362, 2000.

[9] Machado Pinto VM, Master Dissertation, Módulos interactivos de Química em centros e museus de Ciência, Universidade do Porto, 2007 http://nautilus.fis.uc.pt/cec/teses/vitoria/

[10] Holton G, What Historians of Science and Science Educators Can Do for One Another. Science and Education, 12, 603-616, 2003.

[11] Le Couteur P and Burreson J, Os botões de Napoleão: as 17 moléculas que mudaram a história, Rio de Janeiro: Editora Jorge Zahar, 2006.

[12] http://www.algosobre.com.br/historia/crise-do-modo-de-producao-feudal.html

[13] http://www.galeon.com/projetochronos/chronosmedieval/concilium/pandemia.htm

[14] Ujvari SC, A História e suas epidemias, A convivência do homem com os microorganismos, Rio de Janeiro: Editora Senac Rio, 2003.

[15] Erdogan Ceylan MS, Kang D and Fung DYC, Reduction of Escherichia coli O157: H7, Ground Meat by Selected Spices, Institute of Food Technologists' (IFT's), 1998.

[16] http://pt.wikipedia.org/wiki/Canela

[17] Keogh JB and Clifton PM, Health benefits of herbs and spices: the past, the present, the future, Journal of the Australian Medical Association, 185: 4, S1-S24, 2006.

[18] Kiple KF and Ornelas KC, The Cambridge World History of Food, Cambridge University Press, 1757-1759, 1999.

[19] https://pt.wikipedia.org/wiki/Cravo-da-índia

[20] http://pt.wikipedia.org/wiki/Pimenta

Paper presented at the 5th International Conference on “Hands on Science.
Formal and Informal Science Education",
Olinda-Recife, Brazil, October 13 to 17, 2008.

Learning by Doing. Filling Children with Enthusiasm for Scientific Discovery

Erentay N

Introduction

In order to determine a strategy for improving primary science education, TUBA's Science Education Commission held a meeting with field experts on 9 May 2004. The following points of view were adopted at this meeting:

- Setting up a portal on science education which will provide easily accessible materials for teachers and will also enable them to share the teaching methods they use
- Organizing a summer school for science teachers to enhance their own development by exposure to new teaching methods
- Promoting the foundation of science centres in Anatolia to awaken the interest of people towards science
- Cooperating with schools to develop alternative means and practices before the university level to help students grow a liking for science by also using technical tools, and to combat the system of education based on memorizing [1].

Cooperation with different foundations and institutions is envisaged within the framework of this program and certain relationships have already been set up. As a first step, a summer conference was organized for 14 primary school science teachers in Istanbul, between 29 August and 4 September 2004. Following this summer conference for teachers, a pilot study in Turkey was initiated in 2006 under the coordination of Prof. Dr. Yücel Kanpolat in Ankara. A series of conferences, the first of which was held by Prof. Dr. Kanpolat himself, were conducted for the teachers. Prof. Dr. Yves Quere, who is a leading name in the Science Education Movement in France, was invited to Turkey. He delivered presentations in Ankara on 17-18 April, 2007 and in Istanbul on 19-20 April, 2007. In these presentations, Prof. Dr. Yves Quere presented how the 'La main A La Pate' (LAMAP - Learning by Doing) Program was initiated in France, its goals and the responsibilities of the teachers in this program. He shared case stories based on his own experiences. The teachers in the participant schools acquired some first-hand information and hands-on experiences through these presentations [1-3].

Following the conferences, evaluation meetings were organized with the participation of four primary schools. It was agreed that the each participating school would deliver presentations through which they would share examples of their unique approaches related to science education. First presentations were made by four selected primary schools in Ankara in 2007 through which valuable exchanges and new ideas were obtained and which, more recently, led to an evaluation meeting with the same schools. The second round of presentations with the schools occurred in 2008. A regional workshop with the participation of teachers both from primary and government schools, scientists and officials from Turkish Ministry of Education took place in Zonguldak, Turkey between 25 and 29 June, 2008 [1].

Inquiry-based science teaching

Learning by doing is based on the personal investigation which helps pupils develop cognitive processes as well as the sense of curiosity and creativity. In front of new and unexpected concrete situations, they are invited to reason, argue and question the nature itself, thus building up a new relationship to the sensitive world and to the "truth". Inquiry-based activities allow them to acquire new communication skills, through open debates in the classrooms, and with the teacher. Instead of the classical schemes of memorization and concentration of scientific concepts or formulas, the proposed methodology insists on the appropriation of knowledge through the individual investigation and questioning attitude, leading the children to learn by experimenting in partnership with the teacher.

A progressive and interdisciplinary approach of science is favoured in a close collaboration between pupils and teachers. Instead of accumulating large amounts of knowledge, teachers are encouraged to make the children appropriate the scientific concepts and experimental techniques through their own process of investigation [2-3].

Interdisciplinary projects and activities

A number of scientific projects, unique approaches and teaching methods which encourage students' active participation in learning science have been shared during the meetings and workshops for teachers coordinated by TUBA since 2006. Teachers were invited to present their interdisciplinary activities in an integrated teaching, which allows students to reinforce their knowledge in various fields and practice exciting science at the same time.

Four examples of these activities presented by selected primary schools in Ankara in 2007 which successfully contributed to renovate the manner of teaching science in these schools are stated as follows [1].

'Children as Researchers' Project Presented by: Private Arı Schools

In the 2006-2007 academic year, Arı Primary School was involved in The European Union's Lifelong Learning / Comenius Program. The project represents six different European Regions, Turkey, Sweden, United Kingdom, Norway, Lithuania and Latvia.

Aim of the Project

The aim of the project is to explore, compare and identify the best ways to teach young students in primary schools and preschools the skills they need to become active researchers and how this can be further developed and embedded in their curricula.

Integration of the Project into the Curriculum

- Literacy (guided reading, analysis of text and report writing)
- Numeracy (construct graphs, analyse data)
- ICT (MS Power point presentation, MS Excel, general MS Word skills)

Method

In April 2007, an educational program was conducted at Arı Primary School. The teaching program was made up of twelve sessions with eighteen students and ten teachers. For three sessions, the aim and the process of research methods and the skills were discussed with the teachers.

Level (Class)	N° of Students	Research Topics
1	**4**	**Why do babies cry?**
2	**4**	**Is coke harmful? Why is it sold in schools?**
3	**2**	**How should class arrangement be?**
4	**2**	**Why do people do shopping?**
5	**1**	**Which is more interesting Maths or English?**
5	**1**	**Do students like using computer?**
6	**1**	**Why do people blink their eyes?**
7	**1**	**Why do people listen to the music or sing?**
7	**2**	**Are you prepared for an earthquake?**

Table 1. The research questions framed by the students

Students' readiness to begin, continue and conclude studying.
Being ambitious to study
Being in need of the guidance from teacher or parents
Using oral ability, having the ability of self-expression
Participation into the group study
Having the ability of presentation
Studying independently

Table 2. The Evaluation Criteria

Studying processes of eighteen students, from different age levels in the study group, were evaluated within the context of following criteria:

- The pilot group of eighteen students was selected from first grade through seventh grade. Initially, students were informed about the steps of research techniques. In groups of two, they framed a research question and prepared their research plans.

- The students collected data for their research study through interviews, observations and questionnaires over a period of three weeks. After the data analysis stage, the students wrote their own research reports and disseminated their findings.

Conclusion

Study results showed that little grades needed more help from their teachers or parents. However, they were so excited and enthusiastic about the Project.
When their ages were getting upper, they had more bias about their school life, and they could be unwilling during the Project from time to time.
All students finished the Project successfully and stated that they would research another topic. This study showed that, teacher's guidance was very important for students and they needed it. We decided to carry out the Project as extracurricular activity as research club.

Figure 1. The students in Arı College collecting data for their research study and testing hypothesis

Evaluation and discussion

As some of the findings, which were obtained at the end of the project implication period, pointed out students gained:

- critical thinking skills
- study skills: organization, management, analysis, evaluation
- creativity
- communication skills
- heightened ethical awareness
- motivation
- raised self-esteem
- independent learning

Once completed, Children as Researchers Project;

- created a critical mass of research by children and young people

- provided a unique ‘insider’ child perspective
- informed our understanding of childhood and children’s lives.

‘Experiment and Observation’ Presented by Elementary School of Tevfik Fikret

Stating the Problem

At the beginning of the lesson, a problem is introduced to the students. They face with problems for which they have to find a solution through experimentations and debates in a team. For example, the lesson starts with a question like; ‘How can you change brightness of a bulb?’ The answers are discussed among the students and the teacher. A second key question as ‘Can you change brightness of a bulb by keeping all elements of the circuit constant? And how?’
Follows the first one.

Seeking Solutions to Real World Problems

The second step is to help the students build a bridge between the problem case and the daily life experiences by raising a question as ‘Is it necessary to change brightness of a bulb in daily life?’
Some of the students’ answers to this question are as follows:

Ugurcan: “We can save the electricity by adjusting the brightness of a bulb depending on the sunshine.”
Mehmet Ege: “While babies are sleeping, the intense light disturbs them. Thus, we can adjust the brightness of a bulb.”

Testing hypothesis

Small groups are formed in order to test the hypothesis. Each group is given electricity circuit equipments.
Following instruction is given to the students: ‘Examine the circuit equipment and try to change brightness of a bulb by keeping battery and bulb constant’
Then, ‘changing conductive wire in the circuit’ is suggested to the students.
Each group is given:

- two wires at same length and same cross-section, but different type
- two wires at same length and same type, but different cross- section
- two wires at same cross-section and same type, but different length

Students are asked to take notes of their observations during the experiment.

Conclusion

Each student is expected to reach a conclusion of the experiment based on his/her own observations and to share his/her ideas with each other.

Class discussion

Finally, the question of “How can this knowledge affect our daily life?” is asked to the students. An example of the answers is stated as follows:

Ekin: “While I was utilizing devices at home, I noticed the length of wire because resistant was proportional to the length of the wire.”

‘Expansion and Contraction’ Presented by: METU Development Foundation School

Science Activities in K-3

METU Foundation School is associated with Middle East Technical University. Science activities are performed in K-3.
These activities are:

- in parallel with other disciplines
- conducted with the collaboration of home teachers.
- integrated with Social Studies Course.
- based on inquiry based learning
- hands-on experiments
- enjoyable for students and provide positive attitude towards science

General Frame of a Sample Activity
Title: Expansion and Contraction

Grade level: 3rd grade
The program is free and implemented in every two weeks.

Conceptual Strand: Most materials expand (enlarge) when heated, contract (shrink) when cooled.

Guiding Question: ‘What causes most materials to expand and contract?’

Objectives: Based on the topic ’**expansion** and **contraction**’,

Students carry out:

- investigations using inquiry based learning,
- hands-on laboratory investigations,
- group activities.

Students are afforded the opportunity to apply knowledge and prerequisite skills, habits of mind needed for problem solving.
They develop critical thinking skills.

Performance Indicators
At Level 3, the student is able to:

- explore thermal expansion and contraction.
- carry out hands-on experiments through the use of everyday tools.
- solve problems related to expansion and contraction in daily life.

Application in the Classroom
At the beginning of the activity, a problem is introduced to the students as the first step. The students respond to the question of ‘How can you open the squeezed lid of a jar?’ by several answers during the debate. One example of the answers has been noted as follows:

> **Student:** ‘We put the jar into the hot water and then into the cold water, the lid of the jar becomes loose and opens as if saying: I cannot stand anymore!.’

Sample Case
Two pictures that illustrate the position of electric wires both in summer and winter in the same area, is shown to the students by their teacher and the question of ’What causes the electric wires sag?’ is followed. The students search for the answers and bring their personal experiences into the debate by saying for example;

> ‘‘The wires are getting closer in winter.’
> ‘As far as my father is concerned, the rails...’

And the discussions are made about the situation.

Experimental Investigation: Expansion and Contraction of Bi-Material Tape
The students build hypotheses which they have to test through new experiments. The experiments are defined by the teacher in order to help the students. They explore their path step by step before reaching the final solution.
An experiment is conducted in the classroom in order for the students to observe the expansion and contraction.
During this experiment;

- Fifteen cm of clear tape is stuck to the dull side of aluminium foil.
- This bi-material strip is held over a candle, keeping it high enough over the flame to avoid frying it.
- The question of ‘What happens and why?’ is asked to the students.

The students discover the fact that different materials expand by different amounts and at different rates. The bi-material strip bends toward its aluminium side as it heats up; away from its aluminium side as it cools down. On heating, the tape expands faster, bending towards the slightly shorter aluminium. On cooling, the tape contracts faster, bending away from the slightly longer aluminium.

Solving the Problem
At this stage, the question of ‘How do you think you can open the lid now?’ is asked to the students. Without any scientific background, they have to question, search for the answers, speculate how it may be opened, give arguments to support their speculations, draw conclusions and finally learn the scientific investigation process. By experimenting, they put the jar upside down into a bowl filled with hot water. The lid enlarges and leaves the jar.

Applying the Knowledge

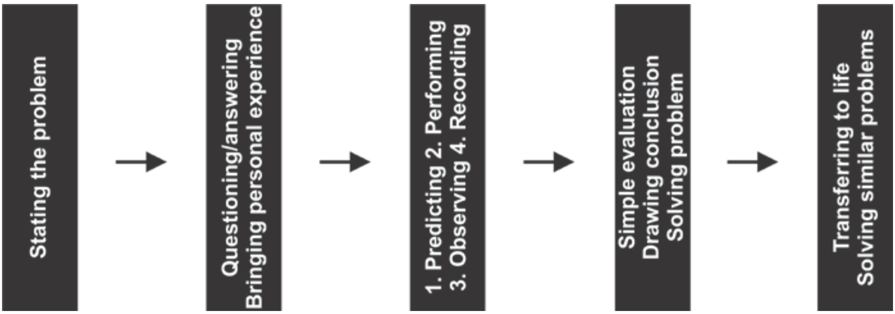
Finally, a number of new problems that may have been originated from the students' personal experiences are discussed with the students. They then are asked to search for the solutions through experimental methods. The sample problems and questions are as follows:

Problem 1: The glasses are locked.
Question: How can you separate two locked glasses?

Problem 2: In summer, glasses become loose and drop.
Question: Can you think of any solution for glasses?

Conclusion

In problem solving approach, the teacher takes on a different role as compared to traditional teaching methods. In this approach, the teacher is a guide. The guide maintains to focus on learning and provides appropriate feedback for each student team. Being hands-on and student-centred, problem solving approach is a very effective method for the students to use their critical thinking skills and practice working in teams.



Problem solving approach has a structured format of different stages when compared to inquiry based learning which has an open format that allows students to create their own learning process.
Teaching methods that incorporate problem solving approach and inquiry based learning may be used at schools since both methods have proved that they are promising practices.

'Science Camp' Presented by: Ankara University Development Foundation Primary School

Description of the Study

Sixty one students from 7th grade and thirty teachers from Ankara University Development Foundation School took part in Science Camp Project in 2008-2009 educational year. Prior to the camp activities, preparatory meetings were organized by the school twice. The students were divided into groups of ten. Groups were guided by their teacher and took after the name of a famous scientist. The students researched for the biography of the scientist and prepared the posters illustrating his/her work. The camp lasted for one and a half day during the weekend at the school backwoods.

Aim of the Project

The aim of the Science Camp Project is to create a nature based learning environment in which, through outdoor activities, the students:

- explore the dynamics of natural scientific processes
- learn scientific methods by example
- learn actively through increased interest and curiosity
- practice hands-on and minds on activities which encourage them to ask and experiment questions
- develop their skills in student-student and student-teacher social interaction

Science Activities at the Camp

1) Let's Make Cookies
2) Nature and Science
3) Food Webs
4) The Relationship Between the Beak Shape and the Feeding Type of the Birds
5) Rodents and Insects
6) Physics, Behind the Natural Phenomena All Around Us
7) Archaeology
8) Bees
9) Observing Sky

Competitions and Games at the Camp

1) Science Station
2) Creating a Frog Model
3) A Sandbag of 100 kg
4) Can You Take An Egg Down Without Breaking?
5) 'The Best Scientist' Presentation
6) 'The Best Plant' Photography Competition
7) 'The Best Animal' Photography Competition
8) 'The Most Attractive Activity' Photography Competition
9) 'The Funniest Memory of the Camp' Photography Competition
10) 'The Most Interesting Memory of the Camp' Photography Competition

Artistic Activities at the Camp

1) Art Workshop
2) Tale Webs and Shadow Games

3) Creating a Camp Picture (Painting Activity)

Data Collection and Findings

Immediately prior to and after completing the camp activities, pre and post tests were administrated to the students. The findings were stated as:

	Pre-test (%)	Post-test (%)
Golden Ratio	3	74
Ratio and Proportion	47	67
Geometry	61	75
Rodents	39	92
Biodiversity	33	81
Plants Museums	47	81
Constellations	39	61

Evaluation and Sustainability

Figure 2. The students in METU Foundation School are separating two locked glasses and students at Science Camp

In the Science Camp for two years, it was observed that the students started to look at the nature from different edges, to be more curious, to ask more questions, and to be more interested in scientists' life. In order for Science Camp Project to be more sustainable, Science Camp was generalized by Scientific Committee. An update / revise in the camp program, according to students' outcomes changed in per year, was accepted as main principle of sustainability. Extending the length of the camp and disseminating the camp to every topic were viewed as the issues needed to be developed.

Conclusion

In the future, TUBA hopes to help teachers by linking scientists, researchers, teaching specialists and teachers dealing with students aged four to eight in Turkish schools through an educational portal (website). This website will be based on the framework of the Science Education Project. From the web site, the teachers will be able to access resources and activities for the classrooms, documentations, ask questions and exchange information with their colleagues and scientists. They will also be linked to the world of research through this site. Development of scientific resources and international projects will be encouraged.

References

[1] http://www.tuba.gov.tr
[2] http://www.lamap.fr
[3] http://www.mapmonde.org

Paper presented at the 5th International Conference on “Hands on Science.
Formal and Informal Science Education",
Olinda-Recife, Brazil, October 13 to 17, 2008.

Partitive Mixing of Colours Interactive Device

Veiga R, Correia R and Esteves JS

Introduction

Partitive mixing of colours is a type of additive mixing of colours and can be achieved by a spinning disk with differently coloured sectors. Most educational devices with such rotating disks use a single motor fitted with an adaptor capable of holding only one disk at a time. So, different disks must be swapped between them. This paper describes an interactive device equipped with five motors, each one holding its own disk. These motors can be switched on individually, which allows more than one disk to rotate at the same time.

The device (Fig. 1) was built for the Mostra Interactiva de Ciência e Tecnologia[1] (Interactive Exhibition of Science and Technology) – integrating part of the Projecto Ciência na Cidade de Guimarães (Science in Guimarães City Project). Since then, it has been used in science exhibitions and classroom demonstrations in several schools.

Section 2 introduces some fundamentals on colour mixing. Section 3 lists the main materials used to build the device. Section 4 gives some details on the construction and operation of the device. Section 5 contains the conclusions of the paper. After the acknowledgements in Section 6, a list of references is given in Section 7.

Colour Mixing

It is common knowledge that mixing blue and yellow paints produces green paint. However, mixing proper amounts of blue and yellow lights produces a white light (Fig. 2). In fact, there is a fundamental difference between mixing pigments or dyes and mixing lights. Mixtures of pigments or dyes are, usually, complicated processes which results are ruled by their power to subtract certain regions of the spectrum from the incident light [1-3]. For this reason, the mixing of pigments or dyes is called subtractive colour mixing. The wavelengths of two or more coloured lights seen together are added. So, the mixing of coloured lights is called additive colour mixing [1-3]. Additive mixing of different quantities of red, green and blue colours produces a wide range of colours, which can be displayed inside an RGB Maxwell Triangle (Fig. 3).

[1] Mostra Interactiva de Ciência e Tecnologia, Palácio Vila Flor, Guimarães, Portugal, April 14 – 20, 2008.

Figure 1. Showing the device in the Mostra Interactiva de Ciência e Tecnologia (Interactive Exhibition of Science and Technology)

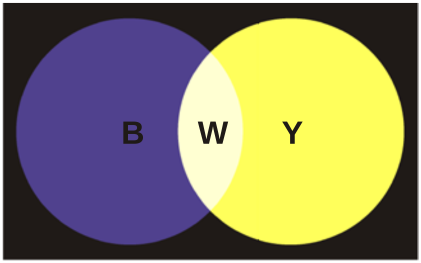
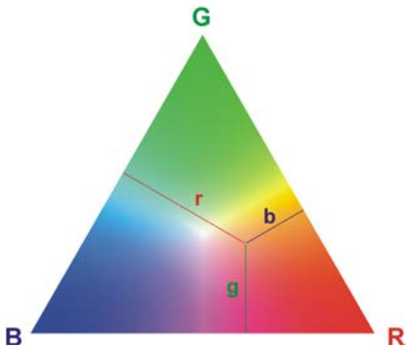


Figure 2. Mixing proper amounts of blue (B) and yellow (Y) lights produces a white (W) light



Line segments r, g and b are perpendicular to GB, BR and RG sides of the equilateral triangle, respectively. The lengths of these line segments represent the quantities of red, green and blue required to produce the colour displayed at the intersection of the segments

Figure 3. The Maxwell Triangle

Cyan, magenta, yellow and white colours can be produced by the following additive mixtures (Fig. 4):

- Mixing balanced green and blue lights produces a cyan light;
- Mixing balanced blue and red lights produces a magenta light;
- Mixing balanced red and green lights produces a yellow light;
- Mixing balanced red, green and blue lights produces a white light.

Red, green and blue are additive primary colours. Each of these colours cannot be produced by any additive mixture of the other two. Cyan, magenta and yellow are secondary colours, produced by mixtures of two primary colours. White is a tertiary colour, since it is produced by a mixture of all three primary colours. The positions of these seven colours on the Maxwell Triangle are shown on Fig. 5.

Partitive mixing with coloured disks

Isaac Newton separated white daylight into a sequence of coloured lights divided into seven colour regions, called Spectrum, and proposed a diagram such that a rectangular spectrum is bent into a cylinder and then viewed in cross-section [4]. This diagram [5] is known as Newton's Colour Circle (Fig. 6).

The proof that all the spectral colours could be recombined to form white light is also due to Newton [4]. One approach to accomplish this recombination consists of rapidly rotating a disk containing sectors with the colours existing on Newton's Colour Circle. The device described in this paper has a disk with 7 colours in 14 sectors. It would also be expectable to obtain white by rotating a disk with balanced red, green and blue sectors (disks with different combinations of red, green and blue sectors are known as Maxwell disks). However, rotating disks can only produce greyish white, as will be explained.

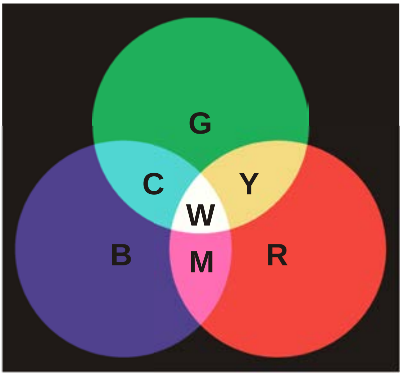


Figure 4. Obtaining cyan (C), magenta (M), yellow (Y) and white (W) lights from mixtures of red (R), green (G) and blue (B) lights

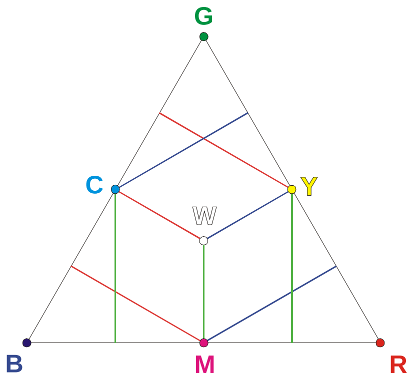


Figure 5. Positions of red (R), green (G), blue (B), cyan (C), magenta (M), yellow (Y) and white (W) colours on the Maxwell Triangle

Obtaining a colour by rotating a disk with differently coloured sectors belongs to a type of additive mixing of colours known as partitive mixing. The amount of each colour in the mixture result is proportional to the sum of the areas of the sectors it occupies in the disk [3-4]. As a result, the brightness of the mixture is lesser than the one obtained with simple additive mixing [6].

In expressions [1-4]:

1) R_{disk}, G_{disk} and B_{disk} are the brightness of red (R), green (G) and blue (B) primaries in the mixtures obtainable using RGB rotating disks with the coloured sectors configurations used in the interactive device (Fig. 7);
2) R_{disk}, G_{disk} and B_{disk} are the brightness of red (R), green (G) and blue (B) primaries in each disk surface.

$$\text{GB disk}\begin{cases} G_{\text{mixture}} = \frac{1}{4}G_{\text{disk}} + \frac{1}{4}G_{\text{disk}} = \frac{1}{2}G_{\text{disk}} \\ B_{\text{mixture}} = \frac{1}{4}B_{\text{disk}} + \frac{1}{4}B_{\text{disk}} = \frac{1}{2}B_{\text{disk}} \end{cases} \quad [1]$$

$$\text{RB disk}\begin{cases} R_{\text{mixture}} = \frac{1}{4}R_{\text{disk}} + \frac{1}{4}R_{\text{disk}} = \frac{1}{2}R_{\text{disk}} \\ B_{\text{mixture}} = \frac{1}{4}B_{\text{disk}} + \frac{1}{4}B_{\text{disk}} = \frac{1}{2}B_{\text{disk}} \end{cases} \quad [2]$$

$$\text{RG disk}\begin{cases} R_{\text{mixture}} = \frac{1}{4}R_{\text{disk}} + \frac{1}{4}R_{\text{disk}} = \frac{1}{2}R_{\text{disk}} \\ G_{\text{mixture}} = \frac{1}{4}G_{\text{disk}} + \frac{1}{4}G_{\text{disk}} = \frac{1}{2}G_{\text{disk}} \end{cases} \quad [3]$$

$$\text{RGB disk}\begin{cases} R_{\text{mixture}} = \frac{1}{3}R_{\text{disk}} \\ G_{\text{mixture}} = \frac{1}{3}G_{\text{disk}} \\ B_{\text{mixture}} = \frac{1}{3}B_{\text{disk}} \end{cases} \quad [4]$$

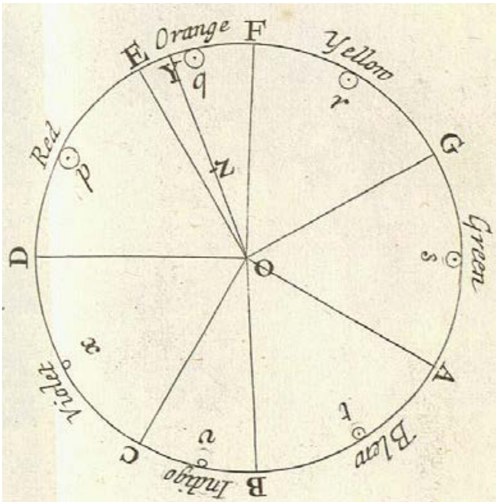


Figure 6. Newton's Colour Circle [5]

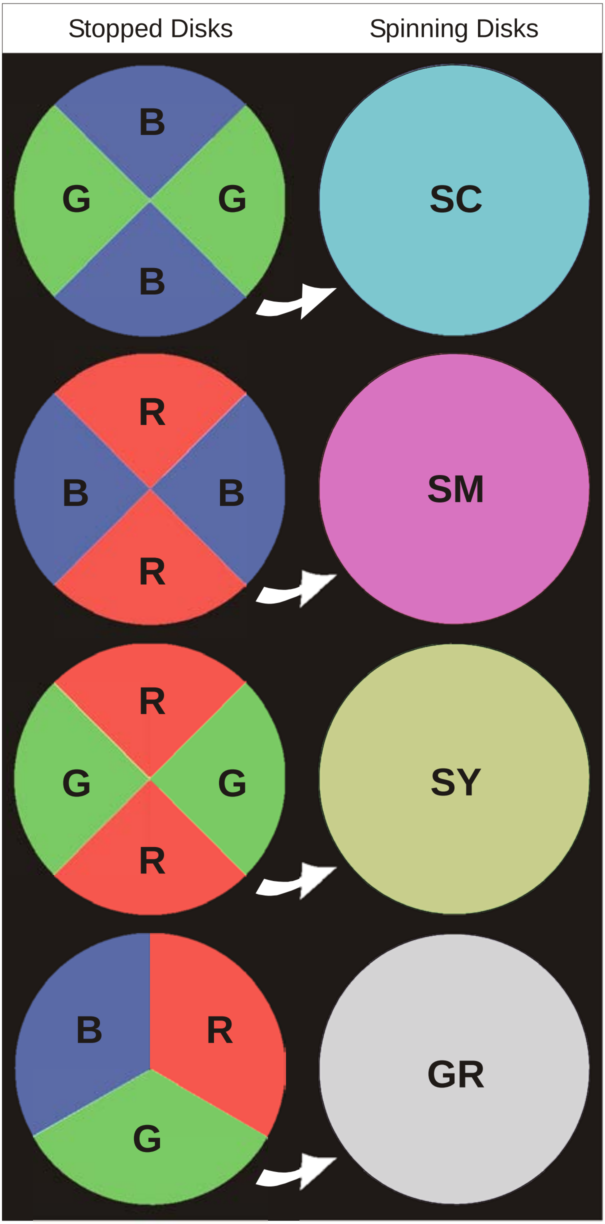


Figure 7. RGB disks coloured sectors configurations and colours obtainable with spinning disks: shady cyan (SC), shady magenta (SM), shady yellow (SY) and grey (GR)

The brightness of the mixture produced by the tricolour RGB disk is only 1/3 of the brightness obtainable with simple additive mixing of its red, green and blue primaries. Moreover, disks use paints and not light sources. Since mixing paints is a “subtraction process due to absorption and scattering, the surface becomes less reflective and can give grayish shades only” [4].

Materials used to build the device

The main materials used to build the device were the following:

a) 4 metallic disks with RGB sectors (diameter: 10cm) (Fig. 8-9);
b) 1 metallic disk with 7 colours in 14 sectors (diameter: 9,7cm) (Fig. 8-9);
c) 5 inox push buttons (Fig. 10);
d) 5 permanent magnet 3V DC motors (Fig. 11);
e) 5 brass adapters (Fig. 12);
f) 1 Bonfil wooden sketch box with 39cm x 31cm x 7,5cm (Fig. 13);
g) 1 DC socket (Fig. 14);
h) 1 HQ non-regulated 500mA power supply (3V output selected), ref. P.SUP.02-HQ;
i) 1 plywood board with 28,5cm x 36,8cm x 1cm.

Other materials include black paint, glue and electric wire.

Some details on the device construction and operation

Figure 8. The device has five metallic disks with coloured sectors

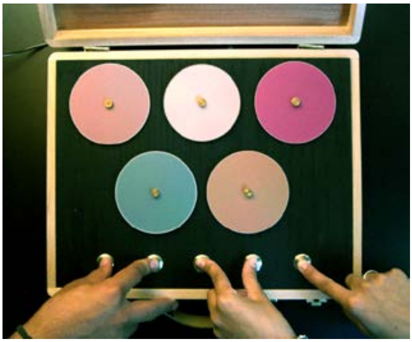


Figure 9. All disks can rotate at the same time

The device has five metallic disks with coloured sectors (Fig. 8). These disks were already described in Section 3. They are activated independently from each other and can rotate all at the same time (Fig. 9).
Each disk is set to rotate by pressing a specific push button (Fig. 10), which switches on the DC motor (Fig. 11) attached to the disk. A brass adapter (Fig. 12) was used to attach each disk to its motor.

Figure 10. Inox push button

Figure 11. Permanent magnet 3V DC motor

Figure 12. Brass adapter

Figure 13. Bonfil wooden sketch box

Ten holes were drilled in a plywood board, in order to hold the DC motors and the push buttons. The board was painted in black before the mounting of the motors and the push buttons. Once the motors and the push buttons were in place, the plywood board was accommodated inside a wooden sketch box (Fig. 13).

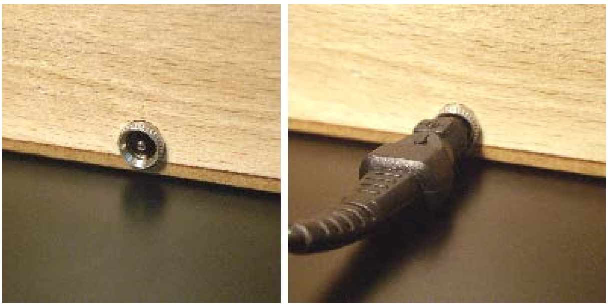


Figure 14. A DC socket placed in the rear of the box allows an external DC power supply to feed the device

A DC socket placed in the rear of the box (Fig. 14) allows an external DC power supply to feed the device. The schematic of the circuit formed by the power supply, motors and push buttons is shown in Fig. 15. As expected, the colours obtained with rotating disks have low brightness (Fig. 9). The two-colour GB, RB and RG disks produce dark cyan, dark magenta and dark yellow. The tricolour RGB disk produces a brownish shade and the 7 colours disk produces a pale grey that is a much better approximation to white.

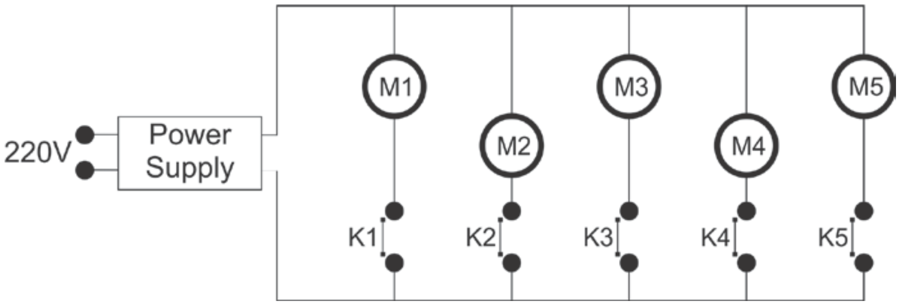


Figure 15. Schematic of the circuit formed by the power supply, motors (M1 – M5) and push buttons (K1 – K5)

Conclusions

An interactive device, suitable to demonstrate partitive mixing of colours, has been presented. It uses the following rotating disks:

- Three two-colour, four sectors, RGB disks;
- One tricolour, three sectors, RGB disk;
- One 7 colours, 14 sectors disk.

The device is equipped with five motors that can be switched on individually and each motor holds its own disk. So, more than one disk can rotate at the same time. It is even possible to make all disks rotate at once.

Some fundamentals on colour mixing were introduced. A few construction and operation details were given, too.

The colours obtained with rotating disks have low brightness, which is inherent to this way of accomplishing partitive mixing of colours:

- Two-colour RGB disks produce shady cyan, shady magenta and shady yellow;
- The tricolour RGB disk produces a brownish shade;
- The 7 colours disk produces a pale grey that is a much better approximation to white than the colour produced by the tricolour RGB disk.

The device has been successfully used in science exhibitions and in the classroom.

Acknowledgements

The device construction was funded by the Projecto Ciência na Cidade de Guimarães (Science in Guimarães City Project), which was sponsored by the Programa Ciência Viva (Living Science Program). The authors are grateful to Pedro Souto, Filomena Soares, João Sepúlveda and Maria Rodrigues for their support.

References

[1] McLaren K, The Colour Science of Dyes ad Pigments, Adam Higler Ltd., 1986.

[2] McDonald R, Colour Physics for Industry, Society of Dyers and Colourists, 1987.

[3] Lucas J, Valldeperas J, Hawkyard C, Van Parys M, Viallier P and Carneiro N, Colour Measurement – Fundamentals, Eurotex, 1996.

[4] Choudhury A and Kumar R, Modern Concepts of color and appearance, Science Publishers, Inc., 2000.

[5] Newton I, Optics: or, a treatise of the reflexions, refractions, inflexions and colours of light. Also two treatises of the species and magnitude of curvilinear figures, London, Printed for Sam Smith, and Benj. Walford, 1704. http://posner.library.cmu.edu/Posner/books/book.cgi?call=535_N56O_1704

[6] Briggs D, Partitive Mixing, The Dimensions of Colour, 2007. http://huevaluechroma.com/

Paper presented at the 5th International Conference on “Hands on Science. Formal and Informal Science Education",
Olinda-Recife, Brazil, October 13 to 17, 2008.

Metals Are Reductive but Some Are More than Others

Oliveira Guedes SR and Pereira da Silva JM

Introduction

When consulting the standard reduction potential table, the students observe the existence of values of negative and positive potential which leads them to conclude on the spontaneity of the reactions that occur when different metals get in contact via an electrolyte [1]. In this experiment the students can verify the change of signal when they move the voltmeter forceps that were used to do the readings. This fact allows us to infer in which direction the redox reaction occurs [2].
Also, from this experiment, the need to establish conditions and choose an element to be used as a standard electrode emerged [3].

Methodology

We can describe the methodology used based on the tasks that were followed in every step.

- Bibliographic research on the table of the standard potentials of reduction;
- Preparation of materials – mop stripes;
- Preparation of the auxiliary equipment – acrylic boards;
- Preparation of the metals studied;
- Preparation of ionic solutions of the metal elements involved with the concentration 1 mol.dm^{-3};
- Preparation of a saturated solution of potassium nitrate.

These experiments were carried on so as to allow, with the results obtained, the building of the tables presented on item 4 of this work.
Also, a table with the values of pattern potential of reduction for the same chemical species studied was similarly built.
By comparing the experimental results with the pattern values that are internationally acknowledged, the students analyzed the reproducibility of the potential of the metals under study so that they could conclude on the pedagogical/didactical value of the experimental work.

The Equipment

Two 330 x 170 x 5-mm acrylic boards (Plexiglas – PMMA) were used. They were holed with a Ø = 5mm screw so that, later, fixing screws can be introduced, according to Fig. 1.

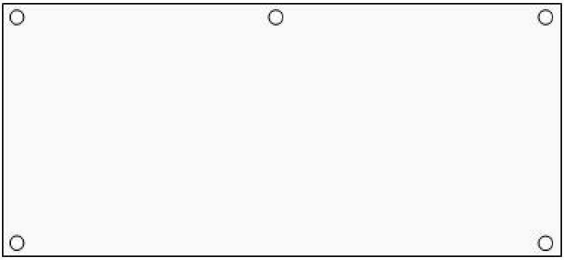


Figure 1. Acrylic board

Seven 120 x 20 x 1-mm stripes of absorbing tissue, usually used in mops at home, were cut. Later they were sunk in an electrolyte concentration and seven different pieces of metal are placed on them (each metal with the corresponding ion concentration, 1 $mol.dm^{-3}$ in the stripes), as it is shown in Fig. 2.

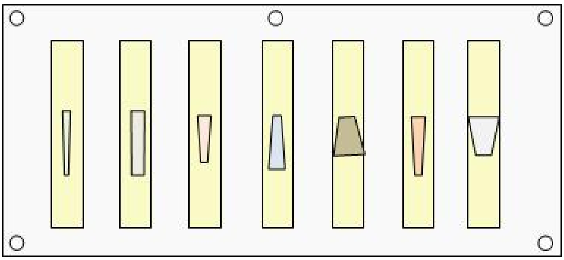


Figure 2. Stripes tissues with metals

Note - Without any pedagogical intent, the metals were placed by order of the atomic number. Thus we have the metal and salt used for the electrolyte of its ion:

$_{12}Mg$ – Magnesium / $MgSO_4$
$_{13}Al$ – Aluminium / $Al_2(SO_4)_3$
$_{26}Fe$ – Iron / $FeSO_4$
$_{29}Cu$ – Copper / $CuSO_4$
$_{30}Zn$ – Zinc / $ZnSO_4$
$_{47}Ag$ – Silver / $AgNO_3$
$_{82}Pb$ – Lead / $Pb(NO_3)_2$

After that, a longer mop stripe, 260 x 20 x 1 mm, was cut and sunk in an electrolyte of saturated potassium nitrate [4] and then placed in a way as to connect all the others “as a comb”, as in Fig. 3.

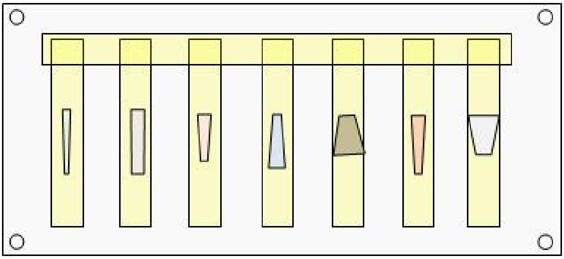


Figure 3. Salt bridge connecting all stripes

Finally, we place a second acrylic board on top of the first one, with 3 mm Ø holes located strategically in the same direction of the metals on the mop stripes to be able to introduce the voltmeter forceps so that the readings of the potential differences can be done, as represented in Fig. 4 and 5.

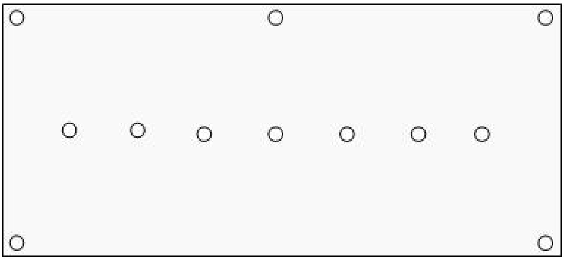


Figure 4. Top acrylic board

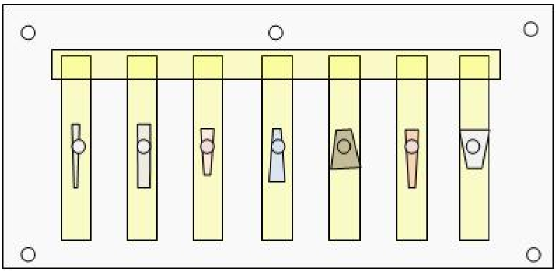


Figure 5. Equipment ready to experiment

Final assembly already fixed and ready for the *ddp* readings. Once the screws/nuts are quite tight adjusting the acrylic boards, the system is ready for the measuring, as shown in Fig. 6.

Figure 6. Final equipment

Figure 7. The equipment and the reading instrument

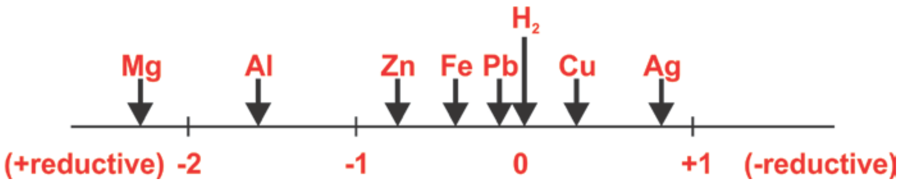
Experimental Readings

The values of standard potential [5] for the metals studied are presented in Tab. 1:

M^{n+} + ne → M^o	*E*º / *V*
Mg^{2+}(aq) + 2e → Mg^o	− 2,36 *V*
Al^{3+}(aq) + 3e → Al^o	− 1,68 *V*
Zn^{2+}(aq) + 2e → Zn^o	− 0,76 *V*
Fe^{2+}(aq) + 2e → Fe^o	− 0,44 *V*
Pb^{2+}(aq) + 2e → Pb^o	− 0,13 *V*
$2H^+$(aq) + 2e → H_2 (g)	0,00 *V*
Cu^{2+}(aq) + 2e → Cu^o	+ 0,34 *V*
Ag^+(aq) + e → Ag^o	+ 0,80 *V*

Table 1. Standard Potential Electrodes / *E*º, of the metals studied

Representing on a line the theoretical position of the metals studied, we have:



Theoretical	Mg	Al	Fe	Cu	Zn	Ag	Pb
Mg	Mg^{2+} Mg^0	+0,68	+1,92	+2,70	+1,60	+3,16	+2,23
Al	-0,68	Al^{3+} Al^0	+1,24	+2,02	+0,92	+2,48	+1,55
Fe	-1,92	-1,24	Fe^{2+} Fe^0	+0,78	-0,32	+1,24	+0,31
Cu	-2,70	-2,02	-0,78	Cu^{2+} Cu^0	-1,10	+0,46	-0,47
Zn	-1,60	-0,92	+0,32	+1,10	Zn^{2+} Zn^0	+1,56	+0,63
Ag	-3,16	-2,94	-1,24	-0,46	-1,56	Ag^+ Ag^0	-0,93
Pb	-2,23	-1,55	-0,31	+0,47	-0,63	+0,93	Pb^{2+} Pb^0

Table 2. Theoretical standard values / *V*

Considering that the spontaneous reactions, the thermodynamically possible ones, are those that present a difference of positive potential among the pairs of metals studied and which can be represented according to the following chemical equations:

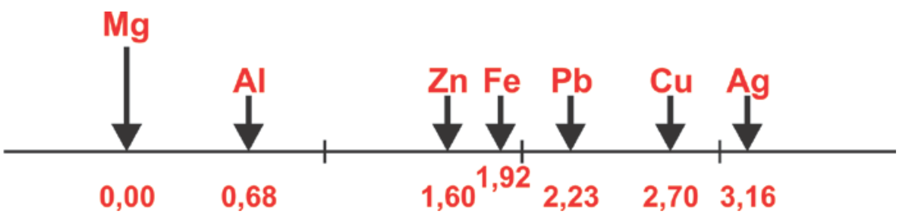
$3Mg\ (s) + 2Al^{3+}\ (aq) \rightarrow 3Mg^{2+}\ (aq) + 2Al\ (s)$
$Mg\ (s) + Zn^{2+}\ (aq) \rightarrow Mg^{2+}\ (aq) + Zn\ (s)$
$Mg\ (s) + Fe^{2+}\ (aq) \rightarrow Mg^{2+}\ (aq) + Fe\ (s)$
$Mg\ (s) + Pb^{2+}\ aq) \rightarrow Mg^{2+}\ (aq) + Pb\ (s)$
$Mg\ (s) + Cu^{2+}\ (aq) \rightarrow Mg^{2+}\ (aq) + Cu\ (s)$
$Mg\ (s) + 2Ag^{+}\ (aq) \rightarrow Mg^{2+}\ (aq) + 2Ag\ (s)$
$2Al\ (s) + 3Zn^{2+}\ (aq) \rightarrow 2Al^{3+}\ (aq) + 3Zn\ (s)$
$2Al\ (s) + 3Fe^{2+}\ (aq) \rightarrow 2Al^{3+}\ (aq) + 3Fe\ (s)$
$2Al\ (s) + 3Pb^{2+}\ (aq) \rightarrow 2Al^{3+}\ (aq) + 3Pb\ (s)$
$2Al\ (s) + 3Cu^{2+}\ (aq) \rightarrow 2Al^{3+}\ (aq) + 3Cu\ (s)$
$Al\ (s) + 3Ag^{+}\ (aq) \rightarrow Al^{3+}\ (aq) + 3Ag\ (s)$
$Zn\ (s) + Fe^{2+}\ (aq) \rightarrow Zn^{2+}\ (aq) + Fe\ (s)$
$Zn\ (s) + Pb^{2+}\ (aq) \rightarrow Zn^{2+}\ (aq) + Pb\ (s)$
$Zn\ (s) + Cu^{2+}\ (aq) \rightarrow Zn^{2+}\ (aq) + Cu\ (s)$
$Zn\ (s) + 2Ag^{+}\ (aq) \rightarrow Zn^{2+}\ (aq) + 2Ag\ (s)$
$Fe\ (s) + Pb^{2+}\ (aq) \rightarrow Fe^{2+}\ (aq) + Pb\ (s)$
$Fe\ (s) + Cu^{2+}\ (aq) \rightarrow Fe^{2+}\ (aq) + Cu\ (s)$
$Fe\ (s) + 2Ag^{+}\ (aq) \rightarrow Fe^{2+}\ (aq) + 2Ag\ (s)$
$Cu\ (s) + 2Ag^{+}\ (aq) \rightarrow Cu^{2+}\ (aq) + 2Ag\ (s)$

In order to record the average values obtained we carried out several experiments. In Tab. 3, we present the experimental results of the driven force between the pairs of metals used in the study.

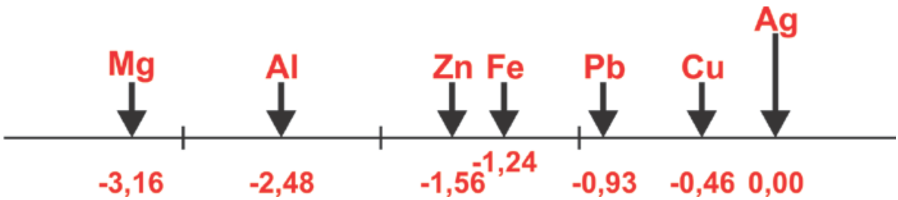
Theoretical	Mg	Al	Fe	Cu	Zn	Ag	Pb
Mg	Mg^{2+} Mg^{0}	+1,24	+1,35	+1,80	+1,49	+2,19	+1,38
Al	-1,20	Al^{3+} Al^{0}	+0,27	+0,59	+0,32	+0,98	+0,13
Fe	-1,25	-0,25	Fe^{2+} Fe^{0}	+0,59	-0,21	+0,98	+0,11
Cu	-1,78	-0,51	-0,58	Cu^{2+} Cu^{0}	-0,47	+0,39	-0,47
Zn	-1,42	-0,36	+0,13	+0,36	Zn^{2+} Zn^{0}	+1,41	+0,21
Ag	-2,16	-0,98	-1,01	-0,39	-1,39	Ag^{+} Ag^{0}	-0,86
Pb	-1,32	-0,15	-0,11	+0,47	-0,17	+0,86	Pb^{2+} Pb^{0}

Table 3. Experimental results / *V*

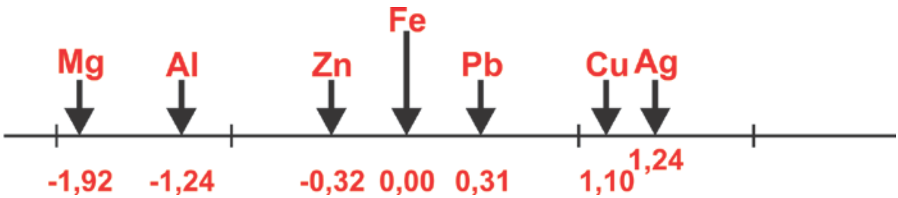
With the experimental results we represent, on a line, as a reference, the more reductive metal. We can see its position compared with the one of its peers.



Similarly, and by using, as a reference, the values obtained for the less reductive metal, we can see the relative position of its peers.



Since iron is quite important in the construction of any structure, which leads to the studies of protection to corrosion, we suggest a representation that highlights its relative position among the several metals studied.



Conclusions

This experiment allows the transmission and/or consolidation of electrochemical knowledge [6], namely the notion of potential and the importance of the existence of the standard electrode. Being aware that there is a wide range of factors contributing to a sometimes substantial difference between the values obtained in the experiment and the standard values, we must consider this the kind of work that can be carried out in a classroom and stands out as a motivator factor.

To name the reasons that justify the not so good results can lead to a valuable and healthy scientific discussion among the students.

To infer which spontaneous reactions, electrical resistances, ionic interferences and concentrations, work temperature and, naturally, the experimental mistakes is always the appropriate scientific attitude.

Acknowledgements

I thank all students that attend the 11th form of the Chemistry, Environment and Quality (QAQ course, in the Colégio Internato dos Carvalhos), who were deeply involved in this experiment. We also thank Edite Pereira da Silva, our English Teacher.

References

[1] Nelson PG, *Quantifying Electrical Character*, J.C.E., 74: 9, 1085, 2007.

[2] Khodakov IV, Epstein DA and Gloriózov PA, Química Inorgânica, Moscovo: Ed. Mir, 1986.

[3] Brett AO and Christopher MA, Electroquímica. Princípios, métodos e aplicações, Ed. Almedina, 1996.

[4] Howell BA, Cobb VS and Haaksma RA, A Convenient Salt Bridge for Electrochemical Experiments in the General Chemistry Laboratory, Journal of Chemical Education, 60: 4, 1983.
[5] Tanis DO, Filtrates and Residues. Galvanic Cells and the Standard Reduction Potential Table, Journal of Chemical Education, 67: 7, 602-603, 1990.
[6] Birss VL and Truax DR, An Effective Approach to Teaching Electrochemistry, Journal of Chemical Education, 67: 5, 403-409, 1990.

Paper presented at the 5th International Conference on “Hands on Science. Formal and Informal Science Education",
Olinda-Recife, Brazil, October 13 to 17, 2008.

Hands-on and Fieldwork Activities in Biology Teaching: A Proposal for Vocational High School Students

Moraes J and Godinho-Netto MCM

Introduction

The science teaching should inspire students to continue their studies and prepare them for recognize and assess the impacts of science and technology in their daily lives. It should also develop skills to permit them to make decisions based on the knowledge acquired. But the progress of various scientific areas in recent decades has been accompanied by a formal education increasingly focused on memorization of facts, data and scientific concepts. Unfortunately, most of the times, the science classes discourage students from thinking for themselves. On the other hand, experimental classes are often presented as a tedious and repetitive activity.

In Biology teaching, less time is dedicated to experimental or investigative activities than to lecture classes. And, when such activities are offered it usually consist of laboratory-based cellular experiments with practice oriented to microscopic observation. In some ways, these practices serve to illustrate and deepen some issues but end up playing the style "chalkboard and chalk", working more as a complement than as an alternative strategy for learning science [1].

The National Curricular Parameters (PCNs) of the Ministry of Education (MEC) of Brazil indicate the guidelines for the Science teaching in both elementary and high school education. It proposes the production of effective knowledge by encouraging the interdisciplinarity and contextualization of the subjects to be studied [2].

Despite PCNs recognize the importance of learning science and its relations with technology, environment and social issues, they also indicate the great difficulty of implementation and effectiveness of new teaching practices in the classroom in Brazil [2-3]:

"The new theories of education, even where they could be widely discussed among experts educators and researchers, are still far from being an effective presence in much of our basic education. Innovative proposals have brought renewal of contents and methods, but we must recognize that little reach most of the classrooms where, in fact, old practices persist. Changing this state of affairs

therefore is not something that can be done only from new theories, but still requiring a new understanding of the same sense of education, the process in which you learn."

The quality of education in science has never before been so discussed and considered in Brazil as it is nowadays. Experts assess that the poor training of teachers coupled with the lack of infrastructure for experimentation and practical classes in schools are the main causes of the poor performance of Brazilian students in the Programme for International Student Assessment (PISA), which has left Brazil in 52th position among 57 countries assessed in 2006. [4].
Some of the MEC efforts are focused directly to basic education, as may be seen in the "Strategy for the Teaching of Science" (originally intended for high school), others are made in order to expand and improve the training of teachers. Meanwhile, it is worth noting that one of the government guidelines is "Encouraging curriculum projects focused on science education and curriculum changes that incorporate practical approaches and investigative of science." [5].

Institutional background and motivation

The Federal Centre of Technological Education of São Paulo (CEFET São Paulo) is an institution dedicated to professional education in technical and scientific areas. It is situated in the São Paulo city (State of São Paulo), one of the largest cities in Brazil which has outstanding economical projection in Latin America. According to the Brazilian Ministry of Education, CEFET São Paulo is considered one of the most important institution among public and private vocational high schools in Brazil being a reference for technological education. It is maintained by the Brazilian government with open access by admission exam.
CEFET São Paulo offers technical courses for students attending high school as well as undergraduate and graduate courses. The technical high school courses focus on areas such as: mechanics, electronics, computers and automation.
In order to assure a broader education, CEFET São Paulo encourages the interaction between the specific technological areas and basic high school disciplines. This is not an easy task for biology because most of the students don't see any relationship between the course area and the discipline.
In this context, the biology team of teachers decide to adjust biology classes and curriculum to meet the institutional requests.

Changing Biology Classes

Despite having a large number of students, (200 / high school/year), CEFET São Paulo has only one biology laboratory equipped with microscopes, stoves, reagents, glassware, fixed specimens and anatomy models. About 20 students are able to conduct experiments at the laboratory at a time. Biology classes are usually offered in ninety minutes weekly classes in three years of the vocational high school.
Some changes in biology classes were proposed by the biology teachers and are summarized below:

1) Adjustment of teachers/students ratio to two teachers per class of 40 students (1:20 teacher/student ratio).
2) Changes in the order of presentation of biology content of vocational high school courses:
   a. First year: Ecology and Diversity (partial).
   b. Second year: Biological diversity (including compared physiology).
   c. Third year: Cytology, Genetics and Evolution.
3) Introduction of “hands-on”, fieldwork and investigative activities in biology classes.

This study aims to describe the first efforts to introduce “hands-on” and fieldwork activities in biology curriculum at CEFET São Paulo.

Methodology of the study

The research reported in this study is essential qualitative, adopting an interpretative and subjective perspective of educational research [6].

Participants

This study was carried out with 200 students of 1^{th} grade from vocational high school of CEFET-São Paulo. It also involved teachers from different technical areas.

Description of the study

The study described in this text involved three different actions: 1. diagnose the scientific literacy of the students of advanced years in CEFET São Paulo; 2. determination of the beginners students profile; and 3. introduction of hands-on and fieldwork activities in Ecology classes. The activities were implemented as curricular component at the beginning of the school year and were related to “abiotic factors”.
The hands-on activities aimed to: (a) develop curiosity of students to environmental issues, (b) develop the capacity of observation, (c) present the basic principles of metrology by simple temperature measurement experiments, (d) encourage the use of mathematical logic and language (E) encourage the application of the use of simple mathematical functions to describe natural phenomena, (h) develop attitudes of working in groups, (i) develop ethical behaviour.
The theme "abiotic factors" is one of the themes presented to students within the subject "Ecology" [7]. The living beings remain complex relations with all the physical environment that surrounds it. The ecosystems depend on the balance between the living and abiotic factors. This balance influence growth, activity and the characteristics of organisms as well as its distribution in different locations. The temperature is one of the main factors that interfere with the maintenance of the organisms in an ecosystem. The “hands-on” fieldwork activity presented here intended to:

1) Assess the temperature in different habitats.
2) Check if the temperature varies according to height.
3) Analyse the importance of abiotic factors in the ecosystem.

Figure 1. Aerial view of the Federal Technological Education Centre of Sao Paulo, CEFET-SP. The temperature was measured in three habitats indicated. Dense vegetation (VD), vegetation (VR) and soil without vegetation (SN). The direction North (N) is indicated by the arrow. Image captured the Google Earth software (http://www.earth.google.com)

Each class of students was divided into three teams of six students working in pairs. The temperature of three types of habitats at CEFET São Paulo wooded campus was compared: dense vegetation (VD), low vegetation (VR) and soil without vegetation (SN) (Fig. 1). One student from each pair was responsible for measuring the atmospheric temperature and the other was responsible for the annotation of the data obtained. Before starting the work, those in charge of annotations, synchronized their clocks and set the time every time measure should be made (Fig. 2).

Five groups of measures were taken for each habitat: the first at ground level and the other respectively to 30 cm, 60 cm, 90 cm and 150 cm from the soil. The thermometers were placed in appropriate positions for five minutes after temperature annotation.

Data were collected at the end of four days of the fieldwork. Each teacher was responsible for 20 students at a time.

After the collection and analysis of the own data each group was encouraged to share their findings with other students. The students were also asked to prepare a report containing detailed introduction, objectives, materials and methods, results, discussions and references. Data analysis was performed in groups and allowed the use of software to produce charts. Moreover, some questions were available to guide the discussion and preparation of the report (data not shown).

Data Collection and Analysis

The instruments for data collection were: interviews, questionnaire and direct observations. In this study, one of the researchers was also the teacher and the other was the coordinator of the activities. The interviews were focused on teachers from other areas at CEFET São Paulo. It aimed to diagnose the scientific literacy of the students of advanced years in CEFET São Paulo. Data were obtained during the weekly meetings held at the end of 2007.

Figure 2. Fieldwork hands-on activity at CEFET São Paulo. A and C: Soil without vegetation (SN); B: Low vegetation (VR)

The students profile involved in this study was obtained through a questionnaire applied at the beginning of the school year. It was elaborated in order to investigate if the students had conducted fieldwork and experimental activities before studying in CEFET São Paulo. It also investigated the frequency of those activities and the students expectations for biology classes in high school. From the 200 students registered in the course, all of them take part of the "hands-on" activities and 193 answered the questionnaire. The direct observations allowed an increased approximation of the researcher to the participants and consequently a better evaluation of the meaning that the students give to their experiments and also of the context of the investigation.

Results and Discussion

The main issue raised by the teachers during the interviews was the lack of scientific skills observed in students at the end of technical courses. Teachers reported that many students, despite technical subjects, have some kind of difficulty in carrying out inquiry activities and show lack of skills like: building and interpreting graphics and texts, gathering evidence, formulating explanations based on evidence, designing an experiment and drawing conclusions. In order to understand the student's previous experience in accomplishing scientific inquiry activities we decided to apply a questionnaire to the students from the first vocational high school year at CEFET São Paulo. The data showed that about 35 per cent of the students did not have any kind of practical classes in elementary school. Most of them considered the lack of infrastructure in their former schools, the lack of interest of teachers and lack of classes intended to this type of activity the major reasons for absence of experimental activities (Tab. 1). On the other hand, the frequency of experimental activities for those students who reported practical classes varied between one per month (29.03%), one per two months (23.38%) and one every six months (16.93%). The most common practical activity executed previously by the students was passive/observational and only about 10% of students reported active involvement (self-planning and execution) in experimental classes. It also deserves highlight the fact that most students, 83,06%, (even those who had experimental classes) have never conducted activities outside the laboratory. But they all said they would like to take practical classes in both the laboratory and field. It is noteworthy that the majority of students were expecting that the experimental

activities in biology would be offered in the same approach and frequency of that had in basic education.
So, it is not surprise that students demonstrated enthusiasm, curiosity and interest in carrying out “hands-on” activities in the field, and understand the importance of the methodology used to collect accurate data. They shared the data and were encouraged to exchange their views and experiences on the implementation of the work. Many of them were enthusiastic about the dynamics of fieldwork activity. Others students were surprised by the possibility of conducting experimental activities outside the laboratory. Some students reported that the “hands-on” and fieldwork activities facilitated the understanding of some aspects of ecology and sustainable development that was never understood in the classroom. Some students reported that:

"*At school, is only book, chalkboard and chalk. From the way we are learning here, any student can better understand the ecological issues.* "

Options	Students' opinion (%)
Lack of laboratory and materials	42.03
Lack of interest of teachers	24.63
Lack of interest of students	7.25
Lack of classes intended for this type of activity in school	26.09

Table 1. Reasons for lack of experimental activities in elementary school

Students also highlighted the steps of the work that most attracted their attention: the collection of data, descriptions of procedures and discussions of the results. According to them, prior knowledge of ecology became more significant after “hands-on” activities in the field. Other students said that “*the subjects are not normally learned so contextualized*”. Furthermore, some students demonstrated surprise to realize the importance of biology in technical courses, according to their words:

"*I had never thought that ecology and biology was so important for a student of Technical Course".*

It also important to note that the students believe they will put into practice various concepts gained from this experience in the near future. After the fieldwork activity, students shared the experience highlighting the most important experimental details. They also made comparisons, analyses and reflections on the data collected. The teacher led the students on the importance of the report as an instrument of objective analysis and presentation of results. Students were instructed to list the issues, problems and solutions raised concerning the activity. Also, all the details concerning the structure of the text of the report were presented in detail. Students were asked to submit their results on tables and, at least, one chart. None specific software was suggested but the most used computer program was Excel 2007 from Microsoft. After that, the charts and statistical analysis were performed using GraphPad Prism version 4.0 program. Some example charts are presented in Fig. 3. The activities carried out in this study sought to engage students actively in the learning process, challenging them to formulate hypotheses, reshape and verbalize their ideas and actions. Classes practices contributed to: (a) identify the variables that interfere with a particular phenomenon, (b) use statistics and probabilities for forecasting phenomena, (c) understand the relationships between the characteristics of living creatures and the environment in which they live; (d) develop hypotheses about the phenomena studied and compare them with scientific explanations or data from experiments, (e) understand the role of models in biology and science in general, (f) relate concepts of biology as those of other exact sciences and humanities.

Conclusions and future work

Many are the reasons for not offer "hands-on" and fieldwork activities in Brazil. Some of the difficulties were appointed by science teachers [3,8]: insufficient quantity of classes, students with delayed in the content, excess of students per class, rotation of teachers, lack of time to plan and prepare the classes, lack of good relationship with the school administration, absence of pedagogical coordination or lack of infrastructure. There is a concern that the amount of "hands-on" and fieldwork activities in high schools are under threat. The practical activities, whether in the laboratory or field, should be designed to stimulate students to participate in the process of learning. In addition, the outdoors activities also address the interdisciplinary, contributing in the expression and communication, research and understanding and sociocultural context.

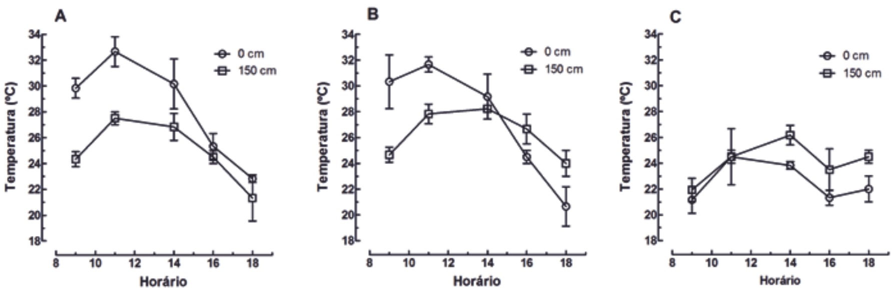


Figure 3. Some examples of charts designed by students

The work described in this paper is the first attempt to introduce "hands-on" and fieldwork activities in biology classes in CEFET São Paulo. But, despite the initiative presented here, lot of work remains to be done regarding the implementation and evaluation of "hands-on" and fieldwork activities in Biology Curriculum. It has to be considered that, despite the large number of pupils (200), they are all freshman and only two teachers were directly involved in the implementation of fieldwork. It will be necessary to expand the range of activities and the project itself to the other years of vocational high school in order to validate this approach in biology classes.

It will be also necessary to introduce follow up evaluation tools to see if the knowledge acquired positively impact the performance of students in advanced disciplines in the future. And it will be interesting to communicate the findings to teachers for other scientific basic areas (physics, chemistry and mathematics).
Nevertheless, the results obtained in this work indicate that “hands-on” and fieldwork activities can increase the interest and participation of students from technical courses in biological issues. This may be considering a very important achievement due to the small students’ interest for biology in technical areas such as mechanics, electronics, computers and automation. Indeed, the introduction of “hands-on” and fieldwork activities in biology curriculum at CEFET São Paulo may facilitate the development of procedural, communicative and attitudinal competences recommended by Brazilian PCNs.

Acknowledgements

The authors would like to thank all students of the first vocational high school year, as well as all biology teachers and courses coordinators from CEFET São Paulo.

References

[1] Barker S, Slingsby D and Tilling S, Teaching biology outside the classroom: is it heading for extinction? A report on outdoor biology teaching in the 14-19 curriculum, FCS Occasional Publication 72, Field Studies Council, 2002.
[2] Secretaria de Educação Básica, Parâmetros Curriculares Nacionais. Brasília: Ministério da Educação do Brazil.
http://portal.mec.gov.br
[3] Augusto TGS and Andrade AM, Dificuldade para a implantação de práticas interdisciplinares em escolas estaduais, apontadas por professores da área de ciências da natureza. Investigações em Ensino de Ciências, 12: 1-17, 2007.
[4] INEP. Programa Internacional de Avaliação de Alunos – PISA.
http://www.inep.gov.br/internacional/pisa/Novo
[5] Secretaria de Educação, Estratégias para o Ensino de Ciênicas, Brasília: Ministério da Educação (Brazil). http://portal.mec.gov.br/
[6] Erickson F, Qualitative methods in research on teaching, *Handbook of research on teaching,* Wittroch MC (Ed.), New York, NY: Macmillan, 1986.
[7] BSCS, Biologia, Versão Verde, Edart, 1976.
[8] Demo P, Escola pública e escola particular: semelhanças de dois imbróglios educacionais. Ensaio: Avaliação e Políticas Públicas em Educação, 15: 55, 181-206, 2007.

Paper presented at the 5th International Conference on “Hands on Science.
Formal and Informal Science Education",
Olinda-Recife, Brazil, October 13 to 17, 2008.

Science in Your Pocket

Wisman RF and Forinash K

Introduction

In the world of students today, cell phones are a necessity; mobility of communication and entertainment devices ordinary. What other possession is student more likely have with them all the time? And who could blame someone caught in a stream of students leaving a class for thinking that checking and answering email, text and phone messages immediately after class was a course requirement? But the ever-present cell phone can be more than just a social networking device; it can also be a tool for science education. The idea of a pocket-sized scientific analyzer is not new, a number of mobile devices have been used in science education for some years (e.g. LabQuest [5]). What is new is that students carry devices that have the capacity to perform some of the same data collection and analysis tasks; often requiring only cell-phone software and a little imagination to be added. In the following, we first present a brief overview of the motivation for using cell phone and gaming technology in science experiments, and then demonstrate two examples of science with devices available to most students: a cell phone sound frequency analyzer and a video game hand wand for acceleration measurement. We close with suggestions for other experiments.

Why Cell Phones?

Cell phones have become pocket-sized personal computers, albeit with an expensive calling plan. The most compelling reasons for their use in science education are ubiquity and mobility; cell phones are with almost all students almost all the time. The cell phone is also small, reasonably affordable and ruggedly packaged for carrying; just right for throwing, dropping from a window, or bringing together a bunch, to create your own experiment. The beauty of cell phone science is that it is always there when the chance comes to use it and is small enough to be tossed around or used in some unplanned manner. And, of course, it is the means of choice by which students communicate through text and talk with their peers; perhaps, we hope, sharing the results of their latest experiment. Transforming a cell phone into a scientific instrument can make science more impromptu and familiar, just part of the technology package students carry in their pocket.

Cell phones, in addition to being programmable, also possess measurement devices for sensing external phenomena and for communicating with other devices.

All phones possess a microphone for sound, a display and keyboard for user interaction, can determine their geographic location, and many possess cameras and accelerometers; all useful for data collection. Cell phone communication capabilities are also a very important component of data collection. These include human-level messaging by voice or text over the cell phone network, useful to coordinate experiments that require multiple data collection points; Internet connections that can be used to aggregate data at a common collection point; and, local wireless networking that allows using the cell phone to collect data from another device. The last point is likely the most important as it implies that a cell phone can collect data from most any phenomena; in an example given below, the cell phone collects acceleration data from a video game hand wand. With computational, sensing and communication capabilities along with ubiquity and mobility, cell phones present an opportunity for extending science education beyond the space and time constraints of a traditional laboratory.
Developing software for a cell phone or computer is very similar. Common languages include scaled down derivatives of Python, Java and C++ [3]. This is an important point when creating software as you can use familiar languages and development tools, incorporate existing software libraries, and develop and test algorithms on the computer before transferring to the cell phone. To promote phone software development, many manufacturers provide extensive development and test environments at little or no cost. After development, the application can be installed to a phone over a public or local network in a manner similar to computer software.

The Problem with Cell Phones

Similar to their larger computer relatives, many current phones are programmable, can input sound and visuals, and can connect to other local devices or the Internet. One would then expect software that runs on your phone to run on that of a student. Unfortunately, where personal computers are open systems that share a common hardware and software architecture, some slower or faster but capable of doing basically the same thing, cell phone models are designed as snowflakes, each unique.
For the time being, the cell phone hardware and software are controlled by service plan providers who have a financial interest in and go to considerable lengths to make their models different and often incompatible from everyone else’s, even their own. If computers were sold under the service plan providers’ model, your computer could only run the programs available through the computer seller. The result, for the time being at least, is that cell phone programs running on one model are unlikely to run on another. However, phones that share a common operating or program execution system can often share programs; examples include the Symbian and Microsoft operating systems and the Java programming language. The good news is that the closed system of plan providers is being challenged, particularly projects such as Google’s Android [4] which promotes a somewhat more open system model that encourages a software development and distribution model where the owner has more control over what runs on the phone.

Development Details

The cell phone used in the following the following demonstrations is a Nokia 61, at birth it was considered very capable but now, at two years old, is barely ordinary. The phone runs Symbian OS on an ARM 9 220 MHz processor. For comparison, the latest iPhone has a 600-700 MHz ARM processor running a version of Apple's OS X. The implementation language of the analyzer is Java ME, promising that the analyzer, acceleration and other Java ME applications will run on systems that support Java ME. The applications were developed using a standard text editor to write the Java ME code and a very simple, freely available development environment called the Sprint Wireless Toolkit.

Two Examples: Sound Frequency Analysis and Acceleration Measurement

To validate and explore some range of possibilities, we chose to implement two experiments in areas common to most basic physics courses, that of sound frequency analysis and acceleration measurement. The experiments also illustrates the cell phone alone as a scientific instrument and in conjunction with a separate, consumer electronics device often available to students, in this case a video game hand wand.

Example 1: Sound Frequency Analyzer

Sound frequency analysis is a familiar topic in a basic physics course. Students are often introduced to Fourier analysis through sound experiments in a laboratory setting using a microphone connected to a computer. A sound frequency analyzer operates by capturing some time interval of a digitized sound signal and performing a Fourier time-to-frequency transformation on some portion of that signal to produce a corresponding frequency power spectrum. Some related experiments possible are the frequency analysis of the harmonic and overtone structure of sound sources such as musical instruments and determining the Doppler shift of a moving sound source.
A modern sound frequency analyzer requires the following hardware, all of which are common to cell phones:

1) Sound digitization capable of recording at twice the highest expected frequency.
2) An interface (e.g. buttons) to control the analysis and a display to see the results.
3) A processor to perform the Fourier time-to-frequency transformation algorithm.

Complicated procedures and equipment are a bane to science education. In creating a learning tool for student use, one danger is that the lesson to be learned is overwhelmed by the tool; the hoped for learning insights are lost in the complexity of running the experiment. The sound analyzer uses only a cell phone and its use is less complex than text messaging. The basic start-to-finish procedure for a student, as illustrated in the examples, is simple: download the analyzer software from a

Web site, start the analyzer, record a sound, and analyze the sound; only four steps are required to capture and perform a Fourier analysis of a sound. Raw data can be exported for sharing or computer analysis, or, as the figures below demonstrate, the analysis screens can be captured and emailed or uploaded for review. Figs. 1-6 illustrate the use of a sound frequency analyzer as implemented in Java on the Nokia E61 cell phone.

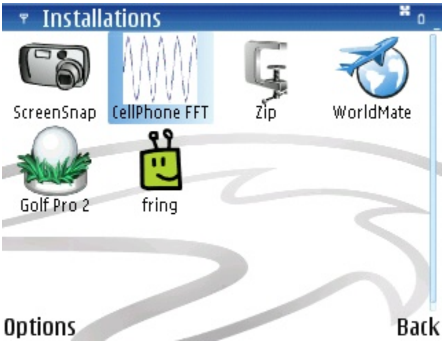


Figure 1. CellPhone FFT as one of several applications; it was downloaded from the school site using the phone Web browser

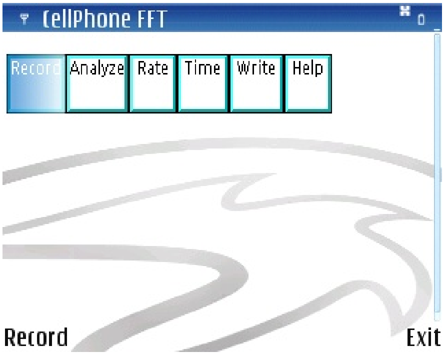


Figure 2. Menu options, Record a sound, Analyze recording, Time and Rate are parameters for data collection, and Write sound data to cell phone file

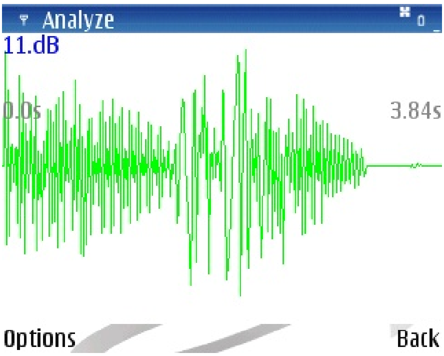


Figure 3. Selecting Analyze initially displays the complete raw signal recorded

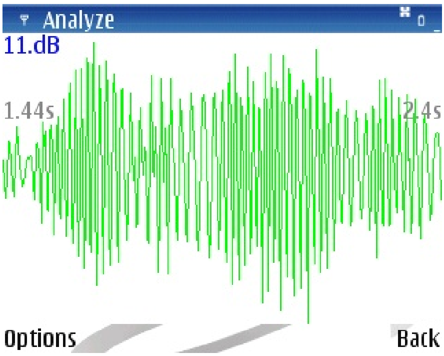


Figure 4. Cell phone directional buttons on allow panning (moving over time) or zooming (increase or decrease time interval displayed) to select a subinterval to view or analyze

To some, that a cell phone can perform a Fourier transform might be surprising, given that real numbers and mathematical functions are required. That a phone can do so with reasonable quickest is a pleasant bonus. From the above example, determining the frequency of the sound sampled over an approximately 4 second interval at 8000 kHz was performed by a Fast Fourier transform on 32768 samples, took about 10 seconds and produced results with accuracy comparable to that of commercial analysis software running on a PC.

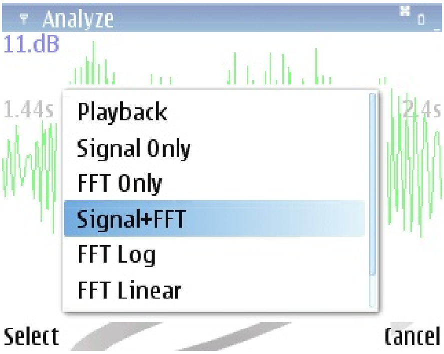


Figure 5. Analysis options that can be applied to the signal section selected includes sound Playback and multiple display views of results

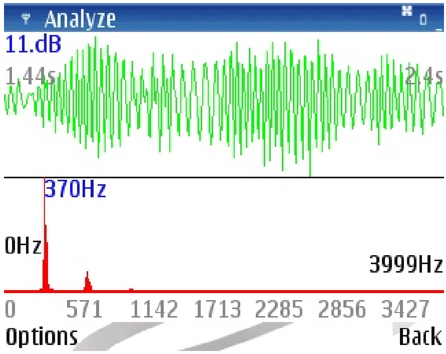


Figure 6. A combined graph of selected raw signal subinterval and Fourier transform

The analyzer is primarily an educational tool for studying sound. As such, a key question to be asked is “does the tool help or hinder learning?” As noted earlier, the tool use should simple, nearly transparent, so that attention can be focused on what is being studied. Further, of course, a measurement tool should be reasonably accurate. An additional challenge for interactive devices when large amounts of data must be processed is that it produces results quickly. The above example demonstrates that a cell phone can meet these criteria, providing a viable complement to traditional laboratory experience. Revisiting the points on ubiquity and mobility, sound analysis on a cell phone provides the opportunity for experiments at a different time and place than the traditional laboratory; available whenever or where ever the chance arises.

Example 2: Measuring Acceleration

Experiments involving acceleration are some of the most fundamental and engaging. Along with the cell phone, video games are one of the most available of consumer electronics devices useful for science. Acceleration can be measured by accelerometers with many recent video games and cell phones including accelerometers to determine the device orientation or the directional force to which the device is subjected. The hand-held Wii Remote (Wiimote), for Nintendo’s Wii video gaming system, includes a three-axis accelerometer to read a game player’s gestures as game input and Bluetooth wireless networking to share the accelerometer measurements with the game console. Fig. 7 illustrates the Wiimote and the 6 directions in which acceleration can be measured.
A Wiimote and cell phone can form a mobile scientific instrument for measuring about the acceleration experienced on a rollercoaster or in the range of -3g to +3g.

The two devices are linked through the Wiimote Bluetooth connection that transmits accelerometer data to the cell phone which records and analyzes the data. This approach, using small, widely available mobile equipment, creates the opportunity to study acceleration in a familiar setting –such riding the elevator or driving a car.

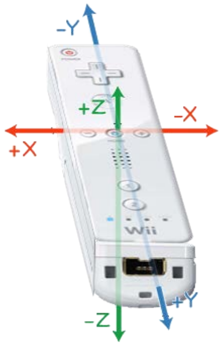


Figure 7. The three axis orientation of a Wiimote accelerometer [6]

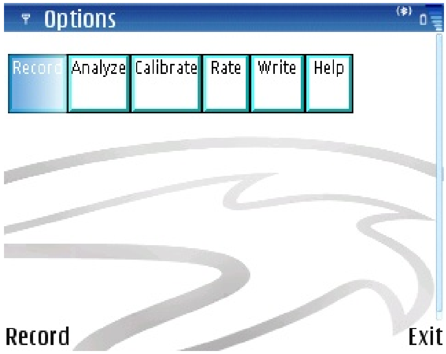


Figure 8. Menu options: Record records acceleration, Analyze acceleration. Calibrate calibrates the Wiimote accelerometers, Rate sets parameters for data collection and Write saves the data to a cell phone file

A cell phone and the Wiimote combination can measure acceleration simply and is adaptable to a variety of experiments. The implementation is entirely in cell phone software requiring no hardware modifications or connections. The Wiimote's data is transmitted via Bluetooth local networking so the cell phone and the Wiimote need only be within about 10 meters of each other. The Wiimote accelerometer provides data on the force applied in six directions; at rest, a horizontal Wiimote should report +g in the vertical direction and in free fall, zero g; the accelerometer data is transmitted continuously and read by the cell phone at predefined time intervals.
A common experiment is to measure acceleration and velocity while traveling along a single axis. Using the Wiimote and phone combination, the basic procedure for measuring acceleration is: orient the Wiimote to the direction of travel, calibrate the accelerometer, start data collection, start travel, stop travel, stop data collection, analyze the data. The following instructions provide a student's view of the experimental procedure, given to illustrate the overall simplicity of use. The steps common to all experiments are:

1) Press the 1 and 2 buttons on the Wiimote to initiate a Bluetooth connection.
2) Run WiiConnect [2] program to establish a Bluetooth connection with the Wiimote. Press the Wiimote Home button when connected.
3) Run Acceleration program.

The remaining instructions would be specific to the experiment being performed. For measuring linear acceleration of a vehicle, the instructions are: While stopped, place the Wiimote on a horizontal surface with the +y axis pointing toward the direction of travel and start recording data. From a complete stop, accelerate to a predetermined speed, then stop the car, and stop collecting data. Analyze the acceleration and velocity on the y-axis. Compare different vehicles (e.g. car vs. bicycle). If you have a helmet or hat, try duct taping the Wiimote to it; compare your personal acceleration with that of the vehicles.

Measuring the linear acceleration and velocity of a car

Linear acceleration and velocity of a vehicle is a familiar experience from riding in a car, elicits natural curiosity in many drivers but is not easily studied using traditional laboratory equipment; using a cell phone and Wiimote, measurement is relatively simple. For this experiment, the Wiimote was placed on the stopped vehicle's floor oriented in the expected direction of travel and acceleration recording began on the cell phone; the vehicle was then accelerated on a straight road having a few small hills and bumps to an analog speedometer reading of about 40 mph. or 18 m/s. and was then braked to a complete stop.

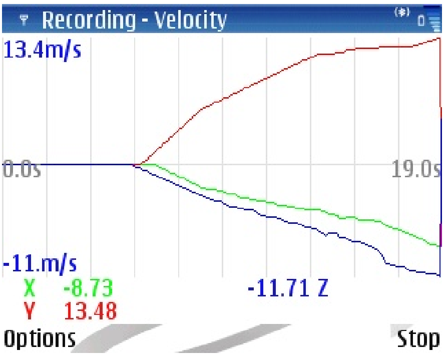


Figure 9. Recording acceleration data while displaying velocity as a speedometer

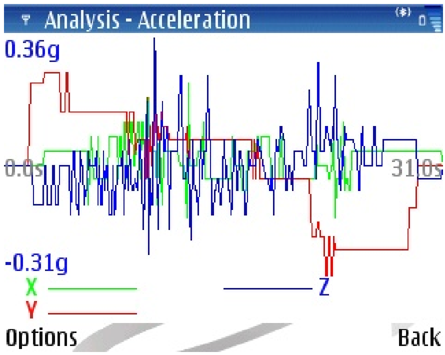
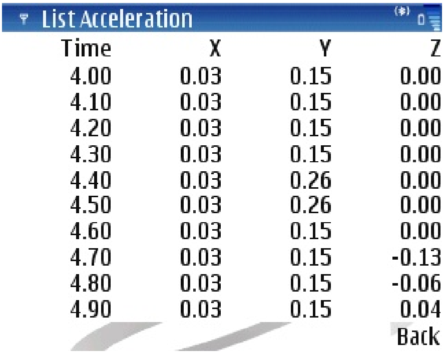


Figure 10. Selecting Analyze initially displays the complete acceleration data for the three axes recorded. Notice the acceleration spikes on the z-axis due to road bumps

Fig. 8-14 illustrate the procedure and results of the acceleration experiment. In Fig. 9, velocity is graphed for each of the three axes along with a real-time display to provide a speedometer; the y-axis is the direction of travel. In Fig. 10, acceleration is shown recorded along all three axes with the travel direction on the red or y-axis; the z-axis showing the hills but most obviously the greatest acceleration being the bumps in the road; the x-axis shows relatively small sideways acceleration. Fig. 13 shows the difference in acceleration following changes to higher gears and braking. In Fig. 14, the velocity corresponding to the acceleration over time is shown alone, illustrating the decline in the rate of increase in velocity as the vehicle shifts into higher gears.



Time	X	Y	Z
4.00	0.03	0.15	0.00
4.10	0.03	0.15	0.00
4.20	0.03	0.15	0.00
4.30	0.03	0.15	0.00
4.40	0.03	0.26	0.00
4.50	0.03	0.26	0.00
4.60	0.03	0.15	0.00
4.70	0.03	0.15	-0.13
4.80	0.03	0.15	-0.06
4.90	0.03	0.15	0.04

Figure 11. Listing raw acceleration data where Y is the linear acceleration and Z the road bumps

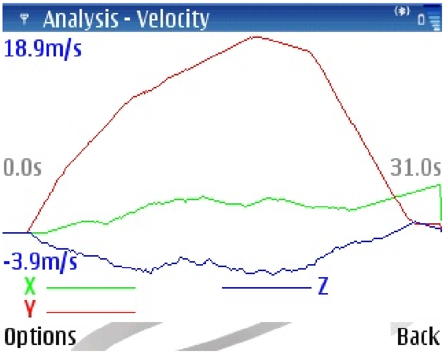


Figure 12. Display of the complete data velocity for the three axes

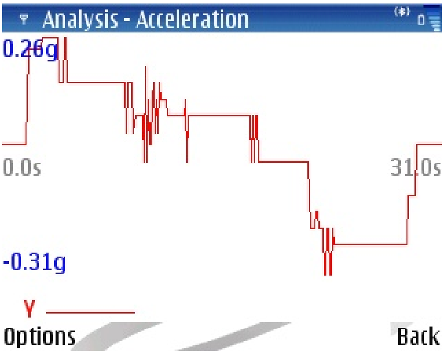


Figure 13. Viewing y-axis shows greatest acceleration in lowest gear with declines following each higher gear change until acceleration is zero and maximum velocity is reached. Negative acceleration is braking

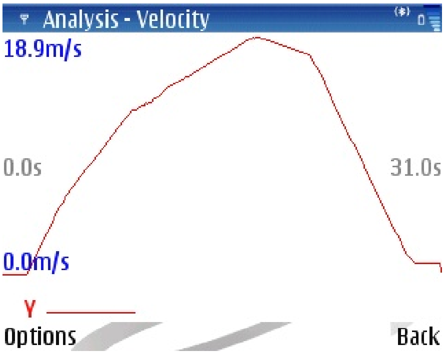


Figure 14. Viewing the y-axis velocity shows the car accelerating to 18.9 m/s, a shift from low to 2nd gear, and braking to a stop

Other Experiments

Keeping in mind that this purpose of this project was to demonstrate the use of widely available, mobile devices in science education, what other experiments are possible with a cell phone? The answer largely depends upon whether the cell phone is used alone or with other hardware such as a Bluetooth enabled device like the Wiimote. Common hardware of a cell phone can digitally record and play sound at CD quality data rates (44.5kHz), track the phone's orientation with accelerometers, determine global position by GPS, digitally record images, and communicate globally over the Internet or locally with nearby devices using Bluetooth. As pointed out by the Wiimote example, connectivity with other devices

is fundamental to expanding the range and type of measurements possible. Other options are to construct measurement devices based on inexpensive Bluetooth-capable consumer electronics, such as headsets, that could be modified to serve as an alternative input device such as a force probe, which measures applied force directly.
Many other experiments are only possible with mobile measurement devices. The following list is not intended to be exhaustive; the expectation is that students will invent experiments that are far more original than those listed below. Note that time did not permit these experiments to be performed using the cell phone and Wiimote combination but are similar to, and should be within the range of those possible for the devices, as the experiments demonstrated above.

- Centripetal Acceleration around a Corner – Take a vehicle to a large, empty parking lot. While stopped, place the Wiimote on a horizontal surface pointing 90 degrees to the direction of travel and start recording data. From a complete stop, make a full-circle left turn at constant rate of speed and then stop. Stop recording data. Compare circular turns of different radii.
- Acceleration in an Elevator - While stopped at the bottom or top floor, place the Wiimote in a corner with the y-axis pointing up and start recording data. Start the elevator and when it stops, stop recording data. Compare upward and downward travel.
- Acceleration of the Vertical Loop on a Roller Coaster - Secure the Wiimote to your lower leg with the y-axis pointing up (long socks might help too) and start recording data. Compare the accelerations at the top, bottom, and sides of the loop.
- Acceleration of a Skydiver [1] – Secure the Wiimote to your lower leg with the y-axis pointing up (duct tape might help) and start recording data. Jump out of the airplane, fall, open parachute and land. Stop recording data and analyze the accelerations on each of the three axes throughout the dive.
- Bumpy Road - Measure the force produced by hitting a bump in the road.
- Roller coaster – Place someone at the front middle and back of a roller coaster and compare accelerations. An example of simultaneous multiple data measurements.
- Doppler shift – Determine the sound frequency as a train approaches, reaches and retreats from a vehicle crossing. Calculate the Doppler shift and the corresponding speed of the train.
- Other Acceleration ideas - Record acceleration experienced when dropping the Wiimote, riding on bicycle, car, boat, trampoline, skiing etc.

Summary

As has always been the case, science depends upon investigative tools for exploring ideas and quantifying the results. The purpose of this paper has been to demonstrate a small portion of the possibilities for placing investigative tools quite literally in the pockets of students. The ubiquitous cell phone, particularly when combined with commonly available consumer electronics, can complement the traditional science laboratory experience with one that is nearly always available and is highly mobile; adding to the number and range of investigations possible while reducing the constraints of time and space.

Classic sound and acceleration experiments have been presented to demonstrate the feasibility of the cell phone as an investigative tool. Students will certainly create other, more original experiments. While building investigative tools from cell phones and other mobile consumer electronics is not without challenges, the educational rewards are tangible and, given the strong economic forces driving improvement in cell phone and consumer electronics technologies, the power, ease of use, and potential of these devices in science education can only accelerate.

References

[1] Chudzinski C and Forinash K, Skydiving with the CBL. http://physics.ius.edu/~kyle/K/skydiving/skydskydi.html

[2] Erifiu A and Mario G, Projects: WiiConnect/WiiRider, 2007. http://symbian-resources.com/projects/wiirider.php

[3] Fitzek F and Reichert (Eds.) F, Mobile Phone Programming and its Application to Wireless Networking, Springer, 2007.

[4] Google Inc. Android – An Open Handset Alliance Project. http://code.google.com/android

[5] Vernier Software and Technology, Vernier Labquest. http://www.vernier.com/products/interfaces/labq2/

[6] http://archive.is/www.wiili.org

Paper presented at the 5th International Conference on “Hands on Science. Formal and Informal Science Education",
Olinda-Recife, Brazil, October 13 to 17, 2008.

Coal Mines and Natural Surroundings, Can They Be Integrated? An Educational Standpoint

Redondas J

Introduction

During the development of the first human societies, from the first stages, the harmony between man and nature has become a basic need to keep in mind and take into account in all artificial activities.

Nevertheless, the aspiration of comfort and a quick and sometimes an uncontrolled growth and development of our economic system in different fields such as agriculture, mining, materials production and transformation, power generation, etc, has given as a result a broad damage of our natural environment.

After some time (years, decades, even a century…) our society realized that this way was not completely right in the direction to achieve a good quality of life.

Then, the concept of sustainable development has emerged as a principle to follow in all the economic and social activities for the future.

School is a suitable scene to develop activities and encourage attitudes in this direction. In this way, a multinational group of secondary school pupils, aged 14-16, from different schools, most of them from European countries, and also Turkey and Canada, conscious of the relevance of their activities for the future, they have been developing, during the last schoolyear, some indoor and outdoor activities studying different environmental fields to promote positive attitudes on the protection of the environment

Since the first edition, started in 2004, the Youth Eco-Parliament (YEP) project is an international educative program that involves each 2 years a great number of schools from the above mentioned countries. The aim of this big plan is to raise awareness of sustainable development.

In this paper we describe the different activities carried out by the students of the CPEB de Cerredo, a public secondary school, located in the region of Asturias, in the north of Spain.

Cerredo is a village of the municipality of Degaña, located at an altitude of 1060 meters over the sea level, where the main economical source nowadays is the extraction of coal even in open-air and underground galleries. The traditional activities of mountain agriculture and forestry have only importance as a complementary activity for some families.

Aims

The main objectives of the Youth Eco-Parliament are to encourage students to observe, analyse and find out solutions for local environmental problems, as well as to broad their thinking and feeling to a global level within the framework of planning and conferring with classmates and others in the international writing group.
The participation in this project gives the opportunity to the students to make contacts and share experiences, feelings and knowledge with other colleagues from different countries and cultures. This collaboration opens their minds to others ways of thinking and contributes to emphasize the concept of European citizenship.
Another important objective is to promote educational and outdoor activities that are especially attractive for teenagers and increases their interest towards the different matters such as natural sciences, technology and English.
The communications and information transfers between the different students, school, coordinators and national and international moderator's results in a key role of the information and communication technologies in this project.
In our case, and due to the special characteristics of our municipality and the surrounding areas, we decided to present our project based on the study of the different types of pollution: air, water, soil as well as noise pollution. We analysed the main sources and the consequences on the environment and the health of people living in this region.

Background

Supported by the organization Pro Europe (Packaging recovering organization Europe) in partnership with Ecole et Nature (a network of organizations and individuals who work in the field of environmental education), the Youth Ecoparliament (YEP) is an international educational platform.

Figure 1. General meeting of the 1st youth eco-parliament in Berlin 2004

In 2004 this project was launched, involving some 3000 European students that have elaborate a European White Paper for the Environment divided into five thematic units: energy, water, food, waste and air. This document, containing resolutions and proposals for action; was given to the President of the European

Parliament Josep Borrell, the President of the Environmental Commission Karl Heinz and to the European Commissioner Stavros Dimas. The second edition, in 2006 takes the form of Open Letter for the Environment, as a document based on assessments and observation and practices on local environmental issues and addressed to influent groups in our society. The addressees of the open letters were: producers and industries, non-governmental organizations, journalists, researchers and scientists, public authorities, educators and also international institutions. The third edition, in 2007-08, consists in the elaboration of the YEP Report for the environment which is directed at UNESCO representatives within the framework of the Decade of Education for Sustainable Development 2005-2014 (DESD). It will feed both the second Biennial and the half-way Report of the Decade to be published in September 2009. In this edition, in 2008, the collective writing of this Report, invited 3500 young people, aged 15 to 17, accompanied by national moderators, to pick out, analyse and highlight environmental education actions with a view to sustainable development.

Structure of the YEP Report

Apart from the general objectives of the overall project involving all the countries, the 67 Spanish schools involved were coordinated in order to elaborate a particular report. This document, written in Spanish language, constitutes an edited book incorporating a compilation of brief outlines summarizing the main topics, the concrete objectives and a short description of each local project developed particularly by each school. Each group of students, coordinated by one or more teachers, presents, in this document, the positive and negative elements of the work organized, as well as the main achievements and difficulties encountered during the progress of the different tasks and stages, the main outcomes and effects on themselves and on the educational community and other agents involved. The final product of the multilateral cooperation is a complete compilation of the conclusions, proposals and feelings emerged during the different activities and experiences developed. This report contains the reflections that came up from our study of 115 youth projects across 10 countries of Europe and Canada. The environmental, social, cultural and economic implications are huge and reach many aspects concerning the life of the world’s population. This educational effort will encourage changes in behaviours that will create (undertaking local actions projects) a more sustainable future in terms of environmental integrity, economic viability, and a fair society for present and future generations.

The Report is organised in 5 chapters:

1) Our Vision: «a positive vision to get started» In this chapter, we intend to demonstrate that motivation is personal before becoming collective. Being in nature as well as meeting others is motivating. We think that it is important to be part of a worldwide network of young people, to share our visions, our values and to start acting however small the action.
2) «Scientific Approach» Our belief is that a change in the habits is enhanced with true scientific knowledge. Realising that actual scientific language is too

complex for us to understand we wish to make sure our results will be understood by everyone.

3) «Start acting now!» Our objectives are to motivate others and not wait that something will happen... Step one: I can do something. Everyone asks himself «What can I do from now on!» (use bicycles, go by foot,...). Step two: Think about friends who are motivated enough to think about local actions and do something with them. Step three: Look for «people with power» (partners: mayor, directors of companies, journalists); use networking...
4) «Public awareness» This chapter aims at showing and analysing different tools that can be used to raise awareness. We had to look at what made us aware and collect the many ideas from all the countries. The main idea is that we should not give lessons to people but we should keep active and try to inform the largest public.
5) «Learning to transform» This chapter is about education from young age to older generations. Learning does not only happen at school and it not only implies lectures but also other teaching methods (dialogue, teamwork, practical training...).

Figure 2. Contribution to the Spanish report and geographical location of Cerredo

Networking is key element in the YEP (exchange of information among schools, persons, with companies, members of parliament, NGOs...). This chapter aims at giving tips on different methods you might use and adapt while taking actions.

Activities developed

Context and situation

Our school, the CPEB (Public centre of basic education) of Cerredo is located in a high mountain area in Asturias, in the north of Spain. Cerredo is a small village (around 1000 habitants) at high altitude (1060 m). This centre has singular characteristics due to the adverse geographical conditions: poor communications with neighbouring towns and important cities and also severe climatic conditions due to low temperatures the presence of significant amounts of ice and snow,

mainly in winter. Our school covers all the levels of compulsory education in the Spanish education system, since we have pupils from 3 to 16-17 years old.
An important part of our municipality is integrated in a natural park (Fuentes del Narcea, Degaña e Ibias), and the traditional life consists in agriculture and forestry. Since the middle of the last century, the main economical source is the exploitation of coal mines, even in open air mines and underground galleries. This coal is entirely employed in the production of electrical energy in two thermoelectric power plants situated at 30 and 50 kilometres far from the location of the extraction areas.
In this environment, we have analysed how the wildlife is being affected by the extraction, transformation and transportation of coal to the thermoelectric plants.

Figure 3. General view of the small village of Cerredo and the glacial lake

The natural park of Fuentes del Narcea, Degaña e Ibias

Declared Natural Park in 2002, is situated in the southwest of the region of Asturias, in the occidental part of the Cantabric Mountains, with an altitude between 400 m and 2000 m over the sea level and an area of 47.589 ha. The name of the park is given by the main rivers Narcea and Ibias. Inside this area there is a region of 60 km^2 of special protection: the integral natural reserve of Muniellos; the access is restricted to a maximum of 20 persons per day with authorization, which constitutes an effective way to safeguard and improve the environmental values. This park is particularly rich in flora and fauna characteristic of European high mountains. Between the vegetal species are especially important the oak (quercus robur and quercus petraea) and beech (fagus sylvatica) forests and there is also chestnut trees (castanea sativa) and birches (betula celtiberica) as well as other small species, mainly different ferns, moss (muscus) and lichens. We have organized several visits to our environment, where our students were guided in order to see, identify and collect the different species or parts of trees and plants.
The wildlife species more important in this park are the bear (ursus arctos arctos), with an estimated population of around 40 members but with clear signs of resurgence in the last years, and the tetrao urogallus, more important due to the special situation of this species in Europe than to the number of members. Regarding this aspect are more important the wolf (canis lupus), the fox (vulpes

vulpes) the wild boar (sus scrofa) and the deer (capreolus capreolus) between the mammalians and the goshawk (Accipiter gentilis) and the sparrow-hawk (Accipiter nisus) in the group of the birds.

Figure 4. Students are identifying different plants and trees in the forest and Students are analysing the wreckage of the coal mines

As it can be understood, it is not easy to find and observe such species directly in their natural environment and this even more difficult with a group of students. Nevertheless, an interpretation centre has been visited and we could examine some bibliographical and audiovisual materials related to the wildlife.

The coal extraction and handling

Cerredo belongs to the south-Cantabric coal basin, one of the most important coal areas in Spain. Anthracite and soft coal are the more abundant types of coal extracted.
The coal is extracted following two different methods:

- In open air mines using heavy machinery, mainly in the highest parts of the mountains.
- In underground galleries, with different levels and interconnected indoors.

The second method is obviously more complicated from the technological perspective and economically more expensive. Nevertheless, the effects on the environment are more significant in the open-air techniques due to the powder emission to the atmosphere, the noises provoked by the movement of the machinery and the detonations, and the destruction of the natural environment and the visual impact. This methods of coal extraction have been evaluated by our students by means of visits to the mines (except the underground galleries because it is forbidden for people aged less than 18 due to security reasons) and interviews and talks with the responsible for the environmental management of the company and the engineer.

Once extracted, the coal is processed in industrial plants usually placed close to mines, with the purpose of separate the unwanted and useless parts of rocks and soil from the coal used as combustible in the thermoelectric power plants.

Figure 5. Open-air coal mines

This washing process generates a large amount of dirty water that needs to be treated before dumped directly to the river. Nevertheless the rain usually drags important amounts of coal and rests of soil to the watercourses.

After the washing procedure, the coal should be milled and converted in small pieces before be sent to the destination. This milling process constitutes another important element of air pollution and also noise pollution that affects directly to the population of the village, since the treatment plants are placed very close to the houses.

Organization of the work

The project was launched in November of 2007 when the CPEB de Cerredo was selected to participate, together with other European schools.

The students of the upper course of this school (fourth level of secondary compulsory education) were selected by the leading teachers to be in charge of this project and all the tasks related. They were guided and organized by the teachers of natural sciences and biology. The national moderators of the project helped also them concerning some procedures and the dates and deadlines to manage the different activities.

The title of our project is: “Coal mines and natural surroundings, can they be integrated?” and, during the school year, the following activities have been developed:

- An initial search for information in different sources (mainly webs, books and the monthly magazine of the local coal extraction company) about two key topics: the characteristics of the natural park and the procedures directed to the coal extraction and handling.

- Exploration on the environment and research and study directly on the same themes: in the neighbouring nature and in the mines and coal handling industrial plants.
- Inquiries to experts who could provide precise and technical information concerning the preservation of the nature values and the waste treatment in the mines and how the coal mines affect the environment.
- Discussions about the information obtained from bibliographical sources as well as from inquiries to experts.
- Elaboration of a set of results, including data obtained and the conclusions of the discussions.
- These outcomes have been presented both in a written version and also as an audiovisual production. In this movie each participant student presents a particular section concerning the tasks carried out and the results obtained, combined with different scenes and outlooks in relation to the environment and the different mining activities.
- Collaboration to the elaboration of the YEP Report to be sent to the UNESCO.

Resources and activities on-line

The international cooperation was achieved thanks to a powerful tool than ensures and makes more easy and fluid communication between the students and teachers of the participant schools. That's the web site of the European Youth Eco-Parliament. All the schools were included in this web site, where each school had the chance to create their own presentation.

Figure 6. Wild fruits (blueberries) are widespread in the environment Cerredo. Traditional practices in Cerredo

Depending on the goal, each class have choose the tool they thought was the most useful for the message and content they wanted to communicate; then they have prepared the web assembling the material in the form of photos, images, films, texts… to facilitate the description of the work done and the results obtained in the

different steps. The web was public, but the possibility to edit the different branches was restrained to the corresponding school by means of a login and a password.
The use of the information and communication technologies helps the students to deal with contacts and links with colleagues from different schools geographically separated, and to know the activities and the results obtained by all the partners.
The students could exchange ideas and respond to questions posed by experts, by participating in the forums. They could start to make connections between their day to day actions and their local situation in respect to the environment and sustainable development. They could share their experiences with other European students.
Additional pedagogical advantages have been offered by the forum: allows students could enter into dialogue with others about environmental issues, promotes the use of Information Technology in an educational framework, contributes to build skills in constructing effective arguments and encourages social behaviour as well as develops reading, writing and verbal skills.

Pedagogical outcomes and evaluation

As it has been mentioned, the final product of this project is a report written collaboratively by the participants on this project and addressed to the UNESCO representatives.
Beside this material product, the main outcomes from which the participant students were benefited can be summarized in the following points:

- The outdoor activities are tasks that engage students to do scientific and cultural research, to explore different ways of sustainable living and implement the use of learning diaries.
- The students are encouraged to share ideas, study directly their environment, collect different categories of data and reflect on what they had learnt.
- The direct experiences carried out seem to be an extremely important factor in educating students to be environmentally aware adults.
- The information empowerment leads to an active participation and awareness of their responsibility towards the community and environmental policies.
- The knowledge and experience gained during such a project is incomparable with common curricular school activities.

Moreover, from the educational, pedagogical and social point of view the skills specially developed were:

- Determine the validity of evidence from a variety of sources.
- Analyse critical issues on economic growth and environmental protection.
- Develop presentational writing skills.
- Work cooperatively in teams.
- Independent research with news journals, magazines, statistical reports, and on-line resources

- Interview skills
- Planning and organizational skills

The participation in this project has also contributed to enhance the use of the new technologies at school and to make the students aware of the relevance of the computers and Internet in the different fields of our world.
Since the project involves international collaboration, the language used within the writing groups is English. In order to allow a good level of exchange an effective communication between students it was essential the collaboration of the teacher of English.

Conclusions

Our work helped us to understand the factors needed to change daily habits and successfully reach the goals of the United Nations Decade of Education for Sustainable Development -for which UNESCO is the lead agency- indeed to integrate the principles, values, and practices of sustainable development into all aspects of education and learning.
We intend to share our experience in leading projects and inspire those around the world who wish to engage in such projects and commit them to change their daily habits.
Through this work we realized that any action, even small, contributes to a world where each and every one might feel good and where human beings and nature will both get their way.

References

[1] Botkin DB and Keller EA, Environmental Science: Earth as a Living Planet, New York: John Wiley & Sons, 1998.
[2] Brown V, Investigating nature through outdoor projects: 36 strategies for turning the natural environment into your own laboratory, Harrisburg, Pa.: Stackpole Books, 1983.
[3] Pringle LP, Taking care of the earth: kids in action. Honesdale, Pa.: Boyds Mills Press, 1996.
[4] Feinsinger P, Grajal A and Berkowitz A, Some themes appropriate for schoolyard ecology and other hands-on ecology education., Bulletin of the Ecological Society of America, 78, 144- 146, 1997.
[5] Hairston N, Ecological experiments: purpose, design, and execution, New York: Cambridge University Press, 1989.
[6] http://www.actionfornature.org
[7] http://www.envirolink.org
[8] http://www.enviroliteracy.org/
[9] http://www.epa.gov/
[10] http://www.globe.gov
[11] International Planet'ERE Collective (IPC), Environmental education towards sustainable development, Montreal 1997.
[12] Levine S and Grafton A, Projects for a healthy planet: simple environmental experiments for kids, New York: Wiley, 1992.

[13] Palmer JA, Environmental education in the 21st century, Theory, practice, progress and promise, New York: Routledge, 1998.
[14] Simon S, Science projects in pollution, New York: Holiday House, 1972.
[15] UN, Air Pollution and Citizen Awareness, New York, 2005.
[16] Redondas J, Environmental Research Activities in an Heavy Industrialized Region, Proceedings of the 3rd International Conference on Hands-on Science. Science Education and Sustainable Development, Costa MF and Dorrío BV (Eds.), Braga: University of Minho, 376-390, 2006.
[17] Redondas J, Experiences for the II European Youth Ecoparliament Project, Proceedings of the 3rd International Conference on Hands-on Science. Science Education and Sustainable Development, Costa MF and Dorrío BV (Eds.), Braga: University of Minho, 433-440, 2006.

Paper presented at the 5th International Conference on “Hands on Science.
Formal and Informal Science Education",
Olinda-Recife, Brazil, October 13 to 17, 2008.

Respiration and Photosynthesis in Context: Experiments Demonstrating Relationship between the Two Physiological Processes

Bannwarth H

Introduction

The most important metabolic processes in living organisms are respiration and photosynthesis [1]. Both are interconnected in many ways (Fig. 2). In a single plant cell, in lichens (Fig. 10), in plant galls (Fig. 11), in natural habitats and in ecosystems they are united in complex biological systems. At school photosynthesis and respiration often are taught separately. But on the other hand they belong together and one should not forget that they are correlated. The emergence concept of modern biology means that the whole, intact and complete system is more than the sum of the parts. From these considerations one may conclude that photosynthesis and respiration should be introduced in context [2]. This may be done in schools with the classic Priestley-experiment, but the problem is, that this experiment cannot be carried out in schools because one should not let die animals by this way (Fig. 9).
On the other hand animals are able to dissimilate and plants to assimilate in different separate organisms in natural habitats. In addition photosynthesis and respiration are opposite physiological pathways separated in isolated compartments like chloroplasts and mitochondria and maintain a metabolic equilibrium in a steady state in a plant cell. Chloroplasts and mitochondria have common features according to the endosymbiotic theory of evolution. They are surrounded by a double membrane layer and are able to synthesize ATP using a proton gradient after accumulation of protons between these two membranes according the concept of Peter Mitchell (Fig. 7). Halobacteria similarly transport protons outside the outer cell membrane comparable to chloroplasts and mitochondria. This outer membrane corresponds to the inner membrane of chloroplasts and mitochondria (Fig. 8).
We will present here an experiment showing the decrease of the pH - value in the surrounding medium when halobacteria are exposed to light. The acidification is due to the light driven proton transport from inside to outside.
Both physiological processes, photosynthesis and respiration, are not visible and only in the rarest cases detectable by our senses. The physiology knows however informative and elucidating experiments, which permit to make important aspects of

such life procedures visible.

Figure 1. Relationships concerning structure and function of photosynthesis and respiration. Green branch pieces without crust pores (“lenticells”) of Jews mantle (*Kerria japonica), left, or* Rose (*Rosa spp.*), right, were compared with grey or brown pieces of branch of Golden Bell (*Forsythia spp.*), left, or Black Elder (*Sambucus nigra*), right, with crust pores (“lenticells”). In every case the green photosynthesizing plant parts had no crust pores while the respirating parts showed a lot of “lenticels” (Table1)

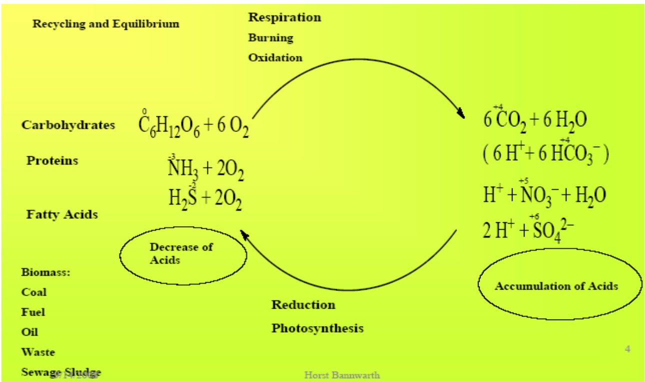


Figure 2. Photosynthesis and respiration in context.
Photosynthesis and respiration represent chains of redox – reactions in a steady state or in a dynamic equilibrium running in opposite directions. During photosynthesis carbon, nitrogen and sulphur are reduced and acid (H+-ions) are consumed. During respiration carbon, nitrogen and sulphur are oxidized an acid is produced. This leads to an acidification of the environment. Burning augment this process. This means that burning should be reduced and photosynthesis reinforced by human actions

Since photosynthesis and respiration both are opposite pathways their effects may be compensated in some situations. In this case one cannot expect to detect any change of an indicator colour in the surrounding medium of a water plant. Alternatively photosynthesis and respiration can easily be studied together in a combination of a photosynthesizing O_2 producing system with an O_2 consuming system (Fig. 6) by a simple experiment measuring the electric potential between both [3].

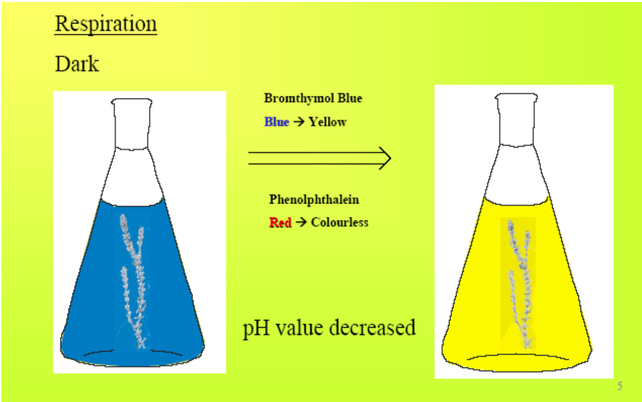


Figure 3. Respiration of plants. The production of acid (Fig. 2) during respiration can be demonstrated by the use of indicators. For instance bromthymol blue changes the colour from blue to yellow

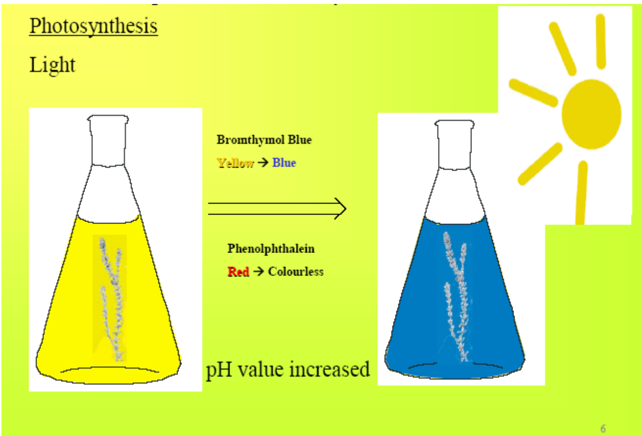


Figure 4. Photosynthesis of plants. The consumption of acid during photosynthesis of plants can also be demonstrated by the use of the same indicator. But in this case the colour of bromthymol blue changes from yellow to blue in the presence of light

Methodology

Results may be obtained by experimenting, by observing, comparing and combining. At first some experimental approaches will be presented and later on further expanding aspects will be included into the consideration in order to elucidate the importance and advantage of the view of seeing photosynthesis and respiration in context.

Respiration of organisms: Base process of life

Questions: How can one show that something lives? Is there for instance life in branch pieces of shrubs in the winter time (Fig. 1)? Do plant roots live (Fig. 5)?
Material: 2 measuring cylinders 250 ml - Erlenmeyer flasks, 50 ml and 250 ml - Short test tubes – Drinking straw.
Chemicals: 1 L of saturated gypsum (calcium sulphate $CaSO_4$) solution coloured with bromthymol blue (0.1% in 20% ethanol) or phenolphthalein (1% in ethanol): Adjust the pH value with a NaOH-solution, c(NaOH) = 0,01 mol L^{-1}, in such a way that the colour change takes place immediately from yellow to blue or from red to colourless with minimal acid addition. Therefore solutions should be added drop by drop!

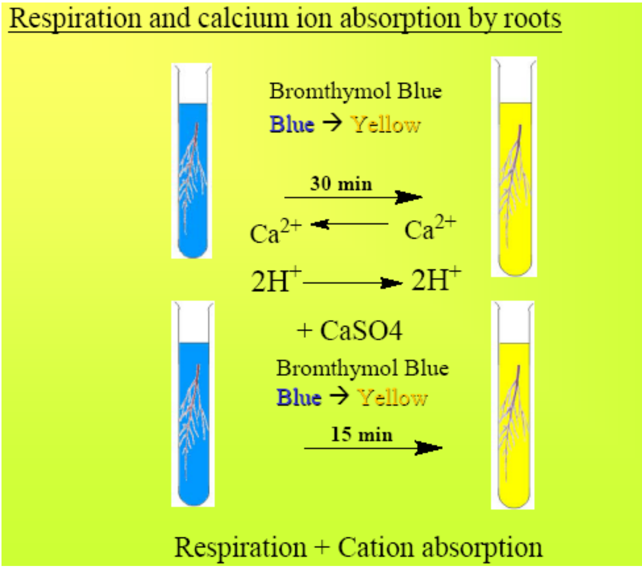


Figure 5. Roots: Respiration and cation exchange. Respiration of roots with and without the addition of gypsum $CaSO_4$.During respiration the pH value is decreased since carbonic acid CO_2 or H_2CO_3 is produced. This decrease is indicated by the change of the colour of the indicator. It is faster in the presence of $CaSO_4$.This is due to the exchange of Ca_2+-ions against H+-ions or protons by the plant roots

Test objects: Roots of the wild flower plants from gardens, tufts of grass, Petty Spurge (*Euphorbia peplus*) or Annual Mercury (*Mercurialis annua*). The plants are loosened with root with the help of a small grave shovel carefully from the ground and washed off afterwards with tap water. - Finger-long grey, brown or red branch pieces of Black Elder (*Sambucus nigra*), Red Dogwood (*Cornus sanguinea*) with crust pores (“lenticells”) as well as green branch pieces of Golden Bell (*Forsythia spp*.), Jews mantle (*Kerria japonica)*, Blackberry (*Rubus fruticosus*) or Rose (*Rosa spp.*) without crust pores (“lenticells”).

All branch pieces were well washed with tap-water before the experiment.
Procedure: The plants are given to the measuring cylinder filled with test solution with their roots. The branch pieces are also placed in test tubes with test solution. A measuring cylinder with test solution without plants serves as control. One also can place recognizably dead branch pieces or roots into the solutions for comparison.

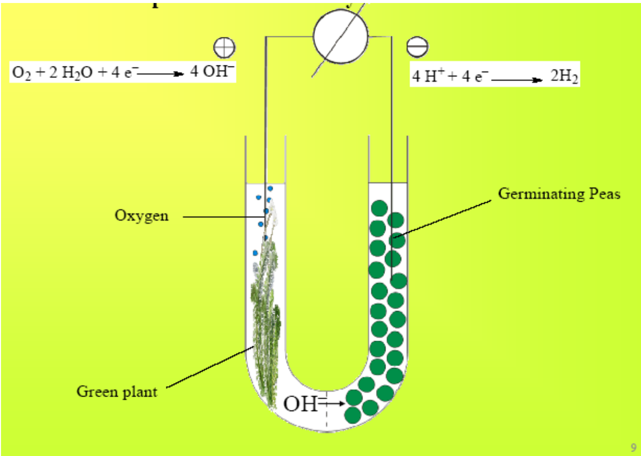


Figure 6. Photosynthesis and Respiration interconnected: Electric potential measurement. Experimental combination of photosynthesis (left) with respiration (right).Photosynthesizing water plants produce oxygen O_2 and respirating peas consume oxygen O_2. By this reason on the left side a plus pole and on the right side a minus pole is developed

The results with the branch pieces are noted in a table, where the colour of the branches, the occurrence of crust pores or “lenticells” and the time until colour change is registered. Subsequently, one can give the comparison solutions in Erlenmeyer flasks and blow with the help of a drinking straw carefully to exhaust bubbles into the solutions (Fig. 1).

Respiration and photosynthesis: A cycle as in nature

Question: Respiration and photosynthesis are the most important physiological life processes in nature. They are opposite running pathways, so that they can be joined to a cycle (Fig. 2). Thus oxidants (O_2) are consumed by respiration and set free again by photosynthesis. The opposite direction of both processes may be demonstrated by indicator changes or with the help of a potential measurement in the following experiment. How may be demonstrated in a model experiment based on the consumption and formation of oxidizing agents (oxygen O_2) that respiration and photosynthesis are included in a natural cycle (Fig. 6)?

Material: Voltmeter - Measuring clips (alligator clips) with cables - U-bend with porous glass -frit - Graphite electrodes - Lamp (200-250 Watts).
Chemicals: Sulphate - rich mineral water (mineral water).

Test objects: For respiration: germinated seeds, e.g. peas (*Pisum sativum*) in mineral waters or alternatively yeast suspension *(Saccharomyces cerevisiae*) in glucose solution (1%). For photosynthesis: Aquatic plant, e.g. Canadian waterweed (*Elodea* spp.) in mineral waters.
Procedure: Respiration is prepared in the left part of the U-bend, photosynthesis in the right part. Connect the voltmeter and note the voltage levels. After 10 min the photosynthesis is started by exposition with the light of a lamp.

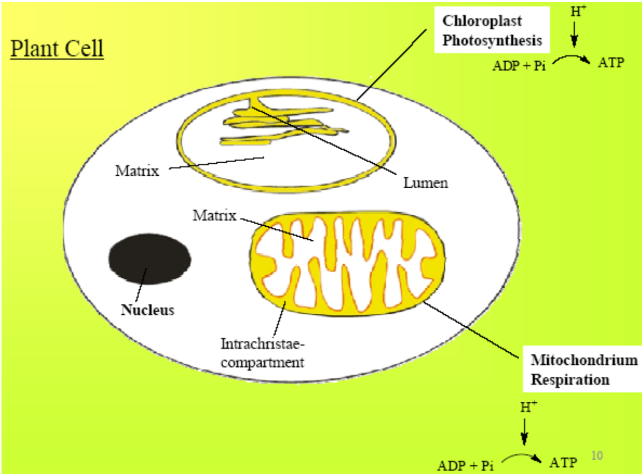


Figure 7. Chloroplasts and mitochondria: Compartments and ATP synthesis. Protons are pumped by the kinetic energy of the moved electrons into the gap between the two membranes (lumen of the thylacoids) in chloroplasts and in mitochondria and cannot be detected therefore in the external medium. This can be done with halobacteria. During the reflux of protons ATP is synthesized according to the chemiosmotic theory

Sun and life: light driven proton transport by halo bacteria

Question: Life needs necessarily energy of the sun. This energy is first taken up by plants. The primary step is the transformation of light energy into electric energy in certain biomembranes, which contain photoreceptors (e.g. chlorophyll). The moved electrons provide the operating proton pumps with energy. By this light-driven proton transport H^+-ions are transported outward into the surrounding medium. The resulting proton gradient at the external membranes is used to synthesize ATP (chemiosmosis). How can the light driven proton export in the external medium be experimentally demonstrated?
Material: pH value measuring instrument with electrode for automatic recording (e.g. Cassy system, pH box No. 524035, Leybold,Hürth,Germany) - 250 ml Erlenmeyer flasks – graduate measuring pipette 5 and 10 ml.
Chemicals: 1L saline solution, c(NaCl) = 4 mol L^{-1}.
Test objects: Suspension culture of halobacteria (*Halobacterium halobium*) in 4 mol L^{-1} solution of common salt NaCl or alternatively suspension culture of blue bacteria (blue-green “algae “, cyanobacteria) in tap - water. Procurement reference: One

may get Halobacteria from journeys to salt lakes (e.g. Dead Sea), but also from research institutes (look into the Internet).

Procedure: As much material is given with a pipette from the halobacteria stock culture to an Erlenmeyer flask filled with saline solution that straight all light is absorbed. The cells from halobacteria are illuminated with a lamp. The pH value is measured in the medium by an electrode connected with an instrument for graphical registration. The measured values are noted and the measuring curve is projected to the wall (Fig. 8).

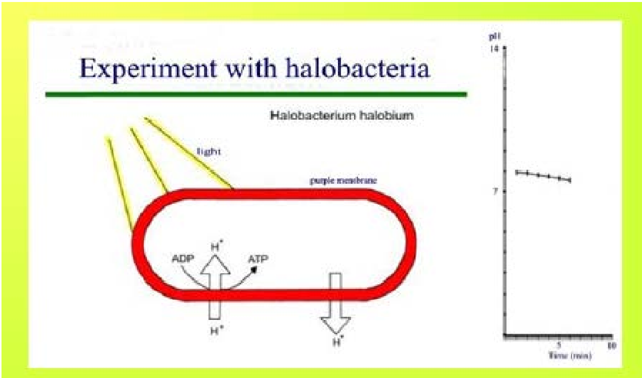


Figure 8. Halobacteria: Light driven proton transport. Under the effect of the light electrons are moved. With the kinetic energy of electrons protons are exported from the cells of the halobacteria (light - driven proton transport).Thus the concentration of hydrogen ions (H+-ions) rises in the medium and the pH value decreases. During the reflux of protons ATP is synthesized (left). The light driven proton transport in halobacteria corresponds to the light driven proton transport in chloroplasts in eukaryotic plants. The pH value drops slightly with illumination of the culture containing halobacteria in the course of 1 hour (right)

Results

Experiments

Respiration of organisms: Base process of life

Observation: Within 1 h, often already after approximately 20 min, it may be observed a clear colour change of blue to yellow with bromthymol blue and of red to colourless with phenolphthalein in direct proximity of the roots or the branch pieces. With the green branches (Jews mantle, Rose or Blackberry) the colour change takes place later than with branches with “lenticells”. The colour change is substantially faster, if one gives breathing air with a drinking straw to the solutions.

Explanation: In all cases acid is excreted over the surface by the living plant parts.

To a large extent this is due to carbonic acid or carbon dioxide, which is set free by the respiration. Additionally in the calcium sulphate solutions $Ca^{2}+$ -ions were exchanged against H+ - ions. Thus the colour change takes place more rapidly in solutions with calcium sulphate salt (Fig. 5).The green branches produce fewer carbon dioxide (CO_2) quantities than the branches with crust pores. Partially photosynthesis may compensate the respiration effect. The crust pores (“lenticells”) are to be interpreted as structures in connection with the respiration and the gas exchange (structure function relationships in biology). As respiration and ion exchange are physiological processes, these experiments are suitable for the demonstration of life phenomena. The experiment with the exhausted air bubbles points out the comparison of human respiration with the respiration of plants and underlines the importance of the respiration for all organisms including humans.

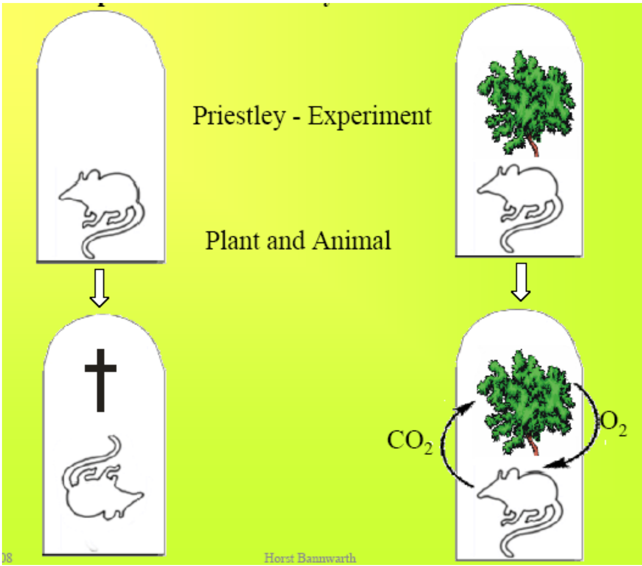


Figure 9. Priestley-experiment. Joseph Priestley (1733 - 1804) described the dependency of animal life from plant metabolism by simple experiments. This experiment is often used in schools for the introduction of the relationship of photosynthesis and respiration in order to clarify the dependency of heterotrophic animals and autotrophic plants from each other. The disadvantage of this approach according to Priestley is that this experiment cannot be carried out in schools. (see the text)

Respiration and photosynthesis: A cycle like in nature

Observation: An electric potential is to be determined between both sides, which increases due to the living processes of the participating organisms during the experiment. When photosynthesis is started a clearly stronger change of the measured electric potential is observed.

Explanation: The oxygen on both sides is differently used by the respiration. Therefore the output potential begins to change. When photosynthesis is started oxygen is produced, so that on the side of the photosynthesis a positive pole develops. In the respiration part the oxygen dissolved in the water is consumed. This may be the onset of fermentation and perhaps even reducing agents (H_2S, NH_3) may appear. Thus a negative pole forms. The changes of the potential are therefore direct consequences of physiological events. They are based on physiological processes such as oxygen consumption and oxygen production (Fig. 6).

Sun and life: light driven proton transport by halo bacteria

Observation: It is recognizable from the course of the curve that under illumination the pH value drops slightly within 1 hour.

Explanation: Under the influence of light electrons are moved (see solar - pocket calculators). With the kinetic energy of the electrons protons from the cells of the halobacteria are exported (light - driven proton transport).Thus the concentration of hydrogen ions (H^+-ions) rises in the medium and the pH value decreases (Fig. 8). It may be of interest to emphasize that the pH value in the external medium rises with the photosynthesis of eukaryotic green plants and algae in contrast to the situation of halobacteria because of the consumption of carbon dioxide or carbonic acid and other acids. On the other hand in eukaryotic plants the light driven proton transport in chloroplasts corresponds to the light driven proton transport in halobacteria. In chloroplasts the protons are pumped into the gap between the two membranes (lumen of the thylacoids) and therefore cannot be proven in the external medium.

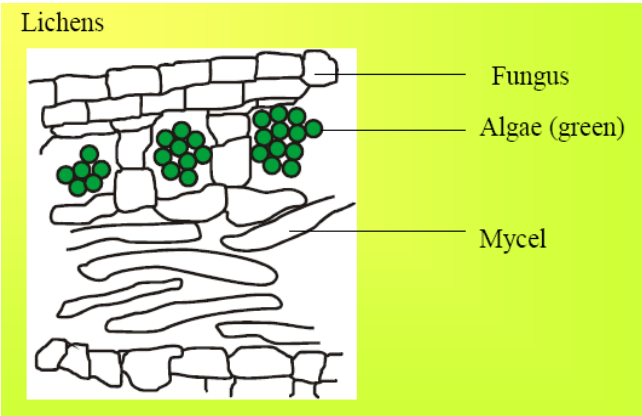


Figure 10. Lichens - symbiosis between alga and fungus. The heterotrophic organism in this case is the fungus which provides carbon dioxide and obtains vice versa oxygen and organic compounds from the autotrophic alga. The alga on the other hand is protected by the fungus by retaining water and keeping wet. Photosynthesis of algae and respiration of fungus are integrated in a living system

Discussion: comparison and combination

The relationship of photosynthesis and respiration is introduced in school books by the well known Priestley experiment (Fig. 9). Here a new approach arising from a direct observation on the living object is offered. The comparison of branches with and without crust pores and the colours of the epidermis lead to a better understanding of structure-function relationships of plant surfaces adapted to photosynthesis or respiration (Tab. 1). In most cases the green branches of shrubs did not have crust pores and in contrast to this observation crust pores occurred on brown, red or grey coloured branches. The conclusion is that green parts maintain photosynthesis and obtain the oxygen by this way and that the others get the oxygen through the crust pores from the air.

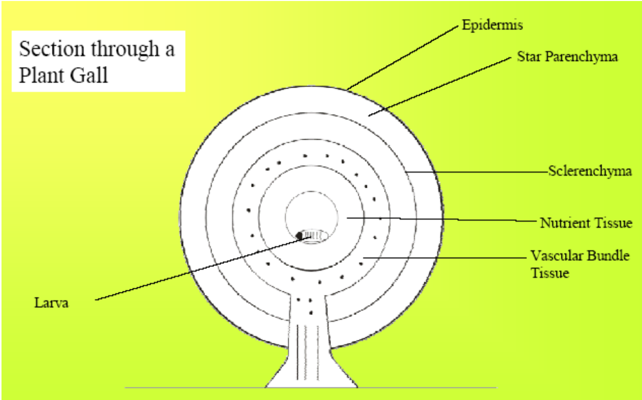


Figure 11. Plant galls - cooperating organisms. The advantage is clearly on the side of the insect larva. It is uncertain that the tree leaf profits from hosting the insect. But it should be emphasized that this is not a parasitic relationship because the insect larva does not normally damage the leaf of the tree. Moreover the plant offers all the animal needs for life and development. This situation is completely different from a parasitic relationship, especially since the plant supports and sustains the foreign animal organism and does not attack it. In this case plant photosynthesis and animal respiration are integrated in an emergent biological system

Object Bough	Bark Colour	Surface	Lenti-cells	Photosynthesis	Respiration
Forsythia	grey-brown		++		
Sambucus	grey		+		
Cornus	red		+		
Kerria	green		–		
Rosa	green		–		
Fargesia (Bamboo)	green		–		

Table1. Survey of properties of selected shrub branches with and without crust pores. The table demonstrates, that objects without crust pores have a green surface and should be able to perform photosynthesis and to produce oxygen O_2.The others which are not green show crust pores. In this case the oxygen is taken up by the pores from the surrounding air

The fact that respiration and photosynthesis are opposite physiological processes can be demonstrated by simple experiments with the indicator bromthymol blue (Fig. 3,4,5). In our hands it changes the colour from blue to yellow within 1 hour during respiration of whole plants or plant roots (Fig. 5). One can accelerate this

change by the addition of calcium sulphate $CaSO_4$ because of cation exchanges between the plant surface and the medium. The opposite colour change from yellow to blue occurs when plants perform photosynthesis (Fig. 4).
In addition to the use of indicators the electric potential between respirating peas and photosynthesizing aquatic plants (*Elodea canadensis*) was measured with a voltmeter. The oxygen consumption during respiration develops a minus (-) pole and the oxygen production during photosynthesis a plus (+) pole (Fig. 6).
The context of respiration and photosynthesis may be extended on the basis of other biological examples: respiration and photosynthesis in ecological systems (Fig. 2), in a plant cell (Fig. 7), in lichens (Fig. 10), in plant galls and in leafs of horse-chestnut (*Aesculus hippocastanum*) after infestation with larvae of the moth *Cameraria ohridella*. These examples show clearly the photosynthesis and respiration in context in addition to well known experiments with plants and other organisms [4-5].

Conclusions

Instructions about photosynthesis and respiration can be combined by simple experiments. By these experiments it could be clarified that both are opposite physiological processes. The idea of emergency in the modern natural sciences is promoted by the concept of regarding photosynthesis and respiration in context. Structure-function-relations of photosynthesis and respiration may be better understood by a common treatment. The inclusion of chemical and physical aspects into a new concept of emergence may favour the biological understanding.

References

[1] Bannwarth H and Kremer BP, Pflanzen in Aktion erleben, Baltmannsweiler: Schneider Verlag Hohengehren, 2008.
[2] Bannwarth H, Kremer BP and Vom Stoffaufbau zum Stoffwechsel, Baltmannsweiler: Schneider Verlag Hohengehren, 2007.
[3] Bannwarth H, Kremer BP and Schulz A, Basiswissen Physik, Chemie und Biochemie. Heidelberg: Springer Verlag, 2007.
[4] Beller J, Experimenting with plants Projects for Home, Garden and Classroom. New York: Arco Publishing, 1985.
[5] Prat R, Expérimentation en Biologie et Physiologie Végétale, Paris: Hermann Editeurs, 2007.

Paper presented at the 5th International Conference on “Hands on Science. Formal and Informal Science Education",
Olinda-Recife, Brazil, October 13 to 17, 2008.

Informal Learning at School. Science Fairs in Basic Schools

Esteves Z, Cabral A and Costa MFM

Introduction

Science Fairs are generally classified as cultural and pedagogical activities that involves all school communities, allowing public presentation of the scientific projects [1] developed by the students, the dialogue, the sharing and discussion of knowledge among students teachers and, hopefully, parents and the community. Work methodologies are developed, research performed, and the creativity of students but also teachers and visitors during the exposition, is explored [2,3]. Science fairs stimulate the construction of the scientific knowledge along the years, the exchange of ideas, work habits and knowledge [4].
However, the success of this kind of event didn't depend only on the effort of students but it is also necessary that they feel the support given by their teachers and parents. The help given by professionals of the scientific area in study might be very important during the development of the project and the preparation of the presentation [4]. However is important that this kind of support begins at home. Therefore, parents should be notified about the realization of the science fair as early as possible [5] and enrolled actively.
A good organization of the science fair is also necessary to make it a success. Therefore organizers should select the appropriate space for the number of participants and visitants that they expect [6], select dates and opening hours carefully [7] and make available materials and services if necessary [6]. If parents are notified sooner, certainly they don't mind to help in the organization, helping the organizing teachers [5,7] and so leave them with more time to support students with benefits also in terms of security and working rules [4].

Development of the project

On previous year project, the first science fair organized at school Externato Maria Auxiliadora was limited to students with ages between 12 and 15 years old (7^{th} to 9^{th} grades) and the scientific areas involved on projects were restricted to Physics and Chemistry. The participants and organizers' lack of experience led to some faults that one tried to remove in this second edition of the science fair.
The fair was advertised sooner by middle October 2007, and the deadline for

submission was 29th November. However, it was necessary to give more time in order to support the formation of groups, the choice of themes and the preparation of the projects. Trying to surpass these difficulties, it was established the end of the 2nd term (March) as deadline for the delivery of the projects. The realization of the fair was set for the beginning of the 3rd term (April), since them the students are not overloaded with works and tests, like it happened last year, and were able to give oneself up to the realization of the projects. The two weeks school' break that preceded the fair was very useful to finish the projects and to prepare the presentations. The proposed date for the fair seems to have been a good choice since the student/teacher interaction could be done in a daily base, and the students could practice their presentations and reinforce their scientific knowledge on the subject of their project. The time gap between the choice of the projects and the realization of the fair, also allowed teachers to check if the projects were feasible or not in terms of presentation at the available space, as well as checking the security conditions, making the students aware of the constraints. The gathering of information in this phase was essential for the subsequent distribution of the physical spaces in the fair. Another factor that contributed to the success of the science fair was the fact that, in the beginning of the year, parents were informed in a general meeting about the realization of this event, and of the importance the activity may have for the students in their learning/"growing" as well as of their active participation in the process. By the end of the 2nd term all parents were informed in writing about the fair date and were invited to attend and participate. Although this initiative was originated at the school's science departments, the Arts and Technological education department was also actively involved for some support on the construction of the fair mascot (Fig. 1) and also helped in some projects. Another pleasant surprise was the enthusiastic participation of the pre-school students, not only in the visit to the fair, but also in the preparation and presentation of two experiences.

Figure 1. Poster with the mascot of the science fair

Results and discussion

101 students (around 67% of the students of the school) participated in the fair. It is possible to see in Fig. 2 that there was a larger participation of the students of the 7th grade and bellow (ages between 10 and 13 years old).

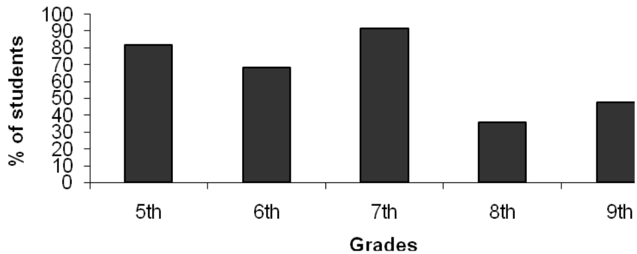


Figure 2. Percentage of students of different grades that participate on the science fair

The enthusiasm and great level of involvement of the new-coming students (last year fair only students from 7th to 9th grades participated) was obvious. It was remarkable the participation of more than 80% of the students of the 5th year, for whom this activity was completely new and that have a still limited contact with science subjects. We may conclude that it seems to be a good age to initiate them into projects of this extent. The enthusiasm in the participation in the process is very important. However it is of great importance the constant surveillance of the evolution of the students' participation in this type of events across the year (and in the subsequent years), creating work habits in the preparation and development of scientific projects, making sustainable this increased interest in science.

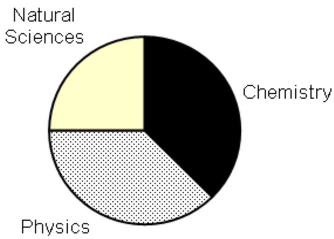


Figure 3. Distribution of the projects between the science fields

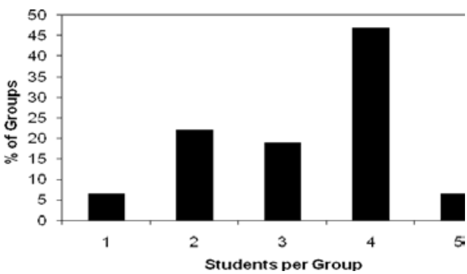


Figure 4. Distribution of students per group

One important aspect that we take into account is the fact that some elder students deliver their projects after the deadline or that disregarded the standards of security imposed. In some cases this lead to the non acceptation of some projects, as a way to emphasize the importance of responsibility, including in what concerns deadlines and security rules. This imposition also led to an improvement of the final products

in comparison to last years' fair.
Also important is the continuity of previous year projects, which is recommended in the literature [4]. Two of last year' projects were further developed and presented by the same groups this year. This fact would have interest, if the improvements were not only aesthetic, instead of scientific ones as it should be.
On Fig. 3, it is possible to see that the distribution of students by subject was homogeneous. These projects were classified in the respective areas take into account the theoretical basis. Among the 32 projects presented, 12 were approached in the Physics perspective, 12 of the Chemistry and 8 in the broader classification of Natural Sciences. This last area was a novelty regarding the previous year, when there were only projects of the areas of physics and chemistry. It seems that this difference can be related to two quite obvious reasons: the biggest involvement and support given by the teachers of natural sciences discipline, and the participation of students from 5^{th} and 6^{th} grades (authors of 5 from 8 projects on this natural sciences group). It is important to stress that, in spite of the homogeneity described previously, the students treated the subjects under rather varied perspectives, i.e. related to the environment, technology, everyday phenomenon explanation,... It was also interesting to see the variety of resources used to improve the quality of presentations, from common posters and dossiers, to reports and Gowin's V explored in the classrooms.
In terms of the number of students' which constituted each work group (Fig. 4), it was verified that around 47% of the projects were developed in groups of 4 students. On larger groups was found no major disparity in what concerns students' knowledge, and it can even be considered beneficial in someway since the students could take turns in the presentations, allowing them to visit other stands and see, and discuss, other projects.
Taking in account the projects development stage, the presentation clearness and the creativity, the jury had chosen five winning projects and, by vote, the students have chosen another. It was interesting to notice that the five selected works were developed by groups of students of the 5^{th}, 6^{th} and 7^{th} grades. This demonstrates the high quality of the projects of these students when compared to those elder students.
We considered, and will work accordingly, very important to check if this quality will be kept in the following years. We can conclude that science fairs are of great interest to schools and their students, since they give the opportunity to students to increase their knowledge in an autonomous way working hands-on. One can finally conclude that the improvement of sciences fairs in schools is dependent on the continuity of the activity, participation and involvement of whole school community, and, probably the most important point, the sharing of knowledge and experiences between teachers.

Future work

This project was awed to be of all school community interest. The continuity of the realization of science fairs is a way of curricular enrichment, and a way to increase not only the success in terms of student' learning of scientific subjects but also as the motivation, at larger, for learning. In addition science fairs are a way to enhance

students' responsibility and autonomy. In the following academic year the project will be developed within "Area de Projecto" classes (project classes), which will allow teachers to have a larger control of the whole process. It will be done an attempt to articulate the projects with other fields of study in interdisciplinary approaches. Another aspect to be improved in the following science fair will be a previous definition of the jury which will choose the winners of the initiative.
There is an intention to open the event to elementary school students of the same institution but organizing this "junior" fair in a different room. This initiative will allow studying the degree of involvement of these students, the quality of projects, the time spent and the number of participations, attitudinal and learning gains.

References

[1] http://portal.mec.gov.br/seb/index.php?opt ion=content&task=view&id=634&Itemid=650
[2] Mancuso R, Feiras de Ciências: produção estudantil, avaliação, consequência, Revista digital de Educacion e Nuevas Tecnologias, 2000.
[3] Abernathy T and Vineyard R, Academic Competitions in science: what are the rewards for students? The Clearing house, 74, 269-276, 2000.
[4] www.feiradeciencias.com.br
[5] Sumrall W, Nontradicional characteristics of a successful science fair project, Science Scope, 20-25, 2004.
[6] Rose J, Smith A, Um K and Demetrikopoulos M, Reverse your science fair with educational partnerships, Science Scope, 16-19, 2004.
[7] Science Fair Plus: Reinventing an Old Favorite, K8, NSTA press, 2003.

Paper presented at the 5th International Conference on "Hands on Science. Formal and Informal Science Education",
Olinda-Recife, Brazil, October 13 to 17, 2008.

New Ways to Learn Science with Enjoyment – Robotics as a Challenge

Ribeiro AF

Introduction

To bring up successful Engineers for the future, the teaching of science to youngsters is extremely important. Multidisciplinary and hands-on projects at early stages can enrich their skills and allow them to feel and experience the difficulties of a real challenge.

The development of Robotics is a good example of such projects. Amongst others, the main advantages for the students consist of acquiring knowledge in various areas such as electronics, programming, communications, mechanics, etc., the experience of working in group, the development of real physical prototypes built by themselves, and also the possibility of participating in robotics competitions with other teams and getting the possibility of comparing their work and discussing it with other people. Above all, this is easily become in the end, a rewarding learning experience. Many new teams are emerging and many others are willing to start this new challenge but sometimes they can find difficulties to start and to get information regarding robotics.

This paper tries to elucidate about the first steps and the first competitions to participate on. It does not describe all the robotics events worldwide due to lack of space but the ones that are most relevant.

Motivation

Many excuses are heard from some teachers not to start such challenge. This is not my field of knowledge – that is not an excuse because anyone can read and learn about the field, there are many introductory books, the level of understanding to build a junior robot is not very high, and above all it is possible to ask help to another teacher to get involved.

There is no budget for such a project – That is also not an excuse because most components are cheap and some others you can find at home. Even recycling is an option, since used motors and sensors from old devices can be used in such robots.

I will not be a team member because this is for youngster and I am too old – The experience of an adult is always important to guide youngsters. Also, teachers must

accept that they learn much with the students during these projects. Students are normally very creative and they integrate ideas from other projects building up unpredictable but working solutions, from which everyone can benefit.
Sometimes, it is the students who come up with the idea of building a robot and the teacher should not avoid their project. The teachers should help and support them. A motivated team is a group of people which will not create problems to the teacher and they become much friendly than before.
It is also important to point out that participating in competitions dignifies not just the team but above all the school which they belong too. When a team has the robot built, they can participate in competitions and the name of the school will be used.

Where to start

There are many robotics kits which you can buy off the shelf and build by yourself [1-8]. They come with a building manual and in the end you get a fully working robot, but just that. But, if you want to participate in competitions, you must bear in mind that each one has its own rules, regarding dimensions, autonomy, tasks to perform, type of sensors, etc. Therefore, you should first decide in which competitions you would like to participate and only then you decide the robot to build. Following, there is a brief description of the most important events on which you can participate.

First LEGO League (FLL)

The FIRST Lego League (FLL) is an international competition for young students (ages 9-16), organized annually by FIRST [9]. There are so many participants that, there they had to separate on local, regional and national competitions before the final which normally is held around April or May.
The contest focus a different science related topic, and the themes used so far were:

1999 – Mission of astronauts in a space station
2000 – A volcano eruption
2001 – The Arctic Impact
2002 – City sites related tasks
2003 – Mars rover mission
2004 – Problems related with disabled people
2005 – Ocean odyssey Marine tasks
2006 – Nanotechnology
2007 – Alternative energy
2008 – Climate of planet earth
2009 – Transportation
2010 – Biomedicine (still to come)

The scenario is completely built out of LEGO bricks and each team has to design a robot (also made of LEGO bricks only) to fulfil the required tasks, build the robot and program it. There are several tasks but these are normally very simple.

Figure 1. FLL Scenario (2004)

This is a LEGO based event, where participants need to buy a special robot based LEGO kit (one or more, depending on the desired degree of complexity).
There are two types on sale: LEGO MindStorms with RCX controller (first version) and a more recent version with the NXT controller [10]. The prices may vary depending on the countries but it will cost around about 200-300 Euros (each box). The box comes with hundreds of LEGO parts, manuals to build many robots, software to program them, proper cables to link the construction to your computer, etc.
The LEGO parts are standard and it is well known that everyone can build LEGOS, which makes the mechanical build up very easy. Then, the programming part is also very accessible because the software environment has a nice graphical user interface which works with objects that are very easy to program. The programming instructions are so simple that the box targets 11 years old kids.
More information about this league available on http://www.firstlegoleague.org/
The Eurobot [11] competition was first held in 1998, and started as a national competition in France but soon became an international amateur robotics contest open to teams of young people (school projects or private clubs). Participate on Eurobot students from secondary school up to university level. Mostly held in France this event was also organized in Switzerland, Italy, Germany, etc. The number of participating teams is over 200 (in France) and then the best three teams of each country get together in the final.
The main objective consists of building and programming a mobile robot to perform a certain task, different every year. The missions so far have been:

1998 – Football
1999 – Castles Attack
2000 – Fun Fair
2001 – Space Odyssey
2002 – Flying Billiards
2003 – Heads or Tails
2004 – Coconut Rugby
2005 – Bowling
2006 – Funny Golf
2007 – Robot Recycling Rally

2008 – Mission to Mars
2009 – Temple of Atlantis
2010 – Feed the World (still to come)

In this event, always compete two teams on the board, trying to eliminate each other. The winner continues on the competition and passes to the next round.

Figure 2. FLL LEGO robot - RCX controller 3.2 Eurobot

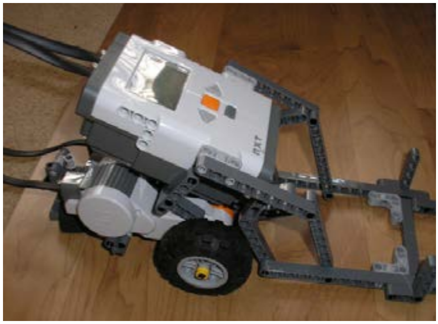


Figure 3. FLL LEGO robot - NXT controller

The budget to build a robot to participate on this challenge can be something between 3 or 4 hundred Euros, up to a couple of thousands, but one should bear in mind that it is highest budget that wins, but the team with more creativity.
The know-how required to build such a robot is relatively high.
Apart from the robotic competition, this is an amazing event gathering fun, high technology, friendship, creativity, education and passion. The environment is very friendly, with lots of activities for youngsters, parties, etc., and youngsters just love it. More information about this league is available on http://www.eurobot.org.

Figure 2. Eurobot official table

Eurobot

The Eurobot [11] competition was first held in 1998, and started as a national competition in France but soon became an international amateur robotics contest open to teams of young people (school projects or private clubs). Participate on

Eurobot students from secondary school up to university level. Mostly held in France this event was also organized in Switzerland, Italy, Germany, etc. The number of participating teams is over 200 (in France) and then the best three teams of each country get together in the final.
The main objective consists of building and programming a mobile robot to perform a certain task, different every year. The missions so far have been:

1998 - Football
1999 - Castles Attack
2000 - Fun Fair
2001 - Space Odyssey
2002 - Flying Billiards
2003 - Heads or Tails
2004 - Coconut Rugby
2005 - Bowling
2006 - Funny Golf
2007 - Robot Recycling Rally
2008 - Mission to Mars
2009 – Temple of Atlantis
2010 – Feed the World (still to come)

Micro-Rato (Micro-Mouse)

This robotics competition is a Portuguese event organized by the University of Aveiro and started in 1995 with his students [12]. It is a one day event held annually in May and consists of a 5m by 5m maze where the robots have to find the way out in the shortest time, guided by infrared sensors. The challenge is the same every year although a few minor changes are implemented.

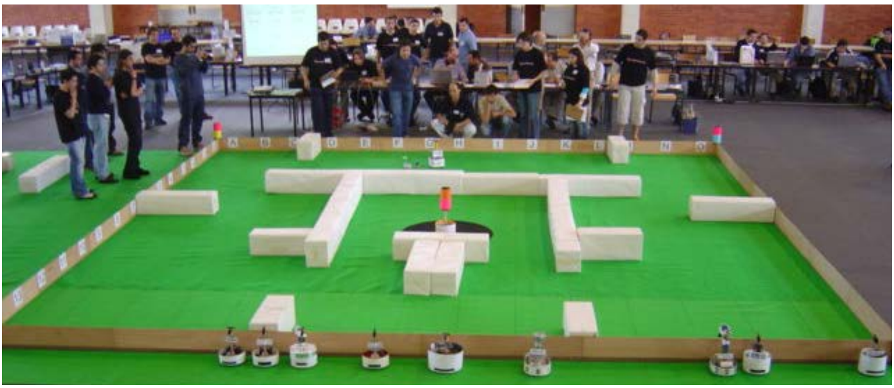


Figure 5. Competition Maze

Participate university students and in the last few years some secondary schools dared to participate and they are having good results. The complexity of this challenge is between the First LEGO League and the Eurobot. The number of participating teams rounds about 20. First a technical inspection is made on the robots, and then the teams participate on rounds. The best times go forward until the final. On each round 3 robots participate at the same time, so that they have to avoid collisions with each other. Rules are available on http://microrato.ua.pt/ (unfortunately, only on Portuguese). There is no standard robotic kit, and this challenge is more suitable for electronics students. The budget to build this type of robot can vary between 100 and 400 €.

Figure 6. Minho team Robot on Eurobot

Figure 7. Two robots built for Micro-Rato

RoboCup

Originally called as Robot World Cup Initiative, consists of an international research and education initiative [13]. The idea is to foster Artificial Intelligence and intelligent robotics research by providing a standard problem where wide range of technologies can be integrated and examined. The football was the main challenge. The idea is to build a team of autonomous robots able to play and win against a human team, by the year 2050. Soon other challenges appear, like the rescue league, the RoboCup@home league, and leagues for juniors.

This scientific challenge started in 1997 in Nagoya (Japan) and since then has been organized annually all around the world, being the next edition in 2010 in Singapore. The last edition received around about 200 participants from 35 countries. Due to the high number of teams willing to participate, each country has a national competition where the best teams are chosen. In Portugal, Robotica [14] is the official tournament and it is held annually in a different location. It started in 2001 in Guimarães and the next edition is in 2010 in Leiria/Batalha. There are three junior leagues [15] and these are described next: Football, Rescue and Dance. On each of these leagues there are two age groups: Primary goes up to 14 years old, and Secondary from 14 to 18 years old. The level of complexity of these robots can vary very much. Most teams can compete there.

Football or Soccer Junior

Each team has to build two robots able to play football in a green field (carpet). The ball used transmits infra-red signals in many directions so the robot can recognise it. The goals are coloured one in yellow and the other in blue. There is a human referee. The robots can be built using the LEGOS or built by the team members using traditional electronic components. Rules available on this webpage: http://www.robocupjunior.org

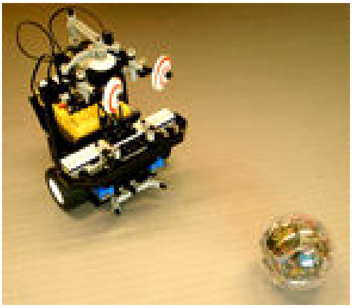


Figure 8. Football junior robot (Primary)

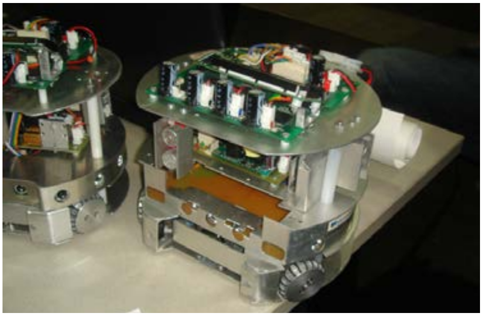


Figure 9. Football junior robot (Secondary)

Rescue Junior

On the Rescue league, the teams have to build one robot able to move in a two levels scenario which contains a black line on a white background, with some victims on the line (figures of man laying down) in two colours (green and gray).

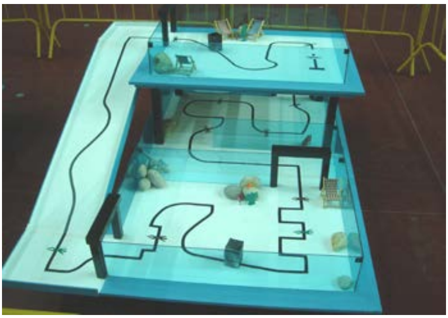


Figure 10. Rescue junior scenario

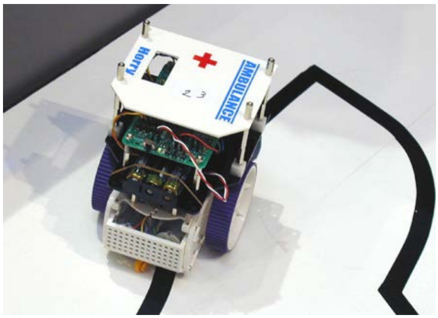


Figure 11. Rescue junior robot (Primary)

Figure 12. Rescue junior robot (Secondary)

Dance Junior

Figure 13. Dance junior robot (Primary)

Figure 14. Dance junior robot (Secondary)

This league gives students more creativity freedom. The main objective is to have robots performing in a stage with music. They are responsible for the robots build up, the choice of music and its choreography, as well as the robots dressing. The human team mates can also perform at the same time as the robots, during the two minutes total time. Some teams make robots dance, some others create bands, where the robots play music, some others perform a play with music as background, etc. A jury will award points regarding the robot build up, programming, robot and team members dressing, subject chosen, number and type of sensors used, number of false stars, etc… Rules available on http://www.robocupjunior.org.

RoboParty – Educational Event

All robotics events consist of competitions between students who build the robots at school or at home. RoboParty [16] has a different approach because the robots are built in the event. It is an annual event organized by the Automation and Robotics Group [17] of University of Minho [18] and by SAR – Soluções de Automação e Robótica [19]. They developed from scratch a robotic kit to be built by people with no knowledge at all in robotics and called it Robot Bot'n Roll ONE [1]. In this event students are taught how to build a robot, how to program a robot, and they can also participate on an optional small competition.

The main purpose is then to teach and not to compete. This is dedicated to those people who want to learn how to build a robot. Every year around February or March, 100 teams are accepted to participate on RoboParty which lasts for 3 consecutive days and it runs 24 hours a day. Teams are made up of 4 people (one adult and 3 youngster) ages between 10 years old and 19 years old. No one from the team needs to know anything about robotics, because there is a specially created training on the event to teach the first steps. In the last few years, some teams were made up of a family (mother, father and 2 kids).

The event consists of lecturing the basics of electronics (how to assemble an electronic board and they have to actually solder the components), mechanics (to build the structure), programming the micro-controller (to make the robot move). All these lectures were developed taking into consideration their age and lack of knowledge on robotics and therefore cartoons were used on the slides to explain simple basics. The teams is accompanied by some 50 volunteers (last year students of industrial electronics degree) in order to help them should some problem occur. In order to avoid an intense period of knowledge acquisition, extra activities also occur like horse riding, golf, tennis-table, football, woodball, basketball, cardio fitness, kick boxing, karate, yoga, indoor air modelling, circus activities, etc… Since so many participants came from so far, the organizing committee prepared 400 gymnasium mattresses and lay them down on the pavilion (parallel to the working area) where they can sleep. About half of them were so enthusiastic that did not sleep at all and continued working full night.

Figure 15. RoboParty training session

Figure 16. Participants assembling robots

In the last day, there are a few optional small competitions, where they can participate with the robot they built to test their capabilities. The competitions are:

- **Obstacles** – The robot is placed in a small maze and it has to come out without colliding with the walls.
- **Pursuing** - two robots are placed on a closed black line. Each robot has to follow the line until it catches the opponent.
- **Dance** – Each robot has 90 seconds to perform a dance. The choice of music and choreography is chosen by the team.
- **Engineering** – The robot is analysed by electronic engineers and they assess the quality of the build up.
- **Aesthetic** – The most beautiful and original robot is the winner.

Awards are given to the three best qualified teams on each of these competitions. There are also sports competitions in parallel and the winners also receive awards.
Each participating team brings a laptop computer and sleeping bags, and the receive at reception a box with all parts to build the robot, manuals, t-shirts, canteen tickets, badges, posters, a form to apply to the extra activities, etc. After the competition the robot belongs to the team (they can take it home). They also take home an official RoboParty diploma stating that they successfully built the robot. The organization also guaranties that all robots leave the event fully working.
As bottom line the participants learn and build robots, learn many areas of knowledge, met new people, got souvenirs, met the facilities at the University of Minho (including sport facilities), and take a robot home with them. The building rate

success has been over 95%. Some of these robotic platforms have been used in other robotic competitions (like RoboCup and Robótica) which means that the students continued developing the robots and improving the software to their needs.

Figure 17. Extra activities – Tennis table

Figure 18. Robots built on display

Main advices for beginners

For those teams who would like to start in these activities, a few advices are left here:

- **Robotic Kit** – Bot'n Roll (www.botnroll.com)
- **Events** – RoboParty (www.roboparty.org) RoboCup (www.robocup.org), www.robocupjunior.org
- **Books**
  - Robots - From Science Fiction To Technological Revolution, by Daniel Ichbiah
  - Robot Building for Beginners, by David Cook
  - Robot Builder's Bonanza, by Gordon McComb
  - Absolute Beginner's Guide to Building Robots, by Gareth Branwyn
  - Intermediate Robot Building, by David Cook
  - Robot Builder's Sourcebook, by Gordon McComb
- **Movies**
  - I, Robot
  - Robots
  - Wallie
  - 2010 space odyssey
- **Spaces -** Robotarium X, Alverca, Portugal

Conclusions

It is important for young students to start working with science and robotics due to its multidisciplinary. Mobile robotic competitions are important because students get very much involved on the subject, they work in group, they compare their work with other schools, etc. A competition is a good work form as it provides students a specific and stimulation goal. The projects are fun and stimulating so that the motivation and desire to make an effort in the course is high.

The main advantages in short term are that they participate in educational projects, students get more motivated to continue learning and they get competences in different scientific areas. In long term, probably more students decide to continue their studies (at University level), there will be more chances of blossoming technological companies, new technological solutions in civil areas, etc.
Participation on this kind of events is relevant not just for students but for teachers, not just because they can also learn but because the participating students are easier to teach.

Acknowledgements

The author would like to thank everyone in the Robotics Laboratory at University of Minho for all the support given in the organization of many events. A special thanks for all the staff at the SAR – Soluções de Automação e Robótica. All the organising committee and volunteers deserve the recognition of their work.

References

[1] http://www.botnroll.com
[2] http://www.lynxmotion.com
[3] https://www.electronickits.com/robotic-kits/
[4] http://www.trossenrobotics.com
[5] http://www.robotshop.com/ca/
[6] http://www.kitsusa.net/phpstore/index.php
[7] http://www.robotadvice.com
[8] http://www.active-robots.com/
[9] http://www.usfirst.org
[10] http://mindstorms.lego.com
[11] http://www.eurobot.org
[12] http://microrato.ua.pt
[13] http://www.robocup.org
[14] http://www.est.ipcb.pt/robotica2009
[15] http://rcj.robocup.org
[16] http://www.roboparty.org
[17] http://www.robotica.dei.uminho.pt
[18] http://www.uminho.pt
[19] http://www.sarobotica.pt

Paper presented at the 6th International Conference on "Hands on Science. Science for All: Quest for Excellence",
Ahmedabad, India, October 27 to 31, 2009.

Environmental Interpretation in Forest Urban in PUC Minas

Sanches-Diniz AC, da Rocha Afonso LP and Leite-Dutra JA

Introduction

The learning with play contact with the natural environment presents us the opportunity to break with ways to feel, think and drive our actions, with values sedimented by a routine that keeps us regarding our animal / natural: intuition, instinct, ability to deal with the unexpected, it all lost the daily urban environment. And being in nature breaks the force, negotiations and confrontations that lead to the construction of new readings on ourselves, our joys, our beliefs about who we are what we like and what we believe (Cassino, 1998).

The Earth gives clear signs of exhaustion due to the adverse impacts caused by human society that has been causing disharmony in nature, affecting the current quality of life and significantly compromising the survival of future generations.

Everyone must know that each one, each citizen is part of the whole and individual attitudes directly affect the environment and land that make up this planet a larger system that also interacts with other systems... Environmental education comes to rescue the positive relationship between man, nature and the universe, helping to develop an ethical awareness of all forms of life with whom we share this planet.

The consumer society needs to change their concepts about the nature, interacting with the environment positively and not just exploratory.

The taste for hiking and exploration in natural refuges always existed and people sought for this purpose trails in natural refuges. The groups were usually led by natives, local people, familiar with the route, pointing curiosities. These activities served as the basis for what is now called the Environmental Interpretation.

The term interpretation of the nature or environmental interpretation refers to a set of principles and techniques to encourage people to understand the environment by practical experience merge.

The basic goal of environmental interpretation is to reveal the meanings, relationships or natural phenomena through practical experience and means of interpretation, instead of a simple statement of facts and figures (Tilden, 1967).

The environmental interpretation includes the translation of technical language of a natural science to be understood by people in general, so interesting for the listener (Ham, 1992)

The objectives of the Environmental Interpretation are to facilitate the knowledge of nature in order to conserve its natural resources, historical and cultural, to achieve the satisfaction of visitors, adding value to the visitor experience, show the need for heritage conservation visited.

The visitor satisfaction is directly related to the new. The more you learn new things, his greatest satisfaction.

Thus, the form of mediation of content must be well done. Interpretations should be more provocative than explanatory, arousing curiosity in the participants, avoiding the implementation of content in long exposures. The visitor must be an active rather than passive.

The interpretation is characterized by informality and charm, the provocation stimulus, curiosity and reflection and the use of interactions, comparisons and analogies with real life experiences, covering topics relevant aspects often overlooked and / or seemingly insignificant.

Initiatives to environmental interpretation in forests are extremely important in process of changing paradigms, review, recovery and reversal of values, because the approach to environmental issues leads to reflections, giving each participant to review their posture facing the environment natural.

For residents of urban centres, trails in natural environments, may have the role of psychological recovery and diversification of activities, offering something different from the routine of work, study and consumption, promoting a closer relationship with nature.

Often the lack of alternatives is that prevents this approach and, according Boo, 1992, Takahashi, 1998, “this fact makes the demand for natural areas increase, especially among urban populations, who are seeking more contact with nature”.

People in cities do not have money or time to go to remote forests, in this way the interpretive activities in urban forests are an alternative to more contact with nature for these people.

Tilden, 1977, in his book “Interpreting Our Heritage”, underscores the importance of direct contact with the elements that are being interpreted through practical activities, in order to give participants a real ownership of the content and inserting each as part of the whole.

The area of this work, the "Forest of the PUC," is a fragment of 10 ha of seasonal semideciduous vegetation (plants lose some of their leaves during the dry season), inserted in a residential area and isolated from any other type of vegetation (Fig. 1).

This urban area has a good diversity of flora and fauna, habitat of several species of invertebrates and reptiles, with two species of mammals recorded, the possum-eared white (Didelphis albiventris) and the marmoset (Callithrix penicillata). The greatest diversity of species is the birdlife, as well-te-vi, soul-to-cat, and toucans, among others. The native vegetation is well preserved, with species such as cedar, alligator-wood, jatoba…

The forest of the PUC is frequently visited by students, such as access to campus officials. The forest is also frequented by school students and public visitors, led by educators, as complement the activities of the Education Program of the Museum of Natural Sciences PUC Minas.

Figura 1. Vista área da "Mata da PUC"

Figura 2. Entrada da Trilha Bem-Te-Vi

Methodology

The idea of environmental interpretation at the PUC Mata came up with bibliographic research on interpretation and environmental education and the need to improve the educational activities developed in the local tracks.

Then began the project "Implementation of the Forest Interpretive Trails PUC Minas, Campus Eucharistic Heart," which began in February 2009, with the main objective to plan and prepare scripts for interpreting the tracks of the Mata da PUC Minas.

There are several types of audiences that visit the Museum PUC Minas suggesting the construction of interpretative activities differentiated to meet children and adults, teachers and students, the elderly and disabled.

In the first stage of the project, which gave her between February and May 2009, the path chosen for implementation of the Interpretation was already used by educators in the museum activities, from then on called "Trail Bem-Te-Vi" due to the constant presence of this bird throughout the route.

Were defined themes and stopping points for organizing the work of educators. This paper describes the techniques, phrases and educational material for interpretation, such as plates, replicas and choice of natural elements to touch.

The proposal also includes ongoing evaluation of activities through questionnaires at the end of the trail, beyond the analysis of perceptions of visitors and educators.

There are many initiatives by the museum educators, to promote lectures, trail rides and other recreational or educational activities that result in better informed and well-being for visitors. However not all of these activities can be classified as Environmental Interpretation. These activities can be considered techniques and instruments that make up the approach of Environmental Interpretation.

The process of interpretation begins in 1957 with the philosopher Freeman Tilden, which considers the interpretation "educational activities, it disseminates meanings and inter-relations through the use of original objects, direct contact with the resource and the ways illustrative rather than simply communicate the literal information."

Thousands of naturalist, historians, archaeologists and specialists are engaged in the work of revealing, to such visitors as desire the service, something of the beauty and wonder, the inspiration and spiritual meaning that lie behind what the visitor can with his senses perceive. This function of the custodians of our treasures is called Interpretation (Tilden 1977: 10)

1) Any interpretation that does not somehow relate what is being displayed or described to something within the personality or experience of the visitor will be sterile.
2) Information, as such, is not interpretation. Interpretation is revelation based upon information. But they are entirely different things. However all interpretation includes information.
3) Interpretation is an art which combines many arts, whether the materials presented are scientific, historical or architectural. Any art is in some degree teachable.
4) The chief aim of interpretation is not instruction, but provocation.
5) Interpretation should aim to present a whole rather than a part, and must address itself to the whole man rather than any phase.
6) Interpretation addressed to children (say, up to the age of twelve) should not be a dilution of the presentation to adults, but should follow a fundamentally different approach. To be at its best it will require a separate programme.

Tilden (1977:9)

To maintain interest and attention, information needs to be presented in interesting and stimulating ways. Interpretation which is boring and monotonous, difficult to read, listen to or work out is not likely to attract much attention or hold an audience for long.
Sam Ham (1992) defines the qualities of effective communication as the PEROT principle. That is Enjoyable, Relevant, Organised and Thematic.

In “Manual de Introdução à Interpretação Ambiental” – Projeto Doces Matas – Minas Gerais (IEF/IBAMA/Fund Biodiversitas/GTZ. Outubro de 2002), “Environmental Interpretation is meaningful, relevant or irrelevant when we are able to relate its contents with something we already know or experience... because the information passing through our list of experiences and personal experiences, so finding, meaning.”

“Humans as a species instinctively pay greater attention to differences and changes. Any repetition will quickly lose visitor attention, and without attention it is difficult to create successful communication.”

Moscardo (1999:28)

In a provocative interpretation the interpreter invites visitors to reflect, ask questions and allows the theories are developed by the visitor, from their observations and perceptions.

“To be at its best it will require a separate programme.” (Tilden1977)

The "identity" of the interpretation is provided by the main message, according to some authors, is the main feature for an interpretation of good quality.
Studies on the capacity of the human shows that only five to nine ideas are treated

at the same time, yet the ideas follow a logical sequence. For an interpretation organized, "there must be a beginning, middle and end."

"The interpreter must prepare a presentation so that visitors can distinguish easily the main points."
"The interpretation should be interesting, pleasant, charming, hold public attention and entertain you. The media used must provide a non-formal atmosphere."
(Projeto Doces Matas – Manual de Introdução à Interpretação Ambiental. Minas Gerais, 2002)

The process for conducting an environmental interpretation of quality depends greatly on the interpreter and the way they communicate with the public. Some factors may compromise the quality of interpretation, such as reporting isolated, disconnected and the use of technical language, that for the general public, causes a certain distance. Moreover, the interpreter must allow freedom of the visitor, without influencing their perception, so that it (yet) has their own feelings and draw your own conclusions. The interpreter can still avoid the use of large text, with too much information, but without reducing it to undermine the content.
Below are the technical data of the Trail Bem-Te-Vi:

Extension: approximately 800 meters Level of difficulty: average time duration (with interpretative activity): approximately 1 hour. Input: area adjacent to the Museum PUC Minas (Fig. 2).
Audience: Community school, organized groups and visitors to the Museum PUC Minas in general**.**

Interpreting the Trail Bem-Te-Vi The topic is the general idea of the interpretative approach. The themes are the messages passed along the way, related to the topic. The topic set for interpretation of the Trail Bem-Te-Vi was the Environmental Conservation, and the themes covered are: characteristics of the fauna and flora, fauna versus local impacts (construction, deforestation, garbage), personal contributions to sustainability, sustainable activities in environmental natural.
Ways and Means interpretation techniques are the various resources used to accomplish the Environmental Interpretation. On the Trail Bem-Te-Vi were selected points, information boards and objects to touch.
Interpretative Points:

The visitor is invited to play in the tree (Fig. 3) and observe carefully, because its trunk resembles the hull of the alligator.
The natural process of nutrient cycling is shown in an area full of dry leaves.
"What we observed in these trees is that in the winter, the leaves change colour and fall. This phenomenon is natural life of these trees. This phenomenon helps reduce loss of water during the dry period. Visitors are invited to observe the trees (Fig. 4).

All are important in the vast web that is life. The web represents the links between

people, which are linked both by their positive attitudes, which help in conserving the environment, as the negative, that contribute to degradation. So it becomes essential to know the consequences of human intervention in environments, so that from the acquisition of consciousness, each one takes its importance in the transformation and reconstruction of an environment conducive to all forms of life. Small acts taken together can and do make a big difference.
The web of life is a dynamic normally used with the goal of integration between teams, through the exchange of knowledge and relationships between participants and, based on this principle, several adjustments are made according to the message you want to work with the group.
The dynamic "Web of Life" was adapted to work awareness of the need for change in attitudes and habits by encouraging a more positive relationship with nature, emphasizing the cultivation of respect in general.
Participants are invited to stay in a circle and say a positive action and a negative relationship with nature. With one end of the string held in the hand, throw the roll to another participant of the wheel, at random. The next person picks up the ball and, after winding the line on one finger, will repeat the same process as the guide. And so, the activity will continue until all of the group have been presented and described their attitudes. At the end of the activity there will be a kind of web formed inside the circle, where the wires are joined to each other. Participants perceive the interaction between all actions, both positive and negative with respect to nature. The reflection on the need for paradigm shift and attitudes is automatic at the end of the activity (Fig. 5).

Figura 3. The visitor is invited to play in the tree (Piptadenia gonoacantha)

Figure 4. Visitors are invited to observe the trees

Rappel were installed in some parts of the trail. This initiative provides plenty of adventure and fun and ends the activity with pleasure (Fig. 6).

Results and Discussion

The interpretation of the Trail Bem-Te-Vi was developed in May, June and July, with students and teachers in nursery and elementary schools, as well as spontaneous public who attend the museum, composed of families, youth and adults. Approximately 300 people visited the trail during this period.

In the July holidays the script was developed in Project Holiday at the Museum, with children of 04 and 09 years, with the presence of characters of Brazilian culture, such as "Caipora" and "India Mayara (Fig. 7-8). With the help of children, the characters addressed the environmental education, collecting the garbage from the forest and saving the animals of the hunter.

Figure 5. Dynamic web of life

Figure 6. Rappel - ending with adventure

Structures for the interpretive trail are being implemented gradually. Feeders were installed at strategic points to supply the fruit, which act as attractive to birds and the monkeys (Fig. 9).

The evaluative questionnaires were administered randomly at the end of each activity to at least 5% of the public who developed the trail. In general the trail, even with little infrastructure, was evaluated as satisfactory by the public. In evaluating the dynamic "Web of Life," 92% of the public interviewed considered that it contributes to awareness. The remaining 8% thought that it does not contribute (Diagram 1). 74% considered the trail in very good condition (Diagram 2). 95% considered the content being used as very good, and 5% rated it as good (Diagram 3). Of the respondents, 92% considered that the Interpretation has been educational (Diagram 4). In assessing the performance of the educator, 7% marked the item "regular" 10% "good" and 83% marked "excellent" (Diagram 5).

The development of the draft interpretation of the Trail Bem-Te-Vi helped in Environmental Education staff, reducing impacts before observed, such as garbage and unnecessary deforestation. It also encouraged the creation of the Revitalization of the Forest of PUC (in preparation), the responsibility of the Museum of Natural Science and the ICB (Institute of Biological Sciences) PUC Minas.

The project "Implementation of the Forest Interpretive Trails PUC Minas, Campus Eucharistic Heart" was proposed and performed by students of Biological Sciences at PUC Betim, Minas Gerais, Jesica Alves Leite Dutra and Lidia Poliana da Rocha Afonso, in the 1st half of 2009 by Discipline Bachelor Stage I, under the guidance of Professor Miguel Ângelo Andrade (Professor at PUC Betim and Coordinator of the Biological Sciences at PUC Minas), and Co-supervision of Ana Cristina Diniz Sanches (Division of Education - Museum).

Figure 7. "Índia Mayara"

Figure 8. "Caipora"

Figure 9. Feeders for birds

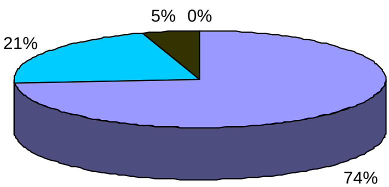


Diagram 1. Quality trail: excellent 74%, good 21%, passable 5%, bad 0%

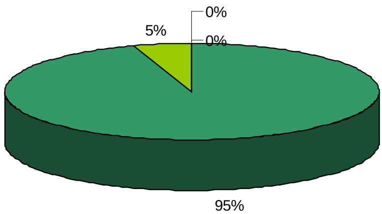


Diagram 2. Quality Content: excellent 95%, good 5%, passable 0%, bad 0%

The second phase of the project, underway since August 2009 is the construction of parts and development of interpretive script from a universal design, aimed at the accessibility of various groups, including the blind, wheelchair users and the elderly, promoting and encouraging interest in conservation. The trails are excellent tools for environmental education, stimulating the capacity for observation and reflection. The environmental interpretation is a way to bring men to rethink the way they see and feel the planet as a whole, from direct contact with the natural surroundings, revealing the everyday reality and rethinking their attitude.

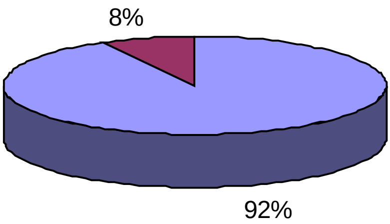


Diagram 3. Interpretation Educational: yes 92%, no 8%

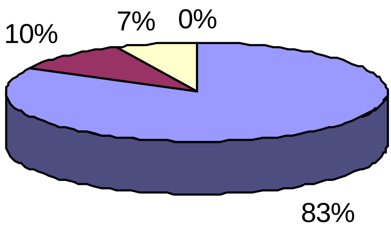


Diagram 4. Performance of the educator: excellent 83%, good 10%, passable 7%, bad 0%

References

[1] Boff L, Ecologia e espiritualidade, Meio Ambiente no século 21, Trigueiro A (Org.), Rio de Janeiro: Sextante, 2003.

[2] Capra F, Alfabetização Ecológica: desafio para a educação do século 21, Meio Ambiente no século 21, Trigueiro A (Org.), Rio de Janeiro: Sextante, 2003.

[3] 50 Coisas Simples que as Crianças podem fazer para Salvar a Terra. The Earth Works Groups, Ed. José Olympio, 2005.

[4] Dias GF, Educação Ambiental: princípios e práticas, São Paulo: Gaia, 1992.

[5] Diegues AC, O mito moderno da natureza intocada, São Paulo, 2002.

[6] Ferrari AD and Campos E, De que cor é o vento? Subsídios para ações educativo-culturais com deficientes visuais em museus, Prefeitura de Belo Horizonte, 2001.

[7] Feire P, Pedagogia da Autonomia, Saberes Necessários à Prática Educativa, 1996.

[8] Manual de Introdução à Interpretação Ambiental elaborado pelo Projeto Doces Matas, Minas Gerais: IEF/IBAMA/Fund Biodiversitas/GTZ, 2002.

[9] Marandino M, A Pesquisa Educacional e a Produção de Saberes nos Museus de Ciências, História, Ciências, Rio de Janeiro: Saúde-Manguinhos, 2002.

[10] O Pequeno Cientista Amador, Massarani L (Org.), Terra Incógnita, Casa da Ciência, 2005.

[11] Unidade de Políticas Públicas, Município Acessível ao Cidadão, Romeiro de Almeida Prado A (Coor.), São Paulo, 2001.

[12] Vasconcellos JNO, Educação e Interpretação Ambiental em Unidades de Conservação, Paraná: Fundação O Boticário, 2006.

Paper presented at the 6th International Conference on “Hands on Science. Science for All: Quest for Excellence",
Ahmedabad, India, October 27 to 31, 2009.

Support Material for in-School Hands-on Experiments

Rangachar B

An NGO perspective

This Paper is written with an NGO perspective at the grassroots level. Our scale of operation is small with 40 plus schools, but our involvement in the last ten years working with Government schools in and around Bangalore and in the interiors has been at a very deep level. At CLT, our work has involved working with one government school with 1,000 children in semi-rural area for 5 years where we provide e-support. An After-school Centre – Intel Computer Clubhouse at CLT- consists of kids from 5-6 villages where technology is central, and approach to learning is exploratory, peer-peer, self-directed, constructivist and mentor-driven. Currently, CLT is engaged in building e-content repository in English and Kannada for State Board syllabus and is being used in 40 government schools, 3 English medium private schools with State Board syllabus, and one non-formal school for construction workers' children.

Scope for alternative education

In this article, the author explores the missed opportunities for learning in the resource-starved rural Elementary Schools in India and the challenges teachers face in a given day.

It also puts forth arguments that support the need for Alternative Education- as early as Elementary Education- and how Education through Technology can play a role in tackling some looming issues in rural schools in India.

As it is generally understood, Alternative education has a role to play wherever and whenever schools and communities can not fulfil their commitment to give a conducive learning environment for their kids.

That could be for various reasons– schools not nearby or just a shell for a school; teachers with multiple classes, teachers not qualified or no teachers for many periods, as commonly seen. As a matter of fact, teachers are not appointed for each grade; it is by number of students [1].

The smaller the village the more chances are there that an entire school of 6 grades has less than 40 kids and the school is not eligible for more than one teacher. Even schools having extra classrooms, combine all grades in one room, with the teacher juggling between assignments on different Black Boards.

Figure 1. Resource-starved classroom, teacher absenteeism and combined classrooms

Percentage of single-classroom schools by category: 2005-2006					
School Category	Number of Classrooms				
	All Schools/ All Areas	Rural Areas	Urban Areas	All Government Schools	All Private Schools
a)	13.52	14.13	7.29	14.56	4.25
a), b)	1.78	1.95	1.05	2.02	1.09
a), b), c)	1.09	1.25	0.82	1.65	0.72
b)	3.31	3.44	2.10	3.35	3.15
b), c)	0.91	1.07	0.44	1.21	0.53
d), e)	**9.54**	**10.37**	**3.99**	**11.04**	**2.43**
d) (2004-05)	10.39	11.33	4.45	11.78	2.62
d) (2003-04)	10.94	11.86	4.96	12.24	2.62
d) (2002-03)	12.08	13.05	5.82	13.35	2.51

Table 1. Single classroom statistics: a) Primary, b) Upper Primary, c) Secondary/Hr. Secondary, d) All Schools, e) All Areas

The strategies for achieving Universal Primary Education with the expansion of enrolment and gender parity have been successful. However, with regard to the retention and survival rate to the last grade to complete elementary education is around 60% and the quality of education is till an issue [2]. The World Education Forum in 2000 emphasized and set goals for Education for All and The Right to Learn with a commitment to expanding learning opportunities for everyone. In the context of India, where two thirds of the population lives in villages, it is seemingly more challenging to attain the Millennium Development Goals without giving access to the opportunities. While schools need to be upgraded without a doubt, they can not be the only platform for the diverse educational needs of the rural population. The time is ripe, as other researches recommend, for several strategies to come together for a flexible amalgam of formal, informal and non-formal approaches to provide e-strategies to support rural education in India [3].

Education technology

We have learnt from our own experience of working with rural government schools, and other supporting research, that the remoteness of schools greatly affects quality of education and that the relative change Educational Technology would make is far greater at the bottom of the pyramid, thus supporting the argument that

“ET should reach the under-privileged first and not the other way around [4].
Remoteness generally implies that the schools are in the interiors and are insulated in many ways without the access to opportunities. On the other hand, it could also include communities that may not be in the interiors, but are excluded from the opportunities that ‘good schools’ offer.

Figure 2. Teacher-mediation

Figure 3. Video capture of teaching

This Paper is based on our work at CLT Resource Centre, a hub that draws teachers from all disciplines to share their best practices. The multi-media content with video-based recordings make its way to spoke schools as DVDs under the banner CLT e-Patashale.
Here, e-support content is intended to be absorbed in 3-4 ways as the situation demands; as a support tool for teacher-mediation; as filler where the teacher might not have in-depth subject-expertise or for a substitute teacher; kids facilitating a e-lesson during teachers’ absence.
The point in case is about inculcating scientific and technological temper for the main-stream schools with the limitations the system has at present. What does the current environment offer? Kids are the passive recipients of information in a directed or controlled space where the communication is dictated by outdated practices of exchange of information from the textbook to the blackboard to the kids’ note books. If time permits, repeat everything in a chorus.

Capturing the teaching moment

A good teacher doing a Science lesson relating to familiar things and situations, with hands-on experiments with locally available materials, virtual though it might be, seems to be the next best thing to a good teacher in a good school with appropriate resources. As the situation warrants, support materials in the form of customized lessons with value additions, teacher-aids, experiments, live-recorded lessons by good teachers could fill the lacunae and bridge the divide that the remote schools face. I would like to add that a special emphasis is placed for CLT e-Patashale Science content to ‘capture the teaching moment’. The process is about exposing best practices of inquiry-based, activity-based, applied learning through live video-captures as opposed to only graphics-design templates driving a Science lesson.
Out of the 40 schools that have the CLT e-Patashale content for more than a year,

five schools were observed for a period of 16 weeks, specifically for the Science content.

Figure 4. Transfer of heat

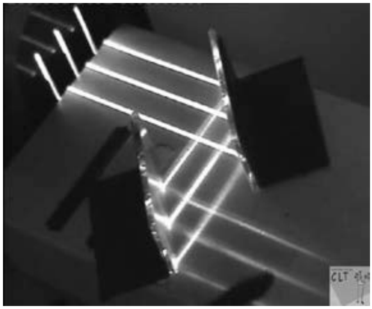


Figure 5. Reflection of light

All teachers had 10 years of formal education with an additional 2 years of teachers training, except for one teacher with a college degree who hoped to get transferred to a High School. Four of the five schools were rural, while one was in semi-rural area. None of the teachers lived close to the villages and some had to travel 2 hours by bus to reach the school. Hence there were some culturally accepted delays.

Our learning

Initially, when we first introduced ET, we were met with the same dialogue as most would with technology – an external foreign element that needed to be dealt with special training and time-slots etc. Almost none of the teachers did any mediation between technology and black-board due to the discomfort in switching gears from technology-aided teaching to delivery. They would use it as one special class during the week. Later, when the format of our content changed to suit their needs better with easy navigation and localization -it was also broken down to many small components giving flexibility for mediation - they gained more confidence to integrate with their teaching. It was generally used as supplementary material after the initial black-board writing in 2 schools. They also liked the images and voice-overs and said that it made it easy to understand the concepts. 2 other schools used it as filler as they found Science too challenging to teach. However, one teacher that had a Science degree was ambitious enough to try a few experiments himself. Although he didn't want to be teaching in Elementary Schools forever, being more qualified than the rest of the teachers with a Science degree, he made many trips to CLT Resource Centre asking for more experiments.
Yet, it is not to say that these Science experiments are being experienced by all the children in hands-on fashion. However, it changed the classroom dynamics with teachers exhibiting more confidence to engage children with queries; they were facing the children more and the blackboard less, thus making themselves little more accessible to children. Kids were more animated as they were engaged. Teachers would Pause and add their comments to the video experiments. Kids

would watch the experiments that were very doable, in some cases, with a lot of interest.
Few months back, we converted all the DVDs to be played on TV/DVD, as well.
Other unrelated observations - Couple of teachers that had kids in elementary schools in small private schools wanted an extra set of copy to take home. During our observation, we saw a teacher writing something on the Black Board and realized that she had an error with the facts after watching the e-lesson. She then went back to the Board and corrected herself.
Some risk factors were stolen PCs – 3 out of 30 schools had PCs missing and teachers' reasons were less than convincing.

Conclusion

In our observations at the After-School Computer Clubhouse, we find that children are naturally drawn to Science and Technology without knowing what it is called! They find it fun when they are engaged - hands-on. They tune out the monotone voice of a teacher coming at them at some point. It is about applied-learning, constructivist, peer-to-peer, collaborative, on their own, doing mistakes, correcting themselves etc. Teacher's role should be only to get their curiosity going to find out more about it by themselves and gradually, 'teachers' evolving to becoming 'Mentors'!
We have a while to go before breaking away from set patterns, especially in rural schools. In the interim, can we create other layers of support for the main stream schools? Although our content is more of an anchor, guide, resources and a teacher's support tool for many, few motivated teachers can emulate certain practices or do good mediation between technology and blackboard to make their teaching more effective.
A few days back, a friend who is educated and has his children in high-end private schools mused, "I wonder though what children gravitate towards if left on their own -on the web - it seems to be music, games..., art? My kids are influenced by peers and play Disney website games, I guess some may even read up on Science, maybe very few. My only question is that kids may not go towards learning, what is required to pass the exams or specific disciplines like math and science-which are required whether we like it or not for passing exams."
Could it be that that we don't apply our knowledge about how children learn naturally and build it into their everyday teaching/learning-hours? Left to themselves with things to explore, kids are continuously learning. Sugata Mitra has left us with a fascinating observation in one of his recent talks that learning is a Self-organizing system and parts of elementary education can happen on its' own!
Hopefully, this argument could lead us all to explore to come up with alternatives for newer vista in education with a special focus to foster Scientific and Technological temper!

Acknowledgement

We are very grateful to Prof D.R.Baluragi for his outstanding commitment and contribution towards development of activity-based science content with hands-on approach.

References

[1] Pratham Foundation, http://www.pratham.org
[2] Future policy choices for education sector in Asia by Shailaja Fennell, http://www.eldis.org/vfile/upload/1/document/0708/doc21182.pdf
[3] Kumar Misra P, E-strategies to support rural education in India, by Educational Media International, 43: 2, 165-179, 2006.
[4] Sugata Mitra - Lift Conference, http://liftconference.com/people/sugata-mitra

Paper presented at the 6th International Conference on “Hands on Science.
Science for All: Quest for Excellence",
Ahmedabad, India, October 27 to 31, 2009.

The Creation and the Creator: A Rewarding Experience in a Functional Neuroanatomy Teaching Course

Nogueira MI, Allemandi W, Chirosa-Horie CA,
Sitamoto C and Sitamoto S

Introduction

Teaching in anatomy as well as in related disciplines has been improved with more detailed knowledge of the body, of its macro- and microstructures, and the availability of such new resources as multimedia, computational equipment and programs. The increasing number of publications and events dedicated to the subject confirms this dynamic [1-2]. These efforts reflect the dedication and enthusiasm of committed professionals convinced of their ideals, and has thus influenced the conclusion that basic education is as fundamental as is research for the sense of nationhood of a people and country.

Individual efforts have been made to minimize the lack of necessary investment in education, and in both human and material resources [3]. The emphasis has been to strengthen pure research and the educational polices of many institutions have served to amplify the imbalance between research and education, especially where the professional has to shine in both activities, and besides administrative tasks as well. Some subjects, like Anatomy, face even additional difficulties [4].

Not only the educators but also the institutions recognize that even though many students have a natural motivation and even excitement at the possibility of handling and exploring anatomic material, still others are apprehensive and concerned about fixatives' smell, appearance of the corpses and presumed health risks. Actually, without proper warn and adherence to necessary security precautions, those risks might indeed become real. On the other hand, the specificity of some school program also promote disappointment to some students not complete aware of their choice Another source of concern might be the presence of this discipline in the first semesters of college, when students are beginning their lives at the university. This period represents for many of them the revealing of challenging possibilities and a traditional independence. These changes taken together with the absence of a direct or indirect tutor might promote concern and distraction. In addition, the students' erroneous impression that learning anatomy is limited to memorizing endless lists of names must be

challenged.
In this scenario, goodwill and the right attitude might be decisively significant in overcoming or minimizing difficulties, attracting and getting the students engaged. Willing to try new approaches, we adopted many interactive procedures illustrating the vital compromise between form and function in the body's structures. In tandem with this, we decided to explore the creativity of the students asking them to plan and construct 3D models of the nervous system.

Figure 1. Collection of the different 3D models of the Central Nervous System produced. The mostly used materials was porcelain Doug (biscuit), strings, plastic tubes, glass bowl filled with gelatine (eye with nerves and muscles)

Material and Methods

Students registered in the courses of Speech, Audiology, Physiotherapy and Occupational Therapy, enrolled in our discipline of Neuroanatomy (one semester long) were challenged to be creators. The innovation we introduced consisted of requesting those groups, formed by three or four students, elaborate two three-dimensional anatomic models; one a general model of the central nervous system and the other specifically related to their area of interest. Their creativity was encouraged through their choice of the anatomic region or structure of the nervous systems to model. It was also required in their selection of the materials to be used. The construction of the model would have to reflect the anatomical and topographical relations and proportions of the human bodies, according to a selected biotype. This proposal aimed to offer an opportunity to the students to apply the knowledge obtained in theoretical lectures and practices, to the task of configuring and constructing the 3D models. This activity, besides demanding attention to the spatial organization of the body, emphasized anatomic and functional differences, intra-specific and gender variability, and also pathologic alterations. The proposal was received with the usual enthusiasm and receptivity displayed by students. The appraisal of the completed models was scheduled for the end-of-term, through a presentation in front of the whole class, when not only the presentation but also the fulfilment of the required topics and the quality of the model would be considered.

Results

We were positively impressed at the creativity and dedication reflected in the models. The beauty, diversity of form and richness of details enchanted both the experts and laity involved with the subject. The materials used were the most diverse; wool, electric strings, wires, wood, nails, hangers, fabric, paper, cardboard, plastic, hand moulded material, gelatine, glue along with others. For example, among the produced models there were an anatomic brain atlas made with superposition of transparencies, and an animation program of neuroanatomy for PC computer (Fig. 1-6).

Figure 2. 3D models of the Nervous system. A. Spinal nerves of the arm represented by strings of wool attached to nails in a wood plate. B. Woman body depicting the central nervous system and at the left side different spinal nerves and respective dermatomes, produced with biscuit and cardboard

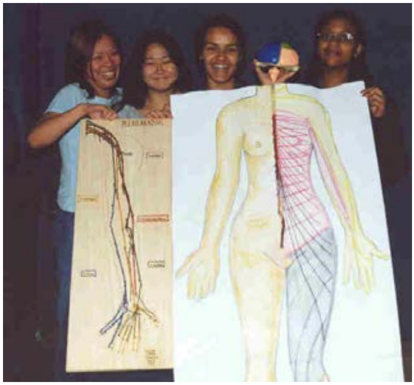


Figure 3. Afferent nerve fibbers passing through the various levels of the Central nervous system. Strings and cardboard drawings were used

The enthusiasm these models aroused among colleagues from others disciplines encouraged us to prepare the first exposition. In this particular instance we felt attracted by the opportunity to recall and reinforce the following aspects: the history of the anatomy, its social, artistic and scientific importance, but also, specifically to illustrate to the students that: the manifestation of creativity in its various forms is essential to the accomplishment of the continuous exercise of living at the professional and personal activities.

This first exhibition was mounted at the library of the Institute of Ciências Biomédicas of the Universidade de Sao Paulo (Brazil), as part of the library's annual commemorations week. An explanatory card with a clarifying text was developed to accompany each model displayed. The written information consisted of the title, the objectives and significance of each model, a list of the materials used as well as the name of the students and their basic specialization. An oversized poster explaining the origins and development of this experience was added to the exhibition as a whole. This poster summarized the history and scientific importance of the anatomy and neurosciences.

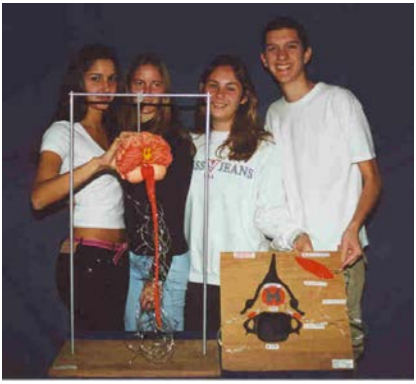


Figure 4. 3D models of the Nervous system. A. Central nervous system produced with biscuit and plastic tubes hanging in a metallic support. B. Model of a spinal cord inside a vertebra, illustrating a muscle reflex, the same material as model A was used

Figure 5. 3D model of the Nervous system inside a plastic doll. A. Dermatomes drawings at the anterior surface and B. inside representation with electric strings of the spinal nerves at the right side of the body attached to the central nervous system made of biscuit

Among the many positive comments related to the exhibition, we point out the observation of one professor on the model of the upper member. This model was built up over a wood plate, in which wool strings of different colours and nails were used to represent the contours of the arm, forearm and the hand, depicting their respective innervations in different levels of depth (Fig. 2A) according to the height of the string as attached to the nail. The professor found very interesting and didactic the resource promoted by this model, because it made so easy to visualize the effects of an anesthetic on a certain area in relation to the point of its injection.

The repercussion of the exhibition performed at the library and the enthusiasm of the participants and visitors, encouraged us to register it in the VI Exhibition of Material for Science Teaching and Social Inclusion, a symposium of the Estação Ciência of the Universidade de Sao Paulo, The Science Museum. Once accepted for registration, the models and their explanatory texts and poster were exhibited for five days (Fig. 7-8). Undergraduate students and some of the post-graduate students of the Anatomy's program took alternating turns as volunteer monitors to explain the objectives and details of the models.

The low cost, beauty, functionality of the models along their didactic possibilities made a very good impression on teachers and students of the primary and high school levels. A similar exhibition was requested by the Institute of Psychology, Program of Neuroscience, at the beginning of the classes of that year. This last one deserved a special report at the newspaper of the university "Jornal da USP" nominated "Nerves of string". Later, this same exhibition was installed at the Institute Biomedical Sciences to the arriving students in general. Part of it, was also at the internet in the site of the Section Culture and Extension Program, for some time, it was relatively well consulted, and was also reached by the Google site. Most students report at the end of the semester they never had so much fun and leaned so enthusiastically, what was confirmed by their grades which median was 40%

higher when compared to the students of the previous course.

Figure 6. 3D model of the muscle spindle reflex, representation with the central nervous system. Strings and biscuit were used and a raincoat hanger

Figure 7. Stand with the models at the VI Exhibition of Material for Science Teaching and Social Inclusion "ICB / USP" – Estação Ciência

Discussion

The knowledge of human anatomy is indispensable to the exercise of professionals in the area of health and physical activities. It requires a basic code, as the alphabet, say, of some basic structures from which others are derived, obeying topographic and functional relationships. This understanding is accomplished with the comprehension of the specific relations pertaining to the different components of the human body [5]. Aristoteles (384-322 AD), considered the first comparative anatomist, identified the human being as the most complex animal, recognizing that the diversity of forms results from the variable potential of each organism to explore the environment. Approximately 500 years later the Greek physician, Galeno of Pergamon (living in Rom, second century AD), in recognizing the preponderance of the function over the shape, achieved contributions that lasted for more than 11 centuries, period of the decline of the roman kingdom [6]. Thus, these contributions established the influence of the environment and its function on the shape and architecture of the body [6-7]. Aspects we planned the students to understand through the constructions of 3D models observing the structural relationships and proportions in the human body.

However, art and science exert a crucial role in awaked creativity that should not be ignored. Which would be the relations among: Anatomy, Art and Science?

Let's rescue some history; in the Renaissance, the artists habitually studied the human body in detail, to better reproduce it. According to that movement, art is a creation of the intelligent linkage of conception and observation. Thus art is under the rule of perfection that might be conquered even formulated to be taught with precision [6]. A splendid result of genius and rigor of representation of human body is the artistic work of Michelangelo Buonarroti "The Creation of Adam" (part of the ceiling of the Sistine Chapel, at the Saint Peter's Basilica, Rome).

A contemporaneous important renovation at the academic-scientific environment was promoted by Andreas Vesalius, physician considered the founder of the modern anatomy. Vesalius, against the principles of the Catholic Church, studied and taught through dissecting corpses. One of his important contributions is the awesome book “De Humani Corporis Fabrica” (1543), illustrating in different planes and positions, the various parts of the human body, which until that time was bare and many times erroneously represented. The title of the exhibitions we performed was a reference to the splendid Michelangelo’s work referred to, and the creative process experienced by the students, reaffirming and illustrating the audacious contribution of Vesalius.

Figure 8. Part of the student team working as volunteer to present the models at the VI Exhibition of Material for Science Teaching and Social Inclusion. At the right we see Prof. E.Hamburger, Director of the Estação Ciência, using glasses, and at the center C.Mattos, Director of events of the same Science Museum

At this point, one might be curious about neuronatomy, its origins, the evolution of the nervous system and its role as science. The phylogenetic aspects of the nervous system were considered by Charles Darwin (1809-1882), with his contemporary Thomaz Laycock (1812-1876) referring to the phylogenetic scale emphasized in the encefalization process the organic basis for the gradual substitution of simple vital process, by the instinct and from this by the mental faculty.

The higher complexity of the encephalization is observed in the human being, and it is evident in arts and science as an expression of mental power. The integrated and plastic ability of the nervous system deriving from its hierarchical functioning was identified by Herbert Spencer, 1855, when he established that in the CNS, new structures or layers were superimposed to attend the demand of exploration of diverse environments [6-8].

Among other considerable landmarks, the origin of the neurosciences is attributed, at the beginning of the XIX century, to the German Ludwig Edinger and to the American brothers Clarence and Charles Herrick, whose works acknowledge that the complexity of the CNS was achieved by the addition of new elements (forebrain)

over one basic structure, phylogenetically ancient, related to the vital functions (the brainstem) [6].
The end of the century XX presented a considerable evolution in the amount of information related to the nervous system concerning its organization, connections, and mechanisms of action, cognitive and behavioural process, among many other aspects. The years 1990-2000 were nominated “The Brain Decade” due to the amount and the quality of research accomplished [9]. Nevertheless, challenges still remain; provoking our minds, depicting that there is much more to be explored.
Working with the students on their feelings and the impression left with “lay people” it became easy to them realize how frequently the acquired knowledge might be classified as banal or trivial. That is, in the workday environment where it was generated; but when considered alongside diverse cultural backgrounds its importance stands out [10-11].
The student’s oral presentations of the results conformed to the usual pattern to their age, with some allowance for inhibitions and undervaluation of their own efforts. However, when reporting to the class the impression made and on their family, friends and whoever had followed the evolution of the work their admiration and interest on the task in progress became evident along with its scientific and clinical implications.
This additional exercise of reflection confirmed the value of the study in light of the different ways of reporting it, in both personal and professional life. An additional interesting gain of this task (again of students producing models based on outside information they had to acquire) was the achieved integration among the disciplines they were taking at that time, whose dynamics involved other teachers, and their disciplines, in questions about the body and the specific subject they choose to represent.
For instance, in the building up of a model on the monosynaptic spinal arc reflex, comprising the muscle, its muscular spindles and its different afferent and efferent fibbers, the spinal cord level at the origin of that specific nerve, as well as its dorsal, ventral, ipso- and homolaterals horns, the physiology teachings were linked to the anatomy ones. Impressions registered by other teachers, lecturing those students, confirmed how important was the adoption of the philosophy of hands- hearts- and minds-on [12-13] since it promotes activation of multiple brain areas therefore making learning, memory consolidation more effective [9,11].

Conclusion

Teaching and learning might represent a simultaneous enjoyable and effective activity. Science and art might coexist, awaking interest and spreading knowledge. Joining different generations; as was the case in this experience seniors and young adults promoted enriched contributions and proved the multidisciplinary nature of the construction of knowledge. Teaching and learning are activities that require dedication, but that also bring rewards, which deserve personal and institutional investments.
The generation of this manuscript was stimulated by the belief that a positive experience should be shared, but even more important, it aimed to encourage procedures that grow out of the emphasized aspects of this work (cooperation,

creativity and search).

"A teacher affects eternity; he can never tell where hers/his influence stops"
A. Henry Adams.

Acknowledgements

The authors acknowledge the stimulus and support of Dr. Margarida de Mello Ayres from the Committee of Cultura e Extensão of the Institute of Biomedical Science, Dr. Ii-sei Watanabe Chairman of the Anatomy Department, the NAP-NeC (IP-USP) and EC Azmitia by the stimulus, as well as the priceless help of Dennis M. Mardon and Charles Jules "friends forever".

References

[1] Chopin SF, Undergraduate Research experiences: The translation of science education from reading to doing, The Anatomical Record, 269, 3-10, 2002.
[2] Haines DE, Hutchins JB and Lynch JC, Medical Neurobiology: Do we teach Neurobiology in a format that is relevant to the clinical setting? The Anatomical Record, 269, 99-106, 2002.
[3] Duschl RA, Schweingruber HA and Shouse AW, Taking Science to School: Learning and Teaching Science in Grades K-8 Committee on Science Learning, Kindergarten through Eighth Grade, 2007.
[4] Philips-Conroy J, The uncertain future of Gross Anatomy, Science, 300, 2031, 2003.
[5] Blits KC, Aristotle: from, function, and comparative anatomy, The Anatomical Record, 257, 58-63, 1999.
[6] Finger S, Origins of neuroscience: A history of explorations into brain function, Oxford University Press, 2001.
[7] Hein GE, Constructivist Learning Theory: The Museum and the Needs of People, CECA (International Committee of Museum Educators), Massachusetts USA: Lesly College, 1991.
[8] Tattersall I, Becoming Human. Evolution and Man Uniqueness, New York: Harcourt Brace & Company, 1998.
[9] Novack CR, Strominger NL, Demarest RJ and Rugiero DA, The Human Nervous System Structure and Function, Sexta edição, New Jersey, EUA: Humana Press Inc., 2005.
[10] Bear MF, Connors BW and Paradiso MA, Neuroscience: Exploring the Brain, Lippincott Williams & Wilkins, 2006.
[11] Hein GE, Constructivist Learning Theory: The Museum and the Needs of People, CECA (International Committee of Museum Educators), Massachusetts, USA: Lesley College, 1991.
[12] Bransford JD, Brown AL and Cocking RR, How people learn: brain, mind, experience and school, Expanded Edition, National Academic Press, 2000.
[13] Pavão AC and Leitão A, Hands-on? Minds-on? Hearts-on? Social-on? Explainers-on? 45 Dialogos & Ciência: Mediaçao em museus e centros de Ciência, Massarani L (Ed.), Rio de Janeiro: Museu da Vida/Casa de Oswaldo Cruz/Fiocruz, 2007.

[14] Wagensberg J, Debates on Education: Educating on the border between intuition and comprehension, Intiative of the Jaume Bofill Foundation and the Universitat Oberta de Catalunya, 2004.

Paper presented at the 6th International Conference on “Hands on Science.
Science for All: Quest for Excellence",
Ahmedabad, India, October 27 to 31, 2009.

Hands-on Optics: Training Courses for School Teachers

Costa MFM and Dorrío BV

Introduction

Science teaching at all school levels should be generalised and rendered more effective in order to guarantee a strong and sustainable improvement of Science and its technological applications while improving and extending scientific literacy in our societies [1]. All over the world this is being, fortunately, accepted by governments and civil society institutions. Europe calls for more Science and Technology graduates trying to achieve the targets set in Lisbon Strategy to make the European Union "the most dynamic and competitive knowledge-based economy in the world capable of sustainable economic growth with more and better jobs and greater social cohesion, and respect for the environment by 2010" [2-5].

These demands add increasing pressure to the school and to school' teachers. Science teachers in particular face higher demands. In these troubled times students and teachers themselves (all of you in fact…), can hardly foresee a future coherent career, teachers must find ways of attract [6] and engage the students into the learning process. Informal and non-formal activities can have a very positive impact [7-8] but in-classroom activities are fundamental and here a hands-on investigative experiments based active learning is fundamental [9]. Unfortunately frequently our science teacher were trained in an essentially theoretical way and are not used to perform experiments and even less to induce or even allow the students to act hands-on, not being taught to understand the process or trained for it.

Light, Optics and Photonics have a crucial importance in our lives and to the prospects of development of our world with breathtaking developments in many different fields, including fibber optics sensor and communications, image acquisition and processing, lasers, photodynamic therapy, real time holography, optical computing, solar energy conversion and light sources… There is a lot of on-line information provided by universities, museums,... that can be directly employed by teachers [10-18].

On these lines we have developed and are running training courses [19] on hands experiments teaching approaches. The general objectives of these Hands-on Optics, supported by the European Commission (Life Long Learning/ Comenius action) are to provide schoolteachers from basic to secondary and vocational schools strong effective knowledge on the basics of optics, focusing on an intensive training in the execution of hands-on experimental activities on the major optics subjects. Hands-on/minds-on skills will be developed allowing the teachers to organise experimental activities in their class in a confident and effective way (Fig. 1). So protocols for searching proper information related with the main topics covered during the course are given in such a way that selected hands-on optical activities can be carried out in an independent way in the future [for example, 20-25].

Methodology

The early as possible in their education the students should introduced to and get acquainted with basic optics concepts as those related to the nature of light, the subjects of general optics, geometrical physical and quantum, but also with advanced subjects of utmost importance and actuality as wave guidance, fibre optics and telecommunications, image digitalization and processing, light production and energy conversion, optical processing and computing,…

Not only specific knowledge must be acquired but also and specially the ability of exploring reasoning, acting interactively to be able to find, analyse and solve new interdisciplinary problems, should be explored and enhanced as extensively as possible.

The best way of achieving an effective sound education of the students on these optics issues is by inducing the students to an active committed participation in the teaching/learning process, through investigative practice and experimentation, making use of the new instruments and resources of the Information Society. Although a strong focus should be put into these hands-on approaches the theoretical perspective should not be forgotten and introspective abstract reasoning activities should be allowed, in particular if the characteristics of a student or group of students advise it. Constructivism [26] construcionism [27] and conceptual learning [28] among many other approaches should be explored.

The structure of Hands-on Optics training course

Although there will be a theoretical introduction to the theme, the course's methodology will essentially be based on practical experimental activities hands-on/minds-on, followed by reflection and discussion. There will be a final assessment/evaluation session.

The pedagogic approach we suggest to be used relies on a functional integration of different pedagogical theories and practices namely the constructivism, conceptual learning and pro-active learning by hands on experimentation and research. Responsibility, critical reasoning and observation, method and flexibility, interdisciplinarity, volunteer self-rewarding commitment, joint efforts and teamwork, are the main keywords that should guide all pedagogical activities. Making use of the new instruments and resources of the Information Society [10-18].

The week long training course is mostly practical and strong personal interaction among the students (the physics and science teachers) and with the trainers and tutors is expected and will be encouraged (enforced…).

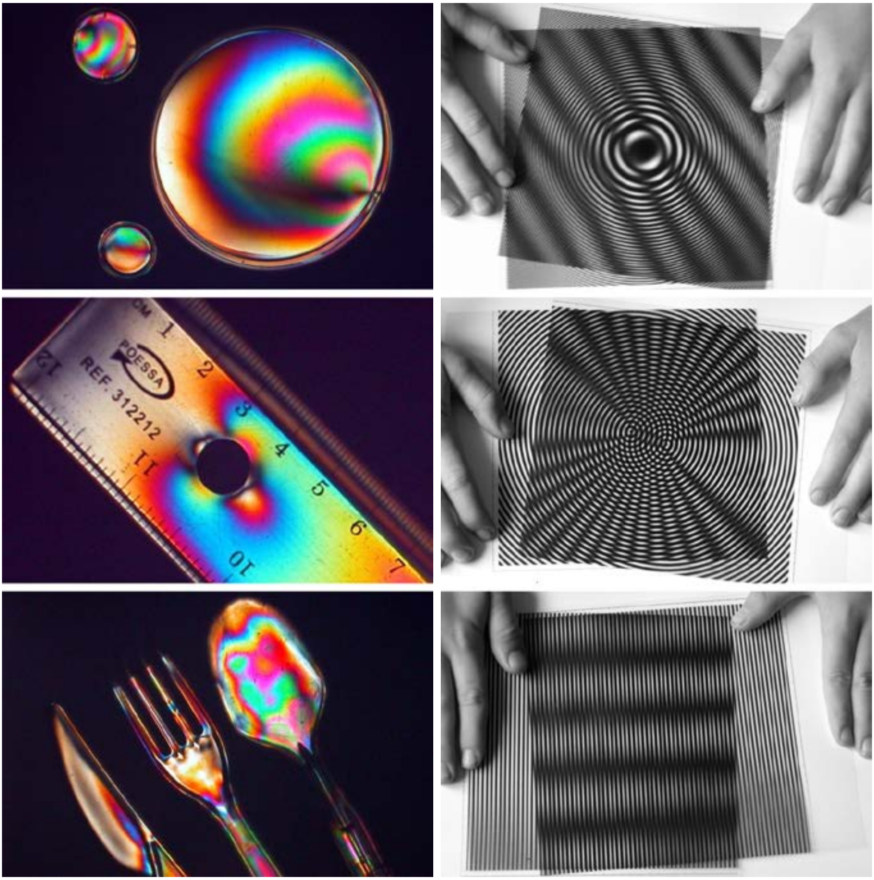


Figure 1. Hands-on optical activities: light polarization and birefringence (left) and Moiré effect (right)

We expect the teachers to act as students also in order for them to better understand the problems difficulties and behaviours of their own students.
Apart from the main curricular optics subjects we introduce lectures and workshop on transversal issues like motivational tools and activities including the resource to non-formal or informal activities. Computer modelling and simulation tools can be very useful in helping complementing or even inducing hands-on experimental works. Often teachers work “alone” and feel that way. The establishment of cooperation mechanisms among schools and teachers from the same environment but especially when coming from different countries and cultures [29] may be very important for the teachers and individuals but also as educators. This issue will also be explored specially addressing the possibilities in the frames of the EU foreseeing other opportunities (Erasmus Mundus like for instance).

1st Training Course on Hands-on Optics, April 3 to 11, 2009, Vigo, Pontevedra, Spain
&
2nd Training Course on Hands-on Optics, September 3 to 11, 2009, Braga, Portugal

Syllabus:

1st day
18:00 Registration

2nd day
9:30 Opening and presentation, M. F. Costa
10:00 Optics. Past, present and future B. Dorrio, D. Sporea, M. F. Costa,
11:30 Hands-on science P. Michaelides
14:30 Introduction to optics. The basics I. M. F. Costa, B. Dorrio, P. Michaelides
17:00 Discussion

3rd day
9:30 Constructivism. Theory and practice I S. Gatt
11:30 Constructivism. Theory and practice II S. Gatt
14:30 Introduction to optics. The basics II. M. F. Costa, B. Dorrio, P. Michaelides
18:00 Discussion

4th day
9:30 Introduction to optics. The basics III. M. F. Costa, B. Dorrio, P. Michaelides
14:30 How to organise a hands-on experiments class. The scientific method P. Michaelides
16:30 Safety issues D. Sporea
18:00 Discussion

5th day
Free day. Visits to local schools and interaction with local teachers and students

6st day
9:30 Hands-on activities I. The nature of light. B. Dorrio, C. Lima, M. F. Costa
14:30 Hands-on activities II. Color and vision. N. Tsaglotis, J Fernandes, M. F. Costa
16:30 Hands-on activities III. Reflection and refraction. J Fernandes, N. Tsaglotis, M. F. Costa
18:00 Discussion

7th day
9:30 Hands-on activities IV. Ray tracing. M. F. Costa, R. Batista
11:30 Hands-on activities V. Prims lenses and mirrors. J. Fernandes, C. Lima, M. F. Costa
14:30 Hands-on activities VI. Fiber optics, polarisation, diffraction, holography. M. F. Costa, N. Tsaglotis, C. Lima
18:00 Discussion

8th day
9:30 "Funny" optics. Ideas for Science Fairs. M. F. Costa, P. Michaelides, B. Vasquez
11:00 Computer simulation on Microsoft Excel. V. Fonseca
14:30 Comenius EU School' cooperation projects. M. F. Costa, P. Michaelides
16:30 Course' evaluation and conclusion
19:30 Farewell dinner

9th day
Departure

(Every day: Coffee break - 11:00 and 16:00; Lunch 12:30; 19:30 Dinner)

Trainers: Professor M. F. M. Costa (University of Minho), Professor B. Dorrio (University of Vigo), Professor P. G. Michaelides (University of Crete), Professor S. Gatt (University of Malta), Dr. D. Sporea (NIPNE), Prof. V. Fonseca (University of Minho). Tutors: Dr. N. Tsaglotis, Dr. R. Batista, Dr. C. Lima, Dr. J. Fernandes.

Figure 2. Program of the "Hands-on Optics" training course

The preparation for the course is considered important [30-31]. The participants receive in advance two Guides for Hands-on Experimental Activities and the Teacher's Handbook, which contains a theoretical presentation on General Optics [32-34]. One of the guides includes 42 experiments, all to be explored during the course, divided into main topics and graded from elementary to secondary level. The other guide call "Continuous" provides a series of observation based investigative activities covering basic light and optics concepts presented in an essentially non-guided way. The essential idea here is not to "show" or present an experiment but yes to induce the discovery process [35].

The follow-up of the course participants is considered of the highest importance. Enquiries and quizzes will be delivered to the teachers, together with support material to be filled by the teachers themselves and their students for a period no shorter than 3 years, to be returned to the course organiser for analysis and statistical treatment. Further training courses on more advanced topics will be made available in a near future [19]. On the other hand we expect the participants to enrol and be active members of the Hands-on Science Network were they will find a mutually supporting and nourishing ground [19].

In Fig. 2 we show the schedule of the two Hands-on Optics training course run in 2009 in Spain and Portugal [35].

Conclusion

The development of optics and photonics requires a large number of well prepared highly motivated scientist and technicians that should be teach and trained as early and as efficiently as possible in a positive rewarding environment. The new stringent requirements of the modern society demand not only the gathering of specific knowledge but also and specially of the competencies the ability of acting interactively to be able to find, analyze and solve new interdisciplinary problems. The best way of achieving an adequate formation of our students on these issues is by inducing the students to an active committed participation in the teaching/learning process, through hands-on investigative practice and experimentation.

Teacher training activities on the hands-on investigative experiments based learning of optics in all school levels and in informal contexts should widely promoted and disseminated.

References

[1] Costa MFM, Hands-on Science, Selected Papers on Hands-on Science, Costa MF, Dorrío BV, Michaelides P and Divjak S (Eds.), Associação Hands-on Science Network, Portugal, 1-13, 2008.

[2] European Commission, White paper on education and training: Teaching and learning-Towards the learning society (White paper), Office for Official Publications in European Countries, Luxemburg, 1999.

[3] European Commission, Europe needs More Scientists: Report by the High Level Group on Increasing Human Resources for Science and Technology, Brussels: European Commission, 2004.

[5] European Commission, Science Education Now: A renewed pedagogy for the

future of Europe, Brussels: European Commission Directorate-General for Research Information and Communication Unit, 2007.
[6] Lisbon European Council, 23 and 24 March 2000, Presidency Conclusions, http://www.europarl.europa.eu/summits/lis1_es.htm
[7] Lima CFS and Costa MFM, Optics and Pool: Play the Game, Costa MF, Dorrío BV, Michaelides P and Divjak S (Eds.), Associação Hands-on Science Network, Portugal, 182-185, 2008.
[8] Costa MF, Dorrío BV, Pavao AC and Muramatsu M (Eds.), Proceedings of the 5th International Conference on Hands-on Science. Formal and Informal Science Education, Espaço Ciencia: Recife, 2008.
[9] Esteves Z, Cabral A and Costa MFM, Informal Learning in Basic Schools. Science Fairs, Int. J. Hands-on Science, 1: 2, 23-27, 2008.
[10] Costa MFM, Dorrío BV, Michaelides P and Divjak S (Eds.), Selected Papers on Hands-on Science, Costa MF, Dorrío BV, Michaelides P and Divjak S (Eds.), Associação Hands-on Science Network, Portugal, 2008.
[11] http://demoroom.physics.ncsu.edu/
[12] http://www.exploratorium.edu/snacks/
[13] http://www.wfu.edu/Academic-departments/Physics/demolabs/demos/
[14] http://physicsdemos.phys.cwru.edu/
[15] http://www.fas.harvard.edu/~scidemos/demotoc.html
[16] http://demolab.phys.virginia.edu/demos/demos.asp
[17] http://demo.physics.uiuc.edu/LectDemo/
[18] http://physicslearning.colorado.edu/PiraHome/
[19] http://www.exploratorium.edu/snacks
[20]https://webgate.ec.europa.eu/llp/istcoursedatabase/index.cfm?fuseaction=DisplayCourse&cid=7412
[21] Branca M and Soletta I, Construction of Optical Elements with Gelatin, Phys. Teach., 41, 249, 2003.
[22] Graham RM, Real image produced by a concave mirror, Phys. Teach., 44, 186 2006.
[23] Gluck P, Compact Disk Optics, Phys. Teach., 40, 468, 2002.
[24] Gluck P, Teaching Image Formation by a Lens, Phys. Teach., 44, 206, 2006.
[25] Mak SY, A simple method to determine the refractive index of glass, Phys. Teach., 26, 526, 1988.
[26] Goodman DS, Optics demonstration with the overhead projector, Washington: SPIE, 2000.
[27] Gatt S, Constructivism–An effective Theory of Learning, in Gatt S and Vella Y (Eds.), Constructivist teaching in Primary School Social Studies, Mathematics, Science, ICT, Design and Technology, Malta: Agenda Publishers, 2003.
[28] Ribeiro C, Coutinho C, Costa MFM and Rocha M, A Study of Educational Robotics in Elementary Schools, Selected Papers on Hands-on Science, Costa MF, Dorrío BV, Michaelides P and Divjak S (Eds.), Associação Hands-on Science Network, Portugal, 580-595, 2008.
[29] Zamarro JM, Molina GJ and Núñez MJ, Teaching Physics Modelling with Graphic Simulations Tools, Selected Papers on Hands-on Science, Costa MF, Dorrío BV, Michaelides P and Divjak S (Eds.), Associação Hands-on Science

Network, Portugal, 69-73, 2008.
[30] Sjoberg S.and Schreiner C, How do learners of different cultures relate to Science and Technology? Results and Perspectives from the ROSE Project, Asian-Pacific Forum on Science Learning and Teaching, 2: 6, 2005.
[31] Dorrío BV, Rúa A, Soto R and Arias J, Hands-on Physics Bibliography, Proceedings of the 1st International Conference on Hands-on Science, Teaching and Learning in the XXI Century, Divjak S (Ed.), Ljubljana: University of Ljubljana, 119-124, 2004.
[32] UNESCO, 700 Science experiments for everyone, New York: Doubleday, 1962.
[33] Costa MFM, Hands-on Introduction to Optics / Introdução à Óptica (bilingual edition), Hands-on Science Network, 2006.
[34] Costa MFM, Learning Optics at Basic Schools by Experimentation, Selected Papers on Hands-on Science, Costa MF, Dorrío BV, Michaelides P and Divjak S (Eds.), Associação Hands-on Science Network, Portugal, 25-28 2008.
[35] Costa MFM, Introduction to Fiber Optics and Telecommunications, Selected Papers on Hands-on Science, Costa MF, Dorrío BV, Michaelides P and Divjak S (Eds.), Associação Hands-on Science Network, Portugal, 492-496, 2008.
[36] http://www.hsci.info/

Paper presented at the 6th International Conference on “Hands on Science. Science for All: Quest for Excellence",
Ahmedabad, India, October 27 to 31, 2009.

Family Hands-on Activities in Science and Technology Education for All: Gifted and Ungifted, Children and Adults

Trna J and Trnova E

Family science education and lifelong education

At the present time, science education is becoming lifelong education. The reason is the rapidly growing number of new applications and the expanding knowledge in science. The fact that science knowledge gained in school does not satisfy the necessities of a human lifetime anymore could be a source of negative attitudes towards science. Many adults are gradually losing touch with current science knowledge and they sometimes do not understand how new appliances work, therefore they frequently do not use them. This negative attitude might be transferred from parents and grandparents to their children who subsequently feel the lack of motivation to study science. So a pedagogical research problem focused on how to reverse this negative trend appeared.

Our research and experience brought us to develop an educational method called family science education (FSE). This type of education is implemented by the transfer of knowledge and skills from the school setting to families. Students who do FSE at home have the potential to inspire their siblings, parents and grandparents. We believe that FSE is an efficient educational method, which nevertheless requires several conditions to be met. The main one is interesting educational content that is based on using relevant knowledge and skills from a student's everyday family life.

FSE could become a significant and effective part of parents' and grandparents' lifelong education. As it is a by-product of formal school education, it does not demand any additional financial costs.

Generational barriers to education result from the considerable acceleration of science knowledge as well as school education. Parents and grandparents are often unable to help students with homework, because they do not understand the educational content and technology. The older generation may come across new knowledge and products they cannot use or manipulate (e.g. ICT). Then complications, even insuperable obstacles may arise in the individual's life. FSE may play a part in the lifelong education of older generations by exposing them to science information that could be beneficial.

Family science education and motivation of students

A crucial problem of contemporary science education is how to motivate students. Research shows that an overwhelming segment of the young population takes a negative or neutral attitude toward science. Science teachers are looking for motivational techniques which would help to eliminate a negative attitude toward science. Our research has produced findings concerning the use of cognitive motivational techniques [4]. We can increase the motivation with a combination of these cognitive techniques. Cognitive motivation has a positive advantage, but using just this type of motivation is not enough.
It is not possible to omit social and achievement motivation that are formed in the social and family environment [1]. The key factor is a student’s family, especially during the primary school age. If a student is surrounded with a family who has a positive attitude toward science, this environment will affect the student's inclination toward science education. This student may be appreciated for good school results in science, and the parents, for example could buy the child science toys, go on science trips; or enrol the child in informal science activities.
The question is how to influence families in order to motivate students positively. It seems that a suitable method might be FSE in which students participates. These students help transfer science knowledge to their families who can subsequently develop a positive attitude toward science. It is essential to find the ideal factors in science education that could be easily used in a family setting. Our pilot research shows the existence of suitable educational contents for FSE, especially knowledge and skills concerning daily and safe living.

Family science education and hands-on activities

Hands-on activities applied to science education have various attributes which can be used in FSE. The most important attributes are:

- Use of objects and materials of daily life (they are commonly found in homes)
- Low-cost objects and materials of everyday life (as they do not increase families’ financial costs, they are accessible to everyone)
- Easy implementation (activities do not require special knowledge and skills – they can be accomplished by most family members)
- Transparency of natural phenomena (natural phenomenon is easily observable and comprehensible to a layman)

Given the reasons stated above, hands-on activities are seen as suitable for FSE. From the motivation point of view, increasing the effect of motivational techniques and methods of their combination is vital. There is a possibility of associating hands-on activities with the educational contents appropriate for FSE. On that account we have applied hands-on activities of the human organism in our research. The first research results are promising and they raise hopes that either lifelong adult education or backward motivational effect on a student will work efficiently. Next we will focus on the theme of science hands-on activities in more detail.

Hands-on activities and daily and safe living in family science education

Daily and safe living is appropriate content used in FSE. These contents are [5]:

- The human organism: Students are acquainted with the parameters of the human body which can be expressed with the aid of quantities, units and laws. Also external conditions are very important for preservation of vital functions of the human organism including health.
- Home, entertainment, sports etc: Students can be motivated by explanation of basic features in everyday life such as heat and light sources, means of transport, audiovisual techniques, chemical agents, domestic plants and animals etc. Information on economical and ecological behaviour in everyday living is growing more and more important.
- Safety risks: Protection against negative extraneous influences on the human organism and information on safe behaviour in transport, at work etc.

For students and adults the human organism is an interesting object. An important advantage of teaching and learning about the human organism is that teaching aids are not needed because everyone has a body.

Understanding human body measurement is a very practical approach to the prevention and diagnosis of certain diseases or risks. The important theme is life protection against dangerous influences, which include the fast change of atmospheric pressure and speed, effects of forces, temperature fluctuations, radiation etc.

Every student can be motivated by the combination of hands-on activities and a human body experimenting and measuring within the educational content. With the assistance of hand-on activities with our body we can also diagnose potential health risks. Prevention of at-risk factors is based on human body measurements. Many human body parameters can be measured by students and adults such as temperature, weight, blood pressure, body mass index etc. We realized the research of educational efficiency of these activities in FSE.

Flat foot

We used the measurement of flat feet as the educational content for our research [6]. The research of the effectiveness of FES was carried out twice (in 2006 and 2009). One hundred students in the fourth grade in primary science lessons were taught how to measure flat feet.

Students' theoretical background:

The foot structure is very important for various movement conditions of the body. The most known disorder of flat feet is caused by fallen arches. Inappropriate footwear is a large contribution to this disorder. That's why the length and width of the foot is important when buying the correct shoes.

Students' hands-on activity:
Paint the sole of the foot with water (oil, ink etc.) and step on suction paper. Use a ruler to measure the widest (w_1) and narrowest part (w_2) of the footprint (Fig. 1). Calculate $I = w_2 / w_1$. Evaluate results using the Tab. 1.

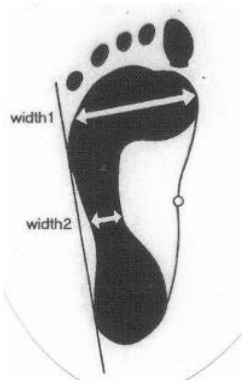


Figure 1. Flat foot

$I = w_2 / w_1$	
normal foot	I = less 0, 45
start to be flat	I= 0, 45
flat foot	I= more 0, 45

Table 1. Flat foot

A questionnaire was distributed to the parents of students after two weeks. Parents were asked to answer four questions concerning the measuring for flat feet. The questions, the percentage of positive answers and the number of questionnaires received back is in Tab. 2.

	%2006	%2009	2006/2009
Do you know a simple method of measuring flat feet?	68	65	75/80
Did you receive this method from your children?	60	62	75/80
Have you measured your foot using this method	24	30	75/80
Have you found latent flat feet in your family?	4	5	75/80

Table 2. Flat foot - research results. Percentage of afirmative answers in 2006 and 2009 together with number of received questionnaries in 2006/2009

The research results verify the effectiveness of FSE in the primary school science by the use of the combination of hands-on activities and human body measurement.

Obesity

The measuring of obesity was used as the educational content for our next research on the effectiveness of FSE in 2008. The obesity diagnosis is also good human body measurement content for FSE. One hundred students of the eighth grade in lower secondary science lessons were taught how to measure for obesity.

Students' theoretical background:
Body weight is defined as an essential parameter that helps us to find out the state of health and even predict health complications in the future. The often used parameter for body weight assessing is body mass index (BMI). The latest investigations verify the importance of the distribution of fat (types of obesity). Fat distribution is possible to find by means of waist and hip circumference which is more predictive of cardio respiratory risks than BMI. The WHR index is the ratio of these two parameters.

Students' hands-on activity:
Use a measuring-tape to measure your waist circumference and hip circumference. Calculate WHR = waist circumference / hip circumference. Evaluate results using the Tab. 3.

Types of fat distribution / health risk	boy/man	girl/woman
Rather peripheral / no risk	up to 0,85	up to 0,75
Balanced / no risk	0,85 – 0,90	0,75 – 0,80
Rather central /low risk	0,90 – 0,95	0,80 – 0,85
Central / high risk	above 0,95	above 0,85

Table 3. Obesity

	%2008	2008
Do you know a simple method of measuring obesity using WHR?	50	84
Did you receive a method of measuring obesity using WHR from your children?	43	84
Have you measured your WHR using this method?	22	84
Have you found latent obesity in your family?	12	84

Table 4. Obesity - research results. Percentage of afirmative answers together with number of received questionnaries

A questionnaire was distributed to their parents after two weeks. Parents were asked to answer four questions concerning the obesity measuring. The questions, the percentage of positive answers and the number of questionnaires received back are in Tab. 4. The results of our second research verify the effectiveness of FSE also in the lower secondary science by the use of a combination of hands-on activities and human body measuring.

Diagnostics of science gifted students by family science education

FSE might hold another essential function. It is believed to be diagnosis and development of gifted students in science. According to today's parental demands, school should provide diagnosis of a student's giftedness and carry out further development [2]. That is a principal condition for making use of student's giftedness for future positions in the labour market and also in developing the economic and social status in life.

Professional orientation and student's progress have a comparable value to desirable physical development concerning future life. Within the FSE method, the student's family is able to find out and/or verify the school's recommendation for their child's area of talent. There are different tools: finding out student's interest in science activities (keeping domestic animals, creating models, trying experiments etc.), family games and diagnostic tests that can be applied by parents. We have developed a diagnostic test for the diagnose of an analytic science observation for students aged 5-11 years. The student's ability is part of science giftedness. Below is an example of this test:

Test: "Find Einstein in yourself".

The test contains 20 items (tasks) with multiple choice. Only one answer A, B or C is correct. Particular items are chosen so as to suit quite a wide age spectrum of children, from 5 to 11years old. We tried to balance the items against age and gender of the involved children so the problems would be taken from the world of both boys and girls. The tasks are also pictorial in order to use the test with younger children but also to support clearness and to develop associate images.

Example of test items:

Mum poured hot tea into three mugs (Fig. 2). The first mug was metal, the second mug was ceramic and the third one was plastic. In which mug will the tea get cold first? (Correct answer: A).

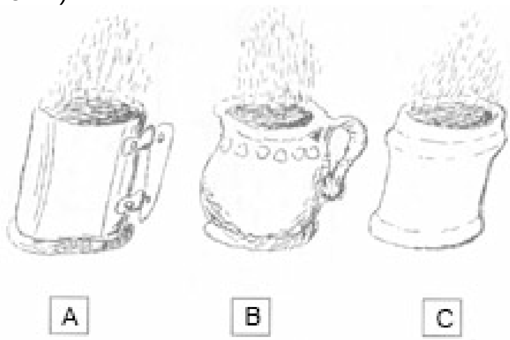


Figure 2. Heat conduction

The test was piloted in the Czech Republic in 1998 on 800 children at the ages of 5, 7, 9 and 11. It was standardized within joint Czech-Polish research [3] on a sample of 5000 respondents in 1999. The test has the following partial aims:

a) to set a level of the analytical observation ability and the ability of creation of preconceptions
b) to determine the relationship between the level of abilities and children's age
c) to find out the relationship between the level of abilities and children's gender

Science teachers training and family science education

As a part of the whole range of other teachers' professional training techniques, the FSE method is regarded as inseparable from science teachers in-service training. It requires understanding the interaction between students and their family background. The basis of professional preparation of a science teacher for FSE is a system of knowledge and skills (pedagogical content knowledge = PCK) which form the competency for this activity. Relevant PCK resulting from FSE implementation would become a subject of research, including the action research of skilled teachers. Promising results could then be given to other teachers within their long life education.

Conclusions

FSE has a great potential to become an essential method for adult lifelong education as well as a motivational technique for gifted and non-gifted students. However, it requires additional research and eventual inclusion into pre-service and notably in-service science teacher training. This training can be supported by efficiently passing on the best elements of skilled teachers' PCK and also by creating teaching aids and curricular materials for practical application.

Acknowledgements

The study was created and supported within the project projects "Special Needs of Pupils in Context with Framework Educational Program for Primary Education" (MSM0021622443).

References

[1] Bransford JD (Ed.), How People Learn, Brain, Mind, Experience, and School, Washington: National Academies Press, 2000.
[2] Kanevsky L, Gifted Children and the Learning Process: Insightness on Both from the Research, Talent for the Future, Monks F and Peters W (Eds.), Assen: Van Gorcum, 1992.
[3] Trna J, Krajna A, Ryk L, Sujak-Lesz K and Lesz A, Predyspozycje fizykalne dzieci przed nauczaniem fizyki w szkole, Biuletin Informacyjny, Centralnego Osrodka Metodycznego Studiow Nauczycielskich w Krakowie, 18/19, 48-52, 2000.

[4] Trna J and Trnova E, Cognitive Motivation in Science Teacher Training, Science and Technology Education for a Diverse Word, Janiuk M (Ed.), Lublin: M. Curie-Sklodovska University Press, 491-498, 2006.
[5] Trna J and Trnova E, Everyday Living and Safe Living in Simple Science Experiments, Science and Technology Education in the Service of Humankind, 12th IOSTE Symposium, Penang: University Science Malaysia, 556-561, 2006.
[6] Trna J and Trnova E, Safety of the Human Body, Selected Papers on Hands-on Science, Costa MF, Dorrío BV, Michaelides P and Divjak S (Eds.), Associação Hands-on Science Network, Portugal, 572-579, 2008.

Paper presented at the 6th International Conference on “Hands on Science. Science for All: Quest for Excellence",
Ahmedabad, India, October 27 to 31, 2009.

Effective Science Communication Practices and Simple Hands-on Activities: Two Important Elements of Teacher Professional Development

Perera S

Introduction

The literature suggests that school science should yield outcomes beyond the confines of mere classroom learning [5,8]. In fact, it is believed that school science is effective only when it is “linked with the broader community” [19, p.19] and when students are able to “generate fruitful and relevant questions and frame them in an effective way for investigation” [7, p.228]. Such a shift in emphasis, from traditional content-based instruction, requires science teachers to “focus more on the nature of science and on the evidence and arguments of scientific ideas, and help students develop skills of engaging in fruitful argumentation” [24, p.670]. Consequently, a key recommendation for science education reform internationally requires teachers in the classroom to emulate the investigative processes of scientific inquiry [13,16-17,22].

Despite the onus placed on student-centred inquiry, recent studies reveal that recommended pedagogy fails to feature in many science classrooms [20]. Instead, it is reported that teachers continue to employ traditional models of content transmission [15]. While the absence of inquiry in most science classrooms is lamented [2], it is irrefutable that teachers’ reluctance to implement inquiry stems from the challenge it represents.

There are two predominating reasons for this reluctance. First, many teachers lack a well grounded science knowledge base with which to facilitate inquiry in the classroom. Second, only a few teachers have had sufficient exposure to scientific inquiry, and are aware of what it entails, to be able to use it in the classroom.

The lack of adequately developed knowledge about scientific concepts, particularly at tertiary level, is a deterrent to inquiry-based pedagogy. For example, it was found that 50% of Australian middle school science teachers did not have relevant university science qualifications [26]. This lack of well constructed knowledge structures is manifested in their disinclination towards inquiry. It also explains their discomfort to uncertainty, questioning and puzzlement that are inherent to inquiry-based pedagogy [4]. In such situations, it is reasonable for teachers to be prone to self-doubt [23], especially those who have not experienced science as a means of inquiring into the natural world [27].

Second, the limited exposure of teachers to inquiry at school and university prevents them from implementing pedagogical reform. In fact, their apprenticeship ingrains traditional models of teacher-centred instruction, dominated by content, which is far removed from inquiry-based pedagogy [14]. Many teachers teach as they have been taught [21], and if they are aware of inquiry-based pedagogy they remain oblivious about how to actually implement it in the classroom.

Professional development for teachers has long been used to complement education reform. Advocates insist that inquiry-based approaches that are grounded on constructivist learning experiences should also be employed in the professional development of teachers [17,27]. This would enable teachers “to learn about science and science teaching with the same methods and strategies as students should learn science in schools” [18, p.190]. This paradigm shift is deemed essential, as it would help teachers to construct confident understandings about science through personally meaningful learning experiences [10]. These understandings are necessary to implement inquiry-based pedagogy. Professional development based on inquiry would also offer teachers the opportunity to actively and collegially experience inquiry hands-on [6].

Studies fail to recognize, however, the potential for short-term professional development programs - essentially the one-day workshop model - to complement education reform. Only a few studies mention the possibility of exploring short-term professional development as a means to motivate teachers to adopt inquiry [18,25]. This paper presents evidence from a qualitative study that explored this possibility.

Research study

The Centre for the Public Awareness of Science (CPAS) at the Australian National University, offers one-day workshops entitled “Creative Science Teaching Using Simple Materials” for secondary school science teachers in Australia and elsewhere. As their name implies, these workshops employ simple, readily-accessible equipment. They also draw on the science centre traditions of public engagement. Interviews with the workshop facilitators, early on in the study, confirmed that constructivist learning principles were used to design the workshop activities. I investigated six such workshops. I present here findings from interviews with a purposeful random sample of 38 teachers (19 Australian, 10 Sri Lankan, 9 Indonesian) who participated in those workshops.

I interviewed the teachers using a standardized open-ended interview format [11]. First, I asked them if they believed the workshops had informed their scientific understandings. The next series of questions probed how the workshops, if successful, informed those understandings.

Results and discussion

All 38 teachers agreed that the workshops informed their understandings. As two Australian teachers remarked:

> “I came away with a really good package of stuff. And that wasn’t just sort of in-the-hand stuff, but in-the-head as well.”

> “Yes it has benefited me because, obviously there are a few scientific concepts that I didn’t understand… the workshop has given me the mental tools, I guess, to be able to convey those concepts to the kids.”

It was evidenced from similar responses that the workshops succeeded in informing the teachers’ scientific understandings. Therefore, it was necessary to find out next how the teachers believed this was achieved in the workshops.
Interview findings highlighted two workshop features that played pivotal roles. The first of these, which all the teachers acknowledged, was the simple materials used in the workshop activities. They used words like “surprise”, “fascination” and “amazement” to describe these experiences. An activity known as the “Buoyancy see-saw” was described by one Sri Lankan as follows:

> “I liked the two cups of water balanced on a strip of wood. When we put our fingers into the water we saw how pressure increased with depth. I was amazed how such a simple device could convey such a deep message.”

A reason behind the teachers’ appreciation of simple materials was their transferability to the classroom. In fact, it is believed that transferability of information should be an important element of teacher professional development [9]. As explained by an Indonesian teacher:

> “Simple materials are easy to get and they are cheap… I think the students would be happy if we used simple materials. They would definitely be more interested in these than standard laboratory equipment that we normally use…”

As one Australian teacher explained further, simple materials are transferable because their workings are obvious to the students:

> “I like hands-on stuff because you can actually see what happens. And I think it is the same with kids, they can see it happening.”

The teachers’ responses indicated that the simple hands-on activities informed their scientific understandings in a similar way. As one Sri Lankan teacher remarked:

> “The results of the experiments done that day were directly evident. All the experiments had definite observable results so it was possible to understand the fundamentals behind it.”

The teachers agreed that in order to teach science, they need to be confident about their own understandings. As another Sri Lankan teacher commented, experiences with hands-on activities had enabled such a level of confidence:

> “… I could only completely understand the concept involved when I was able to experience it for myself. Until then I cannot explain this phenomenon to the student. I myself have to comprehend it first.”

Second, the teachers believed that effective science communication practices helped to inform their understandings during the workshops. In particular, their responses highlighted three such practices: use of narratives, simple dialogue-type delivery style, and animated communications.
The teachers believed that the use of anecdotes and stories rendered familiarity to the scientific concepts. In fact, a recent study states that narratives help to bridge between scientific and non-scientific speech [3]. As explained by one Australian teacher:

> "I particularly remember what we were told about the movie Titanic, as a way of describing buoyancy… These stories of the real world helped to make links to science."

Also, there were two or three facilitators present at each of the workshops. The facilitators interacted with one another while presenting to the teachers. The teachers appreciated this style of dialogue, particularly the way in which the facilitators freely discussed scientific concepts and critiqued each other. They pointed out, moreover, that the facilitators' dialogue-type delivery style was effective because they chose to use simple, easy to comprehend language. As one Australian teacher remarked:

> "The level of dialogue seems a good mix of academic, but at the same time what a general lay person can speak. They could have spoken at a very theoretical level, but they chose not to."

The teachers found that the facilitators' use of body language, voice intonation and theatrical devices animated their communications. By communicating science in such ways the facilitators conveyed ("almost infectiously" as one Australian teacher stated) their enthusiasm and passion for science. The Sri Lankan and Indonesian teachers, in particular, for whom English was a second language, appreciated the facilitators' animated communications because they crossed language barriers. As one Indonesian teacher described:

> "I know enough English to understand what was said, but the body language, gestures, the way they moved their hands and their facial expressions, with these things the message got through much better."

Eminent scientists, like Michael Faraday and Lawrence Bragg, have emphasised good delivery is paramount when communicating science to the public [1]. Their writings also recognise the importance of expression, simple language and simple experiments. In order to engage an audience, Faraday states that "it is necessary to pay some attention to the manner of expression. The utterance should not be rapid and hurried…but slow and deliberate, conveying ideas with ease from the lecturer and infusing them with clearness and readiness into the minds of the audience." A more recent analysis of public physics lectures concur that narrative, visual-story and comprehensible language should form the framework of scientific discourses with the public [12]. The responses above, from teachers in the present study, indicated that science communication practices in the workshops played an important role in conveying scientific ideas effectively.

Conclusion

This study offers evidence that professional development courses which incorporate simple hands-on experiments can offer science teachers much needed exposure to inquiry-based learning. Teachers were able to construct personally meaningful understandings about science. They were, therefore, more confident about their own scientific knowledge. This study also showed that science communication practices played an important role in such learning environments. They helped to build a bridge between science and commonplace events, making science more personally relevant to the teachers. Science communication practices also helped to transcend language barriers in the workshops for Sri Lankan and Indonesian teachers. These benefits of effective science communication practices should not be limited only to the professional development of teachers. Opportunities to explore the potential of science communication in formal science education in the classroom are also needed.

Acknowledgement

I acknowledge Professors Susan Stocklmayer and Michael Gore at and the Centre for the Public Awareness of Science, ANU for enabling the workshops and this study.

References

[1] Porter G and FridayJ (Eds.), Advice to lecturers. An anthology taken from the writings of Michael Faraday & Lawrence Bragg, The Royal Institution of Great Britain, 1986.
[2] Tytler R, Australian Education Review: Re-imaging Science Education, Australian Council for Educational Research, 2007.
[3] Avraamidou L and Osborne J, The role of narrative in science communication, International Journal of Science Education, 31: 12, 1683-1707, 2009.
[4] Barnett J and Hodson D, Pedagogical content knowledge: Toward a fuller understanding of what good science teachers know, Science Education, 85: 4, 426-453, 2001.
[5] Millar R and Osborne J, Beyond 2000: Science education for the future, King's College London School of Education, 1998.
[6] Borko H, Professional development and teacher learning: Mapping the terrain, Educational Researcher, 33: 8, 3-15, 2004.
[7] Burbules NC and Linn MC, Science education and philosophy of science: Congruence or contradiction? International Journal of Science Education, 13: 3, 227-241, 1991.
[8] Black P and Aitkin J, Changing the subject: Innovations in science, mathematics and technology education, Routledge, 1996.
[9] Cohen DK and Hill HC, Instructional policy and classroom performance: The mathematics reform in California, Teachers College Record, 102: 2, 294-343,

2000.
[10] Loucks-Horsley S, Love N, Stiles KE, Mundry S and Hewson PW, Designing professional development for teachers of science and mathematics, Corwin Press, 1998.
[11] Gall MD, Borg WR and Gall JP, Educational Research, USA: Longman Publishers, 1996.
[12] Kapon S, Ganiel U and Eylon BS, Explaining the unexplainable: Translated Scientific Explanations in public physics lectures, International Journal of Science Education, 2009.
[13] Kurikulum 2004, Ministry of Education Jakarta, Curriculum Centre, 2004.
[14] Lee C and Krapfl L, Teaching as you would have them teach: An effective elementary science teacher preparation program, Journal of Science Teacher Education, 13: 3, 247-265, 2002.
[15] Lyons T, Different countries, same science classes: Students' experiences of school science in their own words, International Journal of Science Education, 28: 6, 591-614, 2006.
[16] Ministerial Council on Education, Employment and Youth Affairs, Australia's common and agreed National Goals for Schooling in the twenty first century. Curriculum Perspectives, 19: 4, 8–9, 1999.
[17] National Science Education Standards, National Research Council, National Academy of Science Press, 1996.
[18] Posnanski TJ, Professional development programs for elementary science teachers: An analysis of teacher self-efficacy beliefs and a professional development model, Journal of Science Teacher Education, 13: 2, 189-220, 2002.
[19] Hackling MW, Prain V, Primary Connections, Australian Academy of Science, 2005.
[20] Rennie L, Goodrum D, Hackling M, Science teaching and learning in Australian schools: Results of a national study, Research in Science Education, 31, 455-498, 2001.
[21] Lortie D, Schoolteacher: A sociological study, The University of Chicago Press, 1975.
[22] Science & Technology Curriculum, National Institute of Education Sri Lanka. National Institute of Education Press, 2004.
[23] Shymansky JA, Henriques L, Chidsey JL, Dunkhase J, Jorgensen M and Yore LD, A professional development system as a catalyst for changing science teachers, Journal of Science Teacher Education, 8: 1, 29-42, 1997.
[24] Simon S and Johnson S, Professional learning portfolios for argumentation in school science, International Journal of Science Education, 30: 5, 669-688, 2008.
[25] Van den Berg E, Impact of in-service education in elementary science: Participants revisited a year later, Journal of Science Teacher Education, 12: 29-45, 2001.
[26] Harris KL, Jensz F and Baldwin G, Who's teaching science? Meeting the demand or qualified science teachers in Australian secondary schools, Australian Council of Deans of Science, 2005.

[27] Yager RE, The Constructivist learning model: Towards real reform in science education, The Science Teacher, 67: 1, 44-45, 1991.

Paper presented at the 6th International Conference on “Hands on Science.
Science for All: Quest for Excellence",
Ahmedabad, India, October 27 to 31, 2009.

Pedagogical Material that Promotes Students Interest in Science

Carreira-Leal S and Leal JP

Introduction

A study made at 2006 [1] suggests that experimental work and new technologies are valuable resources to increase motivation of students in science learning. A virtual laboratory, called e-lab, has these two valences: remotely (at home or at school) is possible to execute several experiments. E-lab has real experiments in a virtual environment. The intention is studying several resources to improve the science teaching/learning at schools. The goal of this virtual laboratory is give access to teachers and their students to a laboratory where is possible to collect data at real time, increasing this way the traditional methods of analytic and numerical studies. This laboratory has also the possibility to perform experiments that need expensive material, or perform experiments without the concern about safety precautions. The Ministry of Education in Portugal intends to contribute to the increase of scientific literacy of students, assuming that the learning process should have different velocities. Furthermore, schools and teachers have to organize/adapt the curriculum of each scientific area, according to students they have at school [2]. A study from Berkeley University [3] supports an approach on Science, Technology, Society and Environment that will contribute to the increase of students' scientific literacy. Other source [4] says that students need to participate in their process of learning, which improves positive results. Only students that understand the importance Physics and Chemistry have in our lives are interested in studying science. The pedagogical practice needs to valorise activities that promote students' scientific knowledge and diversified ways of intervention/participation of students in classrooms, creating discussion opportunities inside classes. These pedagogical practices also need to promote the use of new technologies and experimental work in classrooms [5-8]. E-lab is a platform to science teaching that intend to develop scientific knowledge and motivation on students.

Objectives

Physics and Chemistry in Portugal are frequently rejected by students because of the referred difficulty of their curricula [4]. However, Physics and Chemistry are important subjects to the construction of students' scientific literacy knowledge and to their academic path in our technological society. The essential objective of this study is to propose ways to invert this process, giving several and diversified proposals to increase students' interest and motivation in scientific areas such as Physics and Chemistry. To achieve such goal two channels are essentially used: new technologies and experimental work. To implement that, it is important to have virtual laboratories like this to help teachers to perform some experiments that are impossible to do at school either because lack of material or by safety precautions, for example.

Description

Physics and Chemistry teachers face many challenges all over the world. In many countries there is an interest in the number of students who choose Physics or Chemistry as a study subject beyond the point where it becomes an option in the school system. Students' comments on their experience of school science suggest that only a minority finds Physics or Chemistry curricula subjects of great interest. Many of them fail to see the relevance of these to their lives and concerns. Another and different challenge is the quality of teaching and learning. Teachers and educators are becoming increasingly aware that many students fail to grasp some very fundamental scientific ideas, even after many years of study. So we cannot be entirely satisfied with what we are achieving even with those who choose to study the above areas. It's important that school science became more attractive and useful to a higher percentage of school population, and that Physics and Chemistry have a high contribution on this. A study made in 2006 by one of us [1] suggests ways in which we might improve the effectiveness of our teaching of fundamental Physics and Chemistry ideas and more generally, the interface between research and practice. Is fundamental change teachers' orientation about the methods for teaching/learning science? Teachers, have to consider what responsibility they have or what are the reason or reasons to the low motivation in scientific subjects such as Physics and Chemistry. How to motivate students? It is useful to develop collaboration strategies and share knowledge. For example, teachers can: (i) plan problematic situations with interest for the students; (ii) try to solve with students real problems; (iii) show positive expectations in the evolution of learning science. Probably the best answer to increase students' scientific knowledge is expanding the use of new technologies and experimental work in teaching methods [1]. But, in this process, teachers must have a word and be the guides of students' learning. Besides, is important teachers' initial and continuous formation keep up-to-date about new methods of learning/teaching science [9]. Here the interaction school-university is mandatory. This study discusses pedagogical challenges with regard to insert individual flexibility, collective tools and resources in order to increase the interest and motivation to the study of science. In particular, we show the potentiality of a scientific virtual laboratory that can be used any time, anywhere. This e-lab has contents for students and for teachers, and has at this time six working experiments and more than ten are almost ready to use. The six experiments are about gravity; change pressure with volume; speed of sound; change pressure with depth; launching data; and light refraction. One important reason for changing teaching/learning methods is the growing information that is fundamental for students, teachers, and the whole school community. The new curricula in Portugal recommend the need to prepare intervenient and conscious individuals in the future society, a process that begins with teachers and students discussing real problems. The investigation in didactics is always concerned about the quality of scientific education for everyone. Teachers are active agents in the action of the investigation with the implementation of the curricula at school. Nowadays the main objective of educating is forming and preparing the young people for the future, giving them the tools they need to construct their future at professional, social and economic level. In this process new technologies have an important role. New technologies offer a great opportunity but also great challenges to teaching/learning of scientific areas. New technologies give opportunities for the creation of learning environments in an easy way than traditional methods. They can facilitate to bring real world problems into the classroom, and therefore makes the curricula more interesting for students and teachers. These kinds of resources provide tools to improve the quality of today's education. New information technologies cause a revolution in the present society. In fact, the potentialities that propitiate of these resources are crucial in today education. The observation and interpretation of natural phenomena are central goals to increase individuals' scientific literacy. In Portugal scientific education needs to enlarge the proximity between the abstract theory and the observable phenomena. Students often learn subjects by rote. They follow the prepared assignments, and are bound to handouts, textbooks, and worksheets in order to perform successfully on examinations. When faced with a situation that does not provide needed information, students become blocked with no alternative skills for acquiring new information on their own. The research in new pedagogical activities with increased scientific quality is the objective of this project. The e-lab is one of the concepts that we are working on. Problem-based learning with experimental work and new technologies places students in contextual learning situations, creating an education of meaning rather than an education of fact collecting. Students are given a real role in the problem which increases the meaning of that learning. They will readily understand why they need to have access to the concepts and how they are expected to apply them. In a preliminary study we start working with the e-lab (Fig. 1-2) resource, which uses online virtual laboratories. The main advantage of an online virtual laboratory is the usage by schools that don't have other possibilities to achieve material for developing experimental work with students. Till now, students' interest to learn using e-lab is clearly strong. Next step will be the production of pedagogical materials using new technologies of communication and information as virtual learning environments, e-learning projects and experiences, computer software education, videos for learning, digital libraries or repositories, and e-portfolios in order to increase students motivation and interest in science, relating the scientific knowledge with everyday life since primary school (Fig. 1-2). Learning about natural phenomena in everyday life (Physics) and the materials characteristics and transformation (Chemistry) around us are interesting subject matters. According to students [1,4,6] this areas are difficult, they need engagement and the obtained marks are not as high as in other areas, so they choose to study different subjects. It is urgent and necessary to change students' mentality about science, and bring more people to these areas of knowledge.

Conclusion

Teaching nowadays is, as always, a challenge. In order to keep students motivated and worried about scientific questions that appear all the time, in everyday situation, teachers need to change pedagogical methods in classrooms. The use of new technologies and experimental work seems to be a positive option to make students active in their process of studying science, like Physics and Chemistry. It is also important that teachers are motivated and participant in a continuous training [9] to implement virtual laboratories, virtual learning environments, e-learning projects and experiences, computer software education, videos for learning, digital libraries or repositories, and e-portfolios in order to increase students motivation and interest in science, connecting the scientific knowledge with the everyday life as soon as in primary school in order to get the best results. We must never forget that new technologies and experimental work are only fantastic resources when well guided by teachers, to increase the interest in science, and they should never be considered as a rescue strategy to motivate students. The new technologies approach must be introduced increasingly in the teaching/learning process along the academic curricula. Starting with almost nothing, calculating without calculators and practicing mental and scientific concepts, and then increase the use of new technological resources to maintain the interest and motivation in scientific areas like Physics and Chemistry.

Acknowledgements

SC Leal want to thanks the Portuguese Foundation for Science and Technology a PhD grant (SFRH/BD/44889/2008), the travel grant from Hands on Science organization and Instituto Superior Técnico, the Portuguese University Institute that lodge the e-lab platform.

References

[1] Leal SC, A química orgânica no ensino secundário: percepções e propostas, MsC. Thesis, Aveiro, Universidade de Aveiro, 2006.

[2] Ministério da Educação, Departamento do Ensino Básico. Programa de ciências físicas e naturais: Orientações curriculares para o 3º ciclo, Lisboa: Autor, 2001.

[3] SEPUP, Science Education for Public Understanding Program, 2008. http://www.lhs.berkeley.edu/SEPUP

[4] Paiva J, O fascínio de ser profesor, Lisboa: Texto Editores, 2007.

[5] Leite L, Contributos para uma utilização mais fundamentada do trabalho laboratorial no ensino das ciencias, Departamento do Ensino Secundário (Ed.), Cadernos Didácticos das Ciências, Lisboa: Ministério da Educação, Departamento do Ensino Secundário, 78-97, 2001.

[6] Martins A, Malaquias I, Martins DR, Campos AC, Lopes JM, Fiúza EM, da Silva MMF, Neves M and Soares R, Livro branco da física e da química, Aveiro: Minerva Central, 2002.

[7] Martins IP, Simões MO, Simões TS, Lopes JM, Costa JA and Claro PR,

Educação em química e ensino de química: Perspectivas curriculares, Boletim da Sociedade Portuguesa de Química, 95: 42-45, 2004.
[8] Martins IP, Simões MO, Simões TS, Lopes JM, Costa JA and Claro PR, Educação em química e ensino de química: Perspectivas curriculares – Parte II, Boletim da Sociedade Portuguesa de Química, 96: 33-37, 2005.
[9] Marques M, Formação contínua de professores de ciências: Um contributo para uma melhor planificação e desenvolvimento, Porto: ASA Editores, 2004.

Paper presented at the 6th International Conference on "Hands on Science.
Science for All: Quest for Excellence",
Ahmedabad, India, October 27 to 31, 2009.

Astronomy with an 8-Inch

Bhattacharyya RK

Indian culture and heritage in astronomy, astrophysics and mathematics

In India, even today, not more than a microscopic few belonging to the small educated community, not to speak of the illiterate masses, have ever peeped through the telescope to look into the sky. The vast spectacular universe which unfolds itself before the eyes when viewed through the telescope remains entirely un-introduced to them for ever. Is it because of this inability to look beyond the earth that we more often than not get bogged down with trivial earthly problems? But astronomy is not a subject foreign to this country. Ancient Indian astronomers accumulated great knowledge while Europe remained dormant during the period (500-1100 AD). HT Colebrooke's translation of Brahmagupta's Brahmasphutasidd-hanta (628 AD) gives a chronology of ancient Indian astronomers [1]: Varahamihira (200 AD), another Varahamihira (505 AD), Brahmagupta (598 AD), Munjala (933 AD), Bhattotpala, Swetotpala (1017), Varuna-Bhatta (1040), Bhoja-Raja (1150 AD), Calyan-Chandra (1179). Not long ago, possibly holding high the banner of Indian tradition in Astronomy, Radhagobinda Chandra (1878-1975), a village astronomer, an amateur astronomer at that, of Bengal, made original contributions to knowledge on variable stars by peeping through a 3-inch telescope purchased from his humble earnings [2]. Rabindranath Tagore, the poet, and described as "the child of the Upanishads", wrote a book on astronomy titled Viswaparichay (Introduction to the Universe), comprising chapters on "World of Atoms", "World of Stars", "Solar System", "Planets" and "Earth". In writing this book did Tagore not carry with him the ancient Indian tradition and culture in astronomy ([3-5])?

Astronomy and astrophysics teaching in modern Indian education system

However, in modern times, astronomy is taught in undergraduate colleges as part of mathematics or physics courses. There are not many university faculties in astronomy or astrophysics in the country. Punjabi University can boast of having a Department of Astronomy and Space Sciences comprising a 20-inch reflector telescope mounted on a dome at the campus at Patiala. In 1983-84 only two students were awarded doctorate degree in astronomy in the country [6], in

Osmania University. Calcutta University had the tradition of teaching Astronomy from pass degree course to M.Sc. level. Now astronomy has been dropped from B.Sc. Pass course and the course content has been reduced in B.Sc. (Honours) mathematics from 50 to 30 marks only. The University Grants Commission [7] provided 3-inch telescopes to 452 university departments in physics and mathematics and some selected colleges out of 6912 colleges, to observe Comet Halley in 1985-86. All these do not speak highly of the status of astronomy and astronomy in the university system of education. The establishment of IUCAA, the Inter-University Centre for Astronomy and Astrophysics at Pune is, however, a giant leap forward in reviving interest in astronomy and astrophysics in the country. Nevertheless the attempt should start at the grass-roots level, in schools, through colleges and universities and through encouraging amateur astronomy activities.

Amateur astronomy and international Halley watch amateur observers' manual

However, some men not unaccustomed to sciences may question if anything worthwhile is really attainable by amateur observers these days of radio astronomy ('in 30 years, radio astronomy has not only caught up with its elder cousin, optical astronomy, but has overtaken it in some fields') [8] and Ulysses [9] and other gigantic space missions. In answer, it can be asserted that amateur activities may create and sustain interest in astronomy effectively in the society at large. Amateur observation always attracts people of all ages, students, teachers and people of all walks of life. Amateur astronomy has a great role to play on the research plane, in collecting data and in making specific observational investigations of various types. It would be appropriate to quote from the International Halley Watch Amateur Observers' Manual for Scientific Comet Studies [10]: "From the very beginning, organizers of the IHW recognized that amateur astronomers could make valuable contributions supplementing the comprehensive professional observations being planned. Because of the large number of amateurs, the interference of weather with observation s would be minimized and geographic longitude coverage would be more complete than for the smaller number of professionals participating. Also, amateurs are not constrained by telescope time allotments or other duties which might limit a professional astronomer's time. Finally, there are some observations of Halley's Comet and related phenomena which are simply more easily done by amateurs and more comprehensive coverage is possible with their help." A total of 870 amateur astronomers submitted observations on astrometry, Meteor Counts, Drawings, Magnitudes (visual appearance0, Photographs and Spectra of Comet Halley during January 1985 to February 1988 [11]. The data have been analyzed and sent to specialists and to IHW Archives for storage. This clearly indicates the importance of amateur observations in scientific studies in astronomy. Moreover, today's children may be taught to look beyond the planet (in more senses than literal, though!) on the eve of their lapping into the twenty-first century. Coordinated Amateur Astronomy Programme will always attract children to all people of all sections of the society. Author's own experience with an 8-inch reflecting telescope in his Department abundantly affirms this reality. Before we delve into experiences, it would be appropriate to highlight some observational methods depicted in the

Manual. This Manual was published in two parts and addressed to advanced amateur astronomers, with a view to generating meaningful scientific data on COMETS. Part I describes methods of observation and observing techniques. Part II consists of Ephemeris, Maps, Star-Charts and most importantly, Models for recording various types of data such as, visual observation, photographic information, astrometric information, spectroscopic observation, visual meteor observation etc. This manual constitutes one of the most important assets for the observing amateur astronomer. A simple observation technique is mentioned by way of illustration: The *yardstick crossbow* is a simple device used for large scale sky measurements. It is used to measure angular distances in the sky. It consists of a shaft 57 inches long and an ordinary yardstick bent slightly with a string in an arc. Inches correspond to degrees. For observation of angular distances the eye-end of the long stick should be placed in contact with observer's cheek-bone. Final calibration of the device can be made using the star separations given below: Sky Calibration Distances Star Pair: (12)-(13) Separation (in Degrees) Boo Vir 32.8 Boo Leo 35.3 Boo UMa 37.1 Boo Lyr 59.1 Lyr Cyg 23.8 Aql Lyr 34.2 Aql Cyg 38.0 Aql Sco 60.3 Ori CMa 27.1 Ori Tau 21.4 Ori Cru 26.0 Tau Aur 30.7 Cen Cru 15.6 Cen Car 58.0 Cen Eri 61.3 CMa-Sirius, Boo-Arcturus, Lyr-Vega, CMi-Procyon, Car-Canopus, Ori-Betelgeuse, Aql-Altair, Tau-Aldebaran, Sco-Antares, Vir-Spica, Cyg-Deneb, Leo-Denebola, UMa-Mizar, Aur-Capella, Eri-Achernar, Cru-Alpha Crucis, Cen-Alpha Centauri. The manual explains the need for taking dark adaptation, the difficulties posed by atmospheric transparency and sky brightness in observing Comet's tail, the size and magnitude of its coma, meteors etc.

Experience with an 8-inch telescope

An 8-inch reflecting telescope should be the pivotal equipment in Amateur Astronomy. An 8-Inch Newtonian Reflecting Astronomical Telescope with heavy duty equatorial mounting (altitude 12 metres, latitude N, longitude in arc, in time, brings before the eyes of the observer the magnified and distinct images of the Moon, the planets in details, their satellites, nebulae and stars; the binaries can be distinguished, star-clusters are visible; the red, orange, greenish and bluish colours of celestial objects are discernible. The lunar surface topography, ridges and rills and the sun-spots and faculae can be studied rigorously with an 8-Inch. The far, far away worlds of cloudy nebulae such as Orion and galaxies such as Andromeda can be sighted with clarity and excitement! Experiences with the 8-Inch Telescope unmistakably demonstrate that it is capable of exciting immense interest among the students. Some of them have already carried this interest along with them so as to take up Astronomy and Astrophysics as their career subject, some of the young amateur astronomers have thoroughly plunged themselves into amateur observational activities. For others it was found difficult to sustain their interest in Astronomy due to complete lack of photographic, photometric, spectroscopic and other modern facilities within their institutes. All these lead one to conclude that it will always be rewarding to give some more opportunity to our students, with the primary objective to stimulate their interest in the subject, to study and to observe the vastly open, excitingly splendorous sky! Amateurism will lead to professionalism in research in astronomy and astrophysics in no time. This is possibly the most valuable finding resulting from an experiment with the 8-Inch Telescope installed in an undergraduate College! “Urban sky-glow is robbing us of our night skies”, says the Sky and Telescope, in July 1990. It is reported that the 100-Inch telescope atop Mount Wilson in California has recently been decommissioned in part because of severe sky-glow from Los Angeles basin. It is feared that this telescope will not be able again to undertake studies on faint stars or galaxies. This clearly conforms to our experience with the 8-Inch Telescope too. The great nebula of Orion was observed with clarity and satisfaction on the night of 18 January 1980. It was a new-Moon day and the sky was completely dark under a spell of all-out electrical power-cut. This experience never returned to us. The delightful experience of discovering the far away distant worlds of great Galaxies M31 (Andromeda Galaxy: it is a spiral galaxy. Two of its close satellites are: the small Galaxy NGC205 which is very close to the disk and the elliptical Galaxy M32 a little further away) and M33 (the Sc type galaxy in Triangulum) is already a matter of the past. It would be hard to locate the galaxies in future because of the light and dust pollution of the urban night sky. How many stars can one expect to visible through the naked eye from say Shyambazar or Gariahat in Calcutta or from the heart of Beijing in China in these nights of sky-high urban light pollution? A 3-Inch Telescope will just be useless in an urban area.

Conclusion

Amateur astronomy excites professional research, both theoretical and observational, in astronomy and astrophysics. Some steps are therefore suggested below to popularize Amateur Astronomy:

1) District Level Astronomy Centres, equipped with reflecting and or refracting telescopes, binoculars, charts, maps, books and journals such as Sky and Telescope, European Space Agency Bulletin, Khagol etc., may be set up in some district Schools and Colleges.
2) Colleges where some infra-structural facilities already exists for carrying out astronomy activities may be selected for up-gradation that is for strengthening their resources by extending assistance in terms of equipments, part-time or full-time staff etc. In Calcutta, for example, at least three Colleges may be chosen for the purpose: St.Xavier’s College (owning telescopes and telescope dome), Presidency College (owning telescopes and telescope domes) and Brahmananda Keshab Chandra College (owning an 8-Inch reflecting telescope). It is important to select some other institutes of repute located away from Calcutta.
3) An Amateur Observers’ Bulletin may be published. The bulletin will publish charts, maps, ephemeris related to important impending astronomical events. It will discuss various methods such as visual, photographic, spectroscopic etc., and techniques of observing astronomical objects and phenomena viz., comets, meteors, asteroids, the Moon, planets- their satellites and rings, eclipses, galaxies, clusters and binaries. The bulletin will publish reports of amateur observations to explore the possibility to exchange scientific-observational ideas and encourage interaction.
4) The Inter-University Centre for Astronomy and Astrophysics (IUCAA), Pune,

may be urged assume the role of the pivotal amateur astronomy organization to concretize, implement and coordinate the proposals described above.

5) IUCAA may assign appropriate observation programmes to selected amateur centre referred to above.
6) District, State and National Level Amateur Astronomers' Meets may be organized regularly.
7) Prizes for meritorious observations and reporting in the Bulletin may be instituted at different levels.
8) Important publications such as the International Halley Watch Amateur Observers' Manual for Scientific Comet Studies (Jet Propulsion Laboratory, Pasadena, USA) may be translated into regional languages. This initiative is bound to develop interest in astronomy and science in general among the common people.
9) Active amateur astronomers may be invited to IUCAA and other National Centre for Astronomy for training in optical, photometric, spectroscopic and other methods of observation for short duration.
10) The encouragement in terms of assistance, invitation and assignment may be extended to active individual amateur astronomers working beyond the purview of University sector.

All these efforts, in effect, will conform to IUCAA's twin objective of providing (i) a centre of excellence within the University sector and (ii) a centre for science popularization (ref: UGC Annual Report 1988-1989). All these efforts will generate greater interest and zeal for undertaking activities on astronomy and astrophysics and this in turn will encourage and promote professional research too. The European Space Agency (ESA) has undertaken a programme called "Hands-on Activities for Education" with a view to motivating young Europeans for a future in space [15]. The famous Ulysses mission has ended in 1 July, 2008, after 17 years of remarkable success in space research. The Cassini spacecraft is still effectively orbiting the planet Saturn even after 10 years of its launch. "This historic mission's stunning discoveries and images have revolutionized our knowledge of Saturn and its moons". All these information and stimulating descriptions may be made available to our students. Reasonable programmes commensurate with our educational-social-financial environment may be launched with a view to motivating our students taking interest in the sky and space.

References

[1] Algebra with Arithmetic and Mensuration from the Sanscrit of Brahmagupta and Bhascara, Translated by HT Colebrooke, 1817.

[2] Dhumketu (in Bengali), Radhagobinda Chandra, Calcutta: Puthipatra, 1985.

[3] Rabindranath Tagore: A Centenary, 1861-1961, New Delhi: Sahitya Akademi, 1961.

[4] Rabindra Kalpanai Bijnaner Adhikar (in Bengali), Kshudiram Das, Calcutta: Ananda Publishers, 1984.

[5] Viswaparichay (in Bengali), Collected Works, 14, Rabindranath Tagore,

Calcutta: Government of West Bengal Publication, 1961.
[6] University Development in India, Part III, University Grants Commission, New Delhi, 1988.
[7] UGC Annual Report 1988-89, New Delhi: UGC, 1989.
[8] The Cambridge Atlas of Astronomy, Audouza J and Israel G (Eds.), Cambridge University Press, 1988.
[9] Ulysses: A Voyage to the Unknown, ESA, NASA, ESA Bulletin, 63, 1990.
[10] Amateur Observers' Manual for Scientific Comet Studies: International Halley Watch, Edberg SJ (Eds.), Pasadena, USA: Jet Propulsion Lab. Publication, 1983.
[11] IHW Amateur Observers' Bulletin, 20, USA, 1990.
[12] Berg RM and Fredrick LW, Descriptive Astronomy, NY, USA: D. van Nostrand Company, 1978.
[13] The Macmillan Dictionary of Astronomy, Illingworth V (Ed.), London: The Macmillan Press Ltd., 1979.
[14] Crawford DL and Hunter TB, The Battle against Light Pollution, Sky & Telescope, 80, 1990.
[15] ESA Bulletin: Space for Europe, 135, 2008.

Paper presented at the 6th International Conference on "Hands on Science.
Science for All: Quest for Excellence",
Ahmedabad, India, October 27 to 31, 2009.

Introducing Optics in the Kindergarten

Costa MFM, Ayres de Campos J, Lira M and Franco S

Introduction

Young children are always eager to learn to see new things but also to know and to understand the world that surround them.
With reduced “pre-knowledge” usually, there are no previously acquired misconceptions or even prejudices. Also there no exams to study for… “just” the innate survival need to know. However, since they were born a permanent learning process take place at an extremely fast pace.
Children learn from the environment from what they feel from what they live. As we could see when contacting children in this age range, 4 to 10 years old, a constant reference to their every day life and previous experiences is made.
Hands-on [1-2] activities are fundamental and the “natural” approach for these young students.
The first concern of the educator should be, with this clear perspective in mind, to show… or better… to let the children to “see”, to observe, to confront themselves with new objects processes and situations.
Time is fundamental and should be generously given to the young students. Of course some “pressure” can be useful… in due time… respecting each ones pace.
From early kindergarten years the children should “learn”, should be lead to work in group to interact and cooperate with peers towards a common goal.
Care however should be taken by the educator in order to ensure that each student will have, in these group activities, the needed time to establish their own “knowledge” while guarantying that no children, apparently “faster”, feels uncomfortable “waiting” for the others. No sense of superiority, or inferiority, or even of condescendence, in this competition process that always appears in these situations at these ages, should be rewarded. Yet fundamental it is that the each child understands, step by step, the importance of “cooperation”, of listening the other letting the others to know of our findings, helping and accepting to be helped in the sake of a common goal.
How to do that?… a Portuguese popular saying (certainly with equivalents throughout the word!) “words are silver, silence is gold”… be patient give time to the students, and to your self…, open widely your eyes and lead the way smoothly affirmatively and discreetly. Words might be made of silver but it is fundamental that the child is able to verbalise coherently their feelings their findings their opinions.

Hands-on should be complemented with a constructivist [3] approach and others like construcionism [4] and conceptual learning [5].
“Always” hands-on but not blind/mechanically… “… do this and then that and that and…” Learning is discovering… by the student… himself… actively and reflexively.

Light and optics at the kindergarten

Being related to one of our main senses, being the eyes a major gateway to the world that surround us, light related phenomena are rather appealing to young children [6]. Young students readily realize the importance of seeing and the role of their eyes and of light sources. They are particularly attracted to the colour phenomena, to reflection and transparency, to shade and changes in luminosity…
Below we present a set of simple experiments that we designed for 4 to 10 years old students and that may serve as basis for teachers and educators to use in their classrooms and in informal activities [7].
We divided the experiments in three parts. A first one intends to introduce the role of the eye and … we need light to see objects. At the second part we intend to show using a simple model how the eye works. Finally the third part deals with light and colours and is by the most attractive one for our young scientists.

Light and optics experiments in the kindergarten and elementary schools

Part 1

The main concept behind this first set of experiments was: we need light to see objects.
The experiments were design to show that:

- We see an object because the light from the object enters the eye through the pupil. Constriction of the pupil limits the amount of light entering the eye, and dilating of the pupil allows more light to enter the eye. So, in bright light, the pupil constricts, and in darkness, the pupil dilates (Experiment 1).
- There are objects that emit light (i.e., light sources) and others that reflect light (Experiment 2).
- Light is reflected from the surface of objects. Dark objects reflect little light while white objects reflect more light (Experiments 3 and 4. Fig. 1).

Experiment nº 1. Pupil observation

Background: The light enters the eye through the pupil. The pupil has to adapt to different light intensities.
Method: The children are divided into groups of 2 or 3. The room light is dimmed and penlights are distributed to each group. It is asked to one of the children to illuminate his/her eyes while the others observe the pupil closing down.

Experiment nº 2. Luminous and non-luminous objects

Background: There are objects that emit light and others that reflect light.
Method: The room is dimmed. Light emitting objects (of different types) and non-

luminous objects are available and are shown. The similarities and differences between the various types of light sources and objects are discussed.

Experiment nº 3. Brighter and darker objects
Background: The light is reflected from the surface of the objects. The dark objects reflect little light while white objects reflect more light.
Method: Several objects of different colours are placed in a black box with the front face open. The room light is dimmed leaving only a small lamp behind the box. The position of the lamp is gradually changed to allow some light to reach the objects inside the box. As the inside of the box becomes more illuminated the darker objects become progressively more visible.

Experiment nº 4. Light reflected by objects
Background: The light is reflected from the surface of objects. The dark objects reflect little light while white objects reflect more light.
Method: In a very dark room, each child place him self in front of a mirror. One hand holds a penlight on one side of the face in order to lighten the nose. The child is asked to observe his/her face in the mirror (Fig. 1).

Figure 1. The light reflected by the objects' experiment

The experiment is repeated by holding a white cardboard with the other hand, parallel to the side not illuminated. The procedure is then repeated by replacing the white cardboard by a black one and then by cardboards of different colours. Finally the student replace the card a by a second mirror. Children record and discuss what they saw happening on the non-illuminated part of their face when using the different colours or the second mirror.

Part 2

The main goal of these set of experiments is to illustrate how our eye work. These set of experiments were performed with a model of the human eye (Fig. 2). The experiments were design to show that:

- How the image of an object is focused on the retina (Experiment 1).
- What is accommodation (Experiment 2).
- Seeing “bad”… What is myopia and hyperopia (Experiment 3).

Figure 2. How the eye works experiments

Experiment nº 1. Using a bright light source (a candle may be used under teacher’s supervision), images can be focused on the model’s retina simulating the human eye imaging mechanism.

Experiment nº 2. To demonstrate the accommodation the lens can turn thicker or flatter to focus the image on the retina. The lens is a chamber constructed of optically clear silicone elastomer connected by tubing to a water-filled syringe. Water forced into the lens increases its thickness and curvature; withdrawal flattens the profile of the lens, changing its focus.

Experiment nº 3. The eye model can simulate refractive problems (that some children may suffer from). Myopia and hyperopia can be simulated by changing the eyes’ shape (length). It is also possible to use corrective lenses. Whenever there is a child using spectacles it may be used to illustrate the correction effect (if the teacher/educator is not confident enough with the process, is probably better to skip this step unless some students points it out (which often happens… fortunately…).

Part 3

Colour is the main concept addressed at this last set of experiments.
The experiments were design to show that:

- It is easy to separate white light’ colours (Experiments 1 and 2).
- We get white light by adding green, red and blue light (Experiment 3).
- Getting yellow, magenta or cyan colours (Experiment 4).
- Object’ colour depends on the light reflected from them (Experiment 5).

Experiment nº 1. White light decomposition 1.
Background: White light is “composed” of all the colours in the rainbow.

Method: Using a bright white light source (placing a slit in front may help), a beam of white light is projected onto a white smooth surface (target). With a diffraction grating and, or, a prism, the light is decomposed, projecting the light spectrum on the target (it may not be easy to get all colours clearly visible… children must learn to be patient and resilient). Colour filters are placed in front the beam and, as always…, discussed.

Experiment nº 2. White light decomposition 2.

Background: White light is “composed” of all the colours in the rainbow.

Method: CDs are distributed to the children. They observe the decomposition of sunlight (the ceiling lamp or even the light emitted by a computer screen) into the rainbow. The experiment is then repeated with a pocket spectrometer.

Figure 3. Colour shadows

Experiment nº 3 and 4. Mixing light with different colours.

Background: Adding green, red and blue light allows us to get white light.

Method: Three light sources are used - one red, one green and one blue (simple flashlights with colour filter – the teacher must check ahead how red is the red, how green is the green…). The three beams are directed to one point of a smooth, not polished, white wall or board.

Children are also asked to make shadows with their hands (Fig. 3.) and notice all the colours observed. The experiment is repeated with only two lamps connected at a time. The concept of subtractive colour missing may also be addressed.

Experiment nº. 5.

Background: The colour of objects depends on the light reflected from them.

Method: This experiment is done using the same light sources used before and at the same positions. Several cardboard pictures of different colours (the cardboard should not be shiny) are placed on a black board (Fig. 3). Those colour cards are illuminated with one of the lamps and repeated with each one of the other lamps and combinations of them. At the end the three lamps are switched on (Especially for these two last experiments it is necessary to dim significantly room lights).

Brief discussion and conclusion

We decided to invite a group of elementary school students (ages 6 to 10 years old) to the university in order to perform these sets of experiments.

The activity was rather successful pleasing to students and teachers. Although stating their clear preference that the colour experiments were the most pleasant ones, the results were in general very positive, during the execution itself and in the follow-up activities undertaken back at the school.

Figure 4. Demonstrations and visits to museums and science fairs might be very useful if a follow up work is prepared by the educator and conducted in classroom context

Follow-up, in fact, should always be considered very important. These non-formal or informal activities (visits to labs, museums, science fairs or lectures, Fig. 4.) should always be followed of work sessions in the classroom exploring the motivation achieved and developing and or strengthening the knowledge transmitted/acquired. At the end of our activity a series of enquiries and quizzes were delivered to the teachers and asked to be returned for analysis and statistical treatment. Furthermore we distributed to the students material and short guidelines to build, on their own, a kaleidoscope and a simple pinhole camera (a muffin aluminium cup, a rubber band and a soft translucent paper sheet is enough…).

Being clear for us that the students easily and correctly are able to understand the importance of the eye in the process of seeing, we decided to explore a little bit the vision process. We used a simple model of the eye with a pupil, a rubber lens that could be inflated using a water syringe and a retina like displaceable target, which can be easily built. We expected the students to have difficulties in understanding the process or even accepting it … we were inside the eye…! In fact only older students, 9 to 10 years old, were able to deal with it. The age span covered, 4 to 10 years old, is rather large (especially as dealing with children). One must carefully cope with the differences… being flexible but always observing child's' reactions.

From very early ages young children are strongly attracted to colours, in particular to bright principal colours, are fascinated by the wonders of colour mixing and they seem more attracted to additive mixing opposite to what happens with school students that before being presented to the issue had previous experience in mixing ink for paintings (the subtractive process). The hands-on manipulation of colour cards (especially if being part of games) is particularly effective (Fig. 5.).

Figure 5. Shapes and colours

In general the basic concept covered by these experiments (specially part 1 and 3) are readily understood by the young children that immediately after realizing the concept present a series of examples related to their own experience (… when electricity failed and lights went off I was afraid my mama leave me alone in the dinner table…). This type of reaction happens quite often (normally older students are more "careful" expressing their feelings and ideas and restrain them selves) and is a good indication that some level of understanding of the concept was achieved.

References

[1] Costa MFM, Hands-on Science, Selected Papers on Hands-on Science, Costa MF, Dorrío BV, Michaelides P and Divjak S (Eds.), Associação Hands-on Science Network, Portugal, 1-13, 2008.

[2] Gatt S (Ed.), Primary Science Teachers Handbook, European Commission Comenius 3 project: Hands on Science Network, Malta, 2006.

[3] Gatt S, Constructivism – An effective Theory of Learning, Constructivist teaching in Primary School Social Studies, Mathematics, Science, ICT, Design and Technology, Gatt S and Vella Y (Eds.), Malta: Agenda Publishers, 2003.

[4] Ribeiro C, Coutinho C, Costa MFM and Rocha M, A Study of Educational Robotics in Elementary Schools, Selected Papers on Hands-on Science, Costa MF, Dorrío BV, Michaelides P and Divjak S (Eds.), Associação Hands-on Science Network, Portugal, 580-595, 2008.

[5] Zamarro JM, Molina GJ and Núñez MJ, Teaching Physics Modelling with Graphic Simulations Tools, Selected Papers on Hands-on Science (ISBN 978-989-95336-2-2), Costa MF, Dorrío BV, Michaelides P and Divjak S (Eds.),

Associação Hands-on Science Network, Portugal, 69-73, 2008.
[6] Costa MFM, Learning Optics at Basic Schools by Experimentation, Selected Papers on Hands-on Science, Costa MF, Dorrío BV, Michaelides P and Divjak S (Eds.), Associação Hands-on Science Network, Portugal, 25-28, 2008.
[7] Costa MFM, Hands-on Introduction to Optics / Introdução à Óptica (bilingual edition), Hands-on Science Network, 2006.

Paper presented at the 6th International Conference on “Hands on Science. Science for All: Quest for Excellence",
Ahmedabad, India, October 27 to 31, 2009.

Robotics in Child Storytelling

Ribeiro CR, Costa MFM and Pereira-Coutinho C

Introduction

The interest on robotics as an educational tool has increased substantially over the last few years.
In fact, many benefits have been claimed for this tool and many researchers stress that it can be a tremendous source of energy that can be used to motivate both adults' and children's learning.
Those who have used robots say that they spent thrilling moments, the atmosphere is vibrant and that they profited much from the experience.
Many believe that this interest can be used for educational purposes [1]. Yet, before recommending the massive use of this tool in the different levels of teaching and education, it is necessary to study in depth some issues related to the true effectiveness of educational robotics in promoting the acquisition of skills and knowledge.

Objectives

In general, some important issues can be raised about educational robotics, being of foremost importance the following:

- What types of contents/skills can be learned / taught used the robotics as an educational tool?
- What age levels can be contemplated with robotics activities and how this are related with the answers in the previous question?
- What are the main differences between the type of learning promoted by robotics and other ways to learn/teach?
- Which factors in the student's social context can influence her feedback to robotics activities? In particular will the student's gender be a relevant factor in his motivation level and to determine the kind of activities that will be developed?
- What kind of activities can be developed to maximize the potential of robotics as an educational tool?

It is obvious that to obtain adequate answers to all these questions can be an overwhelming task that is quite far from being concluded.

Lego Mindstorms Platform

The Lego Company has a long tradition in the development and commercialization of toys with innovative features that put together the entertainment and the pedagogical components, an aspect that was never disregarded by the company.

Lego has been selling toys that integrate electronic components for nearly 30 years. Therefore, it is not cause for admiration that the company has searched for a leading role in the educational robotics arena. With this purpose, in the beginning of the 1980's, Lego searched by the MIT a collaboration in order to be able to develop robots that could be controlled by computer programs, in a way that could be interesting for children.

This collaboration was based on the pioneering work done by Seymour Papert at the MIT, namely with the development of the Logo language that allowed to program the movements of a turtle in a computer screen. As a result of this partnership, the Lego TC Logo came up in 1986, where robots built with Lego pieces could be programmed using Logo. This collaboration provided more fruits since in 1998, also with the participation of M. Resnick, with the appearance of the first Lego Mindstorms systems, named Robotics Invention System. The large potential of the RCX, the "brain" of the kit, as well as its numerous available programming interfaces changed the landscape of its buyers. Indeed, this kit was mainly acquired by adults [2].

After a short period of enthusiasm, Lego entered a period where the strategy to invest on Robotics seemed to be compromised. This period was ended in 2006, with the release of the new Lego Mindstorms kit based on a new central processing unit, the NXT, that replaced the "old" RCX.

The Hardware of the Lego Mindstorms

The NXT is a programmable robot that has one (or more) motors enabling it to move (and much more), that can use the different sensors to get information from the environment and that is also able to emit sounds. The robot has also the capability of communicating with a personal computer, either through a cable or using the new Bluetooth communication abilities. The Lego Mindstorms kit has in its basis the following hardware components: a microprocessor, a battery, a transformer, cables, sensors (ultrasound, touch, sound, light), motors and numerous Lego pieces for constructing different models.

Programming the robot: available software

The Lego Mindstorms Education NXT software allows us to explore in depth the potential of the robot. It integrates the Robot Educator, a tutorial with 39 activities that allows any new user to learn at its own pace. The initial screen gives access to two different areas: the Robot Education with tutorials and construction plans and the work area that allows the user to freely program the NXT, using a visual programming environment.

Advantages of using the Lego Mindstorms robot

The Lego Mindstorms robot fascinates all children (and adults) that contact it. It has attractive accessories that allow it to interact in several ways with the surrounding

world. The available sensors allow a rich interaction between the robot and the children. There are no doubts that this can make an ideal tool to motivate students in the learning process, since it presents new challenges to develop several learning skills.
The advantages of using the Lego Mindstorms NXT robot are numerous: the fact that it is possible to use it in the classroom or outside the classroom in group work; it enables social and communication skills; it is possible to endow it with the form the users need or prefer; it facilitates a meaningful learning process; it allows multidisciplinarity, interdisciplinarity and transdisciplinarity; it is useful for teaching several contents related to Mathematics, Technological Education, Physics, Biology, Chemistry, Visual Education, among others.

State of the art in Educational Robotics

Over the last decades, in numerous places around the world, many experiments have been conducted using Robotics as an educational tool, with a special emphasis at the secondary or university levels, but involving in some cases the more elementary levels of teaching. Of course, Robotics can be thought as another content, to teach or explain to the students, in a traditional perspective [2]. This is, typically, the approach followed by some university or more technical courses related with Electronics and automation contents.
We should face Educational Robotics under the perspective of a broad tool that can be used in all teaching/ learning levels and as a way to approach several different contents. This view can be well integrated in a constructivist approach to education. According to Chella [3], Educational Robotics can be defined as an environment with several components (the computer, the robot and other electronic artefacts, the program) where the student builds and programs its robots, interacting with all the components and exploring concepts from distinct areas of knowledge.
Competitions are the best example of initiatives that involve a large number of participants (students, teachers and parents).
They are, for this reason, privileged as tools for the divulgation of robotics next to the younger. The major competitions are the First Lego League (FLL) that involves students between the ages of 9 and 16 years old and the RoboCup Junior, where each team has two autonomous robots that play a soccer game against another team in a 3 meter field.
Beyond competitions, other research works are being developed in several schools and have resulted in scientific publications. Within these examples, there are studies where students with ages between 10 and 18 participate in extra-curricular Robotics clubs [2,4-5], as well as qualitative studies approaching the construction and programming of robots by elementary school students to dramatize a popular Portuguese tale [6].

Constructionism

The origins of constructionism can be traced back to the group headed by Papert in the MIT in the 1960’s that was well known with the development of the Logo language. This group built a vision of education based on 4 basic ideas [7]:

1) The constructionist philosophy of education involved the creation of computational environments where children can manipulate materials in an active way, playing with the, learning by doing, through the development of meaningful projects, shared with the community.
2) The importance of concrete objects as a way to learn abstract phenomena. In this case, the computer allows creating and manipulating objects in the real and virtual worlds, thus making a tool of extreme relevance.
3) The so called "powerful ideas" that reinforce the individual's capability to learn, allowing distinct ways of thinking, of using knowledge and of creating interpersonal relationships and epistemological with other domains of knowledge [8].
4) The importance of self-reflection that happens when people are encouraged to explore their own process of thinking and their intellectual and emotional relationship with knowledge, as well as their life story that affects the individual learning experiences.

These four principles of the constructionist philosophy are a commonly accepted basis on the elementary education levels. On the other hand, those are fundamental to the development of Robotics activities.

Potential of Educational Robotics in the teaching/ learning process Curricular areas

Robotics has been used, over its path in Education, as a tool useful for the learning of distinct contents, as well as for the acquisition of numerous skills. Within this large set, the areas of Physics, Mathematics and Informatics are normally emphasized, being the ones more directly connected with Robotics. Regarding Physics, several are the sub-fields where many of the important concepts can be approached using Robotics based activities. The tasks that the robots perform are typically related with movement, involving numerous concepts from Mechanics. Informatics is directly approached by the activities concerning the robot's programming, as well as all the software tools involved. Underlying both fields we have the mother of all sciences, Mathematics. Robotics provides an excellent mean to make lots of different mathematical concepts, at all levels, into very tangible and useful concepts. Robotics makes possible to design activities that implement project based learning approaches.
Furthermore, Robotics also allows working concepts related to areas like Arts Education. In fact, when planning and building robots a number of skills related to these subjects come into play. On the other hand, some of the Robotics activities (e.g. competitions) have been developed in order to include Music and Dance as major areas, being approached activities that involve different types of choreographies.

Robotics in Basic/ Elementary Schools

We believe that Robotics can be used in the teaching/ learning of some of the contents and skills related to the major areas of basic or elementary school (i.e. within the first 4-5 years with students between 6 and 10 years old). Indeed, many of the major contents from areas like Mathematics, Sciences, Languages and Arts can be included into well designed and planned Robotics activities. An analysis to the curricula in the Portuguese system [9] allowed identifying, for the main curricular areas, a set of application domains, learning experiences and contributions to reach the proposed basic skills. We believe that this study detailed below can be easily transposed to other countries and teaching systems.

Mathematics - The emphasis on Mathematics in this level should be focused in solving problems, thinking about them and communicating with others to exchange ideas. Robotics offers a field full of opportunities, allowing working on the main skills of the different domains, such as Arithmetic, Geometry, Algebra and general problem solving.

Sciences – Robotics can contribute for reaching the main aims in the teaching of natural and physical sciences, such as: acquiring a general understanding of the ideas and structures that explain scientific concepts; understanding and applying the procedures of the scientific research; questioning the impact of Science and Technology in our societies. Robotics is able to provide a set of learning experiments that include planning projects with certain aims, detailing the major steps, since the definition of a problem to the understanding and divulgation of the results and doing cooperative work.

Technological Education – Technological Education should be built upon the development and acquisition of skills in a sequence of learning steps along the elementary school levels. These should be able to integrate concepts and skills shared with other areas and promote the application of these concepts into new situations.

Methodology used in the study

The study we undertook is considered as a case study, since it can be included into a class of research studies where, for a number of reasons, it becomes very difficult or even impossible to generalize results, being the aim to describe a given educational phenomena. This option can be intentional or imposed by the nature of the study or by the available resources that prevent the researcher from controlling the events and manipulating the causes of the participant's behaviour [10-11] characterizes the study as a qualitative case study given its descriptive, inductive, particular and heuristic character.

Description of the study

This study involved the development of two Robotics projects, by a group of students from the 4^{th} and 6^{th} grade respectively. Lego Mindstorms kits (as described before) were used in both cases. The activities took place in the 3^{rd} period (April to June) of the curricular year of 2006/2007. A work was developed including activities of Robotics in the curriculum of the two groups of students during these 3 months. One of the groups (4^{th} grade) belonged to the EB1/JI elementary, included in the Gonçalo Sampaio group of schools from the city of Póvoa de Lanhoso in Portugal.

The other group (6th grade) belonged to the Conservatório de Música Calouste Gulbenkian in Braga, Portugal. Both studies involved the participation of the students in activities that took 2 hours per week for about 12 weeks. The project ended with a final year party, where all students from the schools were present, as well as parents and teachers.

Regarding the first group, the EB1/JI da Póvoa de Lanhoso is integrated into a group of schools where the first author was working over the last three years. The necessary robots were gently provided by a project coordinated by the University of Minho. The students opted, in this case, to dramatize a story and use this project as their contribution to the final year party. They decided to show their colleagues a different way of telling stories and chose the popular tale to the "Little Red Riding Hood". Within the group, the tasks were distributed by all: some were in charge of building the scenario (painting boxes, drawing trees), others designed and made the clothes for the robots, others built the robots using the Lego pieces, others programmed them and others still wrote the dialogues.

These students had never had the chance to see and touch a robot previously. The project was structures into 3 major steps: the preparation of the study including learning the basic of the Lego Mindstorms platform; the development of the story telling project; and, finally, the presentation of the final result to the community.

Regarding the second group, the Conservatório de Música Calouste Gulbenkian was one of the schools participating in the project leaded by the University of Minho. In this school, the option was to work with a group from the 6th grade, given the openness and flexibility shown by one of the teachers in order to have an available slot on the busy schedule of these students. The students in this group were all from a medium-high socioeconomic background, but had no previous contact with Robotics. In this school, Music is a major theme and students have little available time for other activities.

The available time was of 90 minutes per week and the group had 20 students. Initially, all members of the group were together making some activities to understand the platform and know how to build and program the robots. In a second stage, the group decided on the projects they would be involved and it was decided to divide the group into two sub-groups, working on different projects: the first opted for the dramatization of the story of the "Three Little Pigs" and the second decided to do a fashion show and also a dance choreography.

Within each session, in the first 45 minutes the 1st group was preparing the scenarios, the clothes for the story, while the 2nd group was programming the robots for the fashion parade and dance. In the second part of the session, there would be a switch, and the 1st group would go and program the robots for the story (e.g. setting the path for each robot and programming the movements), while the 2nd group would work on the characterization of their characters for the fashion show and the dance. In the 1st group, the programming was made in a collaborative way, but more towards the end 5 students were selected for each character, while the other five were working more on the dialogues and synchronization with the robots movements. In the fashion parade, they decided that each student would enter side by side with the robot and with similar clothes.

Characterization of the community and the subjects involved in the study

The students from the 4th grade had a previous history of participating in Informatics activities in their extra-curricular time in school. All students had a previous contact with computers, although there were dissimilarities within the group. This group had 11 students, 6 boys and 5 girls. To program the robots, the students made 5 groups, one per each character in the story. The groups had 2 elements (one with 3), where one of the students programmed and the other tested in the ground. They switched tasks regularly. In the final presentation, one the students were next to the robot to start it when appropriate and the other was the "voice" of the character.

This group was considered to be very noisy by their teachers, but during these activities they were always a disciplined group, obeying the rules with no problems and normally motivated by the activities and anxious to show their progress. Their previous background with computers made it easy to proceed with the programming activities. Whenever one student had any doubts, all the others were ready to help.

The 6th grade group from the Conservatório de Música Calouste Gulbenkian has good skills in working with computers. All students had a computer at home, but they had never contacted Robotics before. The group had 13 girls and 7 boys and the group division was made by alphabetical order. In general, the students had good results in their school subjects, although two of the students were weaker then the remaining. Since the first day, all students embraced the project with enthusiasm and good mood. The worked hard to develop the project in time since the weekly time was not much.

Data collection Instruments

In the study, distinct instruments were used to collect the data for the investigation. These were designed and implemented by the 1st author that collected all data and made its processing and interpretation. In this study, the following instruments were used: participating observation; video films of the sessions and analysis of the documents produced by the students (e.g. files with the robot programs). In a qualitative study, the role of the researcher is primordial in the collection of the data. In this case, the direct observation of the events is very relevant [12]. In our case, the observation was participant since the researcher was also an active participant in the research. According to Vale [13] the observation is the best techniques to compare what is said with what is done. Cohen and Manion [14] emphasize 3 advantages of video recording in the context of educational research: they allow a comprehensive record of behaviours, attitudes, reactions and dialogues, always available for future analysis; they improve the reliability of the study; they allow occurrences to be reviewed repeatedly. In this study, the direct observation and the videos served to allow the narration of the sessions and the main facts that occurred in each, as well as to list the dialogues between students and the researcher. One of the main instruments in the data collection relied on the files produced by the students when programming the robots. Any change in a program was kept for future analysis by creating consecutive versions of the files. After analyzing the files, we realized that, in the majority cases, these changes are not new blocks of code, but rather small changes in the timing of the actions within the blocks. Normally, the right actions were defined pretty soon in the process, but the exact timing was a process of trial-and-error. Therefore, the right program to implement a given path was reached after a considerable number of attempts, mainly for fine tuning of the times involved.

Results

a) Building the robots: In the beginning of the first building session, all were very committed and even the harder ones to convince were enthusiastic with the process of building the robots. When they managed to build a "car", the enthusiasm doubled and they competed to check what the fastest robot was.
b) Programming the robots: The students did not show major difficulties in solving the problems in the first list of proposed activities. The challenges that came next put them in a state of anxiety, and this lead to some problems when then rushed into solving problems as quickly as they could. Initially, the researcher created a script with activities to provide for an initial contact with the platform. The students executed some tasks from the script and checked for the results. Then, orally, the researcher proposed some challenges and the students tried to solve it by programming the robot. In this stage, they programmed directly into the robot using the provided interface. Also, students tried to program a few "random" activities and to understand the result.

When the problems got tougher, they started to use the computers and the provided software, downloading the programs into the robot to test them. At this stage the students started to work with the sensors and create programs that would interact with the environment. This new stage is a big step in terms of complexity and it was visible that the students had more difficulties in getting the robot to behave the way they would like it to. Since, the scenarios and the paths for the robots were ready at this time, the students started to program their own robots and trying to solve the specific problems imposed by their tasks.

Conclusions

One of the motivations for this work is the relative inexistence of studies regarding the application of Robotics as an educational tool, in the context of the first years of teaching (elementary or basic school). This level has been somehow disregarded in these studies, maybe because most of the researchers do not believe that the tool can be applied with such younger children. This project aimed at providing a contribution towards this aim, by successfully conducting a study with students from the 4^{th} and 6^{th} grades. The fact that it was possible to reach the main goals of this project, with both groups, given the underlying complexity involving the use of Robotics kits that implied both building and programming the robots for the specific tasks, is in itself a confirmation of the applicability of this tool to children of this age. In this context, an additional factor to take under consideration is the broad scope of this work in terms of the curricular areas that were involved. In fact, additionally to the traditional areas of Science and Mathematics, this work reached other areas related to Arts and Languages, namely Drama, Plastic Expression, Music and Dance. By providing a pedagogical context to the new technologies, we integrate in the curriculum a huge amount of available information. The main advantages are: it develops the critical thinking; it develops logical thinking; it increases the interaction and the autonomy in the learning process; and, it raises the interest and motivation for learning.

References

[1] Johnson J, Children, robotics and education, Artificial Life & Robotics, 7: 1-2, 16-21, 2003.

[2] Teixeira J, Aplicações da Robótica no Ensino Secundário: o Sistema Lego Mindstorms e a Física, Dissertação de Mestrado, Coimbra: Faculdade de Ciências e Tecnologia da Universidade de Coimbra, 2006.

[3] Chella MT, Ambiente de Robótica para Aplicações Educacionais com SuperLogo, Universidade Estadual de Campinas – UNICAMP, Faculdade de Engenharia Elétrica e da Computação – FEEC, Dissertação de mestrado, 2002.

[4] Costa MFM and Fernandes J, Growing up with robots, Proceedings of the 1st International Conference on Hands-on Science, Teaching and Learning in the XXI Century, Divjak S (Ed.), Ljubljana: University of Ljubljana, 119-124, 2004.

[5] Silva J, Robótica no Ensino da Física. Dissertação de Mestrado, Braga: Escola de Ciências da Universidade do Minho, 2007.

[6] Ribeiro C, RobôCarochinha: Um Estudo Qualitativo sobre a Robótica Educativa no 1º ciclo do Ensino Básico, Dissertação de Mestrado, Braga: Instituto de Educação e Psicologia da Universidade do Minho, 2006.

[7] Bers M, Ponte I, Juelich C, Viera A, Schenker J, Teachers as Designers: Integrating Robotics in Early Childhood Education, Information Technology in Childhood Education Annual, 123-145, 2002.

[8] Papert S, What's the big idea? Towards a pedagogy for idea power, IBM Systems Journal, 39, 3-4, 2000.

[9] CNEB (Currículo Nacional do Ensino Básico, Competências Essenciais, Ministério da Educação, Departamento da Educação Básica, 2001.

[10] Yin RK, Case Study Research – Design and Me, Applied Social Research Methods, 5, 1994.

[11] Merriam S, Case study research in education: A qualitative approach. San Francisco, CA: Jossey-Bass, 1998.

[12] Bogdan R and Biklen S, Investigação Qualitativa em Educação. Colecção Ciências da Educação, Porto: Porto Editora, 1994.

[13] Vale I, Didáctica da Matemática e Formação Inicial de professores num contexto de Resolução de Problemas e de Materiais Manipuláveis, Universidade de Aveiro, 2000.

[14] Cohen L and Manion L, Métodos de Investigatión Educativa, Madrid: Editorial la Muralla, 1990.

Paper presented at the 6th International Conference on "Hands on Science.
Science for All: Quest for Excellence",
Ahmedabad, India, October 27 to 31, 2009.

Science Fairs in Non-Disciplinary Curricular Area

Esteves Z and Costa MFM

Introduction

During the XX century many changes were implemented on the curriculum of the Portuguese Schools to construct a better educational system [1] and decrease the school abandon. One of the last changes was the introduction of “Área de Projecto” that started an experimental way in some schools in 1998 [2].
“Área de Projecto” is a curricular area, non disciplinary with a curriculum conception more flexible and autonomous to the school and teachers [1], and that works with an interdisciplinary method [2-5]. The curriculum of this area is discussed between teachers and students, taking into account the social and economic situation of the students, the reality that surrounded them [2-4] and the partnerships that they can form [1,4].
The major objective on this curricular area is the development of projects where the creativity, the investigation techniques, the text production and the scientific and social knowledge is stimulated [1-2]. All of this will contribute to a better school and, in the future, be responsible for helping the professional orientation of students [1-4], promoting their better comprehension of the world [1,3,4].
This curricular area should be promote a relation between school and general community, like the family but also companies and others institution. Students and teachers improve and develop not only scientific but also personal and social capabilities, since this is an opportunity for students meet and reflect about social, economic, technological, scientific, artistic, … issues [3].
Teachers are responsible for the orientation of the project development but they also can ask for help to others teachers of the class [2-3].
The projects developed should respect a scientific method, promote the debate of ideas [2-3], based on experiments associated to systematic observation, formulation of hypothesis, testing them and finally the analyze, interpretation and explanation of facts and phenomenon of the real world [1,3]. Teachers from Área de Projecto should be responsible to give the opportunity of students to develop a project, therefore, they have to access to internet, movies, books, experimental and non experimental reports, videos... [3].
Science fairs are a way of students to develop scientific projects and learn how to make science. The science fairs can involve actively students during this learning process and the results are scientific productions that can be presented to others

[6-7]. With this work we pretend to show how one extra curricular activity like a science fair, that students like and that can be developed with in this non-disciplinary area. Therefore, we have the opportunity to stimulate students to science without over charging of their free time. It is relevant to inform that the steps presented here never limited students from working at home or in their spare time.

Development of the project

The realization of the 3rd edition of the science fair was announced to students and parents in the beginning of the year on a general meting. However, during the first two school weeks we have remembered/explained the rules and principles of a Science Fair with more detail and present some important dates related with this event.

We announced to students that some time from “Área de Projecto” will be available to them for the development of there work. To students that participate on the Science Club, it will be also given the opportunity to develop their work in that context. Otherwise, students should work at home and could get help from the teachers of disciplinary areas at any time they need.

It is important to say that the involvement at “Área de Projecto” was not mandatory. The teachers evaluate the work developed by this students, but attributed other kind of projects for students that didn’t wanted to participate in the science fair.

The involvement in this non-curricular discipline was important for the students since they didn’t had to work on their free time, giving them the opportunity to research, plane and experiment and make their own conclusions during these classes. It was also a great help to science teachers that organize the science fair since they have more time to plan the science fair and to supervise the students projects.

At the begging of the year, it was explained to “Área de Projecto” teachers what should be done to successfully help the students in their science fair projects. During the year some meetings were made to discuss with those teachers the evolution of the student’s projects. It was explained to them that during the first period students should be able to research from a subject of their interest and form, by themselves, groups with other students with the same kind of project. Those teachers should help students to question about their research topic and help them in the search for solving those same questions. During those “Area de Projecto” classes students had internet access and could search on the school library. They were also invited to discuss their ideas with all kind of people, from family to friends or professionals from that subject. After the students decision about the workgroup and the theme, teachers helped them writing a small report, with the title, the material and a brief explanation about the subject they propose to study, in order to be analyzed and discussed with them.

The only problem faced was the fact that the “Área de Projecto” teachers were not from a science field and couldn’t help students directly with their scientific doubts. But this problem was solved, since the students could use hours from the science club or at lunch time to discuss with their science teachers.

After analyzing all chosen projects we’ve discuss with all groups the viability of that same projects. Some of them were denied due to dangerous material or difficult to

find, or if that same project do not have any scientific interest. Those students had the opportunity to reformulate the projects and many of them did it.
During the 2nd period students continued to develop the projects at school and at home. They still had the opportunity to work on "Area de Projecto", where they could also laboratory facilities.
The evaluation of the students that participate in the Science Fair on "Área de Projecto" was made according to the general parameters already proposed for this school subject as:

- The commitment on the research and development of the theme;
- Autonomy;
- Teamwork;
- Problem solving abilities,
- The final product quality (this parameter was discuss between science teachers and "Area de Projecto" teachers);
- The science fair presentation.

On the beginning of the 3rd period the fair was presented during an afternoon and was open to the entire school community and to all people that wanted to see.
The evaluation of the projects was made taking into account some aspects like:

- The evolution of the work;
- The initial report taking into account scientific issues;
- The originality on the choice of the theme;
- The respect of deadlines;
- The presentation at the science fair.

Taking into account the number of participants, it was decided to select the 3 best projects from the 5th and the 6th grades, and also the 3 best projects from the 7th to the 9th grades. This division was made by ages and because of the limited scientific knowledge in physics or chemistry. To all the others students that respect the parameters proposed, it was attributed an honourable mention.

Results and discussion

The science fair is organized at Externato Maria Auxiliadora since the school year of 2006/2007 and analysing the evolution of the students participation it is possible to conclude that the number of participants it rising as we can see on Figure 1. On the first edition 42,9% of the students participates (that edition were only for students from 7th to 9th grades); on the second edition 65,6% of the students participates and on the third edition it was 77,9%. The major evolution verified this year was on the 5th and 8th grades.
The participation of students from the 9th grade is still limited. The reason appointed from students is that they had too much work at school due to the exams in the end of the year. However, with the largest participation from 8th grade students and the introduction of this activity in "Area de Projecto", we hope that the tendency of

"older" students of not participating at the fair changes next year.
The highest enthusiasm from the youngest students was evident on the excellent projects they present, even better that form the oldest students.

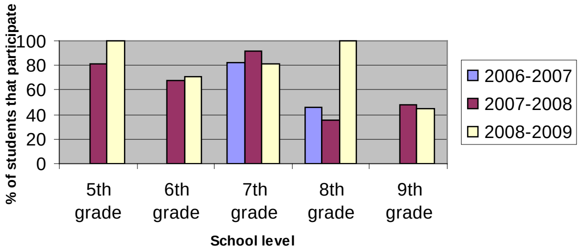


Figure 1. Evolution of the participation of the students at the science fair

Analysing the decisions from the jury, we can conclude that 71,8% (28 of 39) of the projects presented at the fair respected all the parameters.

Figure 2. The pieces of the break system of a car

Along these years it was evident that students preferred to work in groups. However, the tendency of establish groups of four elements (number limit accepted) is decreasing and the individual projects are increasing. Working in pairs is a good choice if students have the same enthusiasm in the project and share responsibility during the development and the presentation of the same. Students start to understand that fact. For this reason they need to start by selecting the subject and not the group. It was also told to "Área de Projecto" teachers to remember the students about that fact.
One interesting feature of this year fair was the inclusion of what we call 4 non experimental projects. These projects didn't have an experimental base that permits to explain or test any factor. They simply explain how some things work. As an example we have the project of two students from the 7^{th} grade that explained the car clutch system, as we can see on Fig. 2. Curiously, this kind of project made a great success between students.

Conclusions

These three years of a science fair organization at Externato Maria Auxiliadora were very helpful, since the experience of working with this project in the same school, with some of the same students allowed us to conclude that a large number of students already understand the meaning of a science fair and how they should develop and present their project.

The fact that the science fair was announced to parents increased the number of visitants and we could clearly see a major involvement from parents and friends during the development of the projects. As an example, we gave the first prize to a group of four students of the 5th grade that explained how the telegraph works, as we can see on Fig. 3. In this case, parents helped the students on the construction of the telegraph, since it was necessary to use some materials that could be dangerous to them, and also helped them in their presentation.

Figure 3. Students explaining the Telegraph

It was curious to see that these four students of the 5th grade made a complete study of the history and operation of this instrument.

The only problem that we appointed this year was the fact that, due to the great number of projects (39) and the limited time (from 14h00 to 17h00), didn’t allowed us to have a clear and calm view of all the projects presentations.

Future work

During the next school year of 2009/2010 we will continue to organize the fourth edition of the fair. The projects will continue to be developed in the same way and we will continue implement this project on the “Área de Projecto” curricular area.

To help on the construction of the materials and posters, the teachers of Visual and Technological Education (EVT) will include the projects of the science fair on their subject.

The fair will be presented during the third period, and will be made on a Saturday and during all day. The event will take place this time on the city of Viana do Castelo downtown centre. We expect that these new features of the event will make possible for more people to see the work of these young scientists.

References

[1] Despacho nº 19308/2008, Princípios orientadores das Áreas Curriculares Não Disciplinares), Ministério da Educação, 21 de Julho de 2008.

[2] Graça E, Bibliotecas Escolares e Área de Projecto. Dissertação de Mestrado, 107-151. Universidade do Minho, Braga, Portugal, 2005.

[3] Orientações de Área de Projecto dos Cursos Científico-Humanísticos e Projecto Tecnológico dos Cursos Tecnológicos, Ministério da Educação. 2006.

Paper presented at the 6th International Conference on “Hands on Science. Science for All: Quest for Excellence",
Ahmedabad, India, October 27 to 31, 2009.

Innovations in Teaching Physics of Sound

Garg A, Sharma R, Dhingra V, Kumar A and Khan Z

Introduction

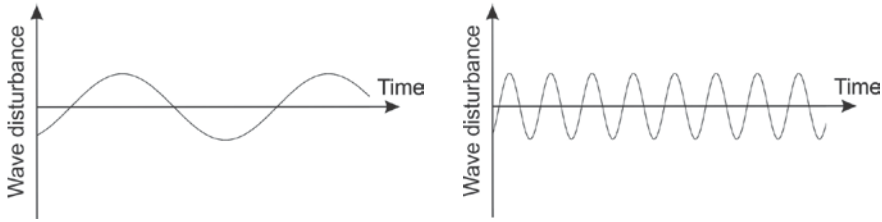
Sound is defined as the vibrations transmitted through elastic solid, liquid or gas, with frequencies in the approximate range 20 Hz to 20 kHz, capable of being detected by humans. There are three important aspects of sound waves that determine what one hears: Loudness, Pitch and Timbre. The amplitude of the sound wave determines how loud a sound is. Musical tones consist of a fundamental frequency which is mostly responsible for the pitch perceived by the ear and a number of higher harmonics, frequencies that are integer multiples of the fundamental. The higher harmonics that are present and their amplitudes comprise the Fourier spectrum of the tone that is responsible for the quality or musical timbre perceived by the listener. Quality or timbre is why different musical instruments sound different even when being played with the same pitch and similar loudness.

Students up to the high school level are taught the basics and various properties of the sound waves. However, the different aspects like audibility range of humans, pitch, loudness and quality of sound wave remain difficult to visualize and understood by the students due to lack of proper laboratory tools/experiments that could reflect the effect of these parameters individually. The developed application can be used as a teaching aid to ease out the understanding of these concepts.

Theory

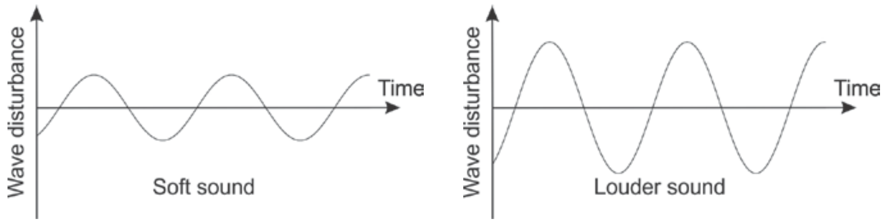
A violin and a flute may both be played at the same time in an orchestra. Both sounds travel through the same medium, that is, air and arrive at our ear at the same time. Both sounds travel at the same speed irrespective of the source. But the sounds we receive are different. This is due to the different characteristics associated with the sound. Pitch is one of the characteristics. How the brain interprets the frequency of an emitted sound is called the pitch. The faster the vibration of the source, the higher is the frequency and the higher is the pitch, as shown in Fig. 1(a) and (b). Thus, a high pitch sound corresponds to more number of compressions and rarefactions passing a fixed point per unit time. Objects of different sizes and conditions vibrate at different frequencies to produce sounds of different pitch.

The magnitude of the maximum disturbance in the medium on either side of the mean value is called the amplitude of the wave. The loudness or softness of a sound is determined basically by its amplitude. The amplitude of the sound wave depends upon the force with which an object is made to vibrate. If we strike a table lightly, we hear a soft sound because we produce a sound wave of less energy (amplitude). If we hit the table hard we hear a loud sound. Fig. 2(a) and (b) shows the wave shapes of a loud and a soft sound of the same frequency.



(a) (b)

Figure 1. Sound signal: (a) low pitch and (b) high pitch



(a) (b)

Figure 2. Sound signal: (a) low amplitude (b) high amplitude

The quality or timber of sound is that characteristic which enables us to distinguish one sound from another having the same pitch and loudness. The sound which is more pleasant is said to be of a rich quality. A sound of single frequency is called a tone. The sound which is produced due to a mixture of several frequencies is called a note and is pleasant to listen to. Noise is unpleasant to the ear while music is pleasant to hear and is of rich quality [1].

Most sounds, including musical notes, are not pure tones. They are a mixture of different frequencies (tones). A tuning fork, when struck, produces a pure tone of a specific frequency. This pure tone is produced by regular vibrations of the source. On the other hand, scraping your fingernails across a blackboard only creates noise, because the vibrations are irregular. Each individual pipe of a pipe organ is similar to a tuning fork, and each pipe produces a tone of a specific frequency. But sounding two or more pipes at the same time produces a complex waveform. Fig. 3 illustrates the combining of two pure tones to make a COMPLEX WAVE.

The quality of a sound depends on the complexity of its sound waves, such as the waves shown in tone C of Fig. 3. Almost all sounds (musical and vocal included) have complicated (complex) waveforms. Tone A is a simple wave of a specific frequency that can be produced by a tuning fork, piano, organ, or other musical instrument. Tone B is also a simple wave but at a different frequency. When the two tones are sounded together, the complex waveform in tone C is produced. Note that tone C has the same frequency as tone A with an increase in amplitude. The human ear could easily distinguish between tone A and tone C because of the quality. Therefore, we can say that quality distinguishes tones of like pitch and loudness when sounded on different types of musical instruments. It also distinguishes the voices of different persons [2].

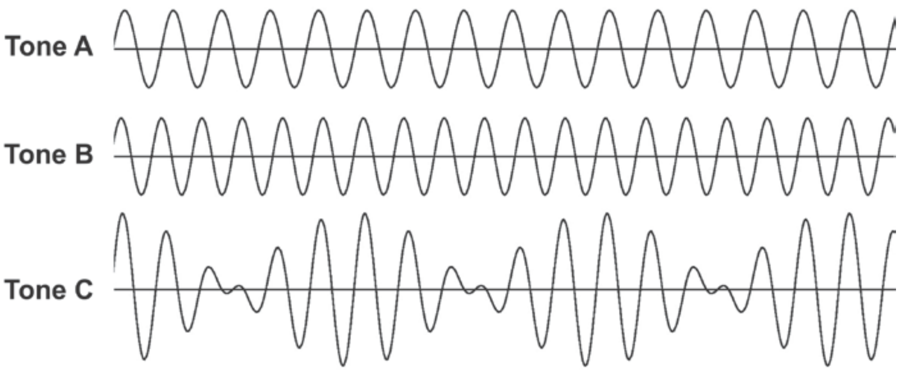


Figure 3. Combination of tones. Resultant is Tone C

Experimental setup

The experimental set up for the developed system utilises the microphone audio input and the audio output through speaker attached to the PC as illustrated in Fig. 4. The sound signal under study is converted to its electrical equivalent through the microphone which is saved as a sound file in wave format. This file or any other file already saved in the same format can be sent to the LabVIEW based developed application program for analysis.

The developed software consists of two sections: Audible Range Verification and Sound Analysis. The section for audible range verification generates a continuous beep sound using the built in speaker in the computer. The frequency of the generated beep can be controlled using a frequency dial control on the front panel which ranges from 10Hz to 100 kHz. The audible range for a person can be displayed based on the frequency values where a user starts and stops to hear a beep when the frequency dial is varied. The output frequency is displayed on a digital meter.

The sound analysis section moves into a deeper study of sound waves by playing and plotting different sound files saved in wav format. The sound wave is displayed in time and frequency (FFT) domain on two separate waveform graphs. The variation in pitch (fundamental frequency) of the sound wave over time is further displayed on a third waveform graph. This section also provides the user with an ability to vary the different components of the sound wave for detailed study. For loudness study, the user can vary the amplitude of the sound wave using the loudness control. Variation in amplitude results in change in the loudness of the sound wave which can be played simultaneously on the audio speaker output of PC. For the timbre study, number of frequency components of the sound wave can be varied using a low pass filter. By varying its cut off frequency, the number of components present and their effects can be online studied for better understanding of the timbre components.

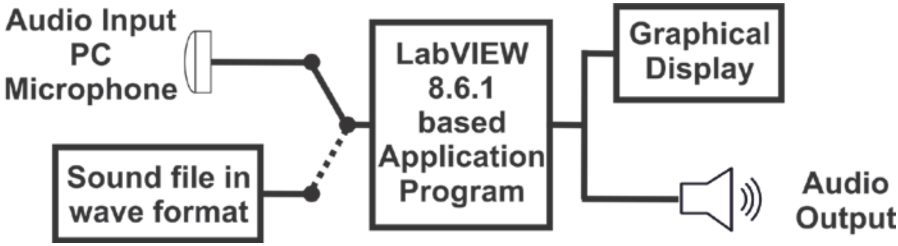


Figure 4. Experimental set up for the developed system for sound study

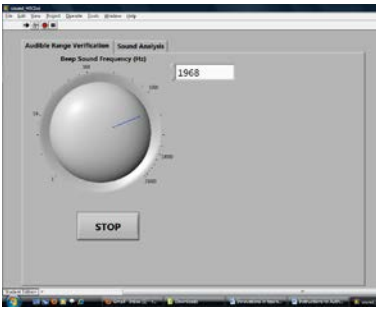


Figure 5a. Screenshot of developed software for audible range verification

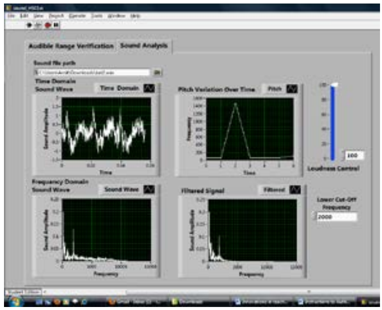


Figure 5b. Screenshot of developed software for sound analysis

Results and discussion

The screenshots of the developed software in two modes are illustrated in Fig. 5(a) and 5(b). The underlying graphical code for the developed system is shown in Fig. 6. The Audibility range section has been tested. Tone is audible in the range of 19 to 14500 Hz. Outside this range, sound is audible as clicks only which signify activation of the speaker with no sound output. The difference in the audible range in comparison to that of human beings can be due to non response of the speakers outside this range and may require some specialized speakers.

Sound signals from various sources were analysed to study the changes in the different components of the signal. The sources included sound signals produced by bats, musical instruments, baby and adult voices, tuning fork etc.

In the sound analysis section, one can browse and select any wav format file from the PC. First display shows the amplitude variation with respect to time. Second display shows the FFT components of the file played. The fundamental frequency has been displayed in the third graph indicating the pitch value. No changes have been observed in the pitch by varying the loudness of the sound. The frequency components filtered and their effect has been shown in the fourth display and changes in the quality of the sound heard can be easily felt.

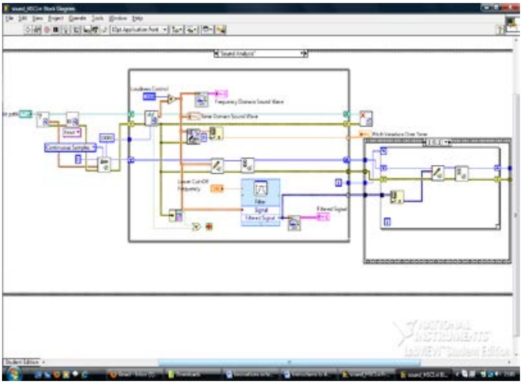


Figure 6. Graphical code for the developed software in LabVIEW 8.6.1

Questions that can be integrated by the teacher with the demonstration to enhance better understanding can be as follows:

1) Explain the terms audibility range, loudness, pitch and timber
2) Run the section 1 of the application and show the audibility range of human beings. The audibility range can be compared with other animals like dog, bat etc. Uses of the sound outside the audible range: Ultrasound, SONAR and Echolocation can be discussed.
3) Run the section 2 and vary the sound in terms of loud and soft sound, high and low pitch sound in order to make the students aware of the concept of loudness and pitch. Effect of varying the loudness and its consequence on the fundamental frequency can be questioned.
4) For demonstrating the Timbre effect, various frequency components can be selected and the expected changes in the sound output can be questioned.

Function of equalizers/music synthesizers can be introduced. The developed software is a handy tool for teaching the concepts of sound with ease. The minimal hardware requirements and the easy availability of a PC system makes the developed tool cost effective, hence it becomes easier to introduce it any level of education system.
Also, teachers can further refer [3-5] for demonstration and reading to improve their understanding of the three acoustic sensations.

Conclusion

The developed system presents a simplistic approach to the idea of associating loudness with wave amplitude, pitch with frequency and timbre with the overlapping of higher harmonics. However, these concepts are quite complex and to an extent interdependent and needs to be related to other factors like our psychoacoustic system. Using LabVIEW, many software applications can be developed that makes it easy to experiment with loudness, analysis-synthesis of sound which bring out the subjective nature of the sensations of loudness, pitch and timbre, providing evidence of the great number of factors on which they depend.

Acknowledgement
Authors, Amit Garg and Vishal Dhingra, duly acknowledge University Grants Commission, New Delhi, India for providing the financial assistance under the major research proposal scheme for the work reported in this paper against sanction no. 34-62/2008(SR) for the project entitled “Investigating science hands-on to promote innovation and research at the undergraduate level”.

References
[1] NCERT, Class IX Science book, 12, 165/166.
[2] http://www.tpub.com/neets/book10/39e.htm, Electrical engineering Training Series, Integrated Publishing.
[3] http://science.education.nih.gov/supplements/nih3/hearing/activities/lesson1.htm
[4] Merino JM, Physics Education, 33**,** 101-104, 1998.
[5] Merino JM, Physics Education, 33**,** 105-109, 1998.

Paper presented at the 6th International Conference on “Hands on Science.
Science for All: Quest for Excellence",
Ahmedabad, India, October 27 to 31, 2009.

Green Chemistry Experiments as Hands-On-Science Tools for Environmental and Green Chemistry Education

Nandi KK

Introduction

The most important goal of sustainable development is to reduce the adverse consequences of the substances/chemicals/techniques that we use or generate. The role of chemistry in general and green chemistry in particular is very vital to ensure the use and generation of chemicals/materials & energy processes in context of sustainability. This in turn depends largely on the principles (12 – principles) & concepts of green chemistry [1]. The green chemistry is defined as the design, manufacture and applications of chemical products and processes that reduce or eliminate the use and generation of hazardous substances. Recent developments in the field are found as exiting and with enormous achievements [2]. On the other hand public concerned over global warming/ green house gases/ chemical accidents/ environmental pollutions are growing. And some of the environmental problems (e.g., DDT, Ozone depletion, Bhopal disaster, Love canal pollution etc.) pose severe threat to the modern civilizations. Now-a-days students are profoundly interested and want to understand how the human actions affect the sustainability of our world. Specially, the chemistry students as they have few experiences at least in the miniature form to face the problem in their laboratory/ classrooms, they have unique scope & experiences to enter into the exciting and expanding field of green chemistry. Green chemistry concepts in collaboration with basic chemical education enhance the scope to cope with the challenges of environmental problems to achieve sustainability. The future sustainability [3], meeting the needs of current generations without sacrificing the ability to meet the needs future generations, can be achieved properly by overcoming many hurdles. First, is to incorporate and integrate the green chemistry concepts and practices into the main stream chemistry curriculum. Second, is to implement the green chemistry education with effective bridging of relevant disciplines including the environmental education in high-secondary and tertiary levels of education. So the concepts of green chemistry must become an integral part of chemical education and research for achieving sustainable future [4-6].

Green chemical practices are increasingly being implemented and new educational materials are also been developed as tools for green chemistry education. Effort and endeavour of educators, including the present author, to include and apply the green chemistry concepts and principles in chemistry classrooms and laboratories are found worthwhile for students (future chemists) to face the challenge of sustainability [6-8]. Many of the laboratory experiments are found to have harmful/toxic parameters. We can see the problems as miniature form of severe environmental problems. Effort to solve these problems can in tern provide necessary knowledge and model experiments for sustainable developments. So the scope of development of model green chemistry experiments in view of safer laboratory practices is enormous. And these model green chemistry experiments, modified with alternative eco-friendly chemicals/ materials, will definitely complements as hands-on-science tools to cope with the curriculum of green chemistry education.

Methodology

The concept of learning by doing is found effective during the development of model green chemistry experiments through active participation of students. This module of green chemistry has been advanced through the following steps:

- **Step-1:** Identification of existing hazardous experiment & systematic recognition of hazards/toxicity as a physical and chemical property that can be modified.
- **Step-2**: Utilization of identified laboratory experiments for illustrating green chemistry concepts/principles by critical evaluation of chemical hazards and effects on human health & environment through total life cycle assessment.
- **Step-3**: Development of alternative green chemistry experiment realizing the molecular basis of hazard/toxicity in view of safer laboratory practices and reducing hazards and wastes by using eco-friendly materials.

Systematic journey through above steps will improve the greenness of the experiment to an optimum level. Out of green chemistry principles [12 – principles] following concepts and measures actually guide us to modify and evaluate the greenness of chemical experiments:

- **Measure-1:** Make less harmful process by the use of inexpensive & eco-friendly materials (catalysts/solvents/ reagents) as far as practicable.
- **Measure-2:** Attain maximum atom economy (incorporation of maximum atoms of reactants into the product) with no or minimum wastes and by-products.
- **Measure-3:** Prefer catalytic and/or recyclable processes as alternative to stoichiometric one.
- **Measure-4:** Reduce energy requirement by performing reactions at ambient temperature and pressure without compromising the yield.

Green Chemistry Module on Friedel-Crafts Acylation of Organic Chemistry

In the present study we have identified and redesigned the Friedel-Crafts Acylation reaction of organic chemistry [9]. This method has chosen firstly, due to popularity of the reaction among both UG and PG students and secondly, due to the fact that most of the concepts/ principles of green chemistry can be discussed/applied using this method.

Reaction: Friedel-Crafts Acylation is generally employed for 'C—C' bond formation.
Acylating agent: acidchloride/anhydride.
Catalyst: Lewis acids catalysts.
Solvents: carcinogenic benzene derivatives.
Scope of developments of friedel-crafts acylation reaction: Critical analysis of Friedel-Crafts Acylation conditions reveals the following **disadvantages**:

a) **Catalysts**: Lewis acid catalysts, $AlCl_3$, BF_3, etc. are hazardous and stoichiometric amounts are required and also lost during working up processes.
b) **Acylating agents**: Acid-chlorides are toxic and acid-anhydrides are less efficient. Both are associated with non-recovery of by-products.
c) **Solvents**: Benzene and its liquid derivatives (carcinogenic) are generally used.
d) **Methodology**: Huge amount of energy lost during heating and refluxing.

Application of green chemistry concepts/measures:

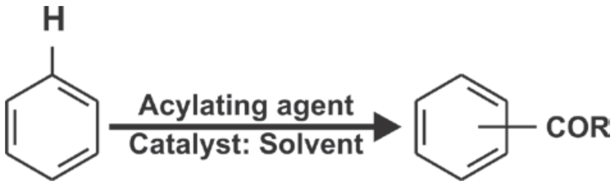
Concept-1: To make **less wasteful/harmful process**, use of hazardous Lewis acid catalysts, $AlCl_3$, BF_3 etc and also that of toxic acid-chlorides are to be avoided. Eco-friendly materials e.g. Reusable Catalysts (ZSM-5; Al_2O_3; and $M(OTf)_3$, ZnO, etc.) and nontoxic carboxylic acids as acylating agents are found to make the process green.

Concept-2: To attain **maximum atom economy** by-products are to be avoided or minimized. From the table-1, it is clear that use of carboxylic acids as acylating agents is best, since the loss in this case is water (18 m.u. only) and found as minimum.

Acylating agent:	R-CO-Cl	$(RCO)_2O$	RCOOH
By-product molecule	HCl	RCOOH	H_2O
Mol. Wt. of lost Molecule	36.5	>60	18

Table 1.

Concept-3: The process to be **Recyclable and with Catalytic pathway.** To avoid stoichiometric use of Lewis acid catalysts, $AlCl_3$, BF_3, etc. which are lost during working up reusable catalysts/ eco-friendly materials e.g. ZSM-5; Al_2O_3; and $M(OTf)_3$, ZnO, etc. may be used. Require amount of Bismuth Triflate is 1% mole only.



Concept-4: Energy minimization. Instead of high temperature heating or reflux, we have to have green Friedel-Crafts Acylation at room temperature and/ or in microwave conditions. Both the above green methods of heating are available in Friedel-Crafts Acylation.

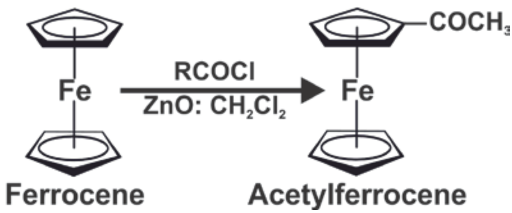
In fact gradual removal of all disadvantages and non-green features of Friedel-Crafts Acylation reactions are possible. Now some of the model green chemistry experiments are discussed which can be well performed by the undergraduate/postgraduate students in their normal laboratory class hours.

EXPERIMENT-1:

Friedel-Crafts Acylation of ferrocene over eco-friendly ZnO at room temperature:

Green chemistry concepts: Less hazardous, Recyclable Catalyst and Energy minimization.

Reaction:



Procedure:

In this approach [10] ferrocene was acylated with different acid-chlorides over eco-friendly ZnO catalyst at room temperature. The reaction completed in 15 minutes (monitored by TLC) and on normal work up acylferrocene was isolated characterized spectroscopically. The acylation of first ring deactivate the second thus only monoacylated product is obtained. The used ZnO was washed reused (2-3 times) without loss of efficiency.

Green advantages:

a) Eco-friendly easily available ZnO as recyclable catalyst.
b) Room temperature reaction and simple method minimize the energy input.
c) Small reaction time and less harmful method.

Non-green features:

a) Toxic acid-chlorides (RCOCl) are used as acylating agents.
b) Chlorinated hydrocarbon, CH_2Cl_2 used as solvent.

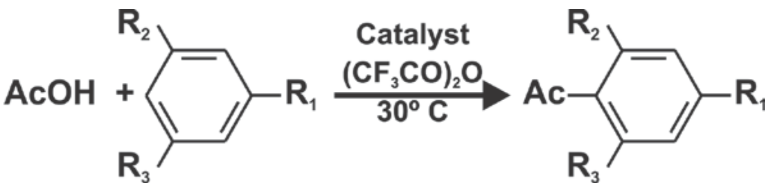
Students have been self motivated to overcome the problem of removing non-green features and tried to find more green experiments. Instructor should guide with necessary informations.

EXPERIMENT-2:

Solventless Friedel-Crafts Acylation with Carboxylic acids at Room Temperature:

Green chemistry concepts: Catalytic & Recyclable Pathway, Green Reagents, Atom economy and Energy Minimizations, etc.

Reaction:



Catalysts: $Bi(OTf)_3$ or $Sc(OTf)_3$ with TFAA ; R_1, R_2, R_3 = H / Me / OMe etc.

Procedure:

In this method [11] aromatic ketones are prepared in solventless condition at ambient temperature using recyclable catalysts (metal triflates) with trifluoroaceticanhydride (TFAA). Both the aromatic and aliphatic carboxylic acids are used as successful green acylating agents. Required amount of catalyst were found 1% mole only. Here recycled catalyst specially, $Bi(OTf)_3$ was found to used without loss of activity [11].

Green advantages:

a) Atom economy of the reaction is higher due to loss of by-product is only water. The water is a small molecule (18) of eco-friendly/ non-polluting nature.
b) Reaction follows actual catalytic pathways (1% mole) instead of stoichiometric amount in conventional method. Catalysts can be recycled.
c) Use of green acylating agents (RCOOH) and no solvent make the process green.
d) Room temperature reaction and simple method minimize the energy requirement.

Instructor should explain how the green principles are applied to Organic synthesis, specially, relating to above four measures discussed in the module.

Conclusion

This study reveals a new module of green chemistry on Friedel-Crafts Acylation Reaction of Organic Chemistry which has many practical and pedagogical benefits for the implementation of a greener curriculum. Re-designed two model experiments can serve as hands-on-science tools for teaching and research laboratory. These new educational materials also teach the relevant considerations for a chemical synthesis including costs, environmental impacts, and effects on personal and public health. Two model experiments of this module are also found to inspire & motivate the students/learners to cope with the prevention of pollution at source & to stimulate themselves to design similar /new experiments in future.

References

[1] Anastas PT and Warner JC, Green Chemistry: Theory and Practice, Oxford University Press, Oxford, 1998.
[2] Horvatd IT and Anastas PT, Chem. Rev., 107, 2169, 2007.
[3] Parent K *et al*, Going Green. Integrating Green Chemistry into the Curriculum, ACS, 2004.
[4] Collins TJ, J. Chem. Educ., 72, 965-966, 1995.
[5] Cann M, Green Chem-, 3, G23-G25, 2001.
[6] www.chemsoc.org/gcn/educate.htm & www.academic.scranton.edu
[7] Doxsee KM and Hutchison J, Green Organic Chemistry, Strategies, Tools and Lab-Experiments, Belmont, CA: Brooks/Cole, 2004.
[8] Sharma RK, Sidhwani IT and Chaudhuri MK, Green Chemistry Experiments, GCNC, New Delhi: Tucker Prakashan, 2002.
[9] Olah GA, Friedel-Crafts Chemistry, Wiley, New York, 1973.
[10] Nandi KK, Proceedings of IUPAC –International Conference on Green Chemistry, New Delhi, 2006.
[11] Matsushita Y, Sugamoto K and Matsui T, Tet. Lett., 45, 4723, 2004.

Paper presented at the 6th International Conference on “Hands on Science.
Science for All: Quest for Excellence",
Ahmedabad, India, October 27 to 31, 2009.

Nature Education in 22 Steps: A Model Proposal

Erentay N and Erdogan M

A brief history of the book: nature education in 22 steps

'Nature Education in 22 Steps' is a guide to outdoor learning with elementary students. It is based on the practical experiences of students in the international project called '*The Unique and Universal Project'.* Students and teachers involved in this project have been engaged in adopting threatened wetland areas and studying them. Students have described habitats, observed endangered species, learned to analyze water quality through the use of their senses to learn about the natural world. They have also used the knowledge they gained to propose ways to improve the threatened environments in order to support the endangered species.

As data is collected, the data is shared with students from other groups in the project – often in other countries. The project has been coordinated by the Middle East Technical University Foundation School since 2005 [1-4].

"*Nature Education in 22 Steps*" is a book written for those who will undertake nature education with a group of people (i.e. students, teachers and parents). The book was constructed on four phases each of which is divided several steps. First phase, *Preparing*, includes six steps. Second phase, *Implementing*, includes seven steps. Third phase, *Reporting*, includes five steps. Last phase, *Sustaining*, includes four steps. These 22 steps are briefly described below for those who would like to utilize this guideline in their own setting.

Preparing (6 Steps)

This phase includes six steps related to establishing a strong base for the project and preparing the structure of the project.

Review of Literature and emphasizing the rationale

In the first step of the project management cycle, comprehensive review of the literature on the selected topic should be undertaken so as to construct the framework and guideline for the project. During the review of literature, previous studies should be searched to find an area of understanding that needs to be filled so that the project can fill the gap in the selected area. In addition to review of literature, the rationale behind conducting such project should also be described.

Calling for volunteer students and teachers, founding school working team

The selection process for the students and teachers who would like to be involved in the project at the beginning of the educational term accelerates the productivity of the entire work throughout the year. The meetings devoted to the project are after school hours. The field trips to be conducted to the area occur on the weekends. The research to be done in the school library and on the internet and the controlled experiments to be conducted at the school laboratories require extra efforts, energy and time for students. Therefore they should be considered volunteer based activities.

Establishing local and global connections, cooperation with NGOs

Expertise, knowledge, experience, effort, volunteerism construct the whole only if they come together and unite to form it. The teachers involved in the project should cooperate with the NGOs and universities and get support from the research assistants on field work.

A national nature project is, at the same time, a global project for nature has no boundaries whatsoever. For example, an endangered plant in Turkey, a threatened wetland in Romania, and endangered animal in USA are global problems to be solved together. These problems and the data should be discussed internationally with all countries in the World.

Forming project preparation team and conducting first meeting

The volunteer members of the project team may vary depending upon the school climate. If the students are to be selected among the 4^{th} and 5^{th} grade, there should be homeroom teachers in the committee. It is also recommended that the committee has arts teachers as well. The guidance of arts teachers may initiate a procedure in which the students discover the close connection between the nature and themselves by using their own instincts and creativity. The students can compose a song, produce a poster, and organize a photography exhibition. These activities also motivate. They can prepare documentaries and share them with other partner schools via internet. There should be an IT teacher on the committee in such cases.

Determining the target species and the target natural area

The target subject of some nature projects can be constructed focused on biological diversity whereas others can be selected as studying a specific habitat. It is quite common that, news about an endangered plant on the national media, a documentary on television about Mediterranean Seals or a pool that is observed by the students at the schoolyard may instantly form the study subject of a nature project at a school. Sometimes different subjects that were studied in different years can be converted into a large scale nature project together. The students should take an active role in determining the study subject of the project.

Preparing annual activity plan

The annual activity plan should be constructed with the cooperation of the school administration, the volunteer teachers, the students and NGOs involved in the project.

Implementing (7 Steps)

This phase includes the seven steps that follow. Data collection instrument is developed in this step. If the study is designed as pre-test post-test experimental model, the data collection instrument(s) should be administered at the beginning and at the end of the field trips / field activities. The teacher / trainer can even develop field trip test(s) and apply it during the field trip. The participants are also certified at the end of this process.

Developing data collection instruments

In the first step of Implementation, the data collection instrument(s) should be initially developed for assessing participants' / target group's attainments at the beginning and the end of the project. While developing the instrument(s), the following sub-steps can be considered: 1) planning conceptual framework, 2) reviewing the existing literature, 3) analyzing the content and objectives for constructing table of specification, 4) establishing item pool, 5) preparing data collection instrument(s), 6) taking expert opinion, 7) conducting pilot testing, 8) assessing reliability and validity, and 9) getting the instrument prepared for the application.
The items and questions in the instrument(s) should be written according to the purpose of the study / project. For example, if you are involved in a project aiming to investigate students' perception and protection of biodiversity, you can design biodiversity knowledge test, attitude toward biodiversity scale, behavior questionnaire, interview schedule and such.

Picture 1. Students are filling the questionnaires before the field trip

Administrating the instruments (pre-test)

In order to assess students background, previous knowledge, attitude and behavior, and what they bring into the project, data collection instrument(s) should be administrated to participants at the beginning of the project as a pre-test (that is, before starting the field trips). Pre-test results help the teachers/trainers understand student's current status and develop his/her activities accordingly.

Getting prepared for the field trip

In this step, the project schedule is introduced to the participants and other stakeholders. Furthermore, the participants can be guided to visit the experts (i.e. academicians, researchers, NGOs) for greater insight on the topic to be investigated during the project. The participants are also reminded how they are supposed to behave/act during the field trips. They are encouraged to have a bag including pencil, note-book, magnifier, boxes and so on.

Observation and experiment sheets can also be prepared in this step. Plant observation sheet, animal observation sheet, and soil observation sheet are some of the examples to be used during the trips. Prototype laboratory experiments (if necessary) can be conducted within the schools to enable the students to better understand the theoretical background of the experiments to be conducted during the field trips. Under the guidance of teachers, the students are encouraged to conduct, analyze and interpret the experiments.

Picture 2 Students are working on prototype in the laboratory

Teachers should visit the site in advance to get well acquainted with the area and to be knowledgeable on the area.

The actual field trip

In this step, field trip is realized within selected and later searched area. One of the most important things during the field trip is to protect participants' health and safety. Before the field trip starts, safety and health protection guideline should be shared with the participants so that field trip can be done without any trouble. The experiments should be conducted by the participants under the guidance of teacher / trainer. This will help the students develop scientific process skills (i.e. observation, data collection, analyzing, interpreting, and reporting).

Picture 3. Students are doing experiments with the water sample taken form the Lake during field trip

Sharing field trip experiences within school community and with other schools

The families, the immediate environment, the local units, the national and international society can be the targets for the message to be conveyed by the project.

Administrating the instruments (post-test)

Once the field trip is completed and the participants return from the trip, it is time to administrate data collection instrument a second time to assess participants' gain. Another option is to administrate the instrument at the end of the projects or series of field trips. Knowledge change can be assessed in a short period, but the change in attitude and behavior can be observed over a long period. Successive administration (i.e. post-test and follow-up test) may sometimes be needed.

Giving certificates to the participants

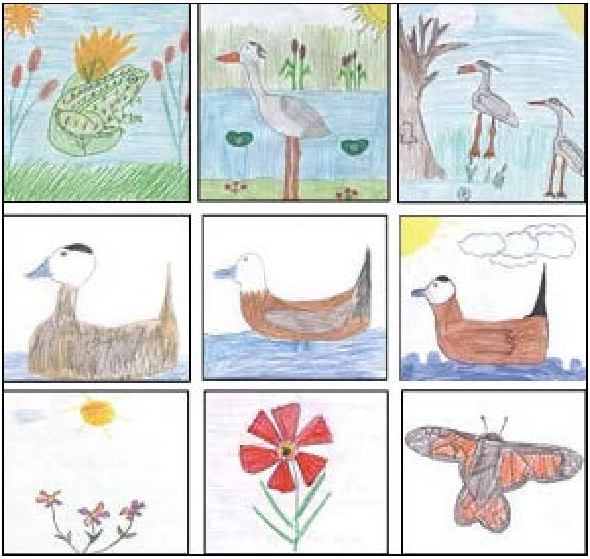
The students are given a stewardship certificate by the coordinator teacher at the end of each project year.

Reporting (5 Steps)

This phase includes further five steps pertaining to reporting and presenting the findings and conclusions.

Analyzing the data

Having collected the data from the participants, it is time to analyze them to establish coherent themes and theory. The analyses should be undertaken based on the nature of the data collected. If the data is qualitative in nature (i.e. word), qualitative data analysis procedures (i.e. content analysis and descriptive analysis) should be utilized. On the other hand, if the data is quantitative in nature, statistical procedures (i.e. descriptive and inferential statistics) though the use of statistical software programs (i.e. SPSS) should be preferred. If the data set consists of both qualitative and quantitative data, mixed method can be used.



Picture 4. Students' drawing of selected endangered species

The readers of the report should be informed about these limitations and how these limitations can be dealt with. If the readers design similar project and/or research in the future, they can easily consider these limitations and overcome the problems during the preparation phase.

Interpreting the findings

In this step, the findings are discussed with regard to the similarity to and differences from the existing national and international literature. The previous findings are compared with the already existing ones. The reasons and the consequences of the findings are discussed in this part, as well.

Discussing the limitations and findings

Each study may include several limitations.

Providing suggestions

At the end of the project report, the implications of the findings for policy and practice, and also further research should be presented with details. This can help the stakeholders (i.e. teachers and researchers) use these implications in their contexts.

Presenting the report

Once the project calendar is completed, the report including all phases of the projects should be presented to required body (i.e. school principal and Ministry of National Education-MoNE). The project report should be designed by including the views and opinions of project team. The report, finally, is signed by project head and project team members.

Sustaining (4 Steps)

This phase includes 4 sub-steps each for sharing the project outputs with other stakeholders and interested groups, and also for tracking the students' development and success.

Presenting the outcomes in the national and international platform

Once the project is completed, the results can be shared not only in national but also in international platforms with interested groups (i.e. teachers, representatives of NGOs, curriculum developers, and researchers). These platforms can be conferences, seminars, journals, magazines, newspapers and TV programs.

Communicating with other schools

The platforms involving schools, teachers and NGOs nationwide can also be used as a tool to disseminate project results to wide range of interested groups.

Communicating with NGOs

Communication with NGOs is also so important to reach wide range of interested groups. There may be research groups, governmental and community groups that are jointly working with these NGOs. Thus, being in touch with NGOs help the project manager/ team to reach variety of people who will show interest your study and findings.

Establishing tracking system

Preparing project report based on the results does not mean that the project has totally finished / completed. The reflection of what the participants learned / attained though the project in the real life can only be traced through developing a tracking system.

Conclusion

Knowledge is often forgotten unless it is put in practice. The application of knowledge when solving problems that the Earth encounters enables the knowledge to become useful. '*Nature Education in 22 Steps'* is based on the application of knowledge. The model proposal offered in the guide book *'Nature Education in 22 Steps'* provides a practical approach to experiential learning in nature with children.

It is the authors' hope that this useful resource leads students, teachers and parents in developing new ways of gaining knowledge that can be obtained through studying in nature and, thus, developing new means of communication in which they can enhance their sense of connectedness to the natural settings.

References

[1] Erentay N and Erdoğan M, The “unique and universal” Project: Exploring and Sharing Our Ecosystems through Scientific Processes, Proceedings of the 3rd International Conference on Hands-on Science. Science Education and Sustainable Development, Costa MF and Dorrío BV (Eds.), Braga: University of Minho, 346-353, 2006.
[2] Erentay N and Erdoğan M, Initial Findings of “unique and universal’’ Project. Proceedings of the 3rd International Conference on Hands-on Science. Science Education and Sustainable Development, Costa MF and Dorrío BV (Eds.), Braga: University of Minho, 390-398, 2006.
[3] Erdoğan M and Erentay M, Children’s perceptions on endangered species and threatened environments: results from Unique and Universal Project, Proceedings of the 4th International Conference on Hands-on Science. Development, Diversity and Inclusion in Science Education, Costa MF, Dorrío BV and Reis R (Eds.), Açores, 141-148, 2007.
[4] Erdoğan M and Erentay N, Children struggling for a sustainable future: impressions from second year of “unique and universal’’ Project, Proceedings of the 4th International Conference on Hands-on Science. Development, Diversity and Inclusion in Science Education, Costa MF, Dorrío BV and Reis R (Eds.), Açores, 148-157, 2007.

Paper presented at the 6th International Conference on “Hands on Science.
Science for All: Quest for Excellence",
Ahmedabad, India, October 27 to 31, 2009.

Understanding Thermal Equilibrium through Hands-on Activities

Pathare SR and Lahane RD

Introduction

The fact that the students have their own network of understanding of how the things work prior to receiving formal education is well accepted by the physics education researchers' community. It is very well known that students enter classroom with their own understanding about the topics that they learn. This has been well established by many researchers.

Some preliminary studies conducted by us in students' misconceptions gave us some idea regarding their understanding about the concepts like pressure, heat, temperature.

There were many concepts with which students were not familiar with. The concept of thermal equilibrium was one such concept found to be falling under the category of non-conception rather than misconception. We felt a need to develop a learning material in terms of a kit which can be used by the students to understand this concept. This paper discusses various activities using the kit developed by us.

Learning by doing approach

The manner in which the subject of thermodynamics is introduced seems to be responsible for such a scenario. Lack of experimentation in the domain of basic concepts in thermodynamics, make students learn them without having a feel about the real life existence. Hence a hands-on science approach becomes an essential factor while learning these concepts. The phrase 'Hands on science' has different meanings for different people. It is more than just handling apparatus and actually means a serious involvement of students in an investigative manner. It requires the student to have a feel about the choice of material, procedures and the developmental problems involved in that activity. Children, especially younger ones, learn science best and understand scientific ideas better if they are able to investigate and experiment. Hands-on science can also help children think critically and gain confidence in their own ability to solve problems. A paper on Syringe Thermodynamics is one such example where in students can understand concepts like hydrostatic pressure, adiabatic changes, work done using the syringes. With this approach in mind, we have developed a few activities to understand the concepts like adiabatic walls, diathermic walls, thermal equilibrium, zeroth law of thermodynamics.

The kit

Material used to make the kit

The following materials were used to build the kits:

a) Kit for Thermal Equilibrium:

i. Teflon container (80 mm × 80 mm × 50 mm)
ii. Teflon lid (100 mm × 100 mm × 5 mm)
iii. Two copper plates dividing the container in two equal chambers (80 mm × 52 mm × 2 mm)
iv. A cartridge heater
v. Two Cr-Al thermocouples connected to digital thermometer
vi. Adiabatic wall (80 mm × 50 mm × 5 mm)
vii. Diathermic wall (80 mm × 50 mm × 5 mm)
viii. A variac supply

b) Kit for zeroth law of thermodynamics:

i. Teflon container (110 mm × 86 mm × 50 mm)
ii. 6 copper plates (50 mm × 50 mm × 2 mm each)
iii. Teflon square rod (15 mm × 15 mm × 52 mm)
iv. 3 Adiabatic and 2 Diathermic walls (50 mm × 50 mm × 5 mm each)
v. 3 thermistors
vi. A cartridge heater
vii. A variac supply
viii. 3 multimeters

Construction

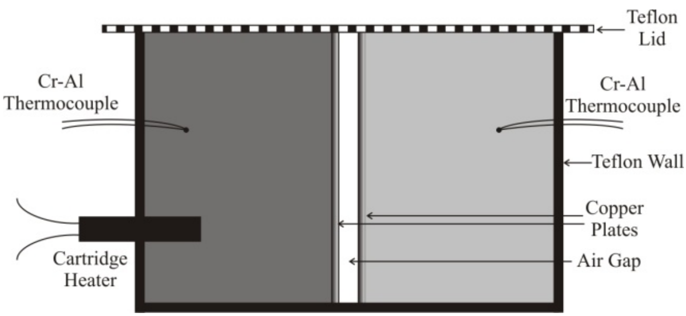


Figure 1. Apparatus for thermal equilibrium (Side View)

The apparatus consists of a Teflon container. Two copper plates are glued inside the container such that the container gets divided into two chambers. One chamber is fitted with a cartridge heater. The heater is being operated using a variac supply.

A Cr-Al thermocouple is fitted inside each chamber. An air gap is maintained between two copper plates. The air gap can be replaced by adiabatic or diathermic wall depending upon the application.

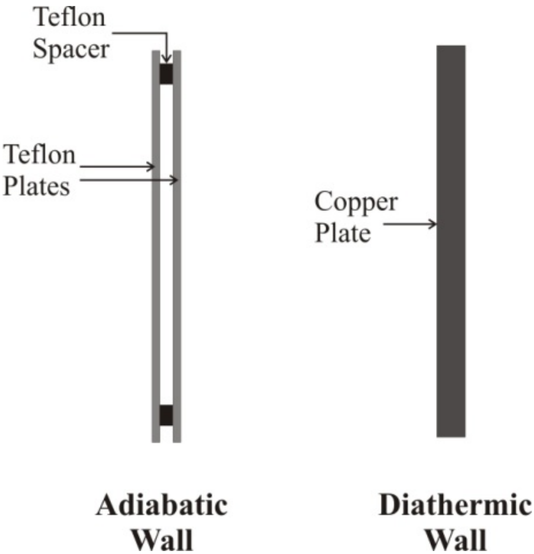


Figure 2. Adiabatic wall and Diathermic Wall

i) Adiabatic Wall: The adiabatic wall is made by two Teflon sheets separated by a teflon spacer allowing an air gap between the two plates.
ii) Diathermic wall: The diathermic wall is a thick and blackened copper plate.

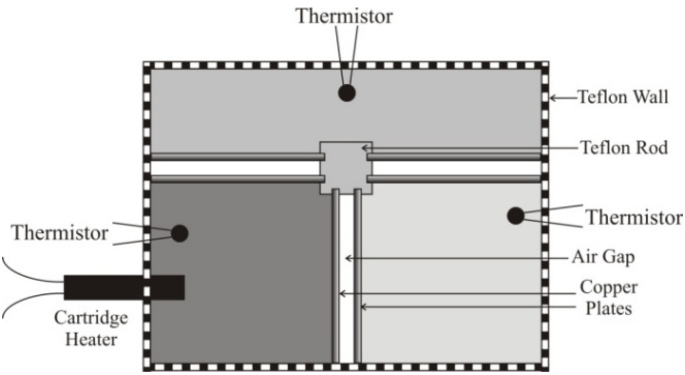


Figure 3. Apparatus for zeroth law of thermodynamics (Top View)

The apparatus consists of a Teflon container. 3 pairs of copper plates are glued in the container such that 3 chambers are formed inside the container. The copper plates are separated by an air gap such that adiabatic and diathermic walls can be inserted in that gap. Each chamber is fitted with a thermistor. A cartridge heater is inserted in one of the chambers. The heater is controlled by a variac supply.

Operation

Thermal Equilibrium

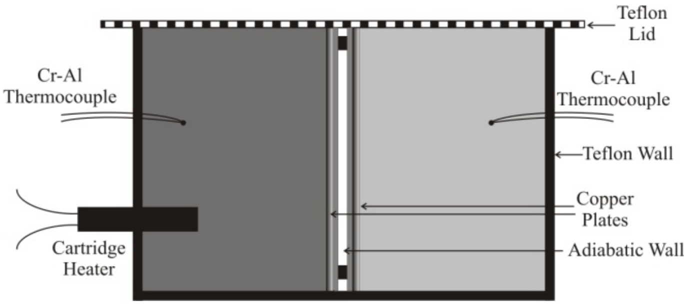


Figure 4. Apparatus for the thermal equilibrium (Adiabatic Wall inserted in the air gap)

Adiabatic wall is inserted into the air gap between the two chambers. Both the chambers are filled with water. The temperature of both the chambers is noted with Cr-Al thermocouple. Left chamber was maintained at 70°C. It was observed that there was no appreciable change in the temperature of the right chamber.

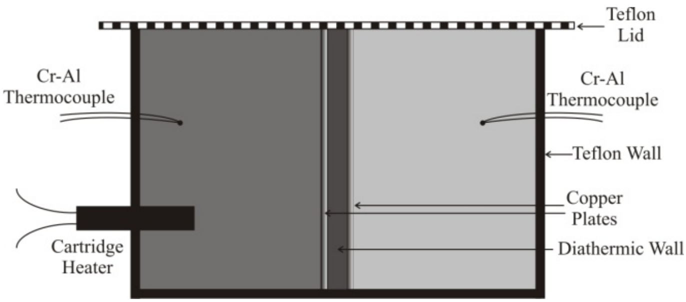


Figure 5. Apparatus for the thermal equilibrium (Diathermic Wall inserted in the air gap)

The adiabatic wall is replaced by the diathermic wall. Due to conduction the temperature of the water in the right chamber started increasing and finally attained 70°C.

This activity introduces students with the idea of adiabatic wall and diathermic wall. Moreover it also makes them understand about the direction of heat flow i.e. from higher temperature to lower temperature. When the temperature of the both the chambers become equal, the thermal equilibrium is achieved, thus giving students a clear picture of the concept.

Zeroth law of thermodynamics

Step 1: Adiabatic walls are inserted between chambers 1 and 2, between 2 and 3 and between the chambers 1 and 3. Water is poured in all the three chambers. Chamber 1 is maintained at 70°C. No change is found in the temperatures of chambers 2 and 3 (Fig. 6).

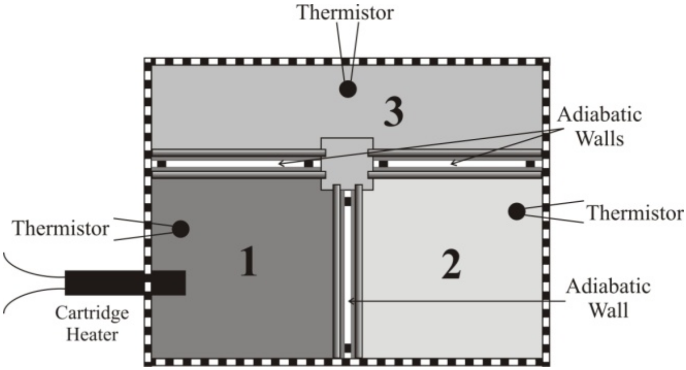


Figure 6

Step 2: Now replace the adiabatic wall between chambers 1 and 2 by diathermic wall. Slowly the temperature of water in chamber 2 will increase and finally attain 70°C. Thus chamber 1 and 2 are in thermal equilibrium with each other (Fig. 7).

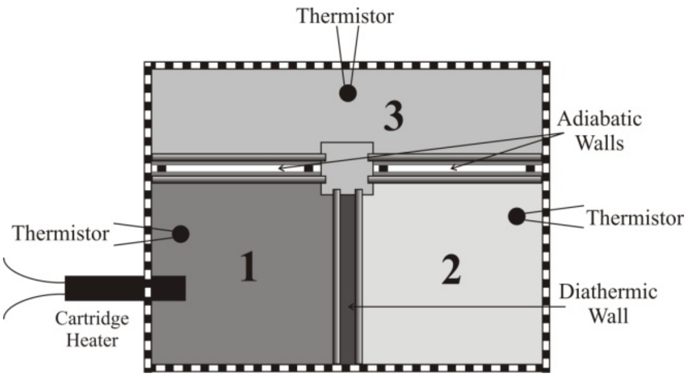


Figure 7

Step 3: Replace the diathermic wall between chamber 1 and 2 by adiabatic wall. Also replace the adiabatic wall between chamber 1 and 3 by diathermic wall. The temperature of chamber 3 increases, finally becoming equal to the temperature of chamber 1. Thus chamber 1 and 3 are in thermal equilibrium with each other.

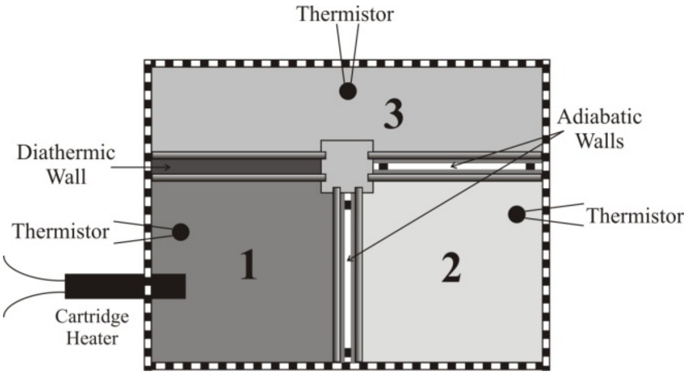


Figure 8

Step 4: Now replace the diathermic wall between chamber 1 and 3 by adiabatic wall. Also replace adiabatic wall between chamber 2 and chamber 3 by diathermic wall. It is found that the temperatures of water in chamber 2 and chamber 3 are already equal. Hence chambers 1, 2 and 3 are in thermal equilibrium with each other. Thus establishing the zeroth law of thermodynamics.

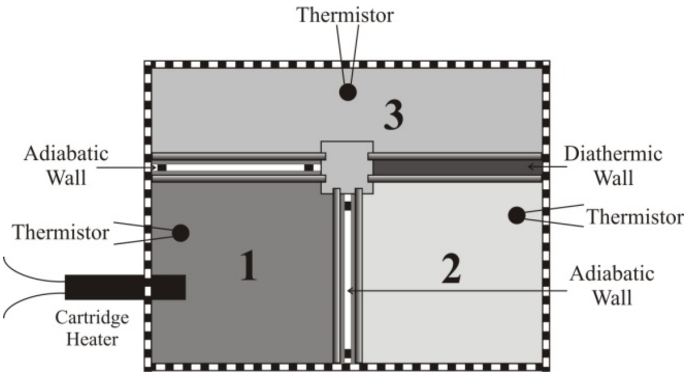


Figure 9

Conclusion

A kit for understanding the concept of thermal equilibrium and zeroth law of thermodynamics was developed. It gives a visual existence of these concepts to the students for better understanding.

Acknowledgements

We would like to thank Prof. H. C. Pradhan for his useful guidance on these concepts. We would also like to thank colleagues from our institute for valuable suggestions.

References

[1] Dittman RH and Zemansky MW, Heat and Thermodynamics, McGraw-Hill International Editions, 1997.
[2] Jackson David P and Laws Priscilla W, Syringe thermodynamics: the many uses of a glass syringe, American Journal of Physics, 74, 94-101, 2006.

Paper presented at the 6th International Conference on “Hands on Science.
Science for All: Quest for Excellence",
Ahmedabad, India, October 27 to 31, 2009.

The Production and Analysis of the Teaching Tool for Showing Spherical Magnetic Field by Ferrofluid

Yan-Qing FU, Qiao SUN, Zhi-Sheng LIU and Xue-Hui LI

Introduction

As is known to all, there is something invisible, intangible around the magnetic body, but it actually exists, which we termed “magnetic field”. Traditionally, the existence and strength of the magnetic field had been proved by putting some needles and iron fillings around the magnetic body (Fig. 1), the needles will deflect, and the iron fillings will show a regular distribution. However, the deflection of needles can’t reflect the overall spatial distribution of the magnetic field, and the regular distribution of iron fillings can show the whole magnetic field on two-dimensional static display merely. All in all, the traditional methods can’t demonstrate three-dimensional spatial distribution of the magnetic field effectively and dynamically. Hence, this paper developed a novel kind of teaching tool—Three-dimensional dynamic ball—to revealing the magnetic field vividly.

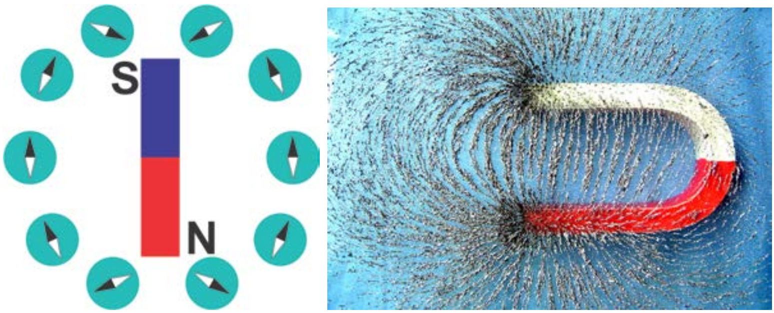


Figure 1. Traditional methods to show magnetic field

Ferrofluid can show the spatial distribution of the magnetic field because of its special composition (Fig. 2): nano-magnetic particles、surfactant and carrier fluid. Under the condition of an external magnetic field, ferrofluid can produce unique spatial distribution along the magnetic field lines, which is influenced by gravity, surface tension and magnetic force, thus interfacial instability occurs and three-dimensional spikes generate (Fig. 2). These spatial distributions of the three-dimensional peaks also reflect the spatial distribution of the magnetic field.

Three-dimensional dynamic ball for revealing magnetic field

Structure and features

The three-dimensional dynamic ball is mainly for showing the spatial distribution of the magnetic field of spherical permeable body. It consists of ferrofluid, transparent liquid spherical permeable body glass container and base. The transparent liquid and the spherical permeable body are sealed in the glass container.

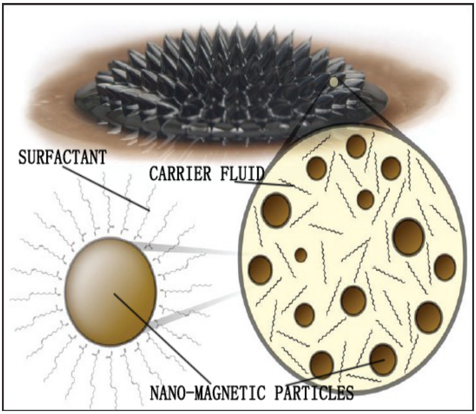


Figure 2. Schematic diagram of ferrofluid and three-dimensional peak phenomenon

The transparent liquid can avoid the phenomenon of ferrofluid capillarity. Due to capillarity, ferrofluid can adhere to the inner walls of the glass container easily, leading to an ambiguity phenomenon of showing the spatial distribution of the magnetic field. After several tests, this paper figures out the production methods of the transparent liquid. The addition of the transparent liquid prevents the phenomenon of ferrofluid capillarity effectively.

Display process and phenomena

The teaching tool can show the spatial distribution of the magnetic field of spherical permeable body in the conditions of permanent magnet and electromagnet. Users can hold the base with the left hand, the permanent magnet with the right hand. Adjusting the relative spatial position of the base and the permanent magnet by the two hands, users can observe the spatial distribution of the magnetic field. If users change the permanent magnet with an electromagnet, they just need to place the permeable material of the base on the upper surface of the electromagnet coaxially, and then change the exciting current. In this way, people can observe the spatial distribution of the magnetic field around the permeable body. The display results are shown in Fig. 3-4. These results can be likened to animals, such as sea urchin and

hedgehog, giving people unlimited imagination.
The teaching tool is well designed, people can easily handle it and has a good display result. Not only can we use it to show the spatial distribution of the magnetic field of spherical permeable body, but also can use it to teach some relevant knowledge about electromagnetism, such as the magnetic field line, permeable materials, and non-permeable materials. Besides, a novel material—ferrofluid—can be known by three-dimensional dynamic ball, such as its special field-induced interfacial phenomenon.

Figure 3. The magnetic field of permanent magnet showed by ferrofluid

Figure 4. The magnetic field of electromagnet showed by ferrofluid

Principle Analysis

As is shown in Fig. 5, the spherical permeable body is magnetized and yield magnetic fieldunder the condition of an external magnetic field, resulting in ferrofluid's three-dimensional spikes. These spatial distributions of the three-dimensional peaks reflect the spatial distribution of the magnetic field around the spherical permeable body .So people can get the spatial distribution of the magnetic field around the spherical permeable body according to the experimental phenomena.

Conclusions and Outlook

Three-dimensional dynamic ball for revealing magnetic field breaks through the traditional two-dimensional planar magnetic field distribution mode and shows the invisible magnetic field distribution, magnetic field lines and other physical phenomena vividly and dynamically. It is easy for students to understand abstract concepts owing to the magnetic field lines shown by the ball visible in mind.
Until now, people took it for granted that strong magnetic property occurred in solid rather than liquid. The teaching tool enable students to observe the ferrofluid in a magnetic field not only magnetically, but also can control with an extra applied magnetic field, which impress student by exquisite 、magic and dynamic pictures. It

plays an indispensible role in stimulating students to study nano-liquid functional materials deeply, fostering students' awareness of innovative, improving the practical ability of students.

To sum up, the three-dimensional dynamic ball for revealing magnetic field breaks through the traditional magnetic field distribution mode, applying two-phase solid-liquid colloidal solution "ferrofluid" into showing the spatial distribution of magnetic field creatively, carrying profound scientific and cultural knowledge and providing better service for education. So, the research of teaching tool based on ferrofluid will be one of the hot R & D of ferrofluid's application, which has promising and far-reaching economic and social benefits.

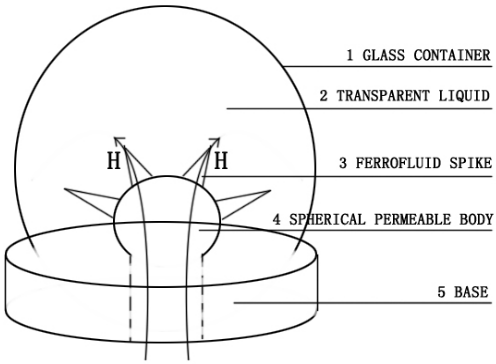


Figure 5. Schematic diagram of the principle

References

[1] Xuehui Li, Sun Qiao,Fu Yanqing *et al*, The Development of Ferrofluid Apparatuses for Presenting Magnetic Field, China, 200910012867, 8， 2009.

[2] Xuhui Li, Nano-ferrofluid—Preparation, Performance and Application, Beijing：Science Press，69-70, 2009.

Paper presented at the 6th International Conference on "Hands on Science. Science for All: Quest for Excellence",
Ahmedabad, India, October 27 to 31, 2009.

Inspiring Science Learning: Designing the Science Classroom of the Future

Sotiriou S

Introduction

The Information and Knowledge Society has emerged as a result of technological advancements of the World Wide Web, the Internet and mobile communications over the last two decades. These technological developments have had; and still have direct impact to every aspect of our personal and social life, thus changing the way we communicate, collaborate, work and learn. Europe has been a world driving force when it comes to these technological developments, however, in many cases European Member States have fall behind in adopting the necessary societal re-organisational changes needed in government, education, health care and cultural preservation. This can be a critical issue for the future of European Union and the future of its Member States within the complex global challenges of the 21^{st} Century.

When it comes to the field of education, this lack of social innovation becomes even more troubling, due to the fact that failing to "re-engineer" our national and European educational systems, effects significantly all other areas of social and economical development, jeopardising Europe's position in the global knowledge-based society. Indeed, Education seems to be a social activity still struggling to improve up to the societal anticipated expectations. Especially, schools appear to remain almost unchanged for the most part despite numerous efforts and investments in technology, teachers' training and infrastructure. Yet, the way we organise schooling and provide education remains basically the same. To put it in another way: "we still educate our students based on an agricultural timetable, in an industrial setting, yet telling students and teachers they live in a digital age".

During the past years, several reasons have been identified separately as possible distractions in aligning schools operations and results to the ones anticipated by the 21^{st} Century Societies. The most highlighted ones being: lack of funds, not enough computers in the classroom, little interest from students and parents, out of date teaching practices, poorly trained teachers, and even a fundamentally flawed way to measure performance at schools.

Many national and European initiatives have been undertaken to tackle these issues separately. Yet, the improvement has been marginal, if any at all. We believe that a holistic approach to the re-organisation of Schooling is needed, rather than sporadic and isolated efforts. To this end, many different organisations with high quality and unique expertise in their field have decided to join forces in a European effort to propose a scientifically grounded, technological sustainable and organisationally disruptive plan for the Technology-enhanced Classroom of the Future that will give to all parties involved in schooling a motivation for change. This is our Discovery Space.

Supporting and improving educational practices in science and mathematics education

The publication of the "Science Education Now: A renewed Pedagogy for the Future of Europe" report [1] brought science and mathematics education to the top of educational goals of the member states (following similar actions in US in 1996 [2-3]). The authors argue that school science teaching needs to become more engaging, based on inquiry based and problem solving methods and designed to meet the interests of young people. According to the report, the origins of the alarming decline in young people's interest for key science studies and mathematics can be found, among other causes, in the old fashioned way science is taught at schools. Although the crucial role of positive contacts with science at early stage in the subsequent formation of attitudes toward science is identified [4], traditional formal science education too often stifles this interest and, therefore, may negatively interact with the development of adolescents' attitudes towards learning science. Kinchin [5] pointed out that the tension created between objectivism (the objective teacher-centered pedagogy) and constructivism (the constructive and student-centered pedagogy) represents a crucial classroom issue to influence teaching and learning. The TIMSS (Third International Mathematics and Science Study) 2003 International Science Report [6] specifically documented that internationally, the three most predominant activities accounting for 57 percent of class time were teacher lecture (24%), teacher guided student practice (19%), and students working on problems on their own (14%) in science classes in the European countries participating in the study.

Therefore, it appears that the current science classroom learning environment is often a mixture of divergent pedagogies and diverse students' orientations or preferences [7-8]. The fact is that there is a major mismatch between opportunity and action in most education systems today. It revolves around what is meant by "science education," a term that is incorrectly defined in current usage. Rather than learning how to think scientifically, students are generally being told about science and asked to remember facts [9]. This disturbing situation must be corrected if science education is to have any hope of taking its proper place as an essential part of the education of students everywhere.

In addition to the aforementioned issues, science learning environment (classroom and lab) seems to have not gone through any significant changes for the past decades. Recent research on learning and instruction has substantially advanced our understanding of the processes of knowledge and skill acquisition [10]. However, school practices have not been innovated and improved in ways that reflect this progress in the development of a theory of learning from instruction. School practices in a realistic sense are cantered on school learning environment. It

is generally recognized among practitioners that our school science learning environment has neither been innovated nor reformed to reflect these new knowledge on learning and teaching. Moreover, modern technologies beyond just the use of computers and internet in the school have not fully integrated/incorporated in current science learning environment.
According to the recent report "Science Education in Europe: Critical Reflections" [11] the deeper problem in science education is one of fundamental purpose. Schools, the authors argue, have never provided a satisfactory education in sciences for the majority. Now the evidence is that it is failing in its original purpose, to provide a route into science for future scientists. The challenge therefore, is to reimagine science education: to consider how it can be made fit for the modern world and how it can meet the needs of all students; those who will go on to work in scientific and technical subjects, and those who will not [12].
In this framework the classroom of the future should provide more challenging, authentic and higher-order learning experiences, more opportunities for students to participate into scientific practices and task embedded in social interaction using the discourse of science and work with scientific representations and tools. It should enrich and transform the students' concepts and initial ideas. These ideas could be both resources and barriers to emerging ideas. The classroom of the future should offer opportunities for teaching tailored to the students' particular needs while it should provide continuous measures of competence, integral to the learning process that can help teachers work more effectively with individuals and leave a record of competence that is compelling to students.

Introduce meaningful ICT-based innovation for quality learning and teaching

The classroom of the future features a collection of interconnected e-systems and Web-enabled services to facilitate teaching, learning and assessment. All these new systems will require interfacing with key existing legacy systems that are characterized by different organizational structures. Creating an IT infrastructure plan for the school of the future isn't just about plugging in the latest and greatest—it's about balancing competing forces. Educators and technologists need to reach for the possibilities of the future, plan for the realities of the present, and account for limitations created by the past—all at the same time. To our view three complementary interfaces shape the technological infrastructure of the science and mathematics classroom of the future:

> *The familiar "world to the desk top" interface*, providing access to distant experts and archives (Fig. 1), enabling collaborations, mentoring relationships, and virtual communities-of practice. This interface is evolving through initiatives such as Web 2.0. The work focuses on the support of learning communities where teachers and learners are helping each other, or work together on certain problems. In order to monitor, analyze and support those learning communities we need to implement tools which capture usage and interaction. We also need personal and digital agents that help to build up a learning context based on content in order to support teachers and students.

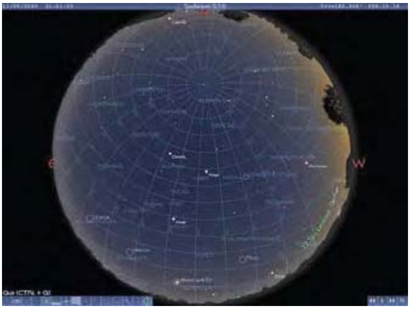


Figure 1. The Discovery Space Observatory provides access to a global network of robotic telescopes and supplies free resources for science and mathematics education

Figure 2. Kick life into the Classroom with the Lab of Tomorrow System: Playing with a "smart" ball with embedded sensors, gathering and manipulating experimental data of real life activities

Interfaces for "ubiquitous computing", in which portable wireless devices infuse virtual resources as we move through the real world [13]. The early stages of "augmented reality" interfaces are characterized by research on the role of "smart objects" and "intelligent contexts" in learning and doing. Those interfaces are intended to provide the freedom to learn "on site" – get into a real problem context and learn on virtual data. Therefore we need mixed reality cross platform devices, to create interfaces that seem to inhabit the users' environment. Those tools should be seamlessly integrated into the users' world. The interfaces should be light weight and least intrusive. The users have to be able to interact within their augmented environment in a most possible intuitive way. In order to create such a ubiquitous environment interfaces should be available at any time and any place where the user can be. Thus one has to build on mobile devices and visible (e.g. QR-Tags, Semacode) and ubiquitous tracking techniques, such as GPS or NFC (near field communication), inertial tracking and a complementary computer vision tracking. One major aspect of those devices is interactivity that allows users intuitive interaction.

Immersive and multi-user virtual environments interfaces, in which users and participants' avatars interact with computer based agents and digital artifacts in virtual contexts. The initial stages of studies on shared virtual environments are characterized by advances in Internet games and work in virtual and augmented reality. In order to implement "Virtual Labs" and multi user environments we demand a VR interface, an underlying context system, a high bandwidth network communication, as well as a hypermedia database. The most important part of a virtual environment is the interface through which users are able to enter the virtual world. Immersion plays a key role, thus all senses need to be stimulated properly. Moreover, it is fundamental for the effect of immersion that the system should behave in a way the user expects it to behave. This is, interaction has to be intuitive, user tracking should be accurate, this is, the system output should be realistic if necessary.

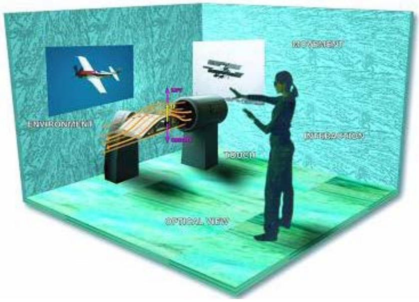


Figure 3. Visualizing the invisible using the CONNECT system: The visualization of natural phenomena could support the conceptual change

Immersive interfaces can foster educational experiences that drawn on a powerful pedagogy: contextualized learning. Situated learning requires authentic contexts, activities and assessment coupled with guidance from expert modeling, mentoring and “legitimate peripheral participation” [14]. The technologies in this type of innovative classroom should be intelligent, interactive, individualized and integrated as the following: (1) intelligent: the classroom technology should be highly context-aware and adaptively support tasks that originally require excessive human interventions; (2) interactive: the classroom technology should facilitate interactions between the teacher and the students; (3) individualized: the classroom technology should react differently in accordance to individual user; and (4) integrated: the classroom technologies should be integrated as one system instead of many separate systems. Technologically-based applications could effectively support the pedagogical requirements for the future science and mathematics classroom, as they were described in the previous paragraphs. Moreover, research has demonstrated empirically the effectiveness of such applications. The question is why has this potential not been realized? Several reasons are very clear: Current schools and classrooms are not designed in ways that can utilize the potential of technology; there is lack of appropriate preparation of teachers in the use of technology both at the pre-service and in-service levels leading to anxiety and low motivation to integrate technology in classes.

Understand and managing underlying change process

Although most of the European educational systems remain highly centralized, ICT policy implementation remains optional and allows for substantial discretion to the implementers, and for a “backward approach” leading to goal and role definitions in the field. In the light of such open-ended and general ICT policies practitioners at the micro level and the communities of implementation they generate as a response to ICT policy can be proved critical in ICT integration into the system. Our work aims to enhance the role of such communities. An important concept underlying the proposed approach is the notion of the community of implementation, which is regarded as a type of community of practice. Within our research work in particular, communities of implementation are regarded as self-reproducing, and evolving entities emerging within the school settings as a response to an externally developed policy. Various authors emphasize the importance of communities of practice for organizations [15-16] and therefore communities of implementation are considered as a purposeful strategy for spreading innovations. For teachers, innovation is a high risk activity and the incentives are few [17]. In a system where the centre has been the innovator, practitioner compliance understandably becomes the habit. The dynamic of change in education in Europe has been described in terms of a set of shifts, first, from “uninformed prescription” (in the 1980s); to “informed prescription”; then towards practitioner-led change [18]. This last was seen as the key to self-sustaining, rapid improvement. It is within this context, that our work aims to take forward the agenda of practitioner-led change at a European level. This work describes what may be its key contribution to the evolution of schools innovation and improvement: a new approach to stimulating, incubating, and accelerating innovation, which is strongly driven by users’ needs. At this level our work is focusing on three aspects: to capture, briefly, what we know so far about the process of encouraging schools to become more innovative; to describe the Discovery Space innovation model which is built upon these understandings; and to describe the practical programme of work which utilizes this model.

There is plenty of evidence pointing to the difficulty of incentivising and empowering teachers to engage in innovation, especially in tightly accountable systems based on performance targets. In education there is no shortage of energy and expertise, and certainly no lack of commitment or moral purpose amongst teachers. How could we support them, and give them the creative space and incentives they need to be innovative? What sort of interventions could both release professional imagination, whilst encouraging work that is disciplined and system relevant? How can the system learn from the resultant innovation and its process characteristics so that these can be taken to scale? How can busy, performance-driven teachers become aware of approaches and techniques which are emerging in other sectors - private and voluntary, as well as across public services more widely? It is enormously difficult in practice to be fully alert to developments and methods outside one’s “zone of operation” (and sometimes even within it) which offer improvement potential. Some school leaders do manage to scan other horizons for ideas with transfer potential. How far can this be done on their behalf, to shortcut the investment of time, and also optimize the scope for adaptation?

Assisting behavioural change and professional development of teachers

Asking teachers to follow advanced ICT methods in their everyday teaching practice constitutes a major behavioural change and at the same a significant development opportunity for them. The task at hand is to manage this change in a uniform way, allowing teachers to realize the potential of the opportunity offered by the Discovery Space initiative, take ownership of their contribution and maximize the output for

both the project and themselves. In a review paper [19], McKinsey management experts identify four key prerequisites for accelerating and establishing change:
A purpose to believe in: "I will change if I believe I should": The first, and most important, condition for change is identifying a purpose to believe in. In our case, we must persuade teachers of the importance of scientific literature in terms of social value, importance to their students and personal achievement through learning and teaching these important subjects. We must carefully craft a "change story" underlining the benefits that the project can offer to all the involved actors. Furthermore, we must cultivate a sense of community, making the teacher feel part of a cohesive multi-national team. This sense of belonging will prove very important for motivating teachers and asking them to take then next, possibly "painful" steps, of learning new skills.
Reinforcement systems: "I will change if I have something to win". From a pure Skinner behaviouristic point of view, changing is only possible if formal and informal conditioning mechanisms are in place. These mechanisms can reinforce the new behaviour, penalize the old one or, preferably do both. In our case, we can use informal reinforcement patterns in order to make teachers commit more to our project. A short list of such methods could include competitions, challenges, promoting the best teacher created content, offering summer schools as rewards, etc.
The skills required for change: "I will change if I have the right skills". A change is only possible if all the involved actors have the right set of skills. In the case of the Discovery Space project, the implementation team should make sure that the training program is designed in such a way that teachers acquire all the skills they will need, both technical and pedagogical.
Consistent role models: "I will change if other people change". A number of "change champions" will need to be established, acting as role models and change agents for the community of teachers. These very active and competent teachers will be a proof of concept for their colleagues that the change is indeed feasible, acceptable and beneficial for them. To achieve that we will have to identify the high flyers among the participating teachers and pay special attention into motivating them, supporting and encouraging them.
All four will specifically be addressed in each of the participating schools of the Discovery Space network. Additionally our team collaborate closely with teachers to develop a set of support services which help teachers to implement the necessary changes, to develop the diagnostics and intervention skills necessary to best plan and then diffuse innovation in their own contexts. An effective training approach provides the starting point for equipping teachers with the competences they need to act successfully as change agents, developing a language/terminology necessary to describe the dynamics of change processes, and making them able to recognize different forms of resistance and addressing it in their own context. At the same time it provides a common basis/experience for "connecting" teachers across schools, within and across national boundaries – engaging them in an ongoing exchange of experiences across school, regions and countries.

The Discovery Space Innovation Model

Taken together, the evidence set out above and the questions and issues it raises suggest some assumptions, which in turn have influenced the educational design of the Discovery Space approach.

The combination of a methodology derived from the available evidence base, with a mobilized group of empowered practitioners motivated by a compelling purpose, supported by dedicated innovation agencies in partnership with the key national bodies, will result in emergent Discovery Space implementation scenarios for the future science and mathematics classroom which will have system significance.

The right group to work with will be drawn from those practitioners who are already pushing at the boundaries of current practice in a chosen area. They will be well aware of practice deemed "best" – will perhaps have generated/adopted/adapted it. But they will be conscious too of its limits, and will have experienced the need to push on further, or in new directions. Skilled and self-confident, these are likely to be practitioners whose deep immersion, and success, in their work gives them the platform upon which to contemplate risk and to lead others. Visionary and energetic, their ideas spring from immersion in practice: not in theory or in ideology. They may well be alert to and interested in such fields, but the practical applications for their own "day jobs" are paramount. Indeed, it is likely that they have a wide field of vision. They will have a lively interest in the overall direction of the service in which they work, and be constantly scanning the environment for ways in which both to influence and exploit it.

Such an innovation programme holds great potential. If we want a powerful innovative culture in schools which is self-sustaining we have to empower system-aware practitioners, working ever more closely with the service users, to create it. And to avoid simply creating interesting but isolated pockets of experimentation, we have to design in collaborative ways of learning and enquiry between professionals – a "pull" rather than "push" approach.

Perhaps the most significant evidence to be considered in the search for how to foster practitioner-led innovation is that concerning the enablers and barriers. Innovators have some obvious needs including legitimation and support; and recognition and incentives (which need not be financial). They suggest also that the availability of experimental "space" can be critical – especially when it is closely tied to the involvement of end-users [20]. Barriers of course include the lack, or reverse, of the above conditions. But interestingly – from the perspective of the design of a support programme – also identified [21] is an over-reliance on high-performers as sources. This finding is difficult to interpret. At one level, such practitioners are invested in their already-successful approach; at another, they are well-placed to know the limits of current "best practice". To embark upon radical innovation requires, one could argue, confidence based on a secure reputation. Innovative initiative is likely to be regarded, (as Schopenhauer pointed out in relation to any "new truth') first with ridicule, then with violent opposition. Finally the outcome will be regarded as self-evident.

The underlying principles of the Discovery Space project approach are:

Creative community involvement: The consortium aims to create conditions for the development of teachers, new ideas, effective participation and new tools and applications to move the community into positive participation in a more equitable digital future. For this to happen the project will be led by interested stakeholders, on the basis of a strong process of creative educational community involvement. Indeed we should not try to force development into a pre-determined mold. The project team will not be repeating what has been done before. Thus creative community involvement plays a critical role in this project.

Design-based research: Design-based research methods respond to emergent features of the setting. Micro-analyses of teachers and learners interactions with activities based on this principle will enable redesign and refinement of the activities and ultimately refinement of the underlying interest-driven learning framework. Thus, emergent behaviours of learners in response to activities drive the development of both intervention and theory, which would have been unimaginable in the absence of real learners' choices. Finally, in a design-based research, practitioners and researchers work together to produce meaningful change in contexts of practice.

Such collaboration means that goals and design constraints are drawn from both the local context and the researcher's agenda, addressing a concern of many reform efforts. Engaging in such partnerships across multiple settings can uncover relationships between the numerous variables that come into play in learning contexts and help refine the key components of an intervention. In particular, these partnerships can help us distinguish between a "lethal mutation" [22] -a reinterpretation that no longer captures the pedagogical essence of the innovation- and a productive adaptation -a reinterpretation that preserves this essence, but tailors the activity to the needs and characteristics of particular learning environments-. Sustainable innovation requires understanding how and why an innovation works within a setting over time and across settings, and generating heuristics for those interested in enacting innovations in their own local contexts. In the early stages of the process, scenarios are used in order to plan the methodology and to characterize episodes or a sequence of activities (like in a story). These "stories" provide the context within which activities are carried out, so as to give us insights about the needs, difficulties and motivations that users have in particular contexts. Key elements for the Discovery Space scenarios are the users and their resistance to change, their goals, their needs, the sources of information accessed during the activities, and the information generated by the users themselves. Emergence of a community of inquiry does not happen by itself and does not emerge until considerable group dialogue takes place.

Teaching and learning techniques and activities that promote student-student interaction and that focus learning on problem solving and on applications to real-world experience, will enhance the development of such communities [23].

The design of the project's approach for the introduction of the innovation is shown in Fig. 4. Each phase is deliberately represented visually by a diamond: it seeks to

capture the movement within each phase from an initial focus broadening to a wider set of generated possibilities, which subsequently become refocused.
The design process is at system level, and consists of reflection – followed by intervention – to clarify the specific practice to be the focus for innovation. The work of analysing the need and scanning the horizon may be of theoretical and policy interest, but the proposed approach seeks to involve potential innovators (including users) in these processes from the start, as a platform for action. Assembling the right practitioners – diverse, accomplished, motivated and already poised to drive forward if the right conditions obtain – is key if they are to be mobilised to embark on significant change. Generate Creative Options is focused on bringing such practitioners together with innovators and provocateurs from other sectors, and with users, to generate creative options for the project field trials. Activities might include focus groups, creative workshops, futures thinking, service design workshops, and the use of open space technology.

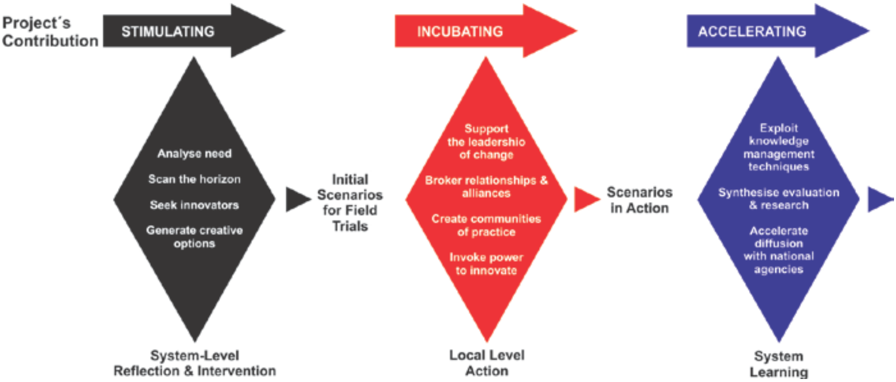


Figure 4. The Discovery Space Innovation Model will facilitate the introduction of innovation in a wide network of schools

A very demanding task of the project's implementation is expected to be the monitoring of the users' activities. In several of our previous projects in the field of application of advanced learning systems, evaluation of the learning environments has been carried out and formative, summative, qualitative and quantitative approaches have been developed and improved. There is though an ongoing demand to improve this methodology in a reverse participation: We are used to ask for a participatory system design in the direction that users or other selected stakeholders participate in the design process, but we are not very much used to the perspective that the evaluation process itself is subject to an intensive participation process influenced by designers and users. This is the case in the Discovery Space approach. This hopefully will not only give new insights into learning processes but also into evaluation methods. Our work evolves through a systematic, multi-step assessment process involving the collection and interpretation of data. The project's assessment places greater emphasis on the results of assessment procedures that sample an assortment of variables using diverse data-collection methods. Thus all aspects of the proposed approach are measured using multiple methods such as performances and portfolios, as well as interviews and questionnaires.

Conclusions – Next Steps

The described Innovation Model has been tested in practice in numerous school environments and it proves that facilitates a shift in pedagogical practice among the staff, enabled by pervasive access to ICT throughout the school. The Discovery Space approach lays the groundwork with a technical infrastructure supported by continuing efforts to introduce new ideas, support the development of technological fluency, methodologies to help harness creativity, and support to develop a pathway for the effective use of advanced technological applications in schools. The new technologies open the possibility of harnessing the enormous scientific and technological progress that has been made in the last five decades (in various fields of science and technology), by placing it at the service of one of the most important sectors of our societies.

Through the creative use of the new technologies and the learning processes they can generate with respect to local school problems, we can address the challenge of the “social appropriation of knowledge” seeking to empower teachers and students through this knowledge and to develop technologies that reflect the school needs. Additionally, the proposed educational approach can make a significant contribution to the development of self-esteem, an increased “sense of belonging”, and an improved perception of one’s own capacity to solve problems and contribute to the “construction of the surrounding community”. These factors have been clearly related to the development of “social capital” and a greater degree of conviviality and peace. Footcloth the school component and the community dimension of the project place an emphasis on developing certain key values and attitudes that play an important role in this process, such as the capacity of team work and a spirit of collaboration as a way of developing learning networks and communities.

Acknowledgements

The Discovery Space initiative builds on the outcomes on numerous projects and initiatives in the field of technology supported science education. The author wishes to thank all the colleagues who have worked in these projects effectively introducing innovation in science classrooms in many European schools during the last 10 years. The Discovery Space approach has been significantly affected from their valuable contributions and experimentations.

References

[1] Rocard M *et al*, EC, High Level Group on Science Education. Science Education NOW: A Renewed Pedagogy for the Future of Europe, 2007.

[2] Committee on Science Learning, Kindergarten through Eighth Grade, Taking Science Back to School: Learning and Teaching Science in Grades K-8, Duschl RA, Schweingruber HA and Shouse AW (Eds.),1996.

[3] Education Development Center (EDC), Center for Science Education, Publications and other resources resulting from a synthesis of research on the impact of inquiry science instruction, 2007.
http://cse.edc.org/products/inquirysynth/default.asp
[4] PISA, Science Competencies for Tomorrow's World, 2006.
http://www.pisa.oecd.org
[5] Kinchin IM, Investigating students' beliefs about their preferred role as learners, Educational Research, 46: 3, 301-312, 2004.
[6] Martin MO, Mullis IVS, Gonzalez EJ and Chrostowski SJ, TIMSS 2003 International science report, Boston, MA: TIMSS & PIRLS International Study Center, Lynch School of Education, Boston College, 2004.
[7] Chang CY and Tsai C, The interplay between different forms of CAI and students' preferences of learning environment in the secondary science class, Science Education, 89, 707-724, 2005.
[8] Chang CY and Hsiao CH and Barufaldi JP, Preferred-actual learning environment 'spaces' and earth science outcomes in Taiwan, Science Education, 90: 3, 420-433, 2006.
[9] Science, 323, 2009.
[10] Bybee RW, Trowbridge LW, Powell JC, Teaching secondary school science: strategies for developing scientific literacy, Pearson, 2008.
[11] Osborne J and Dilon J, Science Education in Europe: Critical Reflections, A report to the Nuffield Foundation, 2008.
[12] Kali Y and Linn M, Designing Coherent Science Education: Implications from Curriculum, Instruction, and Policy, New York: Teachers College Press, 2009.
[13] Druin A, Mobile Technology for Children: Designing for Interaction and Learning, Elsevier, 2009.
[14] Sotiriou S and Bogner F, Visualising the Invisible: Augmented Reality as an Innovative ScienceEducation Scheme, Advanced Science Letters, 1, 114-122, 2008.
[15] Lesser E and Storck J, Communities of practice and organisational performance, IBM Systems Journal, 40: 4, 2001.
[16] Wenger E, McDermott R and Snyder W, Cultivating communities of practice, a guide to managing knowledge, Boston: Harvard Business School Press, 2002.
[17] Hannon V, 'Next Practice' in education: a disciplined approach to innovation, Innovation Next Practice, 2009.
[18] Barber M, The next stage for large scale reform in England: From good to great, 47^{th} Economic Conference, 'Education in the 21^{st} Century: Meeting the Challenges of a Changing World', 2002.
[19] Lawson E and Price C, The psychology of change management, The McKinsey Quarterly 2003 Special Edition: The Value in Organization, 30- 41, 2003.
[20] The Young Foundation, Social Innovation: what it is, why it matters and how it can be accelerated, 2006.
[21] Albury D, Fostering Innovation in Public Services, Public Money & Management Journal, 2005.
[22] Brown AL and Campione JC, Psychological theory and the design of innovative learning environments: On procedures, principles, and systems, Innovations in

learning: New environments for education, Schauble L and Glaser R (Eds.), Mahwah, NJ: Erlbaum, 289-325, 1996.
[23] Schwarz B, Dreyfus T and Hershkowitz R, Transformation of Knowledge Through Classroom Interaction, London: Routledge, 2009.

Paper presented at the 7th International Conference on “Hands on Science. Bridging the Science and Society gap",
Crete, Greece, July 25 to 31, 2010.

Analysis on Science Communication Effect of the Exhibition of China Adolescents Science and Technology Innovation Contest Based on the Assessment on the Theme Exhibitionat Beijing Main Venue of 2009 National Science Popularization Day

Fujun R and Zhimin Z

Introduction

This paper assesses, analyzes and studies the theme exhibition at the Beijing main venue of 2009 China National Science Popularization Day – "Supporting Scientific Development and Leading Future through Innovation: China Adolescents Science & Technology Innovation Exhibition". The paper introduces the National Science Popularization Day activities and the Chinese adolescents' innovation exhibitions over the past few years, describes the features of the content, form and idea of the theme exhibition, gives the purpose, method and index of assessment on the theme exhibition, focuses on analyzing and assessing the shown effect of the theme exhibition, and finally presents some views about the science communication activities among adolescents from the theme exhibition and the assessment.

Background of the theme exhibition

The theme exhibition at the Beijing main venue of 2009 China National Science Popularization Day is "Supporting Scientific Development and Leading Future through Innovation: China Adolescents Science & Technology Innovation Exhibition".

China National Science Popularization Day activities

The China National Science Popularization Day is an annual, large and nationwide science popularization activity initiated by the China Association for Science and Technology in coordination with associations and societies for science and technology at all levels from 2003. Their themes and content keep pace with the development of society and the public's demands of production and living, and their forms include display board, lecture, multimedia show, interactive activity,

experimental demonstration, artistic performance, garden party, etc. The 2009 National Science Popularization Day was themed “Saving Energy Resources, Preserving Ecological Environment, Protecting Safety & Health”, and held in all provinces and cities nationwide.
The activities at Beijing main venue, having always been the focus of National Science Popularization Day, play a public-opinion guiding and exemplary role [1], and are themed “Supporting Scientific Development and Leading Future through Innovation”.

Adolescents Science & Technology Innovation Contests in China

The Chinese government has emphasized developing adolescents’ awareness and ability of innovation since the reform and opening up. China Association for Science and Technology, the Ministry of Education, and the Central Committee of Chinese Communist Youth League, for instance, have organized China Adolescents Science & Technology Innovation Contest, Awarding Program for Future Scientists, China Adolescent Robotics Competition, “Challenge Cup” National University Students’ Extracurricular Academic Science and Technology Work Competition, and other Chinese adolescents’ science & technology educational activities playing a guiding and exemplary role since 1978, which the adolescents nationwide can participate in under the organization of their schools or universities for practice and improvement.

Feature of theme exhibition

Idea of the theme exhibition

The theme exhibition gives full play of the scientific thought and innovative approach reflected in the award-winning inventions of adolescents’ science & technology innovation, explores the social educational function of the exhibition, and displays the top inventions in the Chinese adolescents’ science & technology innovation activities and the reworked science popularization exhibits based on adolescents’ creative inspiration. It publicizes the scientific development concept of saving energy resources, preserving ecological environment and protecting safety & health while inspiring innovative thought.

Content and form of the theme exhibition

The theme exhibition with the content of “Saving Energy Resources, Preserving Ecological Environment and Protecting Safety & Health” highlights the theme of innovation and scientific development, reviews the adolescents’ science & technology innovation activities over the past 30 years since the reform and opening up, and tells the adolescents’ innovation stories. It consists of eight parts: (1) “Thirty Years of National Students’ Extracurricular Academic Innovation Contest” is a display board and multimedia show area which reviews the adolescents’ innovation contests over the past 30 years since the reform and opening up; (2) “My Innovation Story” is an area where the young inventors demonstrate their inventions and tell their innovative thoughts and experience; (3) “‘Adolescents Invention’ Concept Vehicle” centers on the theme of energy saving, where the visitors can participate in the interactive activity of driving simulation; (4) “Stair-climbing Wheelchair” is about the theme of caring, where the visitors can watch the demonstration of the wheelchair and participate in the interaction; (5) “Safety & Risk Avoiding” displays a risk-avoiding device featuring hands-on participation and experimental demonstration; (6) “Sewage Treatment Research” is an experimental demonstration area about the reutilization of treated sewage; (7) “New Energy and New Materials” is an area focusing on experimental demonstration, where the visitors can know the application of new energy and new materials to future life; (8) “Technical Challenge” is a scientific & technological device/model area and displays the adolescents’ inventions in the aerospace field; (9) “New Innovative Life” is an activity area focusing on experimental demonstration and model display and introducing new lifestyle in the future society; and (10) “Show Your Creativity” is a workshop where the visitors can give full play of their imagination by making inventions from newspapers and other used articles (2) to (10) among the above are designed for exhibits based on the adolescents’ inventions.

Assessment on the theme exhibition

Purpose of the assessment

The purpose of the assessment is to know to what extent the theme exhibition exerts a positive influence on the visitors in view of inspiring innovative thought and publicizing innovative concept, and to know the visitors’ particular evaluation and feeling of the planning, design, organization and conducting of the activities, so as to provide a basis for improving the activities in the future. CRISP conducts the assessment on the theme exhibition with the focus on the effect.

Index and method of the assessment

The index system of the assessment is comprehensive, aiming at measuring the multiple aspects of the theme exhibition (refer to Tab. 1).

Order-I Index	Order-II Index
Designation	Content
	Form
	Theme
Implementation	Explanation &consulting
	Exhibit displaying
	On-site organization
Effect	Interest
	Concept & understanding

Table 1. Index of the assessment

On-site questionnaire survey

The one-to-one questionnaire survey was conducted among the visitors at the theme exhibition on September 19-21 and 26-27, 2009. 1,525 effective completed questionnaires are collected, coded, input and then analyzed with SPSS15.0 frequency analysis and cross analysis software.

Observation

15 postgraduate students majoring in science and technology communication from Graduate University of Chinese Academy of Sciences selected and observed 60 groups of the visitors at the theme exhibition on September 20, 2009 to infer the visitors' favorite activities and testify the results of the questionnaire survey from different angles. The specific approach is: the observers secretly follow and observe the visitors and then record information such as visitors' background, staying time, visited areas, on-site spreading information and explanatory information, of which visitors' background includes the visitors' number, age (child, adolescent, the middle-aged, or the elderly), and organization (individual, group or family); the staying time includes the time spent on visiting the entire exhibition and that on each area; on-site spreading information is whether there are publicizing data on the visited sites; and explanatory information refers to the on-site guides, technical service workers, description of the sites, etc.

Characteristics of respondents

Equal proportion of male and female respondents; high proportion of young respondents

Among the 1525 respondents, men account for 49.7% and women 50.3%. From the angle of age distribution, young respondents account for the vast majority. The respondents under 18 years old enjoy the highest proportion of 28.7%, followed by those between 19 and 24 years old: 25.3%, ranking second; and those between 35 and 44 years old: 22.8%, ranking third. The respondents above 45 years old take the lower proportion of 8.1%.

Almost half of the respondents with bachelor degree or above; high proportion of students

From the angle of education, the respondents with bachelor degree (35.9%) and with master degree or above (12.4%) account for 48.3%, indicating an overall high education level.

Science communication effect of the theme exhibition

Most respondents take more interest in the topic of "innovation"

The data shows that 74.9% of the respondents take more interest in the topic of "innovation" to one degree or another after visiting the exhibition; and the respondents under 13 years old and above 45 years old are obviously under a positive influence

Some questions are designed in the questionnaire to know whether there are any changes of the respondents' interest in the topic of "innovation" after visiting the exhibition. The results show that 68.1% of the respondents become more interested and 6.8% become interested while they weren't previously.

From the angle of age, the respondents under 13 years old and above 45 years old obviously take more interest in "innovation". The statistical data from the two options about the positive changes of interest show that 70.8% of the respondents under 13 years old and 73.8% of the respondents above 45 years old choose "interested before, and now more interested", and 9.7% of the former and 9.8% of the latter choose “not interested before, and now interested to some degree”, apparently higher than the average proportion of 68.1% and 6.8% respectively. The proportion of the respondents of the two age groups ranks first and second respectively.

Most respondents are under a positive influence in view of understanding and thinking of “innovation”

The theme exhibition conveys the core concept of “Innovation Anytime, Innovation Anywhere, and Innovation of Anybody”. 4 innovation-related statements are designed in the questionnaire to know to what extent the theme exhibition exerts a positive influence on the respondents in view of the concept of “innovation” and to infer the changes of respondents’ understanding of the statements after visiting the exhibition, which are: (1) Everyone has the potential to innovate; (2) Much innovative inspiration originates from observing and thinking about little things in daily life; (3) To ignore innovative inspiration is to give up innovative opportunity; and (4) Innovation is professionals’ business and has nothing to do with me.

“Everyone has the potential to innovate”

The survey shows that 14.3% of the respondents change their attitude towards the statement from “against” to “for” after visiting the theme exhibition, and 79.8% of the respondents who were previously for the statement say “it is consolidated after visiting”.

From the angle of age, the respondents under 18 years old are most influenced by the theme exhibition. On the one hand, 28.0% of the respondents under 13 years old and 20.1% of those between 13 and 18 years old say they become for the statement after visiting the theme exhibition, the proportion of which ranks first and second respectively ; on the other hand, 87.4% of the respondents under 13 years old and 83.3% of those between 13 and 18 years old who were previously for the statement say “it is consolidated after visiting”, the proportion of which ranks first and second respectively.

“Much innovative inspiration originates from observing and thinking about little things in daily life”

The survey shows that 13.7% of the respondents change their attitude towards the statement from “against” to “for” after visiting the theme exhibition, and 79.8% of the respondents who were previously for the statement say “it is consolidated after visiting”.

From the angle of age, the respondents under 18 years old are most influenced by the theme exhibition. On the one hand, 26.6% of the respondents under 13 years old and 14.5% of those between 13 and 18 years old say they change their attitude towards the statement from “against” to “for” after visiting the theme exhibition, the proportion of which ranks first and fourth respectively, while 18.4% of the respondents between 45 and 54 years old and 17.2% of those between 55 and 69 years old think so, the proportion of which ranks second and third respectively (however, the figures related to the respondents between 55 and 69 years old are not of statistical significance and can only serve as reference because the number of the age group is less than 30); on the other hand, 88.6% of the respondents under 13 years old and 83.6% of those between 13 and 18 years old who were previously for the statement say “it is consolidated after visiting”, the proportion of which ranks first and second respectively.

“To ignore innovative inspiration is to give up innovative opportunity”

The survey shows that 17.9% of the respondents change their attitude towards the statement from “against” to “for” after visiting the theme exhibition, and 80.0% of the respondents who were previously for the statement say “it is consolidated after visiting”.

From the angle of age, the respondents under 13 years old are most influenced by the theme exhibition. On the one hand, 35.4% of the respondents under 13 years old and 18.6% of those between 13 and 18 years old say they become for the statement after visiting the theme exhibition, the proportion of which ranks first and fourth respectively (while 20.2% of the respondents between 45 and 54 years old and 20.0% of those between 55 and 69 years old think so, the proportion of which ranks second and third respectively); on the other hand, 86.9% of the respondents under 13 years old and 82.9% of those between 13 and 18 years old who were previously for the statement say “it is consolidated after visiting”, the proportion of which ranks first and second respectively.

“Innovation is professionals’ business and has nothing to do with me”

The survey shows that 12.7% of the respondents change their attitude towards the statement from “for” to “against” after visiting the theme exhibition, and 66.3% of the respondents who were previously against the statement say “it is consolidated after visiting”.

From the angle of age, the respondents under 18 years old are most influenced by the theme exhibition. On the one hand, 26.7% of the respondents under 13 years old and 13.3% of those between 13 and 18 years old say they become against the statement after visiting the theme exhibition, the proportion of which ranks first and second respectively; on the other hand, 75.0% of the respondents under 13 years old and 68.7% of those between 13 and 18 years old who were previously against the statement say “it is consolidated after visiting”, the proportion of which ranks first and third respectively.

Discussions

The assessment results show that the theme exhibition helps inspire innovative thought and develop innovative concept – which are the purport and intention of the exhibition – to some degree, and obviously exerts a positive influence on the most visitors of the exhibition – adolescents, and therefore enjoys a good science communication effect. It is evident from the analysis on the reasons for the success of the exhibition based on the assessment that the following factors are the preconditions of the good effect:

To influence adolescents by adolescents' innovative inventions and experience is a successful idea

The theme exhibition targets adolescents, to stimulate them with the inventions of adolescents of the same age and to encourage them with the innovative stories of the latter. The assessment on the observation show that in the area of "My Innovation Story", the young inventors serving as guides effectively help improve the adolescents' visiting quality. Therefore, it is necessary to emphasize the communication between the disseminator and the people for the purpose of boosting the science communication activities among adolescents.

Hands-on interactive activities are the soul of the exhibition and the design of them should be in line with the people's understanding level

The assessment results show that the interactive activities are the visitors' favorite, and the on-site questionnaire survey indicates that the respondents favor the three activities – hands-on interactive activity (71.9%), experimental demonstration (69.6%) and scientific & technological device (model) display (59.3%) – to those traditional one-way publicizing methods like display board, multimedia show, innovative story telling, etc.

Some questions are designed in the questionnaire to inquire the respondents' feeling about the difficulty levels of the hands-on activities in the exhibition. The statistics show that 82.2% of the respondents think they are not difficult, 13.8% think somewhat difficult, and only 0.6% think very difficult, which indicate that the hands-on activities are designed in line with the people's understanding level and for the people's convenience, therefore are easy to participate in.

Furthermore, it is worth noting that the science popularization activities are conducted and sustained on the basis of mobilizing lots of social resources. To disseminate scientific & technological knowledge and to facilitate the interaction between science & technology and the people via science popularization activities are the wish of the organizers of science popularization activities, however, whether the activities have desired effect and whether they really respond to the people's demands for scientific & technological knowledge are independent of the intention of the organizers [2]. Therefore, it is necessary to pay more attention to the assessment on the activities. The assessment practice shows that scientific assessment can not only verify the effect of the activities, discover the successful highlights, and also pay a reliable foundation for improving the activities.

Acknowledgements

Acknowledgements to the members of the research group of the large science popularization activity assessment team of CRISP who conduct the assessment on the theme exhibition at Beijing main venue of 2009 National Science Popularization Day.

References

[1] China Research Institute for Science Popularization, Assessment Report on the Activities at Beijing Main Venue of 2008 China National Science Popularization Day, 2009.

[2] Gabriel M and Quast T, Assessment Report of 2005 Einstein Year, Popular Science Press, 2008.

Paper presented at the 7th International Conference on “Hands on Science. Bridging the Science and Society gap",
Crete, Greece, July 25 to 31, 2010.

Science Fairs as Learning Tools

Esteves Z, Costa MFM and Dorrío BV

Introduction

Science fairs are defined as a cultural and pedagogical activity where students display and discuss scientific projects they developed, being thereafter normally evaluated by adult judges [1-2]. We think the focus should be at first instance to the pedagogic value of the scientific research developed by the students in an active committed investigative hands-on way.

To participate at a fair, students have first to overcome many problems and past different phases: subject search, project development, experiment design and problem solving, preparation of the presentation, and the science fair final presentation [2-4].

This activity has an added advantage of promoting students enthusiasm toward science, while in each phase they develop important skills like research capability, decision making, reasoning and communication skills, while having the opportunity to interact with other science interested students [1-2,4-5].

Science Fair Participation

A study about the importance of science fairs on students learning as been developed on a school, in the city of Viana do Castelo, Portugal, during the last four years and is reported elsewhere [3,5-6]. This school, Externato Maria Auxiliadora, is a private catholic school with 135 students from the 5th to the 9th grades (ages between 10 to 15 years old).

We organized a science fair for the 4th consecutive year. Students, with the support of the school and teachers developed, in a voluntary basis, scientific projects extra classroom and presented them at the end of the year to all school community and abroad.

On the first edition 42,9% of school' students have participated (only from 7th to 9th grades); on the second edition 65,6% of the students participated, on the third edition 77,9% and on the fourth edition we reached the 82,6% mark.

With the main objective of knowing students' opinion about science fairs, and the impact it might had on their education, a questionnaire was distributed to 121 students at the beginning of the year of this 4th science fair.

When students were asked about what a science fair is for them, different answers were given as is possible to see on Tab. 1.

When questioned about their participation of the 4th Science Fair, the reasons why, were varied.
The Fig. 1 shows the student answers. The majority of students refer the fact that it was an opportunity to learn something new (31,7%). Others said their participation in this edition happened because they already participated in previous year' editions and enjoyed the experience (25,1%), 9% said it was due to previous visit to the science fair, 23,4% of the students said they wanted to participate as they like science, 6,6% of the students participated due to the fun of the experience and 4,2% because they were required to.

	Nº of answers
Place where you show curiosity about science and / or technology.	35
Place where you have experience and / or projects.	**33**
Place where are sharing of experiences of learning, fun and live.	18
Place where we see projects developed by children / students.	**12**
Place where we show what we know and where to get the best experience	8
Others answers	**8**
Didn't know	7

Table 1. Definition from students of science fairs

This answer, the reference of being mandatory, was due to the fact that some school time was available at the subject of "Area de Projecto" for students to develop their projects, and their commitment and participation was evaluated qualitatively. However, it is important to notice that 4 over the 7 that mandatory participated, said that, despite being mandatory, they participate because they already visited and/or participated in previous years and that they were also fan of science.

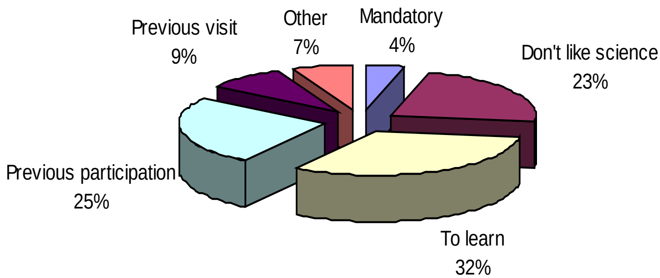


Figure 1. Reasons for students participated on the 4th science fair

Concerning the number of participants we would like to stress that all the 17,4% of the students that do not participated at the fair have ages between 12 and 15 years old. This reinforces the tendency, already verified in previous years, fortunately decreasing, that the youngest students are more participative in these activities.

The Fig. 2 shows the reasons that these students gave for not participating in the fair.
The fair, as in previous years, was announced at the beginning of the school year. Students had deadlines to select a subject and register themselves at the fair. The majority of these "missing" students (34,8%) forgot to register, 26,1% did not want to participate and 21,7% said that didn't had ideas for their participation. The rest of the answers was that they already have too many activities and cannot conciliate one more (8,7%), they don't like science (4,3%) or 4,3% give other responses.

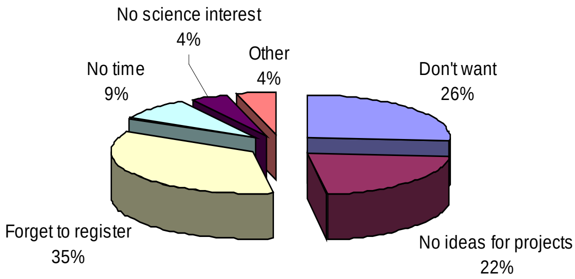


Figure 2. Reasons pointed for the students to not participated on the 4th science fair

Knowledge Evolution

To evaluate student's knowledge, a theoretical inquest was made at the beginning of the school year and at the end, after the science fair. The question presented was about why boats of 45 ton are capable to float. This question was based on a project developed by 2 girls from the 5th grade (10 years old) on this edition of the science fair.

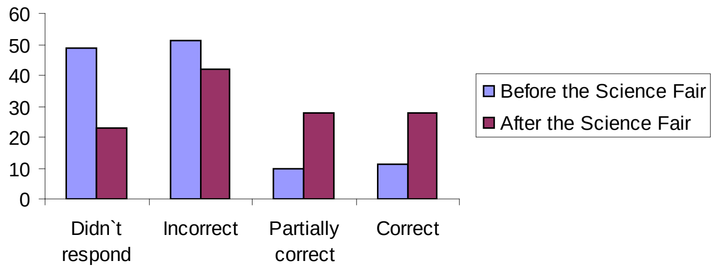


Figure 3. Answers from students to the theoretical question

Fig. 3 demonstrates the evolution of the students answers. It is possible to see that the number of students that did not respond decreased from 40,5% to 19,1%. On what concerns the incorrect answers, most of the students did not know why this fact happen and say that it is because of the characteristics of the materials boats are made of, or give illogical answers. Although not dramatic it was possible to notice that the misconception decreased from 42,1% to 34,7% after the science fair process (yet not directly related to the subject it self).

On the other side, the number of answers partially correct increased from 8,3% to 23,1%. Here, students refer essentially the fact that a large part of the boat is hollow, allowing the fluctuation. Finally the number of correct answers increased from 9,1% to 23,1%.

Conclusions

With this study we can conclude that science fairs are an activity that motivates and approaches students to science. A positive steady evolution on the number of participants along the last four years was noticed as well as in what concerns the reasons given to participate on this activity. Positive results were obtained. A certain tendency of losing interest while growing older was unfortunately also noticed.

References

[1] Grote M, Teacher Opinions Concerning Science Projects and Science Fairs, Department of Education, Ohio Wesleyan University.

[2] www.feiradeciencias.com.br

[3] Esteves Z and Costa MFM, Science Fairs as an Annual Students Project, Proceedings of the 4th International Conference on Hands-on Science. Development, Diversity and Inclusion in Science Education, Costa MF, Dorrío BV and Reis R (Eds.), Açores, 132-135, 2007.

[4] Young T, Science Fair Projects bring it all together, Book Report, 2000.

[5] Esteves Z, Cabral A and Costa MFM, Informal Learning in Basic Schools. Science Fairs, Int. J. Hands-on Science, 1: 2, 23-27, 2008.

[6] Esteves Z and Costa MFM, Science Fairs in Non-Disciplinary Curricular Areas, Proceedings of the 6th International Conference on Hands-on Science. Science for All: Quest for Excellence, Costa MF, Dorrío BV and Patairiya MK (Eds.), Ahmedabad, India, 210-213, 2009.

Paper presented at the 7th International Conference on “Hands on Science. Bridging the Science and Society gap",
Crete, Greece, July 25 to 31, 2010.

Scientific Research Projects in Vocational Training Schools

Esteves Z and Costa MFM

Introduction

Vocational training schools have as primary goal to promote an alternative curriculum to students, giving them the opportunity to acquire a higher level of education and professional qualification. This kind of teaching is in fact oriented to the direct integration of the students on the labour market. The curriculum is prepared according the type of course [1]. There are a wide variety of vocational training courses in Portugal [1-2]. In the official report [1] the courses are divided into:

- Vocational Courses, aimed to insertion of students on the labour market but also allowing the continuation of their studies.
- Learning Courses, strengthening the involvement of companies where students have internship periods in parallel with their studies.
- Education and Formation Courses, aimed preferentially to students older than 15 years and in risk of dropping out from school, that already dropout or, students that already complete high school and want to acquire professional qualifications.
- Courses in Specialized Art Education, based on visual arts and audiovisual programs in domains like dance and music.
- Education and Training of adults, with different school levels oriented to already working students and prepared to certify particular skills.

The technical and vocational teaching in Portugal began on the XVIII century, but only on the XIX century it had a greater development due the necessity of qualified labour workforce upon the Industrial Revolution [3].
For this reason, this different area of teaching was created. It was called the technical-professional teaching aiming to qualify people for the labour market. This teaching promoted the manual dexterity and developed the know-how instead of the theoretical scientific and humanistic knowledge normally taught at regular schools [3].

However, despite these intentions, the fact that these courses do not allow further education at university's level, made them only frequented by students from poor families, from rural zones or by students with learning difficulties [3].
The failure of this approach became soon evident. Since then, several changes were implemented, allowing, for instance, the entry of these students into the university. However, studies reveal that the students attending these vocational schools remain the same [3].
Currently, besides trying to qualify the labour force, these courses seek to minimize the scholar failure an increase the level of literacy of the Portuguese population [1,3], and to promote the articulation between education, training and society, leading to a more significant teaching [1]. For that, the government wants to involve others institutions like universities with the vocational teaching [1,3].

The Project Developed

The work herein reported was made on “Education and Formation Courses” and “Learning Courses”. Most of the times, students registered in vocational training schools reveal major difficulties and no motivation to study [4].
The youngest students, from Education and Formation Courses, were in risk of dropping out from school [2] for different reasons, such as learning difficulties and/or problems with classroom behaviour.
The second group, from Learning Courses, consists of students that already completed the mandatory scholarship, i.e., the first nine years of school, but also want follow their studies [2]. Two types of students are found on these classes: those that already have work experience and need specialization in some particular field, and others that have difficulties in achieving regular school objectives and choose a vocational track.

Competencies to Developed	**Stages of Development**
Documents Analyses. Research of different information sources.	Subject selection
Data collection, selection and organization. Formulate hypotheses. Observation of experiences. Confrontation of ideas and argumentation. Propose solutions to solve problems.	Project Development
Present papers and answer questions. Capability of presenting ideas, oral and writing.	Presentation

Table 1. Some skills to be developed in vocational courses [5] in different phases of the development of scientific projects [6,7]

In both cases physics and chemistry subjects are part of the scientific and technological component of the courses. Since many students cannot find any relation between these subjects and the course practical curriculum [4], it is important to remember them that the idea is not only to be specialized on a specific area but also obtaining the basics of a good education [2,4].

Therefore, this type of teaching should be based on practice with only a minimum of theoretical background [4]. The lack of resources like chemistry labs or materials makes this task more difficult.
The Tab. 1 shows some of the skills that should be developed during the vocational courses and that can be facilitated by the development of scientific projects for the students during classes. The main objective of the development of these skills is to promote the scientific knowledge and, therefore, a better comprehension of the natural world [5]. The contribution of different subjects should be valued because it will allow students to feel the importance of different subjects in their knowledge construction. Furthermore, we expect to promote teaching techniques that develop the willingness to learn.

First Case study: Middle school students

The first case that we present here was done with students of Education and Formation Courses. This class had initially 17 students, 10 boys and 7 girls, and the majority of these students were older than 15 years old. During the course 5 students dropped out for different reasons but mainly due to family problems. Three other students were expelled from the course by the teachers' council due to their large amount of faults in classes. Mainly this situation happened due to the inappropriate behaviour of these students. They didn't respect their teacher's rules and none of the strategies applied seems to have worked on them, and on the other hands they also hindered their colleagues learning. Therefore, at the time of this project, the class only had 9 students.
This project, that will be described, were developed as an interdisciplinary field named "Energy and Environment" that was presented at the "open week"1, were many students from others school visit the training center. Here, students have constructed a small city reusing garbage, like newspapers, milk cartoons… as is possible to see on Fig. 1.
Student's committed involvement during the construction of this healthy city, without pollution and using only renewable energies, was evident. They worked during class time but also during breaks, which is quite unusual in this kind of students with major behavioural problems and learning difficulties.
During this work we also asked to students to perform research about the subject and to create posters in English and leaflets including some relevant information. They worked on the construction of the city and the creation of the leaflets during the classes of Physics and Portuguese. On the English class they create the posters.
The presentation of this project was prepared and practiced. During this phase of the project they presented clearly lower motivation and higher difficulties than during the construction of the project. In fact most students failed on their presentation. This part of the project requires major attention and improvements due to the lack of social skills of these students. However it seams to be an extremely important part of their learning process. One solution could be to involve these students in simpler projects and extend the preparation and presentation' training to the class first and only then they would be more comfortable to present to a larger audience.

Figure 1. Project developed by the students

Second Case study: High School students

This project has been developed with 14 students from the second course. They have already completed the mandatory school years but want to continue the study trough vocational training. About 10 of the 14 students reveal no basic knowledge on physics or chemistry and presented major learning difficulties.

The lack of a suitable laboratory and support materials imposed a different approach: to the students it was proposed to work in groups of 2 or 3 students, choosing a simple topic or experiment that they will study and later on present to the class.

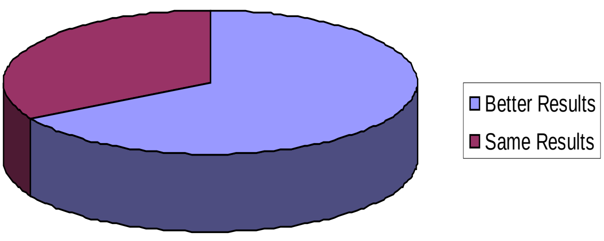


Figure 2. Results of the inquires

All this work process was given as optional and to be developed at home after class. The student should find the materials by themselves and be responsible for the development of their works. These projects (each student had the possibility of presenting up to 3 per year) were evaluated and had an impact to the student's final evaluation.

All students participated, did research for the chosen subject, proposed it to the teacher and set the date to the presentation. The projects were done out of the classroom with only a minimum amount of time being made available on the classroom to clarify some of students' doubts.

To measure the efficiency of this project on students learning, some inquires related with the projects were made one week before their works' first presentation. The same inquiry was given one week after the last presentation.

The Figure shows that on 18 of answers, the students improved their results while on 9 presented no significant improvement. Again a significant feature was that students (4 of the 6 groups) were specially committed on their research and not so much on how to explain/present their specific project. After this first set of presentations, it was possible to reach to the conclusion that the groups should have only 2 elements per group instead of 3, since one had always a lower participation level on preparation and presentation, and also due to the simplicity of the projects. In spite the relatively small population involved, positive changes were observed. However, it is possible to conclude on the greater enthusiasm that students showed on preparation and presentation of these little projects. The interest and participation on classroom subject and their performance also increased.

Conclusions

In both cases, the project developed by all the class about energies and the small projects developed by the older students, we could conclude that students can be motivated by using the development of simple science project. Unfortunately, the lack of suitable materials and other resources make this kind of activities more difficult to implement. However, this fact has a positive aspect as it is possible to show to these students that science is in everywhere and that it is possible to make science with simple everyday resources. We can also conclude that in both project' cases the motivation and the acquisition of knowledge on the particular subject researched was improved. On the second case we could clearly conclude that the overall learning of the subjects of physics and chemistry was improved. With this study, we intended to give a first step on the demonstration of the importance of the development of scientific projects on vocational courses, not only by the knowledge students acquire, but also on developing their interest on science.

References

[1] Programa de trabalho educação e formação 2010, Relatório Nacional de Progresso, 1-25, 2009.

[2] O Sistema de Formação Profissional em Portugal, Profissional, CEDEFOP Centro Europeu Para O Desenvolvimento Da Formação.

[3] Martins AM and Dias C, Ensino técnico e profissional: natureza da oferta e da procura, 97, 77-97, 2005.

[4] Barbosa E, A Disciplina de Física e Química nos Cursos de Educação e Formação nível II, 2008.

[5] Programa de Física e Química, 0-146, 2005.

[6] Esteves Z, Feiras de Ciência: Organização e Implementação, 2008.

[7] Esteves Z and Costa MFM, Science Fairs in Non-Disciplinary Curricular Areas, Proceedings of the 6th International Conference on Hands-on Science. Science

for All: Quest for Excellence, Costa MF, Dorrío BV and Patairiya MK (Eds.), Ahmedabad, India, 210-213, 2009.

Paper presented at the 7th International Conference on “Hands on Science. Bridging the Science and Society gap",
Crete, Greece, July 25 to 31, 2010.

Evolving Facets of Cyberchondria: Primum Non Nocere "First, Do No Harm"

Berezovska I, Buchinger K and Matsyuk O

Introduction

The proliferation of consumer oriented health care information on the Internet and the deceptive ease of locating and accessing such resources through search engines have produced what is being considered a new phenomenon, and a new term for this phenomenon and its sequelae has arisen----cyberchondria [1]. Cyberchondria is still hotly debated in periodicals and other media, and recent studies have outlined a number of issues facing health care information consumers, healthcare providers and IT professionals related to this phenomenon [2].

This paper will continue discussing *cyberchondria* in broad context, present recent survey data, and review recent design recommendations developed by search engine architects to reduce the likelihood that health care information consumers may become excessively anxious about their health.

On-line health-related information searching; motives, habits, and levels of anxiety

The ongoing amount of health care consumers' Internet search activity is so seemingly stable that the Pew Internet & American Life Project, Harris Interactive, Inc. and other researchers have stopped updating their reports; at least no additional recent data on Internet health information search activity is available on their public web-sites. Although most health consumers persist in using a general search engine for online health information gathering, the search results now look somewhat different than in previous years, with sponsored links appearing first in combination with a more limited number of information sources that dominate the health information supply [3].

The motives behind healthcare consumers' decisions about whether and how to engage in health information seeking vary, depending on individual needs and circumstances. In order to understand more about online health information seeking activities we carried out a survey to determine health-related search habits and levels of health-related anxiety in Ukrainian and International students at Ternopil National Technical University (TNTU, Ukraine).

The survey form shown in the Appendix includes some similar questions from Tab. IV and Tab. X, used by the Microsoft researchers in their recently reported survey research [2]. White and Horvitz distributed their survey within the Microsoft Corporation, to randomly selected employees (350 males and 165 females; average age 36.3 years). They argue that they "have no evidence that the employees' experiences with medical Web search differ significantly from those of the general user population" [2].
At the TNTU, survey forms were completed by 66 students (49 males and 17 females; average age 21.7 years) who study computer science. Their responses to the survey questions are summarized in Tab. 1. In the discussion section we compare some of the survey data obtained from the student population to data reported by White and Horvitz [2].

Average number of health online searches per month	1.72
Average number of health-related online searches (for *professionally undiagnosed medical conditions)*	1.05
End-consumer of online search results: • Yourself • Relative • Friend or work colleague • Other	 65.91% 6.82% 11.36% 15.91%
Type of information saught: • Information on symptoms • Information on serious medical conditions • Medical diagnoses • Forums/pages describing others' experiences with similar conditions • Other	 34.09% 9.09% 29.55% 27.27% 29.55%
Average self-rating of health-related anxiety (1-10 scale)	4.37
Being a hypochondriac – self-opinion: • Yes • No	 0% 100%
Being a hypochondriac – opinion of the people around: • Yes • No	 2.27% 97.73%
Unjustified self-diagnosis of a serious medical condition: • Yes • No	 29.55% 70.45%
Escalation of illness anxiety fueled by online search: • Always • Often • Occasionally • Rarely • Never	 2.27% 13.64% 27.27% 29.55% 27.27%

The ranking of online search results is considered an indicator of the likelihood of diseases: • Always • Often • Occasionally • Rarely • Never	 0% 0% 43.18% 29.55% 27.27%
The use of online search as a medical expert system: • Yes • No	 29.55% 70.45%
Scheduling an appointment with a health professional may be urged by the online health care information obtained during searches: • Yes • No	 29.55% 70.45%
The appointment disproved health concerns: • Yes • No	 34.09% 65.91%

Table 1. Responses to the survey questions at TNTU, Ukraine (66 student respondents)

Discussion of survey results

Of some note is that the student population in our survey performed far fewer online health-related searches per month than the Microsoft employees in the White and Horvitz study– 1.72 versus 10.22 per month, however the students' average health anxiety rating is much higher: 4.37 versus 2.78 in the Microsoft study (Rating scale 1-10). High morbidity in Ukraine where 10% of the students suffer from chronic diseases may explain the elevated health anxiety level reported by this student population group. The students in our survey population primarily search for themselves as the end-consumer and target information on general symptoms and possible medical diagnoses, not on the serious medical conditions that were typical search targets of the Microsoft employee survey population.

Nearly three (instead of four in the Microsoft study) in ten respondents reported self-diagnosing a serious medical condition based on their own observations, when no professionally diagnosed condition was present. The students were also far less inclined to review search content on more serious illnesses – 27% of the student population responded that they never did so versus only 8% in the Microsoft survey population.

There is an interesting difference in the data related to how respondents interpreted the ranking of online search results between the student survey and the Microsoft study population. While close to one-quarter of Microsoft respondents interpreted the ranking of online search results as indicating the likely presence of disease, all (100%) of the student respondents interpreted search results in this way only occasionally, rarely or never. Perhaps students' knowledge of probability theory and ranking algorithms plays a role in this case, although a significant proportion of them (29.5%) had used Web search engines as if Web search functioned as a medical expert system.

Comparable proportions of both groups of respondents were persuaded to visit a health professional based on their review of online medical content. However more of the student population (65.9%) reported that they actually had a medical condition that warranted consulting a health care professional (their worries were justified) while only one in four of the Microsoft respondents were reassured that their worries were justified after consulting. Our findings show that this group of young Internet users could be typified as rather discriminating consumers of online health information.

Consensus seems to arise in the doctor-patient-Internet triangle

A recent research study indicates that many patients do not consider the Internet as a substitute for a doctor consultation anymore [4]. They use the Internet as a convenient “first contact” in health-related information access because it is easy to do a search unobtrusively especially if they consider a health concern as too minor to ask a physician or other health care provider. These health-related information consumers then often turn to health care professionals for help in interpreting the confusing nature of online information or to assist in making important health-related decisions regarding diagnosis or treatment. Consumers do need this kind of doctors’ support since focused and accurate information retrieval has become an increasing challenge. Even health care professionals who go through special training were found to be only moderately successful at gathering evidence for clinical question-answering with the assistance of literature searching through MEDLINE [5], so it is no surprise that consumers with far lower health literacy might be even less successful in obtaining accurate, relevant and understandable health information online.

The data from the Health Information National Trends Survey (HINTS) [4] agrees with Pew Internet's findings and shows that health consumers' trust in physicians has increased (odds ratio 1,29) with the rise of the Internet, while their trust in Internet information has declined slightly (odds ratio 0.74) over the time from 2002 to 2008. Thus the Internet seems to take a more proper third party position in the doctor-patient-Internet communication triangle.

Conclusion

Since its identification, the main focus of efforts for reducing *cyberchondria* have been devoted to the development of specialized ranking algorithms and techniques for recognizing health-related queries so that they can be specially handled. The Microsoft study authors suggest some opportunities [2]:

- detection of diagnostic intent
- providing expertise
- debiasing search results and searchers
- evaluating search results to flag candidates for escalation
- click-through tuning

Some IT-based solutions would involve:

- displaying additional information above search results, such as the overall incidence rates of relevant search terms
- linking a small set of the most popular queries with focused lists of results, in automated and handcrafted modes, that are less likely to create unjustified concerns about more serious diseases
- describing symptoms and signs in more detail and in terms that are clearer to information searchers
- creating a handcrafted list of queries flagged as candidates for escalation
- providing special ranking of Web pages frequently present in escalatory events; or submitting them for expert review
- adjusting of rank optimization methods based on input click-through and dwell data "to handle medical queries in a special manner, such that the escalatory potential of a page is also considered alongside interaction features such as the click-through frequency and dwell time when ranking search results" [2].

All these relatively sophisticated solutions, which may be expected to be implemented in the future, tend to formalize both health data presentation and diagnosis making. However, this may further complicate health information acquisition due to conceptual and linguistic mismatches between health care consumers and the architects of search engines. Information system designers and architects of search engines frequently assume that health care consumers desire formal, objective, scientific, biomedical information, "while patients, their families, and their friends often prefer more subjective, informal information about the realities of coping with illness in daily life" [6].
When consumers fail to find materials relevant to their customary reading level, they may rely on "professional help in the process of retrieving credible information and in applying such information to their own health or illness situation by eliciting discussion with their healthcare professionals" [7].
According to the HINTS data [4], it is physicians who most frequently are asked to "translate" medical literature for their less health- and IT-literate patients. Such HINTS findings refer us again to the important subject of health literacy defined by the Institute of Medicine as "the degree to which individuals have the capacity to obtain, process, and understand basic health information and services needed to make appropriate health decisions" [8].
The survey we completed at the TNTU (Ukraine) illustrates that the student population we surveyed are not only skeptical consumers of online health information, they also are more analytical in interpreting online search results, and more careful in applying the retrieved information to their health problems and seem more balanced in seeking professional medical advice to interpret the information they have retrieved online. In other words, they appear to be less likely to become cyberchondriacs and they do not consider themselves to be hypochondriacal. We assume that any possible explanation of the survey responses should include a consideration of the younger age of the student population. In addition, their IT

proficiency and general literacy which could be seen to be at a higher level than in the public in general, once again brings up the question of the impact of heath literacy.

Our findings encourage an alternate view of how the incidence of cyberchondria might be reduced in the future. Strategies of consumer education to develop health information literacy have already been well elaborated in the published literature elsewhere. Such health literacy education would be an effective supplement to the ongoing IT research regarding the improvement of search engine design.

Cyberchondria is rooted in human behaviour and potentially exascerbated by some of the fundamental properties of Internet-based information systems and as such is not a “foreign body” in a health related Internet search which can be completely eliminated. The concept of cyberchondria requires continued examination and research study to be properly managed in the future so that the medical ethics maxim of Primum non nocere "First, do no harm" can be upheld.

References

[1] The Harris Poll®. Internet Provides Public with Health Care Information that They Value and Trust and Which Often Stimulates Discussion with Their Doctors, Harris Interactive, Inc., 2009. http://news.harrisinteractive.com/profiles/investor/ResLibraryView.asp?ResLibraryID=34347&GoTopage=6&Category=1777&BzID=1963&t=11

[2] White RW and Horvitz E, Cyberchondria: Studies of the Escalation of Medical Concerns in Web Search, ACM Transactions on Information Systems, 27: 4, 1-37, 2009.

[3] Fox S, Health Sites: Some Are More Equal Than Others, Pew Internet & American Life Project, 2010. http://www.pewinternet.org/Commentary/2010/January/Health-Sites-Some-Are-More-Equal-Than-Others.aspx

[4] Hesse BW, Moser RP and Rutten LJ, Surveys of physicians and electronic health information, N. Engl. J. Med., 4, 362: 9, 859-860, 2010.

[5] Hersh WR, Crabtree MK, Hickman DH, Sacherek L, Friedman CP, Tidmarsh P, Mosbaek C and Kraemer D, Factors associated with success in searching MEDLINE and applying evidence to answer clinical questions, J. Amer. Med. Informatics Assoc., 9, 283–293, 2002.

[6] Abrahamson JA, Fisher KE, Turner AG, Durrance JC and Turner TC, Lay information mediary behavior uncovered: exploring how nonprofessionals seek health information for themselves and others online, J. Med. Libr. Assoc., 96: 4, 310-323, 2008.

[7] Berezovska I and Buchinger K, Access to Consumer Health Information: is Information Technology Progress Enabling Cyberchondria?, Proceedings of the 6th International Conference on Hands-on Science. Science for All: Quest for Excellence, Costa MF, Dorrío BV and Patairiya MK (Eds.), Ahmedabad, India, 175-180, 2009.

[8] Nielsen-Bohlman L, Panzer AM and Kindig DA, Institute of Medicine. Health literacy: a prescription to end confusion, Washington, DC: The National Academies Press, 2004.

Appendix

Health-related search habits and levels of health-related anxiety survey

1. On average, how many health-related Web searches do you perform per month?
2. On average, how many health-related Web searches for *professionally undiagnosed medical conditions* do you perform per month?
3. Who are your health-related Web searches primarily for?
4. When you seek health-related information online you generally search for? (multiple responses permitted)
5. On a scale of 1 to 10, how would you rate your overall anxiety about potential medical conditions that are not present or currently undiagnosed (1 = don't worry about health issues, 10 = severe anxiety)
6. Do you think that you are a hypochondriac?
7. Have you ever been called a "hypochondriac" by friends, family, or a health professional (e.g., a physician)?
8. Have you ever been concerned about having a serious medical condition based on your own observation of symptoms *when no condition was present*?
9. How often do your Web searches for symptoms / basic medical conditions lead to your review of content on serious illnesses?
10. If your queries contain medical symptoms, how often do you consider the ranking of Web search results as indicating the likelihood of the illnesses, with more likely diseases appearing higher up on the result page(s)?
11. Have you ever used Web search as a medical expert system where you input symptoms and expect to review possible diseases ranked by likelihood?
12. Do you believe you have been in the situation where Web content "put you over the threshold" for scheduling an appointment with a health professional, when you would likely have not sought professional medical attention if you had not reviewed Web content?
13. Did the appointment reassure you that your worries were not justified?

Paper presented at the 7th International Conference on "Hands on Science.
Bridging the Science and Society gap",
Crete, Greece, July 25 to 31, 2010.

Microscope Studies in Primary Science: Following the Footsteps of Robert Hooke in Micrographia

Tsagliotis N

On the early history of the microscope & microscopical studies

In the museum of *Middelburg* a very old microscope is preserved, which is reputed to be an instrument constructed by *Zacharias Janssen* himself, probably with the aid of his father *Hans,* circa 1590-1595 [1].

Figure 1. The Middelburg compound microscope

Despite the fact that there is no direct evidence to link this particular microscope to the *Janssens* and their craftsmanship on lenses at the time, it is still a remarkable instrument, which includes two draw tubes that could slide out of another outer casing tube, acting as a supporting sleeve. The lenses were in the ends of the draw tubes; the eyepiece lens was bi-convex and the objective lens was plano-convex. There was no stand provided for this instrument, which was apparently held in hand whilst in use. It is estimated that it was capable of magnifying images approximately three times when fully closed and up to ten times when extended to the maximum.

Galileo Galilei (1564-1642) mentioned in *Il Saggiatore* [The Assayer] (Rome, 1623) that he had probably achieved to have a *"telescope modified to see objects very close"*. It appears that in 1625 a member of the *Accademia dei Lincei* and friend of Galileo, *Johannes Faber* (1574-1629) conferred on the instrument, until then called "occhialino", "cannoncino", "perspicillo", and "occhiale", the name of "microscope". In the second half of the 17th century, remarkable results were achieved by the Italian instrument makers *Eustachio Divini* (1610-1685) and *Giuseppe Campani* (1635-1715), while in England levels of excellence were reached by *Robert Hooke* (1635-1703) or opticians and instrument makers like *Christopher Cock* (circa 1665).

Figure 2. Divini's vase-shaped microscope (left), Campani's ivory turned monocular microscope (centre) and Cock's compound microscope, manufactured in London for R. Hooke (right)

Microscope studies began during the course of the 17th century with *Federico Cesi* (1585-1630) and *Francesco Stelluti* (1577-1651) in the *Apiarium* (Rome, 1625). *Melissographia* (also appearing in Greek as "*ΜΕΛΙΣΣΟΓΡΑΦΙΑ*") is a work of *Stelluti*, covering a single folio of extraordinary size, containing detailed descriptions on bees, seen as a free inquiry into nature from the bondage of scholastics *"who have presumed to dogmatize on Nature"*, as *Bacon* criticized. Later, *Giovanni Battista Hodierna* (1597-1660) published, in *L'occhio della mosca*, a text dedicated to the anatomy of insects, a masterly example of naturalist research conducted with the aid of the microscope.

Robert Hooke has been undoubtedly one of the greatest personalities of English science of the 17th century. He was one of the first to realize the potentialities of the new invention of the microscope, which had been recently brought to England from the Continent. He was born in 1635 in Freshwater, Isle of White, and upon the death of his father he was apprenticed to a portrait painter in London. He soon abandoned this, however, and went to Westminster School and subsequently to Oxford. It appears that the originator of the superb microscopical illustrations later to be drawn in *Micrographia* (1665) had not only artistic talent, but also some formal training in a branch of art, which required accurate delineation and observation of detail [1].

Hooke was a scientist with a curious mind. From a very early age he worked in many scientific fields such as physics, chemistry, geology, biology, meteorology and astronomy, thus he has often been called the *Leonardo* of England [2]. He also knew and worked with some of the greatest scientists of the 17th century, like *John Wilkins*, *Robert Boyle*, *Christopher Wren*. He also discussed his ideas with *Isaac Newton*, *Christiaan Huygens* and *Johann Hevelius,* although he had strong disagreements and finally became rival with all three of them on different scientific issues [3].

Figure 3. The cover page of *Melissographia*, by *Francesco Stelluti*, 1625

Figure 4. A detailed drawing of an ant by Robert Hooke [4] with the description on page 203 of *Micrographia*

Hooke became associated with the newly formed *"Royal Society of London for Improving Natural Knowledge"*, which was initially a small group of scientists, called *fellows*, who met once a week to discuss their latest experiments and scientific ideas. In 1662 the group decided to hire someone to do experiments and then report the results. Hooke was the first choice for the job, so he became the "Curator of Experiments". It was this time that he carried out microscopical studies, and the Royal Society recognizing the importance of this new branch of study, encouraged this endeavor. In 1663 he was solicited by the Society to prosecute his microscopical observations in order to publish them eventually and he was also instructed to *"bring in at every meeting one microscopical observation, at least"* [1]. Hooke faithfully complied with this directive and showed the Society fellows the appearance under the microscope of common moss, the view of the edge of a sharp razor and of a point of a needle etc. He demonstrated various insects such as the flea, the louse, the gnat, the spider, the ant and various types of hairs. All these observations and many others besides were published in 1665 under the long title *"Micrographia: or some physiological description of minute bodies made by magnifying glasses with observations and inquiries thereon"*.
Micrographia was a huge book and was filled with descriptions of what Hooke saw under the microscope. He claimed that his goal was to use *"a sincere hand, and a faithful eye, to examine, and record the things themselves as they appear"*. Along

with texts of lucid descriptions, Hooke included stunning, detailed drawings of what he saw under the microscope's lens, which often folded out of the book. For the first time ever, natural scientists as well as common people could see a new world around them which they barely knew it existed [3]. His lively drawings of insects made them seem *"as if they were lions or elephants seen with the naked eye"*, he commented. The book was a great success and still ranks high today as one of the great masterpieces of microscopical literature [2].
No original painted portrait of Hooke is known to exist. It is said that any existing portrait disappeared when Newton was elected president of the Royal Society. Despite the claim that a recently discovered portrait is considered to be the one of Hooke's [5], it is still not fully accredited and/or mutually accepted as such. Nevertheless, for the educational purposes of this inquiry, for the children to have a more immediate link to the scientist and his work, a visual image of Hooke has been drawn out of the paintings of the history artist *Rita Greer*. Her paintings, based on two detailed written descriptions, aim *"to put him back into history"*, in an attempt to recreate his face and appearance.

Figure 5. 'Robert Hooke, Engineer'. A memorial portrait by the history painter *Rita Greer*, 2009

(Re)constructing a simple microscope

The construction of a microscope with common and readily available materials has been the first part of the twofold objective of this inquiry. The second part has been its implementation into practice, within the framework of children's laboratory work linking it with Hooke's *Micrographia* [4].
The initial idea for the microscope construction was one that resembled to the first *Middelburg* compound microscope, in a simplified version with one tube, two lenses and a diaphragm [6-7]. Thus initially the children used a PVC tube (16,5 cm length and 16 cm inner diameter) and two plastic lenses (objective and eyepiece), which had been extracted out of single-use disposable cameras. A piece of black carton was rolled and inserted inside the plastic tube, to avoid light reflections. The lenses were put inside adequate metal washers and affixed with sticky tack. To reduce colour and spherical aberration, the aperture of the objective lens needed to be reduced, thus a black rubber washer was used as a diaphragm and stuck on top of

the washer of the objective lens. At the other end of the microscope tube, a black film can was cut and fixed accordingly at the eye piece, providing a smooth dark base for the observer's eye. The microscope was finally fixed inside the niche of a 2-tube base glued on a third bigger supporting tube. This base was glued with a glue-gun on a piece of cardboard and the microscope was ready for observations.

Figure 6. The materials used & the first version of the constructed microscope with 2 lenses

The microscope tube was held onto the base with two or three elastic bands and it moved up and down to focus. The children made some initial observations on small objects, like sand, salt, but also feathers, pieces of cloth etc. A small and cheap reading spotlight was used to shed light to the objects under inspection.

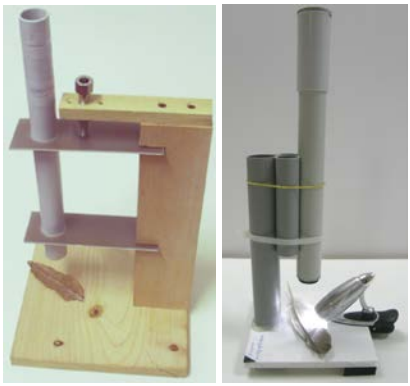


Figure 7. The improved microscope proposed by Vannoni *et al*, 2007 (left) and the one constructed by the Primary Science Laboratory, 2009-10 (right)

Rather soon, we realized that we could make an improvement to the microscope, in order to have more precise and crisp images, with less distortion. The idea was to use an extra *field lens* to achieve this. So, by extending the microscope tube with a conjunction piece we added a third lens. Thus, an extra field lens was fixed in between the end of the initial microscope tube and the new location of the eye piece, placed at the end of the attached conjunction piece (Fig. 7). The microscope tube was stabilized to the supporting base with a plastic cable tie fastener, which enabled the children to focus on images and remain stable for longer observation time. The friction created by the cable tie fastener, forcing the microscope tube and its base in contact, kept it firm and steady. In order to focus on the specimen, the children now had to turn the microscope gently and simultaneously move it up and down. To reach upon this cost effective, simple solution, we had spent quite some time trying out alternative ideas, always in search for the better one, dealing with a particular problem with an intentional added value in the result.

These improvements have completed the construction of a simple compound microscope. In fact, we made more than 45 of them, ready to be used for microscope studies.

Following the footsteps of Hooke in microscope studies

The children were very curious to put their microscopes into action and investigate various specimens. In classroom discussions, after some arbitrary microscope observations, we agreed that we needed some sort of guidance to lead us along the way of microscope investigations. It was exactly at this point that the idea of linking our observations with those of a distinguished scientist came into context. Thus, Robert Hooke, in fact the first scientist to conduct systematic microscope studies in his *Micrographia*, was introduced to the children, in order to act as a scientist from the past to assist us with our studies. For this to be a successful endeavor, children had to know more about who Hooke was, starting from his early age on the Isle of White, till the writing of *Micrographia* and further on. Thus, Hooke had to be placed into a historical context, didactically transposed in an adequate manner, familiar and suitable for the children of this age. A presentation has been developed for this purpose, using many paintings of *Rita Greer*[**], the history artist, which helped a lot to visualize aspects of Hooke’s life.

Robert Hooke was often sick as a child and his parents thought that he would not survive his childhood, but eventually his health improved as a teenager. His parents decided to teach him at home rather than send him to school. He developed a natural intelligence and curiosity about the world around him. Surrounded by the sea, he seams to have taken an early interest in ships and he had constructed a very detailed model toy ship [3]. He would have seen tall chalk cliffs on the Isle of White and worn seaside rocks. He had probably discovered fossils, remains of ancient plants and small animals preserved in the soil and rock of the island (Fig. 8). The young Robert also showed his artistic skills by copying paintings he saw in his family’s house with impressive detail. Soon after the death of his father in 1648, Robert, at the age of 13, moved to London to begin his education as a scientist in the Westminster School, one of the oldest and best schools in England. As a teenager, he studied Euclidian geometry and learned Greek and Latin. He also

[**] These paintings are available in the following URL:
http://commons.wikimedia.org/wiki/Category:Paintings_by_Rita_Greer

developed practical skills by learning how to use the lathe, a machine used to shape wood or metal. In 1653, Hooke left Westminster and moved to Oxford University to study "natural philosophy", which included many branches of science such as physics, biology and chemistry. By the time he published *Micrographia*, in 1665, he was in his thirties, a distinguished member of the Royal Society, a polymath, a very skilful scientist and probably the first systematic microscopist.
The children were impressed by the presentation of the life story of a scientist such as Hooke and were very curious to see more closely what he had actually written and drawn in *Micrographia*. They mentioned that it would be interesting to have him alongside as a "teacher", to guide us through our own microscope studies.

Figure 8. 'The Fossil Hunter'. Robert Hooke as a ten year old child on the Isle of Wight at Freshwater Bay. Oil on board by *Rita Greer*, 2005

Hence, for the purposes of this inquiry, seven worksheets have been designed, starting from adequately translated pieces of Hooke's text and drawings, which turned into hands-on classroom investigations and observations with similar specimens (i.e. point of needle, a printed dot, seeds of thyme, the ant). These investigations were extended to the study of other resembling specimens, which have been discussed in class and the children were curious to observe (i.e. the seeds and parts of the petunia plant, other insects like the isopods etc.). In the end, they had developed the skills and the interests to study lots of various different specimens, which were waiting for them, just outside the Science Laboratory, at the school garden. Thus, they concluded their observations with a "free study" to investigate *"something particularly of our own"*, as they insisted. A brief discussion of all these studies follows in the subsequent sections.

Microscope studies on the point of a needle and a printed dot

The first two study worksheets were linked to the beginning of Hooke's studies in *Micrographia*. The worksheet on the study of *the point of the needle* is directly linked with page 1 of *Micrographia*, where Hooke comments that "we will begin these our Inquiries therefore with the Observations of Bodies of the most *simple nature* first, and so gradually proceed to those of a more *compounded* one" [emphasis in the original]. This appears to be an interesting scientific, but also didactical proposition, which we adopted with the study of the point of the needle and later with the printed dot. Both symbolise something extremely small and rather dimensionless, similar to the Euclidian “point” in geometry or the “physical point” according to Hooke, which might in fact look rather different and huge under the microscope.

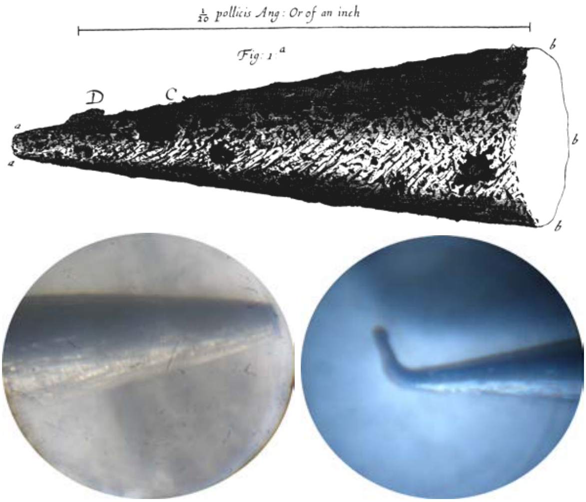


Figure 9. Hooke’s drawing of the point of the needle (top) and two digital photos of needles the children observed under their microscopes

The children read in class Hooke’s description of the point of the needle, which referred to the relevant detailed drawing (Fig. 9, top). Then, they were invited to observe the point of a needle with their microscopes, record their own description and make their own drawings. In the beginning, they had some difficulties in finding the point of the needle and then focus on it, but rather quickly they developed skills and their own techniques, which they shared with each other. Each worksheet was kept in a plastic pocket inside a binder folder. So, at the end of children’s microscope studies all of the worksheets together constituted an *observation notebook* [8-9].

Hooke noted that the point of the needle looked rather sharp and smooth to the naked eye, but under the microscope it *“could not hide a multitude of holes and scratches”*. A child wrote in his description that the point of a needle *“although in reality it is very straight and very sharp, under the microscope it is a bit curved and not sharp at all. It has a slight bump, probably from its bad use. At the rest part of the needle there are cracks and small bumps”*. Another child noted that *“the needle has an edge, which looks as if it is cut. It is as if it has a lot of damages on it, like long narrow bumps. It has a dark colour and a small cut. Anyhow, it is not as flat and sharp as we could imagine. At the centre the needle is more flat than at its point.Under the microscope it reminds me more of the point of a pencil”*. Although

the photos of Fig. 9 are not very clear, because of the inappropriate contact of the digital camera lens on the eye piece part of the microscope, it appears that the children could observe the point of the needle in a similar magnification to that of Hooke's. But, they reported a greater variety of cases, since they even found a couple of "imperfect", rather curved, needle points in each class.
Observing the printed dot, or *"a mark of full stop or period"*, Hooke mentioned that it had various irregularities and in fact it reminded him *"a great splatch (splash) of London dirt"*. One of the children wrote that *"the dots appear totally different under the microscope than with the naked eye. This one has a gray-black colour and it looks like a hairy fur ball or like a splash. It has a strange and uneven shape, which looks like the surface of the sun. At some points it appears that small sticky points are edging out of the dot".* Another child compares a printed dot with a handwritten one and claims that the first *"has a lot of "peaks" and it appears like a big black hole"*, whereas the latter *"looks like a big cloud of smoke"* and also *"some curly pieces of hair are formed, all around the dot"*.

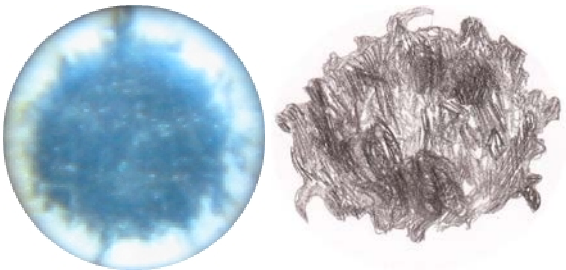


Figure 10. A digital photo of a printed dot under the microscope (left) and a child's drawing (right)

Microscope studies on the seeds of thyme and petunias

Moving on with the microscope studies, we examined *the seeds of thyme* as Hooke had also described in *Micrographia*. He noted that the seeds had a variety of shapes, whereas *"each of them exactly resembled a Lemmon or Orange dried; and this both in shape and colour"* and they were different from common seeds like beans and peas. The children used the needle, they had examined earlier, as a tool to put the small thyme seeds in place under the objective lens of the microscope and again they had to deal with some problems regarding the focus and the lighting of the specimens under inspection. Soon these were resolved with persistence and patience; virtues which children started to develop, improving their technical and methodological skills. One child wrote that some of the seeds of thyme *"have bumps and others have peaks and they look like lemons, oranges, olives and some look like "choco pop" cereals. Most of them have some small "bumps" than others which have "scratches". Most with the scratches look like nuts, whereas those with bumps look like the skin of a rotten orange and their colours are black brown or brown with black"*. Another child noted down in her worksheet that the seeds of thyme reminded her of lemons or oranges and *"they are all in a different position. There is a great variety in the volume and shape of the seeds. The seeds under the microscope have a black or a brown colour. The seeds are nosey or common like* *lemons. Every time we observe things they are not as we see them. The seeds look bigger and different than we see them with the naked eye. Thus, we should never say we see something unless we observe it with other methods like the microscope etc."* The latter statement appears to be an interesting epistemological note.

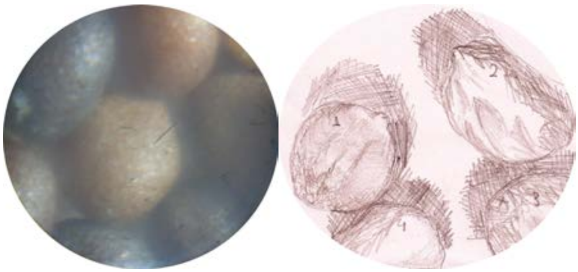


Figure 11. A digital photo of seeds of thyme under the microscope (left) and a child's drawing (right). Notice the shadows she has observed and drawn, created by the small reading spotlight lamp, which illuminated the seeds from an angle

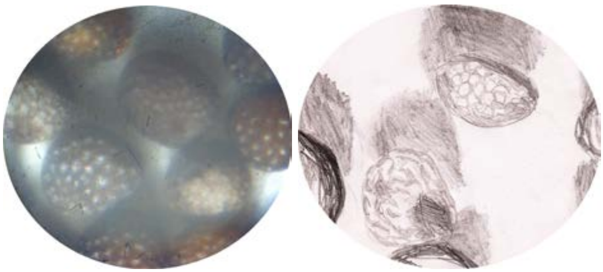


Figure 12. A digital photo of seeds of petunia (left) and a child's drawing (right)

Figure 13. A digital photo of the tip of a "hairy" petunia leaf (left) and petunia roots with some soil (right)

When the children were preparing their seed plants to be raised in the greenhouse of the organic school garden, they were impressed about the small size of some seeds. The smallest seeds they had planted were the petunia seeds. Hence, they were very interested to observe them under the microscope and this is exactly what happened as an extended investigation, following the one on the seeds of thyme. A child commented that *"the colour of the petunia seeds is dark brown. Their shape is round and they have holes and bumps. They look like small insects. In front they have something like a piece of string hanging out, whereas the back side is a bit round"*. Another child wrote that the petunia seeds *"are very small and different to those of thyme, but under the microscope they look rather big. They remind me of raisins, rotten fruits, cereals, small olives etc. They look like small bumpy marbles with brown colour"*.

The children went on to observe parts of the petunia plants they brought out of the greenhouse at the time of the microscope studies. One child inspecting a petunia leaf recorded that it was very strange, since *"petunias are beautiful plants, but you never know what they are hiding. Their leaves have very small white hair on their surface and they glitter as they stick out of the leaf, but they also look a bit transparent"*. Another child noted that *"the roots of petunias look like hands with fingers sticking out, with some soil on them and short hair. The roots are very small and thin, but I can see them clearly."*

Microscope studies on insects like ants and isopods

The next study was an investigation on insects, an *"insectigation"* in a creative term [10]. Hooke had conducted several studies of insects in *Micrographia*, but one of his most descriptive and at the same time more familiar to primary school children is the one on the ant. He mentions that he had a hard time trying to keep the ant steady under the microscope for observation. Having selected some ants he *"made choice of the tallest grown among them, and separating it from the rest, gave it a Gill of Brandy, or Spirit of Wine, which after a while knocked him down dead drunk, so that he became moveless, though at first putting in he struggled for a pretty while very much, till at last, certain bubbles issuing out of its mouth, it ceased to move"*. Then he was able to take the ant under the microscope and study it (Fig. 4), although after an hour or so *"upon a sudden, as if it had been awaken out of a drunken sleep, it suddenly revived and ran away"*. He records that this could happen a few more times, so he could inspect the insect without killing it.

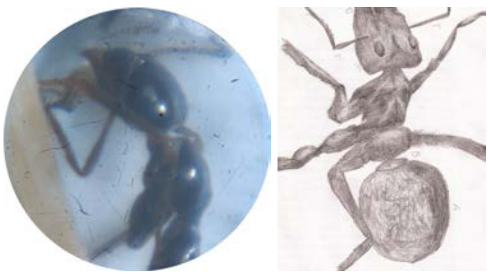


Figure 14. A digital photo of an ant held down with a tooth stick (left) and a drawing of an ant by a child, with letters in various parts of its body for text descriptions (right)

The children found this whole process rather strange at first, but fascinating later on, since they had to deal with the exactly same problem in their study of the ant. So, they went out in the school garden "hunting for ants" to be kept in small plastic

pots filled with alcohol lotion. They observed that the ants were “unconscious” after 10 minutes in the alcohol lotion, ready to be put under the microscope for inspection. All of a sudden, most of them revived and started moving after 20 to 30 minutes or so. In this way most of the children managed to observe the ants in a steady position, but also in motion and they were very thrilled to be able to do so.
One child mentions that *“the ant was very difficult for me to draw, since it did not easily stay in its position. When I took the ant out of the alcohol lotion it was asleep and I could observe it for a while and I started drawing it, but after 15 minutes it woke up and started moving again. The shape of its head is triangular and its eyes are sticking out. It has a big mouth with bumpy sawing teeth and it also has two long horns in front. The biggest part of its body was its belly, which is connected to its legs with some sort of small waist. Over all, it is a very strange insect under the microscope and it surprised me when I saw it so big for first time”.*
The children decided to look at another very common insect of the school garden, which was the *isopod* (*Armadillidium nasatum*). They knew that they could find them in dark and wet places, under rocks or grass. So, now they went for “isopods hunting” in the garden and they also collected them in small plastic pots filled with alcohol lotion. Similarly to the ants, the isopods fell “unconscious” for a while, but then again they revived after 15 minutes or so. The children observed the isopods in whole, but also some of their parts like their legs, heads etc.

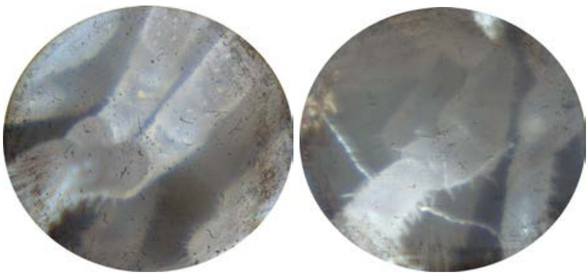


Figure 15. The legs of the isopods under study

Figure 16. Drawings of an isopod & its legs

A child, describing the isopod, comments that *“it is like an insect with a suit of armour all over. Its body also reminds me of a stair, challenging me to climb up the* *steps. Its front part has two horns, which have something like joints. There is also something like a mouth in front and a sort of tail at the rear part of its body; a strange insect indeed."*

A free microscope study

By this time, the children had performed several investigations and they had developed interests in various organisms, plants and insects, they wanted to examine more carefully. Hence, they went once again to the school garden to collect their specimens and examine them under the microscope. They brought back different kinds of leaves and flowers, but also all kinds of insects from bees to spiders etc. They observed them thoroughly and they created their own final worksheet.

One child, for example, collected and observed a raspberry and was impressed by its *"bright red colour, which looks like a small red ball with some sort of tinny yellow horns hanging out of it. Observing them more carefully I found out that they look like yellow hair magnified by the microscope"* (Fig. 17).

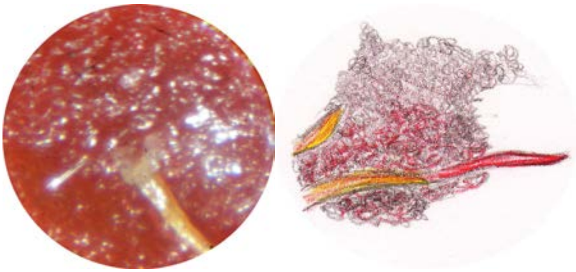


Figure 17. Photo and drawing of a raspberry with "some sort of tinny horns hanging out of it"

Concluding remarks

It appears that the children have been mentally and emotionally involved in their microscope studies and they have been led with interest into their investigations and observations. The microscope studies, as approached through the texts and drawings of Hooke, appear to enroll elements of intentionality with an increased interest for the outcome and the recorded observations. During the process of recording the observations and/or descriptions, it was noticed that they came about smoothly, whereas the framework of the activity seemed to have facilitated and enhanced the text production and drawings.

The descriptions produced seem to have an initial influence from those of Hooke, whereas they are simultaneously developed and enriched within a concurrent field of language and communication. The drawings, either simple or more complex and more descriptive, appear to be created by children with interest and commitment, because they claim that they want to work in a "scientific" way as Hooke has done. Even if some children complain that they cannot make "nice drawings", they get into the endeavour of "drawing something" and attempt to comment on it verbally.

It appears that the whole framework of these microscope studies has elements of authenticity and the children get into the process of *"doing science themselves"*. The character and nature of science is being demystified as it becomes an everyday activity dealing with an instrument, the microscope, constructed by children themselves with simple and common materials. Yet, it appears to introduce them "naturally" to a framework of scientific study and investigation.

References

[1] Bradbury S, The Evolution of the Microscope, Pergamon Press Ltd, London: Oxford, 1967.

[2] Inwood S, The forgotten genius: The biography of Robert Hooke 1635-1703, MacAdam/Cage, 2003.

[3] Burgan M, Robert Hooke: Natural Philosopher and scientific explorer, Minneapolis, Minnesota: Compass Point Books, 2008.

[4] Hooke R, Micrographia, London: Royal Society, 1665.

[5] Jardine L, The curious life of Robert Hooke, NY: HarperCollins Publishers Inc., 2004.

[6] Vannoni M and Molesini G, Constructing a microscope, Instituto e Museo di Storia della Scienza, Florence, Italy, 2006. http://brunelleschi.imss.fi.it/esplora/microscopio/dswmedia/risorse/erisorse.html

[7] Vannoni M, Buah-Bassuah PK and Molesini G, Making a microscope with readily available materials, Physics Education, 42: 4, 385-390, 2007.

[8] Klentschy M, Using Science Notebooks in elementary classrooms, Arlington, Virginia: NSTA Press, 2008.

[9] Martin DJ, Elementary Science Methods: A constructivist approach, Thomson Wadsworth, 2009.

[10] Blobaum C, Insectigations: 40 hands-on activities to explore the insect world, Chicago: Chicago Review Press, 2005.

Paper presented at the 7th International Conference on "Hands on Science.
Bridging the Science and Society gap",
Crete, Greece, July 25 to 31, 2010.

A Hands-on Experimentation and Educational Study for a 2000 Years-old Puzzle, the Mpemba Effect

Gousopoulos D, Oikonomidis S and Kalkanis G

Introduction

The purpose of this paper was to study the experimental parameters which mostly affect Mpemba's Effect appearance and contribute experimental data to the international bibliography. Moreover, we used Mpemba Effect in order to give an alternative approach to the "heat transfer" teaching at the Greek secondary education.

The Mpemba's Effect was well known in the previous centuries. A characteristic example is that in 350 BC Aristotle wrote:

"If water has been previously heated, this contributes to the rapidity with which it freezes" (Meteorologica)

Aristotle used this observation in order to support his theory called "antiperistasis", according to which there is a sudden increase in the intensity of a quality as a result of being surrounded by its contrary quality.

In the 15th century Clagett described Giovanni Marliani's experiments. More specifically he wrote the following:

"... In order to support his contention that heated water freezes more rapidly, Marliani first points to a passage in Aristotle's Meteorologica affirming it. However, does not depend on Aristotle'sstatement alone. He claims that not only has he often tested its truth during a very cold winter night, but that anyone may do so.

Moreover in 17th century both Francis Bacon and Descartes did experiments in order to confirm or reject Mpemba's Effect.

In the "Novum Organum" Francis Bacon wrote:

"...water a little warmed is more easily frozen than that which is quite cold..."

Descartes wrote in his famous book called "Les Meteores":

"... And we can also see by experiment that water which has been kept hot for a long time freezes faster than any other sort...."

From all the above historical statements, we can see that Mpemba's Effect was well known in the past, and many famous scientists and philosophers have study this strange phenomenon.

Mpemba's Effect was reintroduced by a secondary school student Mpemba in 1963 in Tanzania. Mpemba and professor Obsorne (professor from a local university) undertook several experiments in order to test the effect and published their results. After this publication, it had been revealed that this phenomenon was well known in the food-freezing industry and for the ice cream makers.
Recently, new theories have been developed which try to explain Mpemba's Effect. So, according to the previous mentioned theories the parameters that possibly lead to Mpemba's Effect appearance are the following:

- Evaporation: Suppose that we have two bodies of water. The initial temperatures for the hot and cold water are 70^oC and 30^oC respectively. Our goal is to measure the time in which cold and hot water reach 0^OC and examine if Mpemba's Effect appears. A parameter that might change during the experiment is the mass of water. Both bodies of water initially have the same mass. But if the initially hotter water loses mass due to evaporation, then the 70^oC water cooled to 30^oC will be easier to freeze. In other words, due to the fact that initially hotter water loses mass, less energy will need to be removed in order to freeze it. This is one of strongest theoretical explanations for the Mpemba Effect.
- Convection Currents: Another parameter is the temperature distribution of the water. As the water cools convection currents are developed and the temperature becomes non-uniform. Suppose that we study the previous mentioned experiment. When the initially hotter water has cooled to an average temperature of 30^oC the top of the water will be hotter than 30^oC, whereas the bottom of the water will be cooler than 30^oC. This non-uniform temperature distribution with an average temperature of 30^oC will lose energy faster than uniformly 30^oC water. Convection Currents are extremely influenced by container shape, as a results this factor to have different impact to different containers. Moreover, "Convection Currents" parameter can easily be combined with "Evaporation" parameter in order to lead to Mpemba's Effect appearance.
- Environmental Influence: Another important factor for Mpemba's Effect appearance is Environmental Influence. The initially hotter water can change his surrounding environment in such way so as to affect the rate of cooling. In details, suppose that the containers are sitting on layers of frost. Hot water causes the layer of frost to melt, establishing better thermal conduct. This means that initially hotter water cools faster than the initially cooler water.
- Gas Content: Generally hot water contains less dissolved gas than cold water. Gas Content affects water properties. Based on this factor many theories have been developed until today, but none of them can be proved experimentally
- Supercooling: Is the process of lowering the temperature of a liquid or a gas below its freezing point, without becoming a solid. Many experiments have been developed in order to reveal supercooling affect to Mpemba's Effect appearance.Unfortunately, none of them have shown clearly in which way supercooling is significant for Mpemba's Effect.

The experimentation

Based on the previous mentioned theories, we designed an appropriate experimental procedure. In details: As a mean of cooling we used a rock salt and ice bath, we measured a chosen volume of water into a pyrex beaker and we used two thermometers and one stopwatch.
We chose 4 different experiments in order to study Mpemba Effect:

i) 50mL water - pyrex beaker
ii) 50mL water with a layer of oil on top of the water-pyrex baker
iii) 100mL water-pyrex beaker
iv) 100mL water with a layer of oil on top of the water- pyrex beaker

Furthermore, we chose 5 or more initial temperatures to test Mpemba Effect and followed the same procedure for each initial temperature:
Firstly, we heated the water to the desired initial temperature, we measured the chosen volume of water into a pyrex beaker and then quickly weighed the beaker and placed it in the rock salt and ice bath. During the procedure we had been recording water's temperature per minute, till it reaches 0ºC. We should underline that we have chosen to measure the time until water reaches 0ºC, since we did not want to involve supercooling in our experiment. Moreover, we should mention that we used oil layer on top of the water so as to reduce evaporation.

The experimental procedure

Data Analysis

For each initial temperature we plot the temperature-time graph. Then we created a diagram of temperature differences for each minute. Finally, based on the previous diagram we divided the graph into 2 or 3 parts and we used Logger Pro III software, in order to determine the average rate of temperature for each part.
For instance, at the initial temperature of 22.5^{o}C (50mL water-pyrex beaker) we have the following graphs and diagram:

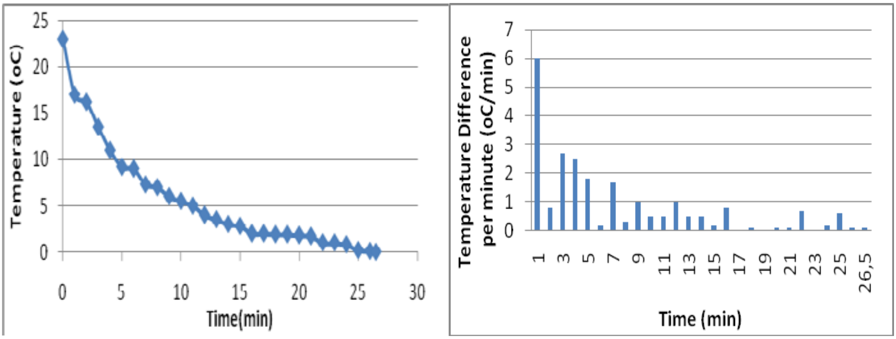


Figure 1 and Figure 2

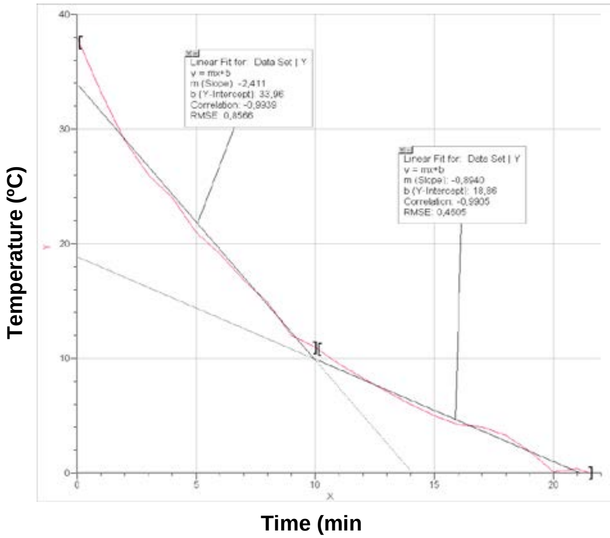


Figure 3

Moreover, at the initial temperature of 38^{o}C (50mL water-pyrex beaker) we have graphs and diagrams (Fig. 4-6). Based on the previous graphs and diagrams we can see that at the 10th minute, the temperature in the 1st case was 5.5ºC and in the 2nd case was 11ºC > 5.5ºC. However, figures 3 and 6 show us that at the same minute the rate of temperature change was 0.314ºC/min in first case (initial temperature: 22.5ºC), whereas in the second case (initial temperature: 38ºC) the rate of temperature change was 0.9ºC/min >> 0.314ºC/min. So, the body of water in the second case, despite the fact that at 10th minute has 2-time higher temperature, comparing to the first case, it reached 0ºC first, since it was characterized by 3-times higher rate of temperature change at the same minute.

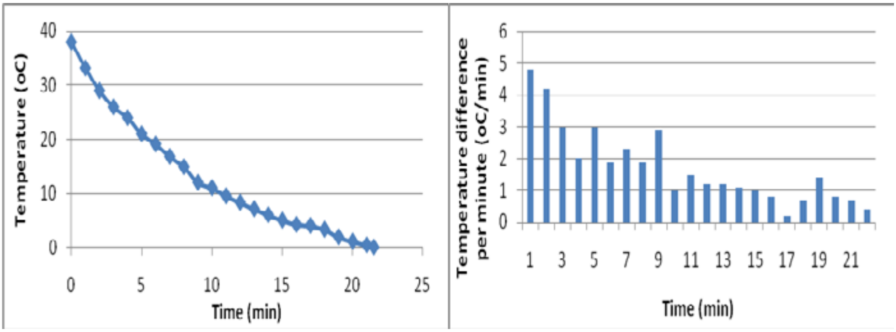


Figure 4 and Figure 5

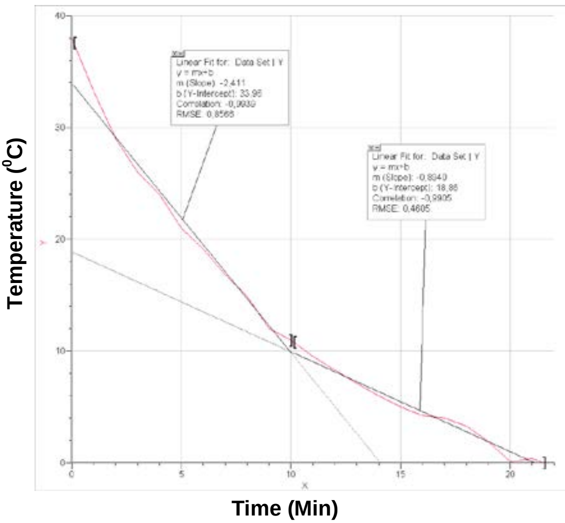


Figure 6

The previous mentioned data analysis methodology was applied to the remained initial temperatures in all four types of experiment.

Conclusion

After analyzing experimental measurements, we construct the graph in Figure 7. The x-axis shows the initial temperature of the water. The y –axis shows the time it took for the water to reach 0ºC. Based on this graph, we conclude that in the 1st experiment (50mL water in pyrex beaker) samples that were initially hotter reached 0^oC faster than samples that were initially cooler, confirming Mpemba's effect. In the 2nd experiment, where the only difference was the oil-layer on the top of the water, Mpemba's Effect has not been confirmed, showing how important evaporation is in order Mpemba's Effect to occur 3rd and 4th experiments did not confirm the phenomenon we examine. Although, there have been stated many interpretations on Mpemba's Effect, there has not been developed any mathematical equation so as to describe time evolution of the temperature, such as Newton law of cooling. So, using our experimental measurements, we intent to give a quantitative approach to the effect we study.

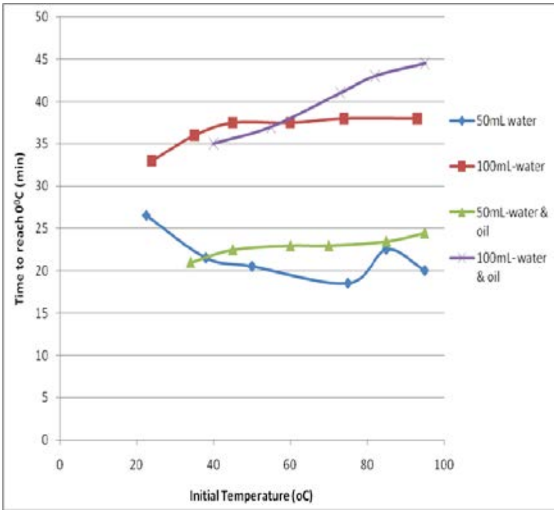


Figure 7

Finally, we can use this unusual phenomenon in order to give an alternative approach to "heat transfer" teaching at secondary education. In details, we created appropriate worksheets which are based on the "scientific / educational by inquiry model". The 5-steps which characterise our worksheets are the following:

1. Trigger of Interest
2. Hypothesizing expression
3. Experimenting- testing the hypothesis
4. Concluding
5. Application

Mpemba's Effect introduction to "heat transfer" teaching constitute an enriching activity of Greek secondary education curriculum.

References

[1] Jeng M, Hot water can freeze faster than cold?, Am. J. Phys., 74, 514-525, 2006.
[2] Kell GS, The freezing of hot and cold water, Am. J. Phys., 37: 5, 564-565, 1969.

[3] Van der Elsken J, Dings J and Michielsen JCF, The freezing of supercooled water, J. Mol. Structure, 250, 245-251, 1991.
[4] Freeman M, Cooler Still—An Answer?, Phys. Educ., 14, 417-421, 1979.
[5] Kalkanis G, Educational Technology, University of Athens, 2002.
[6] Kalkanis G, Educational Physics, University of Athens, 2002.
[7] Science & Engineering Indicators 2008, Elementary and Secondary Education, Chapter 1, 2008.
[8] Investigating the Mpemba Effect: Can Hot Water Freeze Faster than Cold Water?, http://www.sciencebuddies.org/science-fair-projects
[9] Does hot water freeze first? http://www.physicsworld.com

Paper presented at the 7th International Conference on “Hands on Science. Bridging the Science and Society gap",
Crete, Greece, July 25 to 31, 2010.

A Unique Call for S.O.S.: Students Around the World are Getting Together for the Project 'Saving Our Species'

Erentay N and Erdogan M

Introduction

When students are given an opportunity to study in a natural setting, they are able to gather data directly using their own senses and careful examination. They observe the interactions between living and non-living components of the ecosystem and also interactions among various life forms. By being directly involved, the students develop not only a cognitive understanding of the environment, but also affective and action skills. When they are encouraged to design investigations in a natural setting they develop a sense of responsibility for that habitat and those who live in that habitat. They can use scientific process skills making use of observation, in-depth questions and experiments to answer the questions. Through working in a natural setting, students develop a sense of stewardship for the natural world and find their own place within the environment they are studying.

Project S.O.S. has mainly concentrated on the endangered species and their habitats worldwide. The core subjects have been studied by primary school volunteer students from different parts of the world.

Based on the data and findings of the previous pilot project *'Unique and Universal'*, which lasted three years, Project S.O.S. aims to develop an action plan by gathering the students around the theme of scientifically studying endangered species and their habitats, sharing the data among partner schools and thus drawing global attention to the significance of taking responsible action towards these species [1-7].

The project was initiated in Turkey in 2009 with the participation of 122 students from nine primary schools located in Turkey (n=98), the USA (n=6), India (n=5) and Romania (n=13).

Initially, schools were asked to volunteer for the project through the National Eco Schools Meeting held in Muğla, Turkey; the 6th International Hands-on Science Conference held in Ahmedabad, India and the Teacher Training Seminar held at Akdeniz University in Antalya, Turkey in 2009.

With the participation of the nine primary schools and their co-ordinating teachers from Turkey, the USA, Romania and India, a website where all the participants have been able to share their labwork, artwork and fieldwork data has been constructed; initial instructions were given by the first author at the beginning of the educational year 2009. This website has served as a motivating platform on which innovative ideas and unique practices have been constantly shared and 'brain stormed' by the teachers and students involved in the project.

Activity plans were developed to be shared by the schools and ideas were exchanged. Due to the differences between physical settings, flexibility remained a key feature of the implementations realised both at school and also during field work, amongst the participating schools.

During the year, the students were taken on field work trips to make observations according to their activity plans. They formed model water ecosystems and researched the effects of pollutants in still waters, by using scientific methods at the laboratories. In the field, the students took water and soil samples to conduct water quality tests and recorded their findings. They were mainly guided throughout the whole process by the instructions given in the project handbook, *'Nature Education in 22 Steps'* [7].

It is hoped that the students involved in Project S.O.S. will continue to collaborate with their partners in the project. The scientific methods used, together with the close observations they made, should promote their sense of curiosity and their understanding and interpretation of environmental cause-and-effect relationships in nature. As a result of all these practices, in which they view themselves as an intrinsic part, they develop a sense of caring for the natural world, followed by the wish to protect and enhance. Meanwhile, the students' awareness of natural phenomena increases. Thus they develop positive attitudes towards endangered species and their habitats, by contributing to the project. At the beginning and the end of each semester, pre- and post participation assessment tests are given to the students in order to assess the outcomes of the project on their development.

Summary of Study Species and Sites

The endangered species, together with their threatened habitats, as selected by the nine volunteer schools located in Turkey, the USA, Romania and India involved in S.O.S. Project are summarized in Tab. 1.

Methodology

Participants

122 students from nine primary schools located in Turkey, the USA, India and Romania have been voluntarily involved in Project S.O.S.

Turkish Sample

The total number of students joining the project from Turkey was 98, from six schools located in Ankara, İzmir, Orhaniye, Diyarbakır and Düzce. The students ranged in age from 9 to 15 years. The Tab. 2 shows the number of students involved in the project from different locations in Turkey.

Country	School	Study Area	Study Species
Turkey Coordinat or country	Göktürk Primary School	Ankara Beynam Forests	Imperial Eagle *Aquila heliaca*
	Kavaklıdere Primary School	Ankara Atatürk Forest Farm	Angora Rabbit *Oryctolagus cuniculus*
	Şehit Öğretmen Nuriye Ak Primary School	Diyarbakır Dicle-Fırat Rivershed	Euphrates Soft- shelled Turtle *Rafetus euphraticus*
	Uzunmustafa Primary School	Düzce Efteni Lake	Caucasian Festoon *Zerynthia caucasica*
	İnci Narin Yerlici Pimary School	Orhaniye Çetibeli Sığla Forest	Anatolian Sweetgum Tree *Liquidambar orientalis*
	İPrivate Ekin College	Seyrek Menemen Gediz Delta	White Stork *Ciconia ciconia*
USA	Roland Park Country School	Baltimore Butterfly Meadows in Cheseapeake Bay Watershed	Monarch Butterfly *Danaus plexippus*
Romania	School Number 5 Satu Mare	Satu Mare River Tur Valley	Noctule Bat *Nyctalus noctula*
India	Panchayat Union School	Cuddalore Kundiyamallur Lake	Bird species at Kundiyamallur Lake

Table 1. Selected species and their habitats

School and Location	# Students
Göktürk Primary / Ankara	20
Kavaklıdere Primary / Ankara	15
Uzunmustafa Primary / Düzce	22
Şehit Öğretmen Primary/ Diyarbakır	6
İnci Narin Primary / Orhaniye	15
Ekin College/ İzmir	20
Total number	98

Table2. Number of Students joining the project in Turkey

The USA Sample

The number of students varies throughout the year. In the months of September to November the Butterfly Club, which is the alternative name of Project S.O.S., is large because that is when the Monarch butterflies are in the area. In the spring (February to May) there are only about six students - that is when they are mainly working in the garden. They ranged in age from 10 to 13 years.

Romanian Sample

Thirteen students from School Number 5 in Satu Mare, Romania took part in the project. Some of the students had previous experience in outdoor fieldwork. The students ranged in age from 13 to 14 years.

Indian Sample

Five students from Kundiyamallur in Cuddalore district, India took part in the project. The students ranged in age from 13 to 15 years.

Summaries of Project Activities Performed by Partner Schools

A sample of one semester action plan that was created by the first author was shared by the partner schools on the website at the beginning of the educational year, in order for the partner schools to be generally informed. Following this step, each school was expected to create their own unique action plan that is most appropriate for their physical settings, curriculum agenda and their surrounding environment.

Göktürk Primary School, Ankara, Turkey

In Göktürk Primary School, following a preparatory period, the project had a prompt start in December 2009. The students were already studying the Eco Schools Project and they were very excited by the idea of a new environmental project to action. A series of meetings followed.

They researched local endangered species generally and decided to study the Imperial Eagle. Their activity plan was constructed by exchanging ideas through brain storming. At the beginning of the study, the students were set assessment tests. They prepared Power Point presentations and a poster. The poster was presented on their Project S.O.S. Bulletin Board.

While drawing Imperial Eagle figures on the picture forms, they realized that they could distinguish significant differences between Imperial Eagles and the other eagle species.

Figure 1. Birdwatching around Mogan Lake

Figure 2. Poster designed by students at Göktürk Primary School

Poetry and drawing competitions were organized at the school. First, second and third prize winning ceremonies followed these competitions. From these drawings, a calendar was created by the students. Each week on Wednesdays, a seminar whose topic was the question of ‘What can we do to protect the Imperial Eagles?’ was delivered by the students in the classes. The stories about Imperial Eagles written by the students were shared by the students in classes. Through all these

activities the students' mutual interest towards Imperial Eagles was awakened.
Following the field work, photographs were placed on the bulletin board. Other students at school became more interested in and concerned about the project practices and many students at school wanted to get involved in the project.
The students corresponded with their Romanian and American counterparts.
The first field trip with students took place in May 2009 to Eymir Lake in order to search for the habitat of the species. This visit was accompanied by the Middle Eastern Technical University *'METU' Birdwatching Society.*
The second trip was in June 2009 to Mogan Lake. The S.O.S. Team in Göktürk Primary had support from the METU Birdwatching Society on their second trip also.

Kavaklıdere Primary School, Ankara, Turkey

In Kavaklıdere Primary School, following the choice of Angora Rabbit as their study subject, the students' increasing interest in rabbits resulted in them researching a wide variety of this species. The students adopted rabbits and brought them to the school.
Pre-tests were administered to the students. They prepared bulletin boards, carried out research and recorded their findings. In May 2009, a field trip was made with students to Atatürk Forest Farm. The students were informed about the fact that it was not possible to see a pure Angora Rabbit around anymore and those ones that could be seen were hybrids. With the hope of being able to observe at least a few Angora Rabbits, they contacted the Ministry of Agriculture and Forestry.

Figure 3. Caring for rabbits at Kavaklıdere Primary School

Figure 4. Poster created by the students at Kavaklıdere Primary School

The research about the Angora Rabbit was reinforced by creative techniques. The students wrote many poems, stories, composed songs and prepared power point presentations. They also created posters and brochures for their presentations. After the post-project tests were administered, their certificates were given and a closing party organized.

Şehit Öğretmen Nuriye Ak Primary School, Diyarbakır, Turkey

Five volunteer students accompanied by five teachers were involved in Project S.O.S. at Şehit Öğretmen Nuriye Ak Primary School. The *Nature Help Team* was formed and activity plan was constructed. The first creative work achieved was designing the poster and logos.

Figure 5. S.O.S. Poster designed at Şehit Öğretmen Nuriye Ak Primary School

Figure 6. Observing soil at Şehit Öğretmen Nuriye Ak Primary School

Pre-project assessment tools were administered to the students at the beginning of the study. In these tests it was clearly observed that the students' knowledge about endangered species and the causes of extinction were limited.

The first outdoor work was achieved in the school garden by observing the soil components and the living beings on it. They enclosed four different areas of one square meter on the ground and called them *stations.* These *station observations* helped them to realize the fact that there was a great variety of creatures on a place even as small as one square meter. During the outdoor work, they were enthralled and astonished by observing the abundance of nature, about which, as they themselves emphasized, they had previously been unaware.

Great interest in Project S.O.S. was reflected by the students after the work was presented on Bulletin Boards in the school hall in May 2010. Students did not know about the scientific terminology of water quality tests such as pH, ppm and dissolved oxygen, prior to the field trips. While conducting the tests on water quality at the laboratory, they became familiar with these terms. Field trips followed the laboratory implementations.

A field trip was organised to the Fırat Riverside. The students took water samples from the river, observed and tested two types of parameters in order to get qualitative and quantitative data during the field work. These were: *Physical parameters* of water quality, such as temperature, depth, and turbidity. *Chemical parameters* of water quality, such as DO (dissolved oxygen) and pH.

Colorimetric tests were conducted to analyze water samples. During the testing activities and observations, La Motte test kits were used.

In April 2009, the third outdoor study was undertaken by the project team students in the school garden, for a second observation and comparison on soil quality. They were very surprised when they observed that worms were replaced by the ants on spring.

A presentation on soil characteristics, flora, fauna and the causes of soil pollution was delivered to the students. Thus, the students started to answer for themselves the question, *Why does a s pecies become endangered?* Additional information,

concerning the extreme rarity of this turtle, which is nearly extinct in the wild, reinforced the students' keenness to prevent such tragedies in future.
In the laboratory, a basic experiment was set up using four jars filled with sample from the Fırat River; river water with detergent added; plain tap water; and tap water with detergent added, in order to test *'The effects of detergent on water environments'*. The students observed the colour changes in the water samples. They recorded and compared their findings.

Figure 7. Euphrates Soft-shelled Turtle surrounded by rubbish, as seen through the eyes of a student at Şehit Öğretmen Nuriye Ak School

Figure 8. Testing effects of pollutants

As far as the students' observations were concerned, there had been a slight change in the colour of the plain river water sample. There had been no significant colour change in either jar of tap water. They also reported the fact that there had been a vivid green colour change in the jar containing river water with detergent added to it. As a result of all this observations made by the students, they could understand and highlight the human impact on the destruction of nature, for the first time throughout the project period.
The students wrote impressive poems, compositions and letters filled with nature protection messages. The post-project tests were administered to the students in June 2010 and their certificates were presented at the closing ceremony.

Uzunmustafa Primary School, Düzce, Turkey

The project started with the participation of twenty-two volunteer students on 18th January 2010 at Uzunmustafa Primary School in Düzce. The butterfly *Zerynthia caucasica* was the species studied, together with its threatened habitat, Efteni Lake. The students researched the properties of this species and its habitat.
The meetings for the team members were planned twice a week, each of which lasted two hours. Pre-project assessment tests were administered to the students before the project work was started. Themes such as: *'Protecting nature, the endangered species, Zerynthia caucasica, Efteni Lake and their significance'* featured on the bulletin board, which was prepared by the students themselves.
In the laboratory, the students prepared natural pH indicators by using red cabbage and instant coffee filter papers. As a further step, they also prepared separate solutions in water of lemon juice; vinegar; toothpaste; flour; orange juice; fertilizer; aspirin; and coca cola. By testing the pH of these different solutions and painting

the colour change observed on indicator papers onto a separate box, they developed a pH observation kit. They then took this kit into the field to make comparisons when conducting water tests.
They took water samples from Efteni Lake to set up model aquatic environments in the laboratory. In this lab experiment, five jars were filled with plain tap water. Then, original water samples taken from Efteni Lake were added to improve the quality of model. The jars were placed by the window in direct sunlight kept at ambient room temperature.
The students were told that these model aquatic environments were used to test *effects of fertilizer and other pollutants that came from homes.*
The students brought in samples of household products to use in the experiments. It was explained that they would be conducting pollutant tests with the models that were set up before.
One jar was used as the ‘control’. Three of the jars were used as ‘the students’ household product samples’ and the last one was used as the ‘excessive fertilizer’ sample.
Two tablespoons of selected detergent; enough motor oil to cover the surface; ¼ to ½ cup of vinegar; two teaspoons of plant fertilizer were added to each jar and the carefully labeled jars were left in the sunlight as before.
The students were asked to observe the jars every other day and record their observations.
Artwork creations based on the theme *Zerynthia caucasia* followed the labwork implementations. Students created puzzles out of posters and prepared a drama about the species and the lake.
The presentations and drama work were delivered to all primary classes and 1st graders at school by the Project S.O.S. Team.
The Forestry Faculty of University of Düzce was visited by the students in order to learn about the special plants that *Zerynthia caucasia* prefers.
From this visit, the idea of forming a plant bank by drying, pressing and laminating the plant species living in the adjacent area was developed by the students, for the very first time.
The importance of meadows and green fields for ecological life was emphasized during the visit to the National Office for Agriculture. The project students undertook interviews with the elderly people living in built-up town areas, which had once been green pastures. The sorrow of these elderly people because their grandchildren could not find a suitable green area to play anymore was witnessed by the team students during the interviews.
Before the field visits took place, the students’ observatory skills were improved through games. The significance of making careful observations were discussed with the students and the games were occasionally played at the beginning of meetings to test their observation skills.
A field trip took place in the nearby surroundings of the River Asar around the school. The students recorded their observations on to the observation sheets during the outdoor work. Water quality tests were conducted to measure pH; dissolved oxygen; temperature; and turbidity. The observed and measured parameters from the River Asar by the Project S.O.S. Team on 13th May, 2010 were

as follows:

Efteni Lake (a wetland area) was the main study site for Project S.O.S. by Uzunmustafa Primary School in 2009-2010. The number of birds living around this wetland area has been estimated as approximately 150. The students bird-watched and searched for the Caucasian Festoon Butterfly's favourite milkweed plant *(Aristolochia Iberica)* during this visit.Unfortunately, they were not able to find any signs of this plant species in the area.
During the second visit to the same area, the students mostly concentrated on using their five senses and thus improving their natural observation skills. They were instructed to perform a silent '*Five-Minutes-Notice'* when they arrived at the area. They were then asked to write down what they sensed in the wetland during the five minutes of peace and quiet. At the end of the period, they described their observations.

Figure 9. Testing water quality parameters during field work

Figure 10. Preparing model of Anatolian Sweetgum Tree

At the second field trip organized to Efteni Lake, water quality parameters were observed and measured, and the findings were recorded by the team students.
Before and after the field trips, the students answered the questions on the field work tests in order for their pre- and post-project knowledge to be assessed and compared. High levels of eutrophication (the invasion of lakes and ponds by plant material) on the water surface were observed by the students. Tab. 4 indicates the measured parameters from Efteni Lake.
At the end of semester, it was observed that the students' motivation for sustaining this project work was rapidly accelerated and they decided to collaborate with NGOs next year. The presentation of their stewardship certificates took place at the closing party.

İnci Narin Yerlici Primary School, Orhaniye, Turkey

For the students, adapting to the studies concerning Project S.O.S. was an easy process because they already had been involved in the Eco Schools Projects for a number of years. The team had support from a NGO throughout the whole project period. After the species to be studied and its study area were determined, the project was started with fairly easy and interesting spontaneous activities such as

drawing pictures of *Liquidambar orientalis* and creating songs. The initial number of volunteer students in the project was seven and as the project progressed, this number went up to fifteen. Amongst them there were students who had not been involved in any environmental project before. The meetings with the team were organized as often as twice a week and in most lunch breaks.
The assessment tests were administered to the students both at the beginning and at the end of project year and it can clearly be seen that there is a statistically meaningful difference in the end of project answers given by the students to identical test questions. Moreover, when the picture forms which were administered for the second time to the team members are observed, it is obvious that the drawings of study species are far more detailed in the students' later efforts.
A model of an Anatolian Sweetgum Tree was produced by the team students and mounted onto the wall in the school hall. The method of making the model by cutting each leaf and seed from paper ensured that students learned the properties of the tree very well. The students also prepared a poster identifying the provinces in which the Sweetgum Tree was most abundant.

Figure 11. Planting young Anatolian Sweetgum Trees in Hisarönü Village

Figure 12. Posters of the White Stork produced by the team members at Ekin College

The students decided to prepare a metal plaque with the project name on it and composed a song. They emph asized that because of this song they had learned the Latin name of Anatolian Sweetgum Tree, *Liquidambar orientalis* very well. The name of Anatolian Sweetgum Tree was mounted on the door of one of the classrooms. The bulletin boards prepared with messages and news about the Project S.O.S., featuring team members conducting experiments holding test tubes and other scientific equipment, attracted attention from many of the other school students.
The students planted young Anatolian Sweetgum Trees in Hisarönü village within the framework of Forestry Week activities on 25th of March, 2010.
Two field trips were organized to Çetibeli Forest, Marmaris. Prior to the experiments, the students performed a *'Five-Minutes-Notice'* whilst they were standing quietly, listening to the sounds and smelling the scents of the forest. After the experiments had been carried out, they photographed the trees and played some appropriate games to reinforce the experience.

According to their own reports, going on a field trip and conducting scientific tests was an unforgettable experience for all of the students who participated in Project S.O.S. at İnci Narin Yerlici School. They were even excited when testing the temperature of water.
Three sub-teams were formed to perform field tests. Their observations and ideas were exchanged and their findings were interpreted by these groups. As far as the tests were concerned, there was no significant difference in their findings.

Ekin College, İzmir, Turkey

Project S.O.S. was begun in December 2009 at the privately-funded Ekin College, with twenty volunteer students and one teacher. After the study subject and study area were determined as the White Stork and the Gediz Delta, the students researched the species and the area, produced posters and exhibited their works on the school Bulletin Board.
At the beginning of the project period, the students were assessed with attitude tests, knowledge tests and picture forms. The school intends to continue the project in the year following the initial study.

Roland Park Country School, USA

The *'Save Our Species Club*' at Roland Park Country School had a special name, *'The Butterfly Club'*. In September 2009, when the students returned from summer break, they went straight into action because this is the season when Monarch Butterflies migrate through their area. Students learned to identify the caterpillars, the chrysalis and the butterfly and quickly learned what milkweed looks like.
Then they started to look for the caterpillars, to catch them for rearing in captivity. The Monarch butterfly changes from an egg into a caterpillar and then into a chrysalis. The adult butterfly emerges from the chrysalis about thirty days after the egg is laid. By bringing the caterpillars inside during their metamorphosis, this resulted in a high survival rate. The students brought in fresh milkweed leaves every day for the caterpillars, until they changed into the chrysalis stage. The caterpillars ate a great deal of milkweed and grew tremendously.
Butterfly chrysalis attaches to a leaf of milkweed and hang in the air suspended by a thin strand of silk. The students watched this process closely in the small containers where they raised the Monarch butterflies. Once the butterflies hatched, the students tagged them and released them, hoping that they would survive the 3500 mile journey to Mexico, where they spend the winter.
In the spring, Monarch butterflies begin the return journey north to spend the summer in areas where milkweed grows wild. They reproduce several times during the summer. Students were very interested in following the Monarch's life and also connected, through the internet, with their migration on the 'Journey North' website.
To encourage the Monarchs, the club created a butterfly garden in the school grounds to grow several kinds of milkweed, as well as various nectar plants to attract the adult butterflies. The students planted several different kinds of plants in the butterfly garden and learned to identify them. They had over twenty-five different plants, including five species of milkweed for the caterpillars.
The opinions of the teacher partner for Project S.O.S. is given below:

'The garden has been growing for five years and is now quite mature. Next year the students will begin to "split" some of the plants and sell samples to families of the school who want to establish a butterfly garden. All of the plants are perennials, which means they return to growth each spring and thus do not have to be replanted every year. Their seeds are saved in the autumn and used to breed new plants in order to fill any gaps in the garden.

Figure 13. Monarch Butterfly at Roland Park Country School

Figure 14. Drawing the Noctule Bat at School Number 5, Satu Mare

Soon, the students will also sell these young seedlings to interested people. In this way the S.O.S. Club is able to help the Monarchs, which are endangered, by both rearing the young caterpillars to increase the survival rate and also by expanding their habitat, by increasing the garden supply of nectar and larval plants essential to their survival'

School Number 5, Satu Mare, Romania

The 8^{th} graders began their involvement in an environmental project a few years ago, with their participation in the pioneer project *'Unique and Universal'.*[1-4,6] They enriched their knowledge about the world and endangered species, raising their awareness that the Earth is not ours to abuse, but to protect - nowadays more than ever!

At the beginning of the 2009-2010 educational year, together with their volunteer teacher, they became involved in Project S.O.S. They selected as their study species and study areas the Noctule Bat, with the River Tur Valley as its endangered habitat.

Within the framework of the project, they completed questionnaires; listened to experts telling them about the endangered species; and absorbed, processed and internalised the information received, thereby making it their own to pass on, because theirs are the voices that will be heard in future generations.

The opinions of the partner teacher of Project S.O.S. are given below:

'*They left the school this year to fulfill their destiny to high school and, later on, at college and university. All of them will choose different paths in life but there are things that will keep them together in their fight to protect the environment.*

Wherever they may go, they will always remember endangered species like the Grey Stork, the White Headed Duck, the Pool Frog, the Golden Eagle, the Monarch Butterfly or the Noctule Bat.[1-4,6]
They will tell their children about endangered species and protected areas, making our work worthwhile'.

Figure 15. A logo for S.O.S Project designed by a student at School number 5

Figure 16. Field trip at Kundiyamallur Lake with Panchayat Union School

Panchayat Union School

Five Students from Panchayat Union School, Kundiyamallur, India, together with their volunteer teacher, were involved in Project S.O.S. in December 2009.
The selected study area by the school was Kundiyamallur Lake. Selected species have not been reported as yet. At the beginning of the project, the first field trip took place at Kundiyamallur Lake in Cuddalore district. Since then, no further data has been reported. It is hoped that the school will continue to collaborate with its project partners in following years.

Conclusions

Project S.O.S. was carried out in the 2009/2010 Educational Year with 98 students from six schools in Turkey, 13 students from one school in Romania, 6 students from one school in the USA, and 5 students from one school in India. Within the frame of Project S.O.S.: (1) A unique study species and its habitat were selected by each partner school, (2) A website was constructed as a common data sharing platform; (3) An activity plan that was flexible but based on shared practices was scheduled; (4) Field trips were organized by each school. The number of field trips remained flexible, depending upon the different physical conditions of the partner schools; (5) Concerning the activities, Science and Art were two closely related disciplines applied; (6) The findings and letters were shared among all schools throughout the project period; and finally, (7) The partner schools confirmed that they wished to continue the project in the subsequent years.
Throughout the year, the students were encouraged to participate in field trips (organized near their school), where they could observe the cause-effect relationships among living and non-living organisms. Furthermore, under the guidance of the project teacher, the students carried out their own experiments with

the soil and water samples taken from study areas. Their observations and experiments helped them collect data which contributes to understanding possible effects (physical, chemical or biological) on endangered species and threatened habitats. In each school, they created a Project Corner to share their findings with their peers and used internet connections and emails to share their findings with their colleagues in other countries. Finally, they developed shared ideas into action plans for protecting endangered species and threatened habitats.
Project S.O.S. showed the vital importance of taking students on field trips in order to develop their motivation to take action to protect the natural environment. During the project, easily accessible materials were used for the experiments. We, the authors, recommend that other teachers follow similar strategies to encourage and develop responsible behaviour amongst students towards the environment in general, and, in particular, species and natural regions.

Acknowledgements
To these dedicated partners of the project, we extend heartfelt thanks for their great contributions to our project:

- Martha Barss, Teacher at Roland Park Country School, Baltimore, MD, USA
- Ancuta Nechita, Teacher in School Number 5 Satu Mare, Romania
- Kumarasamy Sampath, Teacher in School, Panchayat Union, Kundiyamallur, India
- Betül Aydoğan, Teacher in Göktürk Primary School, Ankara, Turkey
- Mehmet Salih Çelik, Teacher in Şehit Öğretmen Nuriye Ak Primary School, Diyarbakır, Turkey
- Ümit Çakır, Teacher in Kavaklıdere Primary School, Ankara, Turkey
- Dilek Balaban Teacher in Uzunmustafa Primary School, Düzce, Turkey
- Senem Şahin, Teacher in Private Ekin College, İzmir, Turkey
- Cihan Şen, Teacher in İnci Narin Yerlici Primary School, Orhaniye, Turkey

Thanks to La Motte Company for their technical support with water monitoring test kits and also to Jill Aslan for her editorial and proof-reading assistance. And finally special thanks to all dedicated students and their parents in partner schools, who have been volunteers in Project S.O.S.

References

[1] Erentay N and Erdoğan M, The Unique and Universal Project: Exploring and Sharing Our Ecosystems through Scientific Processes, Proceedings of the 3rd International Conference on Hands-on Science. Science Education and Sustainable Development, Costa MF and Dorrío BV (Eds.), Braga: University of Minho, 346-353, 2006.

[2] Erentay N and Erdoğan M, Initial Findings of Unique and Universal Project, Proceedings of the 3rd International Conference on Hands-on Science. Science Education and Sustainable Development, Costa MF and Dorrío BV (Eds.), Braga: University of Minho, 390-398, 2006.

[3] Erdoğan M and Erentay N, Children Struggling for a Sustainable Future: Impressions from Unique and Universal Project, Proceedings of the 4th International Conference on Hands-on Science. Development, Diversity and Inclusion in Science Education, Costa MF, Dorrío BV and Reis R (Eds.), Açores, 148-157, 2007.

[4] Erdoğan M, Erentay N, Children's Perceptions on Endangered Species and Threatened Environment: Results from Unique and Universal Project, Proceedings of the 4th International Conference on Hands-on Science. Development, Diversity and Inclusion in Science Education, Costa MF, Dorrío BV and Reis R (Eds.), Açores, 141-148, 2007.

[5] Erentay N, Wetlands in the Classroom: Discovering Outdoor Wet Facts through Controlled Experiments Indoors, International Workshop on Science Education in Schools.11-14 September, Bucharest, Romania, 2007.

[6] Erdogan M, Erentay N, Barss M, Nechita A and Kostova Z, An International Project on Endangered Species and Threatened Environments: "Unique and Universal", 34th North American Association for Environmental Education Annual Conference and Research Symposium, Virginia Beach, USA, 13-14, November, 2007.

[7] Erentay N and Erdoğan M, 22 Adımda Doğa Eğitimi (Nature Education in 22 Steps), Ankara: ODTU Yayıncılık, 2009.

Paper presented at the 7th International Conference on "Hands on Science. Bridging the Science and Society gap",
Crete, Greece, July 25 to 31, 2010.

Hands-on Science in Prison!

Lelingou D

Introduction

During 2008-2009 scholar year an educational programme of Astronomy has been organized in the Second Chance School of Korydallos Prison of Athens in Greece by Hellenic Physical Society, a scientific association with an intensive action in the field of education that represents the Greek scientists of Physics. The project, has been realized in occasion of the International Year of Astronomy 2009 and it has been approved by the National Academy of Athens as a greek national action of the Astronomical International Year. The astronomy project, titled “Touching the stars…!”, was an educational activity of the European Programme Exploring “Science as Culture through the European Science Museums”, a Grundtvig Lifelong Learning partnership (numbered 07-GRCO1-GR04-00025-1), conducted from October 2007 to July 2009, that connected Science Museum with Adult Education. The European Lifelong Grundtvig Project (www.anakalypto.eu) aimed to the creation of teaching procedures of distance learning with the use of New Technologies as didactic tools and to the promotion of innovative pedagogical lifelong procedures of informal and non formal forms of Science and Museum Education. It was addressed to museum visitors and museum educators, to adult school students and teachers involved in adult education, to financially and socially inferior groups, such as prisoners. The programme “Touching the stars…!” was aimed at men adults prisoner-learners aged 20 to 65 years and it was conducted, once a week, in the Second Chance School of Korydallos Prison in collaboration with the teachers of the school. The basic group of work was composed of 10 students, but a lot of activities have been proposed to all 75 prisoner-students of the school.

Educational scenario

The pedagogical action was based on an interdisciplinary approach of study and it was composed of a variety of didactic approaches [1], such as research on Scientific Museology, use of New Technologies, laboratories, lectures, interactive workshops, constructions and performances. The educational scenario covered an extended range of astronomical issues: history of Astronomy, differences between satellites, stars and planets, basic constellations of northern hemisphere with specific references to the constellations of Hunter and Scorpion, orientation using the Polar Star, comprehension of astronomical maps, study of the Planet Earth, the moon, the sun, the solar system and of our galaxy.

Use of New Technologies and hands-on experiments

During the project elements of Science Museum Education have been introduced and prisoner-students had the opportunity to realize the importance of hands-on exhibits and interactive exhibitions [2]. Because of the impossibilty of the learners to visit museums the most important European Science Museums and Planetariums have been visited virtually. The educational material was based on the use of New Technologies [3]: special softwares such as Crazy Talk and Crocodile Physics have been utilized. Using Crazy Talk, a computer program for generating talking characters from an image or photo and facial animation for video, the participants created an artefact ‘talk’ of the solar system lending their voices to each celestial body.Using Crocodile Physics, a simulator that lets model a range of physics experiments, they practiced physics simulations. An interactive board, a whiteboard capable of interacting with a computer and projecting images in a screen, has been used constantly and students learned how to use it. 3D films of astronomy have been also watched using special 3D glasses.

Figure 1. Experiments on waves

Figure 2. Construction of the solar system using newspapers and glue

For a better comprehension of the astronomical issues, lessons on physics notions have been activated and physics experiments have been realized. A small laboratory of physics has been created for the first time inside the prison school, in order to promote the scientific knowledge of the students in combination with hands-on activities. All 75 students of the school practiced experiments on motion, forces, optics and waves. All spaces of the school have been used, even the corridors were converted to laboratories for the realization of experiments with very long springs.

Lectures, workshops of art and body expression, theater performance, creation of an exhibition of astronomy.

Lectures related to the theme of the project have been also organized for all 75 prisoner-students. The basic issues of the lectures were on Museum Education, on the use of New Technologies, on Astronomy and Cosmology. Our efforts have been

supported by European experts and University Professors of Physics who came inside the prison to explain complicated scientific notions in a simple way.
The educational programme has been enriched not only with hands-on experiments but also with a variety of interactive workshops. The movements of celestial bodies in the solar system, such as the rotation and the revolution of the earth and the rotation and revolution of the moon, were understood through specific workshops of body expression.

Figure 3. Painting of the Universe

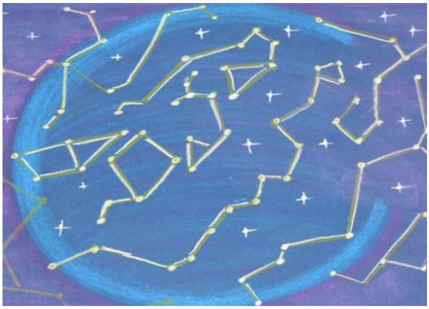


Figure 4. Painting of the sky and constellations

Art theater workshops have been also organized and a theater performance, an abstract of the book of Brecht's "Life of Galileo", has been presented to public. At the same time prisoner-students attended labs of painting and created constructions of the solar system from different kinds of materials, such as alfa-block, newspapers, glue and even bread crumbs and sugar! The painting and construction creations implemented an art exhibition of astronomy which took part to the Art & Science Symposium "Meeting in the Early Universe" that Hellenic Physical Society organized at Harokopeio University in October 2009. Thanks to the exhibition of astronomy the prison school partecipated also and won an award to the Panhellenic Competition of Astronomy 2009.

Methodology

The methodology used was based on "project method", that means in-depth and indisciplinary study of a subject [4] in which ideas, questions and interests of students direct the course of research and shape the experiences among learners [5]. The project has prompted us to develop applications of «interactive experience model» according to Falk and Dierking [6]. In addition, we focused on activities of «discovering learning» following the didactic approach of Freeman [7] that includes: i) guided discovery, ii) resolution of the problematic, iii) student action.
Particular emphasis was placed on assessing students' ideas. The educational programme focused in a particular way on the correction of misconceptions and on the reconstruction of previous knowledge, for a right understanding of scientific concepts [8]. The encouragement of curiosity and motivation, a systematic non-passive attitude of students and their active involvement through observation and partecipation in hands-on activities were main objectives of the educational process

[9]. The encouragement of group discussion was also an important methodological key in order to facilitate the socialization of students [10].

Results

The results of the project were very encouraging:

- All students were strongly motivated and they would like to repeat this experience.
- The variety of interactive cross-curricular teaching activities from the area of non-formal education has led to the sharp increase of interest for astronomy and physics science and improved the apparent astronomical knowledge of learners.
- The encouraged student action and the enrichment of the educational programme with parallel interactive workshops contributed to make prisoner-learners more social and creative.
- The integration of non formal and hands-on activities in a formal environment promoted the group work and the interaction among students.
- The use of New Technologies as teaching tools is very useful to the the creation of innovative learning teaching procedures.
- The long duration educational programmes offer substantial and specialized pedagogical results.
- Prisoners are often depressed and have low self-esteem. Such educational actions provoke the augmentation of the self-estimation of their abilities & capacities.

Conclusions

These extremely encouraging results demonstrate that:

- The interdisciplinary teaching methods incorporating actions of non formal learning and hands-on activities “refresh” the formal educational system and contribute to science and society approach.
- Scientists and teachers of science should be governed by the philosophy that the relationship between science and society must be interactive.
- Hands-on science can be introduced even in socially disadvantaged environments such as prisons.

Acknowledgements

The author wish to thank Mr. Panagiotis Fildisis, A’ Vice-President of Hellenic Physical Society, for his contribution to the realization of the European Grundtvig Project Exploring “Science as Culture” through the European Science Museums. Also Mr. Georgios Zouganelis, Director of the Second Chance School of Korydallos Prison of Athens, for his permanent psychological and practical support in implementing the Astronomy Project “Touching the stars…!” conducted inside the prison school.

References

[1] Bruner J, The culture of education, Cambridge, Mass: Harvard University Press, 1996.
[2] Pedretti E, Challenging convention and communicating controversy: Learning through issues-based museum exhibitions, In principle, In practice: Museums as learning institutions, Falk J, Dierking L and Foutz S (Eds.), New York: AltaMira Press, 2007.
[3] Pelton JN, Technology and education: Friend or foe?, Research in Distance Education, 3: 2, 2-9, 1991.
[4] Matsaggouras H, Interdisciplinary on School Knowledge. Reconstruction of concepts and work plans, Greece: Grigoris Press, 2002.
[5] Chrysafides K, Communicative-Experiential Teaching, The introduction of Project Method at school, Athens: Gutenberg Press, 1994.
[6] Falk G and Dierking L, The Museum Experience, Washington D.C.: Whalesback Books, 1992.
[7] Freeman R, The discovery gallery, Royal Ontario Museum, 1989.
[8] Driver R, Students' Conceptions And The Learning Of Science, International Journal of Science Education, 11, 481-490, 1989.
[9] Frey K, Project Method. One form of teamwork in school as theory and practice, Thessaloniki: Kyriakidis, 1980.
[10] Vygotsky LS, Mind in Society, Cambridge, MA: Harvard University Press, 1978.

Paper presented at the 7th International Conference on "Hands on Science. Bridging the Science and Society gap",
Crete, Greece, July 25 to 31, 2010.

A Robotic Chemical Analyzer

Tsigris M, Anagnostakis S and Michaelides PG

Introduction

Educational robotics [1] seems to be an appreciable area for the growth of self-activity, spontaneous energetic attendance of students and groupwork study. The majority of the students are familiar with computers. It allows us to focus all our effort in the organization of the construction through a well determined project. This project starts from the point "what I want to manufacture", it then examines ways that given software may be used to serve the needs of the construction, continues with the description of the technical materialization of the construction, and is completed with the matching of the hardware with the software to have the required result.

This is a multilevel planning which, combined with the fact that the majority of educational robotics is a team work, will result that the particular action from each member of team, begins as individual action but is fulfilled through the team, and produces a collective result, in which the autonomy of the individual action is obvious. The personal inspiration and the individual planning should be presented in an appropriate form in order to be negotiable with the team. A project like this includes all the important elements of self-activity of energetic attendance of groupwork study, imposing an essential internal treatment for each member of the team [2]. For the schoolteacher of natural sciences, it appears that initially, educational robotics can be a carrier of all desirable training attributes that we would appreciate to be available in natural science students [3-4].

Hence, the challenge for a connection of educational robotics with the natural sciences is present. For a robotic application of a creative game type, that is comprehensible from the student, it translates to "what should I do". The construction in educational robotics based on the science application does not cause itself the interest but it is stimulated by the usefulness of application and the challenge to manufacture "exotic" robotics appliances of trade. The sense of control of the total construction, as well as each of its individual department, the analysis of total in the parts and the composition of total from the parts, are an unusual experience for the students. From the side of science such a construction requires a interdisciplinary approach of the application, which meets a fertile ground as science is not end in itself, but is used in order to it attributes to us a measurable and useful result. We believe therefore that the enlargement of application of the educational robotics in spaces of utilitarian applications of the science opens a new field of experimental applications.

Methodology

A project for the materialization of the above mentioned didactic proposal is the construction of a robotic chemical analyzer according to the following methodology.
A common measurement method in the chemistry is the titration. Titration is a method in which a known volume of an unknown concentration solution reacts with known concentration reaction agent. The end of reaction becomes obvious with a variety of ways, usually with chromatic change. Follows calculation, for the determination of the unknown concentration. On the manual method of titration, we use a probe for the progressive addition of the reagent up to the chromatic change. The above process can be automated with a robotic construction. A typical application, which can constitute the initial challenge for the students, for such analyzer, it is the measurement of acids in the wine. The application for the students will start from an initial search for the wine and its history, the factors affecting the tasty and smell characteristics of the wine and the importance of acids for these characteristics. What type of acids exists in the wine, how these are associated with the local and weather particularities how we measure their quantity. Follows a short laboratorial experience of acids measurement manually with the use of a probe, reagent of sodium hydroxide and phenolphthalein as an indicator.
The experience that will be acquired constitutes the needed spark for the construction of a robotic chemical analyzer.

The Application

In this particular project, we used the system Mindstorm of LEGO. It was an effort to construct the titrator with the parts of one single set. The construction is based on logic of substitution of human manual work by the robot. The system is constituted by the following departments (Fig. 1):

1. Sampler: It is circular sample carrier. For its construction, they have been used parts from a common home blender. The sample carrier has at the first place the blank sample, at the second the standard following by the unknown samples. A step motor, controlled by the computer unit, moves the carrier to the proportional sample.
2. Syringe for the Reagent's Volume Measurement: It is a common syringe, the piston of which is connected with a screw, controlled by step motor of LEGO. In each complete rotation of the motor, the piston moves at an equal to the step of the screw distance. This corresponds in a concrete reagent volume that is added and the computer in each measurement enumerates the number of turns of the motor that was spent up to the end of reaction.
3. The Valve: The syringe after each measurement will be supposed to fill with reagent for the next measurement. This become through a 2-way valve, which is controlled by a step motor via the computer. In the first position, it adds the reagent for the measurement and in the second it reabsorbs the used reagent, in order to be ready for the next measurement.

4. Optical Detector: The optical color detector determines the end of the reaction (equivalent point) from the change of color.
5. Magnetic stirrer:It is independent exterior unit which stirs the sample during of reaction time.
6. Unit of computer: In this unit are connected the motors and the detector. Also it is loaded and executed the software.
7. Software: The structure of the program.

Figure 1

The first sample is blank; it contains all reagents and water instead of sample. Reagent is added until the detector realizes change of color. The turns of the syringe motor are measured. The valve changes position reabsorbs the spent reagent that it had been add in the measurement. The valve comes back in the position of reagent's addition. The motor of the sampler moves the second sample for measurement, which is the standard (known concentration sample). The number of syringe motor turns are measured as already described. The sampler motor moves to the first unknown sample. Number of turns are measured as already has described.
For the calculation of the unknown concentration, we use the formula:

$$CS=(RS-RB)CST/RST-RB \qquad [1]$$

where:

CS: the concentration of the unknown sample
RS: the number of turns of the syringe motor at the measurement of the unknown sample
RB: the number of turns of the syringe motor at the measurement of blank sample
CST: the concentration of standard sample
RST: the number of turns of the syringe motor at the measurement of standard.

According to the above calculation the system gives the result. It continues with the next samples.

Upgradability

The upgradability of the system concerns the software, the hardware and the applications. The upgradability gives in this project a diachronic development and a continuous improvement. Each extension, acts also as a critical regard of already existing system,

Program upgradability

The upgradability of the program, concerns important points of his structure, which influence the faculty of system to be friendly in the user, to be able to invite new applications, to optimize the conditions of speed and effectiveness, to avoid interruptions of the operation caused by program's weaknesses.

Applications upgradability

The system with suitable changes of the reagent, the program, and probably with the use of auxiliary systems, could extend its operation, in other interesting applications. Such an application is the measurement of acids in the olive oil, which has some additional difficulties on the sample treatment.

Hardware upgradability

We constructed the parts of the system, by using common materials, without special laboratory equipment, constitute a source of inspiration for the students is a challenge to improve and to supplement their constructions as individual units, as well as for the composition of new appliances in combination with additional ideas. This is the objective of such an application, to have the student a challenge of autonomous interest in science. For example, we can in order to upgrade the system, to add one unit for the preparation of the sample, which adds a second reagent, phenolphthalein or the dilution reagent for the measurement for the olive oil.

Connection with other sciences

This type of applications, are able to connect directly a number of sciences. Local tradition that concern special care for the production of qualitative foods, for example wine, olive oil, and the connection of their quality with measurable chemical parameters. Students can study also hoe the collection time, the morphology of the area, and the illnesses of the plants that affect the quality of the foods. It can be connected with nutritional value of the food. However the most important connection is with the mathematics. The significances of precision, reputability and resolution of the measurements are clearly statistical significances. The calculation of the concentrations use mathematic formula, via which, we can comprehend the significance of measurement's unit and its use. On the other hand, the use of a pHmetric detector constitutes an important application for Lyceum students, because the calculation of equivalent point requires the use of derivatives on the curve of pH- volume of reagent.

Epilogue

Our laboratory has already a long experience on the application of self-made experimental apparatuses using simple materials, focusing especially on polymorphic [6] quantitative measurements [7]. We have also an equivalent experience on the educational robotics [8-9]. With the proposed type of robotics application, we effort on the combination of our two fields of activity. A limited initial application on the students our laboratory and science teachers of secondary education shows that exists an important interest. A future extension of our applications will allow us to enounce more intergrated conclusions.

References (and Notes)

[1] Robot means any (mechanical) device capable of performing (pre-programmed) physical tasks (e.g. moving, controlling other devices, reacting to changes in their environment, etc.) and may be considered as the evolution of automata. Robots may be controlled by a human (for example the different kind of probes used in the exploration of earth or space and in surgery) or be controlled by appropriately programmed computers separate from (or being part of) the robot construction. Although the popular notion of robots relates to humanoids (former term used androids), robots may have any form appropriate for the task they were constructed for. The word robot (originating from robotovat meaning to work, to serve) appeared for the first time in the play RUR (Rossum's Universal Robots) by the Czech Karel Čapek in 1920 to describe humanlike creatures obeying a master. They are now very popular in (science) fiction.

[2] The goal of constructionism is "giving children good things to do so that they can learn by doing much better than they could before (Papert S, Mindstorms: Children, Computers, and Powerful Ideas. NY, New York: Basic Books, 1980)." Is a natural extension of constructivism and emphasizes the hands-on aspect. Papert discovers ways in which technology enables children to actively use knowledge they have acquired.

[3] Michaelides PG, Training of the IT Primary School Teacher, 5th Pan-Hellenic Conference with International Participation on the 'Didactics of Mathematics and Informatics in Education, University of Thessaloniki, 12-14 October 2001 (in Greek).

[4] Krystallia Halkia, Difficulties in Transforming the Knowledge of Science into School Knowledge, Proceedings of the '1st IOSTE Symposium in Southern Europe – Science and Technology Education: Preparing Future Citizens', Paralimni-Cyprus, 76-82, 2001.

[5] Michaelides PG, State of the Art in Science Teaching, Proceedings of the 1st International Conference on Hands-on Science, Teaching and Learning in the XXI Century, Divjak S (Ed.), Ljubljana: University of Ljubljana, 11-17, 2004.

[6] Polymorphic teaching in Science and Technology includes a common psychomotive activity (e.g. constructions, measurements, experimentation ...) which consequently is morphed into different education levels depending on the (previous) cognitive attainment and/or the mentality of the students. It resembles multilevel teaching (i.e. teaching pursuing more than one sectors

and levels of learning). The need for polymorphic practice teaching arises usually in the training of teachers to the subjects they are going to teach in school where there is a requirement of teaching in an advanced level for the teachers themselves and teaching in a level more accessible for the pupils. See more in Michaelides PG, Polymorphic Practice in Science", Proceedings of the 1st Pan-Hellenic Conference on the Didactics of Science and the introduction of New Technologies in Education, University of Thessaloniki, 399-405, 1998.

[7] Tsigris M, The didactics of Science through polymorphic self-made experimental apparatus of quantitative determinations. An alternative proposal for the teaching of Natural Sciences, Proceedings of the 2nd International Conference on Hands-on Science. Science in a changing education, Michaelides PG and Margetousaki A (Eds.), Rethymno: University of Crete, 2005.

[8] Anagnostakis S and Michaelides PG, Laboratory of Educational Robotics - An undergraduate course for Primary Education Teacher – Student, Proceedinds of the 3rd International Conference on Hands-on Science. Science Education and Sustainable Development, Costa MFM and Dorrío BV (Eds.), Braga: Gráfica Vilaverdense, 329-335, 2006.

[9] Margetousaki A and Michaelides PG, Affordable and Efficient Science Teacher In-Service Training, Proceedinds of the 3rd International Conference on Hands-on Science. Science Education and Sustainable Development Costa MFM and Dorrío BV (Eds.), Braga: Gráfica Vilaverdense, 105-111, 2006.

Paper presented at the 7th International Conference on “Hands on Science.
Bridging the Science and Society gap",
Crete, Greece, July 25 to 31, 2010.

A Proposal for an Experimental Approach of Vectors

Tsigris M and Michaelides PG

Introduction

In previous articles [1-2] we have reported on the value of laboratory applications, based on self made experimental apparatuses, made of simple materials, for quantitative measurements using polymorphic experiments [3]. The present work is an experimental application with mentioned characteristics, in the comprehension of a difficult concept for the students, the vectors. A number of references [4-5], confirms that a concept like the concept of *vector* has two components. The mathematical concept (algebraic and geometric) of the *vector* and a physical concept (representation) that connects vectors with science applications. For the second component, absence of simple experiments connecting directly the concept of *vector* with the measurement on a natural phenomenon is observed). For the natural phenomena that require the use of vectors, the mathematization is done without the participation of the student and without any direct connection to natural experience.

The experiment we propose, prepare the student for the connection between the mathematic and physical representation of vectors. Also the students are trained to discover the sources of the errors through the knowledge of the physical phenomenon. At the same time it constitutes an exercise for the significance of unit of measurement, the use of proportions and the use of trigonometric numbers in practice. From the application of the experiment, they may acquire a series of psyhomotive skills, the fineness of handlings that require the experimental provision, the drawing of parallels and the accurate measurement of lengths. The results on each step, constitutes an important experience of self-assessment for the students.

Methodology

The experimental application is based on a common exercise that the students are called to solve. To calculate the resultant of two forces, using either the rule of parallelogram or with the rule of triangle. This particular exercise can function on a very simple way as a laboratory experiment. The experiment consists on the question “what is the weight (or mass) of a body” with the use of threads and

pulleys and known weights (masses). The students have to construct an experimental apparatus as in Fig. 1. With the use of two pulleys and threads and two known weights, conditions of balance of three weights are created with the unknown weight as one of the three. With a piece of paper behind the threads they make an imprinting of the directions of the threads with special attention to not disturb the balance of the system.
Based on this imprinting, they can start the process of calculation. The first control that the students can run in order to evaluate the precision of imprinting, is to produce the directions of the three lines up to meet each other at the same point. In case where the divergence is big, it will be supposed they have to repeat the imprinting. The effort of a precise imprinting requires accurate handling and develops psyhomotive skills to the students. Then they have to design in scale the two known forces. At this point the significance and the use of unitary vector become perceptible. Then with the use of a parallelogram or triangular they design the resultant of the two forces. The design of a parallel helps in the acquisition of kinetic skills of the students and the understanding of geometrical terms. At this point, we have a second self-assessment, while the resultant of the two forces should be on the same rule line with the third force. Whoever, divergence shows a fault either on the design of the parallel, or in the imprinting of forces with base the unitary vector. Finally, based on the unitary vector, they calculate the third force.
Such an experiment is appropriate for students of the second and third class of the High School. According to the analytical program, the students in Greece meet for the first time the mathematical and physical concept of vectors. The experiment is also useful for the students of the pedagogic departments in combination with the next experiment, as it works as a polymorphic experiment.

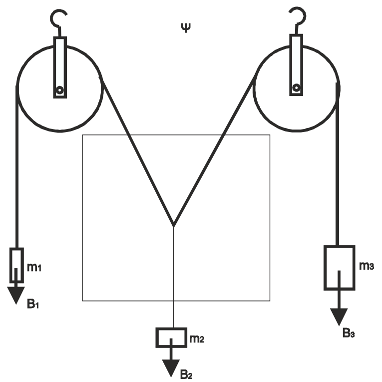


Figure 1. Scheme A

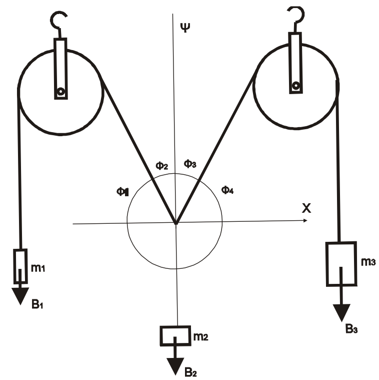


Figure 2. Scheme B

A version of the above experiment, that is appropriate for Lyceum and Pedagogical department students, is to place at the centre of threads, a protractor or its photocopy. With the system balanced, we turn the protractor suitably to fix a system of axes, with axis X horizontal and axis Y vertical, in order to overlap with the thread of B2 (Fig. 2). This helps the students, to become familiar with the usefulness of the freedom on the choice of axes. Then we can follow two ways. On the first way, they imprint the directions of the forces, based on the measurable angles on a piece of paper and develop the experiment as it was described above. On the second way, they are analyzing the forces in horizontal and vertical components, so students practice themselves on the balance of the components of the forces in every axis. In this application we have to mark two fundamental points; a/the weight of protractor has to be added on the B2 weight and b/we decrease the psyhomotive activity of the students and some stages of self-monitoring of the application (but it gives the opportunity to exercise with the trigonometric numbers and the analysis of vectors in components).

Epilogue

We applied the above described experiments on students of Department for Primary Education of the University of Crete and on students of second class of high school. The students of high school worked pleasantly in small teams. They had a better comprehension of the concept of vectors. The second version was faced pleasantly by the students of our laboratory and showed to help to the physical application of a mathematical concept. The self-assessment that is also included in both experiments is pleasant for the students and they assist in the effort of a spontaneous self motivation. The analysis of the errors helps on the comprehension of individual effects caused by the parts of system as pulleys friction or what affect the precision. They were able to locate both, the systematic errors but also their handlings errors, the random errors.

References (and Notes)

[1] Tsigris M, The didactics of Science through polymorphic self-made experimental apparatus of quantitative determinations. An alternative proposal for the teaching of Natural Sciences, Proceedings of the 2nd International Conference on Hands-on Science. Science in a changing education, Michaelides PG and Margetousaki A (Eds.), Rethymno: University of Crete, 2005.

[2] Michaelides PG, State of the Art in Science Teaching, Proceedings of the 1st International Conference on Hands-on Science, Teaching and Learning in the XXI Century, Divjak S (Ed.), Ljubljana: University of Ljubljana, 11-17, 2004.

[3] Polymorphic teaching in Science and Technology includes a common psychomotive activity (e.g. constructions, measurements, experimentation ...) which consequently is morphed into different education levels depending on the (previous) cognitive attainment and/or the mentality of the students. It resembles multilevel teaching (i.e. teaching pursuing more than one sectors and levels of learning). The need for polymorphic practice teaching arises usually in the training of teachers to the subjects they are going to teach in school where there is a requirement of teaching in an advanced level for the teachers themselves and teaching in a level more accessible for the pupils. See more in Michaelides PG, Polymorphic Practice in Science", Proceedings of the 1st Pan-Hellenic Conference on the Didactics of Science and the

introduction of New Technologies in Education, University of Thessaloniki, 399-405, 1998.

[4] Demetriadou H and Tzanakis C, Pedagogical approaches applied during teaching of vector concepts to 15-years old students, Proceedings of the 3rd colloquium on the didactics of Mathematics, University of Crete, Rethymnon, 79-103, 2003.

[5] Demetriadou H and Tzanakis C, Vectors return to the High School: didactic proposals and comments, Proceedings of the 5th International Colloquium on the Didactics of Mathematics,University of Crete, Rethymnon, 205-223, 2008.

Paper presented at the 7th International Conference on "Hands on Science.
Bridging the Science and Society gap",
Crete, Greece, July 25 to 31, 2010.

Helop – Heliostatic Ornamental Panel

Ribeiro Vaz AT, Fernandes Lapa MI, Soares Costa RF, Coutinho Costa AT, Gonçalves Pinto J
and Pereira da Silva JM

Introduction

Throughout human history energy has always been a highly “desired” study object by all of those who have contributed to the construction of scientific knowledge. In our days, the installation and setting of equipments for the use of solar energy in public and private buildings often end up being aesthetically aggressive, thus causing a visual/environmental impact which depreciates the architectonic framing of the constructions.

Catch, store and convert the energy made available by the sun in a sustainable design perspective became for us the big challenge that allowed the conception, development and implementation of this project.

The option of turning to the use of raw materials natural resources (slate, black schist), or even other transformed, like for example the glass (sand), well demonstrates our intention of valuing endogenous natural resources abundant in our country. This way we have combined piece design, and all together, the noble purpose of energetic use of solar radiation.

The application of this project results in an increase of energetic efficiency of the buildings with environmental effects in the corresponding reduction of CO_2 emission and natural saving of fossil fuels.

Project methodology applied

We can describe the methodology used based on the tasks that were followed in every step.

- Bibliographic research into solar radiation and its annual course; thermal characteristics of the materials used in the production of the pieces; energy equivalents; etc.
- Study, conception and production of a piece model for laboratory tests.
- Study and conception of the standard piece with real dimensions.
- Preparation and setting of each type of piece according to its functionality: natural light, thermal inertia, thermal collector and photovoltaic generator.

- Study into the integration of the pieces in panels and other components of urban design.
- Setting of panels in the exterior for tests and gathering of experimental data.
- Conclusions and future perspectives.

This Project was developed with secondary school students attending the Scientific-Technological Courses of Chemistry, Environment and Quality and Arts and Graphic Industries from Colégio Internato dos Carvalhos in an extracurricular school atmosphere.

The HelOP Project

The first and most important studies produced on optical physics focused on the course of radiation through blades with parallel faces (Fig. 1). These allow demonstrating the deflection of light and the possibility that part of that radiation is retained, producing the greenhouse effect [1]. Some of the physical characteristics (Tab. 1) of the used materials [2], as well as of the solar light were analysed so as to come to a conclusion on the possibility of using the greenhouse effect in the interior of the piece combined with the dark bodies' theory (Stefan-Boltzmann) (Fig. 2). Out of this symbiosis would emerge cooperation for the use of solar energy [3].

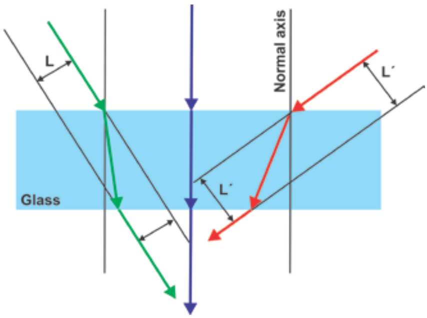


Figure 1. Deflection of Light

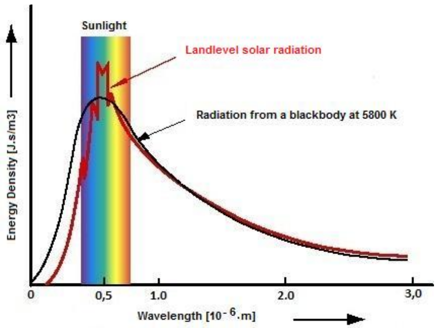


Figure 2. Radiation Overlapping

Material	ρ/g·cm^{-3}	C/kJ·kg^{-1}·ºC^{-1}	α/m·ºC^{-1}
Slate	2,70	0,837	$8{,}0\cdot10^{-6}$
Marble	2,70	0,837	$8{,}0\cdot10^{-6}$
Black Schist	2,70	0,837	$8{,}4\cdot10^{-6}$
Glass	2,57	0,836	$9{,}0\cdot10^{-6}$

Table 1. Characteristics of the Materials

Experimental model

The experimental model was conceived and built in the shape of an equilateral triangular prism with a 60 cm face and 15 cm high. On the exterior face was put glass and on the basis of the box was put a 2 cm thick slate plate (Fig. 3). This model was used to perform the first laboratory tests and allowed to infer the high

potentiality of a piece with identical characteristics and the same purposes, allowing a step further on its application.
The tests with the model piece were conducted in the laboratory next to a window directed to the south and during January and February 2010.

Figure 3. Assembling the experimental Model

Acknowledging that the laboratory temperatures were not the same as the exterior, the valid tests presented appreciable data in the slate temperature capable of encouraging us to continue the project. Tab. 2 and the Graphic 1. that follow result from data obtained experimentally on the 28th January 2010.

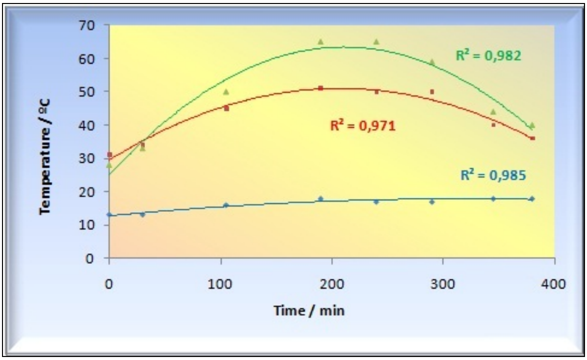
t – Time / Minutes
T1 – Room Temperature / ºC
T2 – Inside HelOP Temperature / ºC
T3 – Slate Temperature / ºC
U – 3 Photovoltaic Cells / V
E – Light Intensity / Lux

HelOP - Study on 28 January 2010 (Clear Sky)						
Time	*t / min*	*T1 / ºC*	*T2 / ºC*	*T3 / ºC*	*U / V*	*E / Lux*
10h30m	0	13	31	28	3,95	2400
11h00m	30	13	34	33	3,95	2450
12h15m	105	16	45	50	3,89	2400
13h40m	190	18	51	65	3,87	2300
14h30m	240	17	50	65	3,86	2350
15h20m	290	17	50	59	3,85	2250
16h15m	345	18	40	44	3,23	2400
16h50m	380	18	36	40	2,19	2400

Table 2. Laboratory Tests

Original HelOP Element

From the study conducted on the experimental model of higher dimension was conceived the original piece of HelOP (Fig. 4.a), b), c) and d)}, built in the shape of an equilateral triangular prism with a 30 cm face and 8 cm high to be applied in different outdoor areas, preferably directed to the south or adapted to the design and/or functions [4].



Graphic 1. Temperature Curves

The already mentioned materials were cut, worked and handled in the construction of four different piece models [5]. One piece [4.a)] – glass/slate – or – glass/black schist – that was created with the goal of retaining heat (thermal inertia). Another piece [4.b)] – glass/ copper pipe/slate – that was created as thermal collector used in water heating. A third piece [4.c)] – glass/photovoltaic [6] cell/marble – to the production of electric energy and finally a fourth piece [4.d)] – glass/glass – to natural light.

Figure 4. Different HelOP elements, from left to right: a) thermal inertia, b) thermal collector, c) photovoltaic cells, d) natural light

Of all the created pieces the ones that presented higher difficulties were those that required the fitting of a twisting copper pipe later painted black in the slate basis. These are meant to lower the slate face to fit the pipe (Fig. 5)

The pieces dedicated to the photovoltaic present a white marble in which two small 1V e 500 mA cells were fixed. The future intention is to cover the entire surface basis with photovoltaic material to obtain maximum output. The six units were linked in series so as to allow the charging of a 12 Volts battery. The position of these pieces in panel must be done to avoid the direct exposure to the sun since the cells lose output when they heat.

Of the four different pieces only the one used to natural light, entirely made in glass, offers less construction work. All the pieces were glued using silicon. The faces were covered with a thin skin of white sponge, simulating concrete, to protect its panel union [7]. After building 6 elements for each described function the HelOP pieces were fixed on a support structure for exterior tests (Fig. 6).

Figure 5. Lowering the Slate

Figure 6. HelOP – Exterior Testing Panel

Sustainable urban design

Introduction

In the last years many questions have been made regarding environmental conditions, ecological balance and implicitly life quality. Ecological concerns, consumerism and the feeling of economical vulnerability have an impact on the options of design and architecture so as to make them more sustainable [8]. This notion of sustainability in Design [9] (being Design a planed and creative activity that aims to contribute to the improvement and enrichment of the human life) intends to find a balance between the functional, aesthetical, economic, social and cultural dimensions of global development [10].

The growing rises on energy costs and weather changes have been “awakening” people and institutions to the importance of the environmental impact of the anthropogenic activities. Sustainability is no longer seen as an “interesting” option and has become the main goal of any activity [11].

The relation between the principle of planetary sustainability and the concept of eco-efficiency of a product is the main conditioning item on Design of products to the XXI century [12]. So it has become more and more important and urgent that Design may give answers to these new needs and act in a socially responsible way [13].

The design study of the presented panels, in its whole, will be used as the example for a possible application of the studied pieces without neglecting other bolder proposals (Fig. 7).

Imagination is the conducting wire that links creativity and innovation together!

Figure 7. Design Panel Sample

Applied design methodology.

The methodology used with students is part of the contents taught in the school subject Theory of Design – Project Methodology and was seen under the following steps:

1) Problem definition (identification of aspects and functions).
2) Synchronic Analysis (competition analysis) and Diachronic Analysis (analysis of the historical evolution of the product).
3) Development of Ideas (Creative Synthesis).
4) Evaluation/Discussion of alternatives and ideas presented.
5) Project Development.
6) Prototype/Model Development.

Application in Industrial and Architectural Design Projects

This innovative project is a Redesign based on a covering material – glass brick – that contains aesthetical/ornamental functions and the capacity to let light get through. The HelOP has a major ecologic concern in the creation of panels that present different functions and that promote the sustainability of public or private spaces.

The students presented the study of 3 different applications for the developed materials:

Figure 8. Multifunctional school sports area

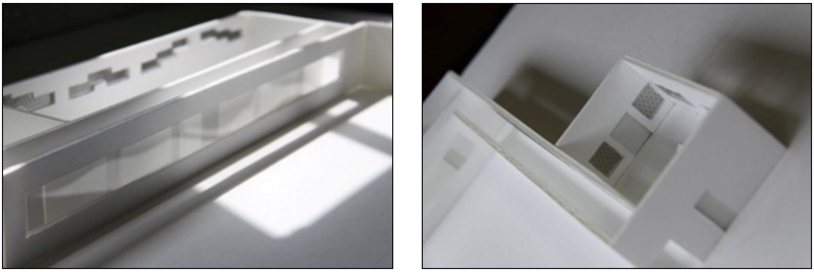


Figure 9. Private house or cottage

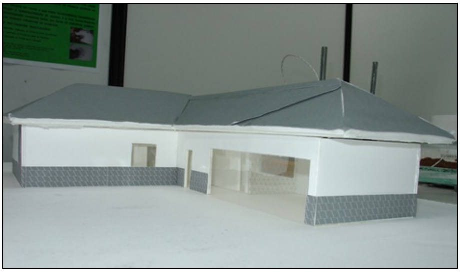


Figure 10. Bus Stop

The use of each panel in the spaces will always take into consideration its synergic potential demonstrated by its higher functionality and profitability together with its aesthetic and ornamental aspects. Being able to combine sustainability of area and its visual shape/impact, both interior and exterior, has been a constant concern regarding the HelOP objectives.

Acknowledgements

I thank all students that attend the 11th form of the Chemistry, Environment and Quality (QAQ) course and the 12th form of Arts and Graphics Industry in Colégio Internato dos Carvalhos), who were deeply involved in this experiment. We also thank Luis Leites, our English Teacher.

References

[1] SAINT-GOBAIN GLASS, Informações Técnicas.
[2] http://pt.saint-gobain-glass.com/upload/files/3.1.4_o_vidro_e_a_radia__o_solar.pdf
[3] Watson KM, Hougen OA and Ragatz RA, Princípios dos Processos Químicos, Ed. Livraria Lopes da Silva, 1972.
[4] Potter MC and Scott EP, Ciências Térmicas – Termodinâmica, Mecânica dos Fluidos e Transmissão de Calor, Ed. Thomson, 2007.
[5] Bennett CO and Myers JE, Fenómenos de Transporte – Quantidade de Movimento, Calor e Massa, McGraw-Hill, 1978.

[6] FDE, Fundação para o Desenvolvimento e Educação, Pedras Naturais.
[7] http://catalogotecnico.fde.sp.gov.br/meu_site/servicosE2.htm
[8] Hinrichs RA and Merlin K, Energia e Meio Ambiente. Ed. Thomsom, 2003.
[9] Branco JP, Revestimentos e Protecções Horizontais e Verticais em Edifícios, Ed. Escola Profissional Gustave Eiffel, 1993.
[10] Brezet H and Van Hemel C, Ecodesign: a promising approach to sustainable production and consumption, UNEP, The Principles of Sustainability, London: Earthscan, 1997.
[11] EcoDesign: The Sourcebook, Alastair Fuad-Luke, Chronicle Books LLC, 2002.
[12] Munari B, Das coisas nascem coisas, Arte e Comunicação, Edições 70, 1968.
[13] Birkeland J, Design for sustainability – a sourcebook of integrated eco-logical solutions, London: Earthscan, 2005.
[14] Dormer P, Os Significados do Design Moderno, Centro Português do Design, 1995.
[15] Ecodesign: A Manual for Ecological Design, Ken Yeang: Academic Press, 2006.

Paper presented at the 7th International Conference on "Hands on Science. Bridging the Science and Society gap",
Crete, Greece, July 25 to 31, 2010.

Science Education for Pupils with Special Needs in a Non Formal Environment

Ferreira D, Nilza C and Trincão P

Introduction

The development of the different scientific disciplines, the growing specialization, as well as the notion of applicability of his knowledge, made science apprenticeship a subject of basic importance for the functioning of the society.
Science education seeks to provide situations of learning that promote the understanding of the natural world, and it's (inter)relations with the social world. It will also contribute for the development of the pupils' skills and attitudes that allows them to act in the future like explained consumers and able citizens, of intervening, in a responsible form, in the resolution of day by day problems.
Martins [1] defends that science education must pass with a social framing so that all the pupils can realize science contribution for the citizenship.
A recommendation of the *Declaration on Science and the Use of Scientific Knowledge* of written at *World Conference on Science for the Twenty-first Century: A New Commitment* carried out in the day 1 of July of 1999, reinforces these convictions:

> "Governments should accord the highest priority to improving science education at all levels, with particular attention to the elimination of the effects of gender bias and bias against disadvantaged groups, raising public awareness of science and fostering its popularization" [2].

Legal framework of students with special needs in Portugal

In Portugal the education system is compulsory for all children and young people, for 9 years, corresponding to basic education, according to Tab. 1.
Over those years of schooling, science education is presented at Tab. 2.
To promote a democratic and inclusive school, looking for responding to the diversity of characteristics of all students, including children and young people with special educational needs, there is legislation which sets out to provide specialist support and educational measures to be applied, updated in Law 3/2008. The most restrictive is the Individual Specific Curriculum (previous Alternative Curriculum, according to Law 319/91). This replaces the skills defined for each level of

education and training. This curriculum is designed from the identification of strengths and weaknesses of each student.

		Average of ages
1st cycle	4 years	6-9
2nd cycle	2 years	10-11
3rd cycle	3 years	12-14

Table 1. Portugal education system

	Physical and Natural Sciences
1st cycle	(generalist)
2nd cycle	Sciences of the Nature
3rd cycle	Natural Sciences Physics and Chemistry

Table 2. Science education at compulsory education

Science in individual specific curriculum

Was done a collecting information at Aveiro (Portugal) schools, between May and June 2007, that showed that the pupils, of the 2nd and 3rd cycle of basic education with special needs with an Alternative Curriculum, do not have Physics and Chemistry and only 34.7% have Natural Science.

The data collected by interview to the teachers responsible for the construction of curricula for students, allow concluding that the reasons why students do not have the science disciplines were:

- characteristics of the content (complexity, abstraction ...);
- characteristics of students (cognitive difficulties, ...);
- other (lack of appropriate materials, lack of preparation of teachers, ...).

However, all the teachers interviewed believed that is important or very important to include science in pupil’s curricula.

Science education in a non formal environment

The concept of education supported by the "World Declaration on Education for All" [3] beyond the limits of formal education and includes non-formal environments. As above, "Supplementary alternative programmes can help meet the basic learning needs of children with limited or no access to formal schooling ...." It also says that "Other needs can be served by: skills training, apprenticeships, and formal and non-formal education programmes in health, nutrition, population, agricultural techniques, the environment, science, technology, family life (…) and other societal issues.”

Seeks to clarify the meaning of these names we can say that formal education is developing in its own institutions (schools) and is characterized by being highly structured, following pre-defined programs. The non-formal education is an organized and systematic educational activity that happens outside the formal system [4-6] and is conveyed in the museums, science centres, media or other counterparts.

According to Gadotti [6] the non-formal education should not be seen as opposed to formal education, arguing for the complementarity and coordination between the two. Know their potential bring them to the benefit of all. To Ávila [7] we can not conceive education isolated from society or accept that the formal school is the sole locus of expression of educational intentional processes.

Non-formal education characteristics, such as flexibility concerning time and space, reinforcing the relevance of the role that a less formal environment - outside school - can have on education for pupils with special needs that have a particular rhythm and development. It permits to respect differences and capacities of each one. According to Gadotti [6], non-formal education programs don't need a sequential and hierarchical progression.Gohn [8] states that non-formal education gives conditions for individuals to develop feelings of self-recovery, the rejection of prejudice that they are addressed, the desire to be recognized as equals in their differences which reinforces the idea behind this project, increasing the environmental non-formal education in science for students with special needs. The environments of non-formal learning enabled by museums and science centres, according Chagas [9], are very rich and diverse that approximates the natural environments where the child spontaneously, creates its own knowledge. Some studies [5,10] emphasize the role of a non-formal environmental education in science. They believe that it have a huge potential to be exploited, especially to motivate pupils, to develop their creativity and, above of awakening the interest of the young in science.

The current movement of museums and centres that are dedicated to the spread and communication of science and technology is highlighted by his enormous public acceptance. Such acceptance is due, fundamentally to the appellative form as they show up, as well as the dynamic ones of exploration that stimulate the participation and interactivity, not forgetting the scientific correction. His structure invites the visitor to explore and to lift questions to all the public. According to Chagas [10] science centres assume so a clearly educative function using interactive techniques of exhibition and it stimulate curiosity and pupils participation.

In this sense, in Portugal, the program Ciência Viva, was created like one unity of the Ministry of the Science and Technology (Law 6/MCT/96), with the principal objective to produce spaces for the spread of science and technology, corresponding to new social practices, like non-formal interactive institutions.

Visit interactive science exhibitions is one of the processes that can be used in the science education that has been showing sign of quite elevated levels of implication and apprenticeship. That happens, because in these visits the experimental situations are of essentially playful nature, where the pupils explore / observe, not having certainly or wrong and where the rhythm is established by owns them. So, all the pupils, even that have learning problems, have possibility to develop several competences and capacities such as attention, cooperation, critical spirit or creativity.

So, the development of interactions between science centres and schools must not be restricted to punctual situations but be translated to a deeper collaboration.

Proposed project

Considering the previously presented, we can note that we were before a population that in spite of frequenting the school will be illiterate scientifically.

Assuming the relevance of science education for all, it has to be put in a multidisciplinary and multidimensional perspective, with community implication. To Ferreira [11], pupils with special needs problems must not be discussed or solved like an isolated reality.

It is necessary to think about a cooperative proposal, looking for new methodologies that provide pupils development, in the society, in a process of autonomy and inclusion. This idea is reinforced by Latas (1990 quoted by Sousa [12]), what suggests the use of alternative resources to provide experiences of apprenticeship that are adapted to the different necessities of the individual pupils.

Only an included education in a social context will allow enjoying the full right of citizenship. So, the true inclusion implicates to understand the concept of education as a whole, implicating a school restructuring, passing by a fusion between the formal and non-formal education.

In this sense a proposal project was developed, in a partnership between Fábrica Centro Ciência Viva of Aveiro (a science centre), the Department of Education and Educative Technology of the University of Aveiro and the schools that were making part. The great mark of this project was to develop competences (capacities and attitudes), through science education, contributing to the educative inclusion of pupils with specific individual curriculum.

The implementation of this project implicated to include in the curriculum of the pupils, a science area, with a weekly periodicity (during 90 minutes), what was happening in Fábrica Centro Ciência Viva.

Why Fábrica Centro Ciência viva

Fábrica Centro Ciência Viva is a non-formal science education environment, in constant growth, which gives him a set of own characteristics that potentiate it and allow pupils a rich, diversified and differentiated experience.

Is a centre with a multiple offer capacity, making possible the exploration of different spaces with opportunity to carry out activities of different levels (interactive, thoughtful, reflexive,…) and with different communication ways (sound, light, image, writing, …). This plurality stimulates the curiosity and interest of the pupils, allowing them to explore, to question, to manipulate, to try,…, while they interact with other visitors.

The implementation of the project

Participants

There were wrapped 18 pupils of two Aveiro schools, divided in three groups (Tuesday group: 6 pupils of the 3rd cycle of the basic teaching; Thursday group: 6 pupils of the 2nd cycle of the basic teaching; Friday group: 6 pupils of the 2nd and 3rd cycle).

Besides the investigator himself, that had an active paper, they were also implicated Special Education teachers, responsible for the pupils, who supplied information on the pupils and of the impact of the implemented dynamic ones in them development. This information were also supplied for persons in charge of education of the pupils and of elements of the Executive Councils of the Schools.

Dynamic

During the academic year 2007/08, the pupils wrapped in the project carried out, once weekly, several activities proposed in the Fábrica Centro Ciência Viva. The pupils of the School João Afonso were moving accompanied by an educative assistant, and stay there alone. Those of School Aradas were accompanied by the respective teacher of Special Education.
For the School EB João Afonso, the project had beginning in the 1st period, being extended up to end of the academic year:

- Group of the 3rd cycle (Tuesday) – total of 31 sessions:
  - first session: 02 / October / 2007
  - last session: 17 / June / 2008
- Group of the 2nd cycle (Thursday) – total of 29 sessions:
  - first session: 04 of October of 2007
  - last session: 19 of June of 2008

For School Aradas, for reasons foreign to the persons in charge and project promoters, like the late placing of the teacher of Special Education in the School and pupils dislocation, project had beginning only in the 2nd period, being extended up to end of the academic year, to Friday, having carried out a total of 16 sessions:

- first session: 11 / January / 2008;
- last the session: 20 / June / 2008.

Each group developed sessions of activities, organized at three moments:

- 1st moment (orientated by the investigator): preparation / motivation of the pupils for the activity to develop, where different strategies were used, such as the placing of a question problem, resolution of an enigma, …;
- 2nd moment: realization of the activity. When the activity was belonging to one of Fábrica it orientated by his monitors. Before the session to happen there was always a prior approach to monitors, by the investigator, of how to potentiate the session dynamic, attending to pupil’s characteristics. The sessions boarded quite diversified themes, trying to attend to pupil’s ages, development, interests and motivations. Someone sessions were prepared and / or adapted for the effect.
- 3rd moment (orientated by investigator): systematization of the activity; reflection; resolution of the question problem...

Gathering information

The instruments of gathering of data of the observation were: notes, photos, registers of the meetings carried out with the schools and wrapped teachers,

materials produced for and on the pupils, such as graphic different registers of descriptive and reflexive character.
They were done interviews to the different intervenient in the study (pupils, teachers, parents).

Articulation with the schools

Along the whole academic year straight contact was maintained between the investigator and pupils Special Education teachers. In the end of each period there were formal moments, when interviews were carried out. Of these contacts agreements were born to the implementation of the project, such as:

- the development of activities in the School, continuing sessions carried out in the Fábrica;
- the presentation by pupils of the activities developed in the Fábrica, in their own schools.

In the end of each period there was carried out, by the investigator, a global evaluation of each pupil who consists of his school registers.

Conclusions

On basis of the collected data, we can say that pupils benefited, with pleasure, the proportionate activities. Besides to go out from the routine of the school, the sessions corresponded to his curiosity and interest, surpassing expectations. There was a global development, in all the pupils, at several levels, such as: social behaviour, relation with others, language. Besides these aspects highlights still the knowledge built through the individual discovery. Along the academic year there were carried out several activities that provided to the pupils different experiences, the contact with " things " what they would never have access if it was not this project, which led to the development of general competences and of capacities and attitudes.

References

[1] Martins I, Educação e educação em ciências, Aveiro: Universidade de Aveiro, 2002.
[2] UNESCO e ICSU, Declaração sobre a ciência e a utilização do conhecimento científico agenda para a ciência - quadro de acção Lisboa: UNESCO, 1999. http://www.unesco.pt/pdfs/ciencia/docs/Declaracaociencia.doc
[3] UNESCO, Declaração mundial sobre educação para todos, 1990. http://unesdoc.unesco.org/images/0013/001393/139394por.pdf
[4] Hamadache A, Articulation de l'éducation formelle e non formelle, Implications pour la formation des enseignants, Paris: UNESCO, 1993.
[5] Bianconi ML and Caruso F, Educação não-formal, Ciência e Cultura, 57: 4, 20, 2005.
[6] Gadotti M, A questão da educação formal/não-formal, 2005. http://www.paulofreire.org/Moacir_Gadotti/Artigos/Portugues/Educacao_Popular_e_EJA/Educacao_formal_nao_formal_2005.pdf

[7] Ávila AR, Educação não-formal ou educação informal? Uma questão de intencionalidade.
http://www.fundacioncya.org.ar/common/rumbos/imagen/dwn_16.pdf
[8] Gohn MG, Educação não-formal, participação da sociedade civil e estruturas colegiadas nas escolas, Ensaio: avaliação e políticas públicas em educação, 14: 50, 27-38, 2006.
[9] Chagas I, Aprendizagem não formal / formal das ciências. Relações entre os museus de ciência e as escolas, Revista de Educação, 3: 1, 51-59, 1993.
[10] Rodrigues AAV, Ambientes de ensino não formal de ciências: impacte nas práticas de professores do 1º CEB, Universidade de Aveiro, 2005.
[11] Ferreira MS, Educação regular, educação especial.Uma história de separação, Porto: Edições Afrontamento, 2007.
[12] Sousa C, Activação do desenvolvimento cognitivo e facilitação da aprendizagem - Ensino das ciências no 1º ciclo do ensino básico, Braga: Universidade do Minho, 1993.

Paper presented at the 7th International Conference on “Hands on Science.
Bridging the Science and Society gap",
Crete, Greece, July 25 to 31, 2010.

Teacher Training on the Implementation of Science Research Projects In Classroom Context

Esteves Z and Costa MFM

Introduction

European Union studies [1] revealed that better results on education lead to a higher economic and social development.
For a better education, it is important to improve not only the initial teachers training but also the training that they should attend during their carrier, lifelong learning [2].
The need to address teachers' training relies on their unique influence on development of innovation and motivation occurring inside classrooms. Therefore, the training proposed to teachers should give them a permanent update to new techniques and methodologies [3].
On some countries, like in the USA, science teaching has changed due the development of the science fairs. Teachers recognize that the development of scientific projects like activities in the context a science fair preparation process promotes an active learning possibility not commonly available on regular classes [4].

The need for the course

The recent Rocard report [5] on science education inside the European Union stresses the declining interest of students on science, pointing the need of a more active, participative and investigative learning. According to the Lisbon report [1], Portugal had to achieve the following goals until 2010:

- Reduce to 10% the number of young people that abandon their studies prematurely;
- Reach the mark of 85% of the people with ages between 20 and 24 years old with the secondary education complete (12 years);
- Obtain a percentage of 12,5% of adults already working (with ages between 25-60 years old) to increase their qualification.

To fight the students lack of motivation, that teachers have been feeling in their classroom, the use of new methodologies to improve the teaching process is needed [5-6].

The Portuguese curriculum is theoretically geared to a learning where students must relate the acquired knowledge with scientific discoveries, technological processes, and their implications to daily life [7-8].

High school science curriculum is oriented to taking into account previous learning' to lead to a more practical and investigative teaching [8]. So, with the implementation of scientific projects as a different introduction of students to science and technology, we expect to increase the motivation of students to these subjects and to science based careers [6] while cooping with curricula requirements. To have a fair curriculum is not enough. Teacher's role is fundamental for their development.

Phases	Resume
Presentation of the methodology	Importance of this methodology Analysis of some case studies Analysis of the Portuguese curriculum
The Science Fairs	Science Fairs: definitions A way to present scientific projects developed by students
Organization	How to use in the Portuguese curriculum Calendar Objectives Guidelines and indications to students Rules
Theme choice	What themes can students choose Advices/strategies to project selection Research sources
The development of the theme	Guidelines to help students during the project development How to present a scientific project
The preparation of the presentation	Graphical aspects of the presentation Selection of main ideas and organization
The evaluation of the activity	Parameters to evaluate Construction of an evaluation guide in different contexts
Organization of the science fair	Last details (organization of the space, …)

Table 1. Phases of the teacher training course

Objectives of the course

The development of scientific projects is a teaching tool with a great relevance since it involves actively the students in investigative and hands-on learning/discovering activities.

Therefore, the main objective of the training course we developed is to provide to the teachers alternative means, in particular ways of implementing scientific research projects to contribute to the effort of motivating students to learn science and technology. This methodology also promotes an improvement on a investigative based education, where students participate learning. A set of guidelines on how to apply the development of scientific projects at the Physics and Chemistry classes, "Área de Projecto" (a "project" discipline with no a-priori defined subject), in the context of a Science Club or as an extracurricular activity, was presented to teachers.

Organization of the Course

The course was planed to allow teachers to lead the student organize a Science Fair by developing science project, with the final aim to expose and present their projects to the school community. The different phases are described on Tab. 1. During the course, activities, projects and moments of reflection were employed for teachers to better promote and apply this methodology.
The course was all trough oriented to implement the scientific projects in the classroom while given to teachers indications on how to organize a science fair (in a way that students could show their work and thus allowing more people to learn from the projects and further recognition of the students work).

Difficulties	Solution
Not enough time at classes	Create partnerships with other teachers that have subjects in common or teachers from “Área de Projecto”
Lack of skills from students: • Didn’t know what kind of project they should and/or could choose. • Didn’t know where to search for a project. • Didn’t know how to conduct a scientific research	Give to students some examples of projects Recommend them to research in the web, on libraries, or talk with family and friends… Give them some references of websites or books Discuss the results with the students Question them, and lead them to think on what they can/should do within their project

Table 2. Difficulties of implementation felt by teachers and proposed solutions

Results

At the beginning of the course, teachers were a bit apprehensive since they had doubts on the possibility of using this methodology in their classrooms. They all agreed on the advantages of the methodology but express some problems with its implementation (Tab. 2). Despite all the problems that these teachers presented, at the end of the course they were more receptive to the idea and managed to implement with success small projects of investigation with their students. It was also proposed to the teachers to plan a larger scale project to use on next year’ classes.

Conclusions

So far we could conclude that teachers should overlook carefully the evolution of the student’s scientific projects. Personal experience is fundamental on this task. With time students will also become familiar with this type of projects, and the sooner they start working on it the sooner they develop the necessary skills.
The difficulties encountered along the course revealed the importance of teacher training in this subject. Since it is impossible to ask students to develop these activities alone, teachers have to know what can be done, or how to plan this activity in a way possible to manage within school schedule or even in extra-curricular activities.
Teachers should take the opportunity to develop this kind of projects extra classes and develop the “scientific spirit” into students.
In-service teacher training in the implementation of investigative hands-on type of activities, like students research of scientific projects in the frame of science fairs, is

fundamental to an effective change in the way science teaching occurs in our school.

References

[1] Progress towards the Lisbon Objectives in Education and Training: Indicators and Benchmarks, Brussels: SEC, 1284, 2007.
[2] Morgado JC and Reis I (Org.), Formação e desenvolvimento profissional docente: perspectivas europeias, Braga: Centro de Investigação em Educação da Universidade do Minho, 2007.
[3] Forte A, Formação contínua: contributos para o desenvolvimento profissional e para a (re)construção da(s) identidade(s) dos professores do 1º CEB, Master Thesis, Universidade do Minho, 2005.
[4] Grote M, Teacher Opinions Concerning Science Projects and Science Fairs, Department of Education, Ohio Wesleyan University.
[5] Rocard M *et al*, EC, High Level Group on Science Education. Science Education NOW: A Renewed Pedagogy for the Future of Europe, 2007.
[6] Esteves Z, Cabral A and Costa MFM, Informal Learning in Basic Schools. Science Fairs, Int. J. Hands-on Science, 1: 2, 23-27, 2008.
[7] Galvão C (Coord.), Ciências Físicas e Naturais – Orientações Curriculares 3ºCiclo, Departamento da Educação Básica, Ministério da Educação, 2001.
[8] Caldeira H and Martins I (Coord.), Programa de Física e Química A 10º Ano. Departamento do Ensino Secundário, Ministério da Educação, 2001.

Paper presented at the 7th International Conference on “Hands on Science. Bridging the Science and Society gap",
Crete, Greece, July 25 to 31, 2010.

The HUNVEYOR-Project. A Novel Way of Teaching Science and Physics

Hudoba G and Bérczi S

Introduction

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.

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.

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.

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.

The frame

Our frame – which is a little bit smaller than the earlier Hunveyors - is a tetrahedral light-weight rigid skeletal structure, made of aluminium. The whole frame consists of about 100 pieces.

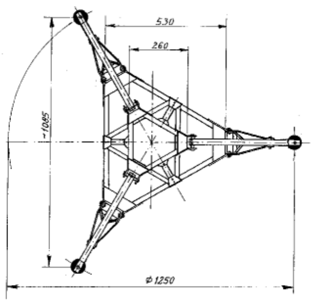


Figure 1. The frame of the Hunveyor-4

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

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.

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 web camera 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). Besides 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

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.

Figure 4. The LED spectrometer

Figure 5. The HUNVEYOR-4 in construction

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.

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

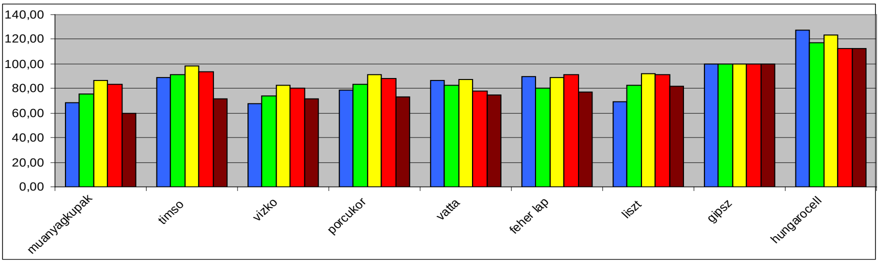
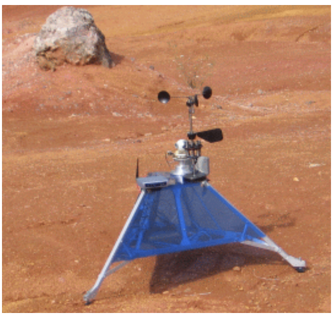


Figure 6. Spectrum collection of different white materials obtained with the LED spectrometer



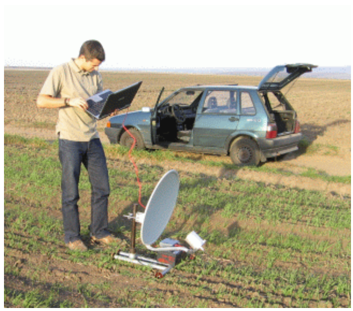


Figure 7. HUNVEYOR-4 in an Martian analogous terrain (left) and remote communication with the space probe (right)

Public outreach

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

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.

References

[1] Bérczi SZ, Cech V, Hegyi S, Borbola T, Diósy T, Köllõ Z and Tóth SZ, Planetary geology education via construction of a planetary lander, LPSC XXIX, 1267, LPI Houston, 1998.

[2] Bérczi SZ, Drommer B, Cech V, Hegyi S, Herbert J, Tóth SZ, Diósy T, Roskó F and Borbola T, New programs with the Hunveyor experimental planetary lander in the universities and high schools in Hungary, LPSC XXX, 1332, LPI Houston, 1999.

[3] Hegyi S, Kovács B, Keresztesi M, Béres I, Gimesi L, Imrek GY, Lengyel I and Herbert J, Experiments on the planetary lander station and on its rover units of the Janus Pannonius University, LPSC XXXI, 1103, LPI Houston. Pécs. Hungary, 2000.

[4] Kovács ZS, Kõvári IE, Balogh R, Varga V, Kovács T, Hegyi S and Bérczi SZ, Planetary Science Education Via Construction of the Hunveyor-3 Experimental Planetary Lander on Berzsenyi College, Szombathely, Hungary: Rock Radioactivity Measurements, LPSC XXXII, 1130, LPI, Houston, 2001.

[5] Bérczi SZ, Hegyi S, Kovács ZS, Hudoba E, Horváth A, Kabai S, Fabriczy A and Földi T, Space Simulators in Space Science Education in Hungary: Hunveyor Orientations and Astronomical Observations on Martian Surface, LPSC XXXIV, 1166, LPI, Houston, 2003.

[6] Hudoba GY, Sasvári G, Kerese P, Kiss Sz and Bérczi SZ, Hunveyor-4 Construction at Kandó Kálmán Engineering Faculty of Budapest Polytechnik, LPSC XXXIV, 1543, LPI, Houston, Székesfehérvár: Hungary, 2003.

[7] Hudoba GY, Kovács ZS, Pintér A, Földi T, Hegyi S, Tóth SZ, Roskó F and Bérczi SZ, New Experiments (in Meteorology, Aerosols, Soil Moisture and Ice)

on the New Hunveyor Educational Planetary Landers of Universities and Colleges in Hungary, LPSC XXXV, 1572, LPI, Houston, 2004.
[8] Szikra I, Ferenczi GY, Varga T, Darányi I, Hudoba GY, Földi T, Hegyi S and Bérczi SZ, A New Form of Space Science Education: Preparations for Phoenix Lander Mission Simulations by Hunveyor in Terrestrial Conditions, XXXVII LPSC, 1169, 2007.
[9] Györök G, Self Embedded Hybrid Controller with Programmable Analog Circuit. IEEE 14th International Conference on Intelligent Systems, Gran Canaria, 59: 1-4, 2010.

Paper presented at the 8th International Conference on “Hands on Science. Focus on Multimedia",
Ljbljana, Slovenia, September 15 to 17, 2011.

Chemistry Education: Children and Chemistry

Fernández-Novell JM, Zaragoza-Domènech C
and Fernández Zaragoza J

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 [1], placing The International Union of Pure and Applied Chemistry, IUPAC [2], 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 [3]. Catalan students, older than 13 years old, have chemistry as a subject in their curricula but, younger students do not have this subject [4-5]. 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 [6]. 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.

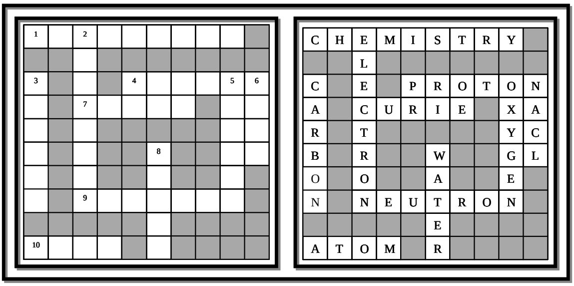
Methodology

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 [7] 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.

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 a horizontal reading (across). Each student decided which words used, where he or she obtained the information and, students created their own crossword puzzle [8] on chemistry. Here is a summarize crossword puzzle using the most repeated definitions prepared by the students and the solution.

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.**



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 cards with 8 chemists and ask the participant if his or 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

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.

Broadcasting chemistry

Authors have developed several programs about science in an effort to present them with a new perspective to the students and society [9-10]. 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. 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.

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.

References

[1] www.chemistry2011.org
[2] www.iupac.org
[3] www.mec.es/educa/sistema-educativo
[4] www.xtec.es/estudis/eso/curriculum_eso.htm
[5] phobos.xtec.cat/edubib/intranet/file.php?file=docs/primaria/curriculum_ep.pdf
[6] Zaragoza Domènech C and Fernández-Novell JM, Teaching science with toys: toys and physics, Proceedings of the 7th International Conference on Hands-on Science. Bridging the Science and Society gap, Kalogiannakis M, Stavrou D, Michaelides PG (Eds.), Rethymno: University of Crete, 63-68, 2010.
[7] Dennick RG and Exley K, Teaching and learning in groups and teams. Biochemical Education 26, 111-115, 1998.
[8] www.crosswordpuzzlegames.com/create.htlm
[9] Fernández-Novell JM and Zaragoza C, Badaciència i Juguem amb la ciència programs de ràdio com a recurs didàctic (“Badaciència” and “Juguem amb la ciencia” radio programs as a educational resource), Perspectiva Escolar, 252, 67-71, 2001.
[10] Fernández-Novell JM and Zaragoza Domènech C, Broadcasting Science: a New Bridge between Science and Society, Proceedings of the 7th International Conference on Hands-on Science. Bridging the Science and Society gap, Kalogiannakis M, Stavrou D, Michaelides PG (Eds.), Rethymno: University of Crete, 57-62, 2010.

Paper presented at the 8th International Conference on “Hands on Science.
Focus on Multimedia",
Ljbljana, Slovenia, September 15 to 17, 2011.

Hands-on Experiments for Demonstration of Liquid Crystals Properties

Pečar M, Pavlin J, Susman K, Ziherl S and Čepič M

Introduction

Students often have no motivation for learning science. The lack of motivation might be improved by using scientific knowledge in everyday life [1]. That is why it is essential for the students' learning to make the gap between the school science and the "real" world narrower [2]. 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 [3]. 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 synthesized in the school laboratory and later used for hands-on experiments in physics lectures [4].
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.

Hands-on experiments

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 (Fig. 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). 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).

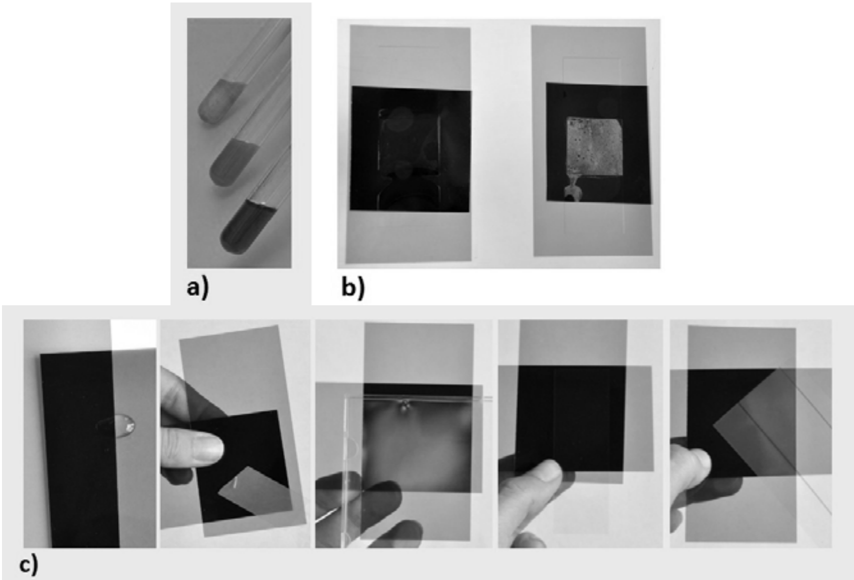


Figure 1. From top to bottom, a) crystalline, liquid crystalline and liquid phase; b) liquid and liquid crystalline LC between two crossed polarizers and c) different materials between two crossed polarizers (water, sellotape, CD frame, microscope slide and cellophane)

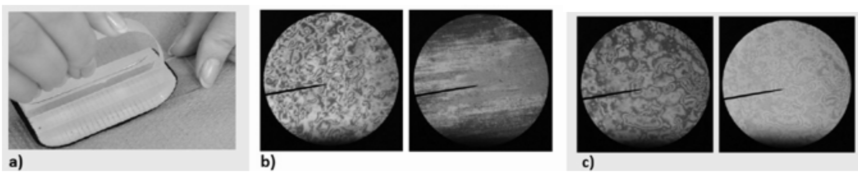


Figure 2. a) Rubbing the microscope slide with velvet soaked in alcohol, b) A non-oriented and an oriented LC cell under microscope and c) LC cell under microscope with crossed and parallel polarizers

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).

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. 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).

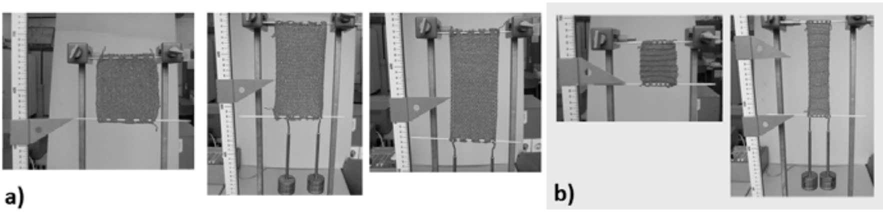


Figure 3. A knitting model with a) less anisotropic property (equally weighted extended length in one direction 7,5 cm and in the other 12,5 cm) and b) with greater anisotropy (equally weighted extended length in one direction 3,0 cm and in the other 11,7 cm)

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 Fig. 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). 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.

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 Fig. 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 [5].

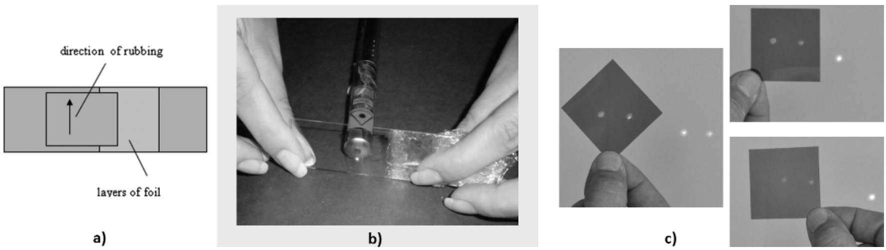


Figure 4. a) Experimental set-up of a wedge cell, b) observing double refraction of a laser beam and c) determining the polarization of the beams on the remote screen

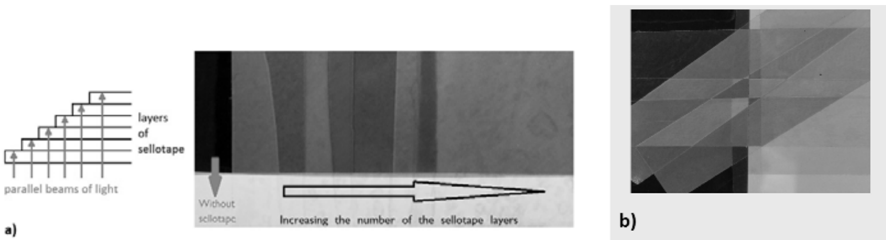


Figure 5. a) Observing the colours with increasing the optical length of the light passing through the sample of different thicknesses and b) complementary colors of sellotape between crossed and parallel polarizers

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 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 [6]. 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 Fig. 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.

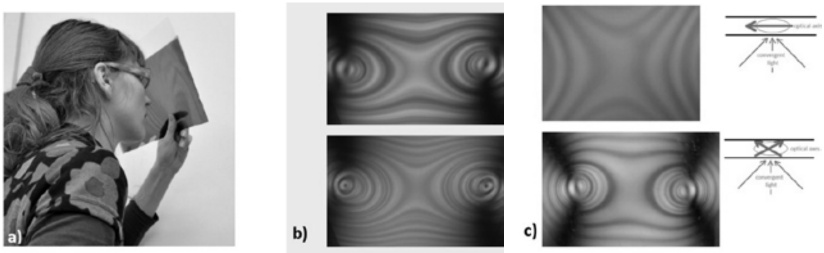


Figure 6. a) Observing conoscopic images with a model conoscope, b) conoscopic figures of samples with different thicknesses (upper image - thickness d and lower image - thickness 2d) and c) of uniaxial material - upper image (many layers of sellotape, material cut parallel to the optic axis) and biaxial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

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. 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 Fig. 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.

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 [4].

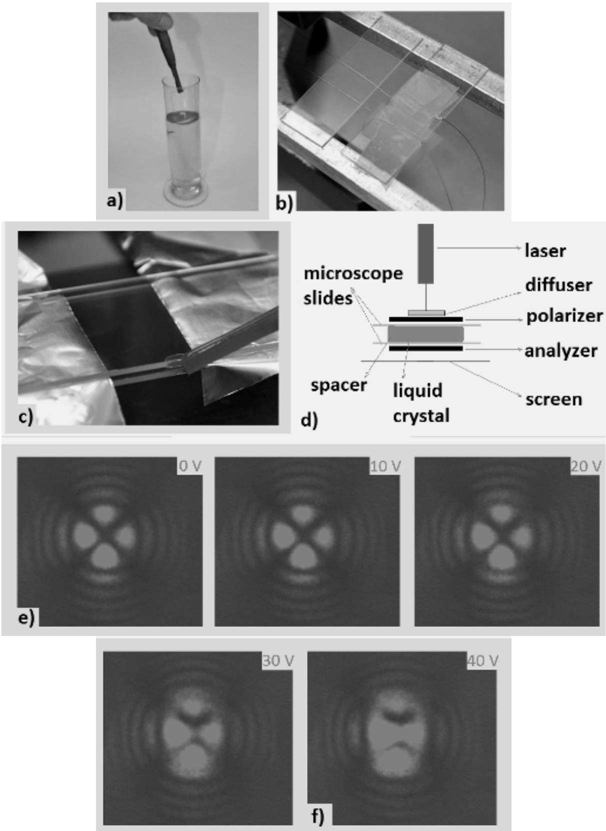


Figure 7. a, b, c, d) Construction of a liquid crystal cell, e) its conoscopic figure and f) its conoscopic figure after application of an external electric field in a horizontal direction. Liquid crystal used in the experiment was RO-TN 605

References

[1] Brophy J, Motivating Students to Learn. Boston: McGraw Hill, 1998.
[2] Osborne J and Collins J, Pupil's view of role the value of the science curriculum: A focus-group study, International Journal of Science Education, 23: 5, 2001.
[3] Whitelegg E and Parry M, Real-life contexts for learning physics: meanings, issues and practice, Physics Education, 34: 2, 68-72, 1999.

[4] Pavlin J, Susman K, Ziherl S, Vaupotic N and Cepic M, How to teach liquid crystals, Molecular Crystals and Liquid Crystals, 547, 255-26, 2011.
[5] Babic V and Cepic M, Complementary colour for a physicist, European Journal of Physics, 30, 793-806, 2009.
[6] Berry M, Bhandari R and Klein S, Black plastic sandwiches demonstrating optical biaxial anisotropy, European Journal of Physics, 20: 1, 1-14, 1999.

Paper presented at the 8th International Conference on “Hands on Science. Focus on Multimedia",
Ljbljana, Slovenia, September 15 to 17, 2011.

Kids University and the Fair of Natural Science in Olomouc

Holubova R

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 [1]. 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 [1-2]. 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. 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. [3]

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.

Hands on activities at the Faculty of Science in Olomouc

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.

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 takes 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. 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.

Figure 1. From the trade fair

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 is hands on experiments.

Conclusions

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.

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

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.

Figure 3. Kaleidoscope

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.

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.

Acknowledgments

This article was prepared with the support of the European Community in the framework OPVK under the Project No CZ.1.07/1.1.04/03.0042 and the project MSMT-FRVS 2011/157.

References

[1] Holubová R, The Innovation of Physics Teacher Training at the Palacky University, The International Journal of Learning, 14: 2, 41-46, 2007.
[2] Driver R, Squires A, Rushworth P and Wood-Robinson V, Making Sense of Secondary Science: Research into children's ideas, New York: Routledge, 1994.
[3] Behrendt H and Schlichting HJ, Versuche mit einfachen Mitteln - zwischen Physik und Alltag, Unterricht Physik, 11: 57, 96-98, 2000.

Paper presented at the 8th International Conference on “Hands on Science. Focus on Multimedia",
Ljbljana, Slovenia, September 15 to 17, 2011.

The Casimir Effect: A Multimedia Interactive Tutorial

Bonanno A, Camarca M and Sapia P

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. 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 [1]. 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 [2-3]. 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.

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:

$$\Delta E \cdot \Delta t \geq \cdot h/4\pi \qquad [1]$$

where the quantities are, the energy and time uncertainties, ΔE and Δt, and the Planck constant h – 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 $h/(4\pi\cdot\Delta E)$ 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 [4] these photons can also be viewed as electromagnetic 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.

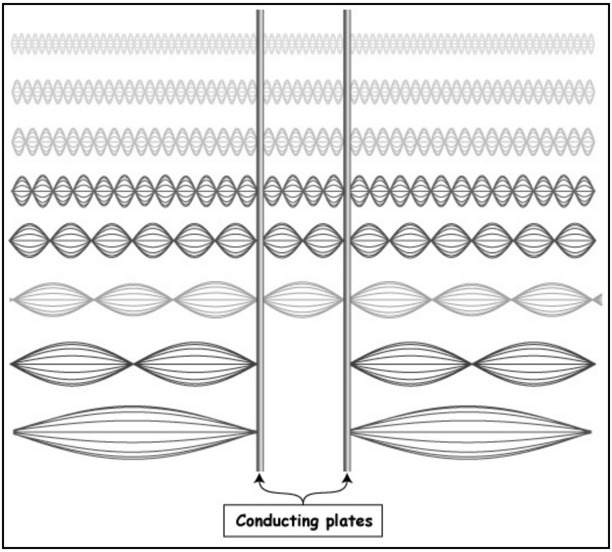


Figure 1. The effects of the boundary conditions on the electromagnetic field in presence of two conducting plates. Between the plates only a fraction is allowed of electromagnetic waves existing outside. This gives rise to an unbalance in electromagnetic pressure, which is greater outside than inside: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

The tutorial

The proposed multimedia tutorial (http://www.fis.unical.it/didattica/mptl16/casimir) 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:

“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.

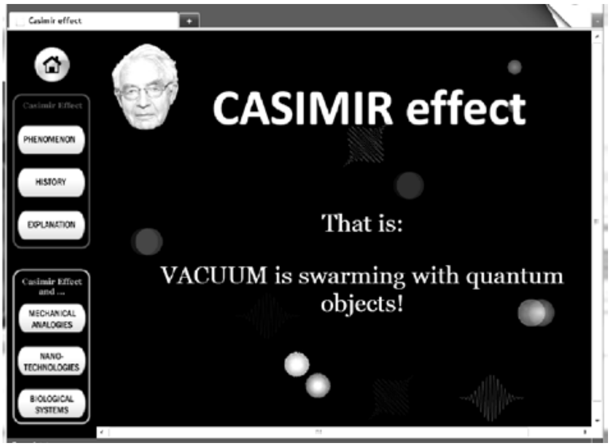


Figure 2. The main page of the tutorial, from which one can navigate through the various sections using buttons on the left side of the window. In the black portion of the window under the title, a continuous animation illustrates pictorially the “swarming” of particles pairs and photons in the quantum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

“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 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) [5]; ii) two ships lying parallel each other, close together on a wavy sea surface [6].
- “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

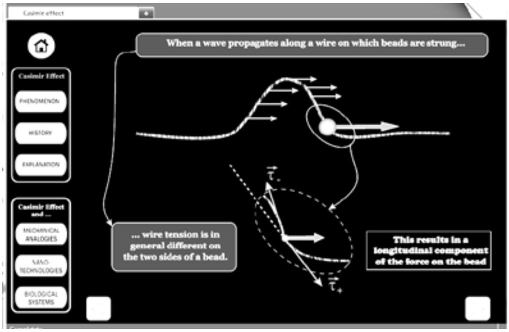


Figure 4. Snapshot of the animation explaining a mechanical analog of the Casimir effect: beads strung on a vibrating wire seems to attract one another

Conclusion

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.

References

[1] Casimir HBG, On the Attraction between Two Perfectly Conducting Plates, Proceedings of the American Philosophical Society, 51, 793–795, 1948.

[2] Bordag M, The Casimir effect 50 years later, Hackensack, NJ: World Scientific, 1999.

[3] Lambrecht A, The Casimir effect: a force from nothing, Physics World, Sept. 1, 29-32, 2002.

[4] Feynman RP, Leighton RB and Sands M, The Feynman Lectures on Physics, Vol. 3 – 2nd Ed., Reading, MA: Addison-Wesley, 1964.

[5] Griffiths DJ, Ho E, Classical Casimir effect for beads on a string, Am. J. Phys., 69: 11, 1173–1176, 2001.

[6] Boersma SL, A maritime analogy of the Casimir effect, Am. J. Phys., 64: 5, 539-541, 1996.

Paper presented at the 8th International Conference on “Hands on Science. Focus on Multimedia",
Ljbljana, Slovenia, September 15 to 17, 2011.

Photographing Mirages above the Sea Surface

Blanco-García J, Dorrío BV and Ribas-Pérez FA

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, [1-2]), 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.

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

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 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 [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 [1,4-7].

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 [8]; 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.

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 educational activities that promote the self exploration of the bending of light between two different media according to Snell Law [9-11].

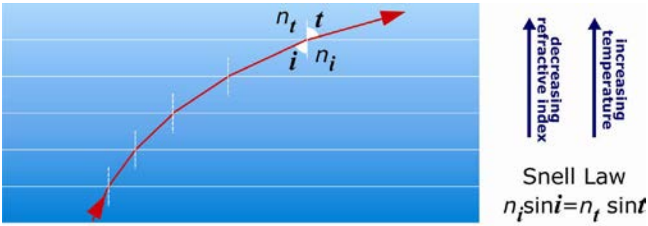


Figure 3. Direction change of a ray that passes through decreasing refractive index layers

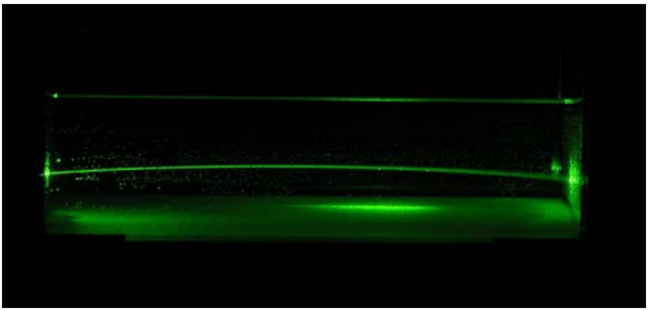


Figure 4. A laser beam is bent downwards when passes through a variable-concentration dissolution (in this case, decreasing upwards)

On the other side, hands-on activities related with experiences in the real world make learning significant [12]. 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 [13], heating and cooling simultaneously air [14], generating a gradient-concentration dissolution [15-20], 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 [21]. 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.

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 [7]. 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 [7,16,20].

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 [22]; and a computer ray tracing in [23]).

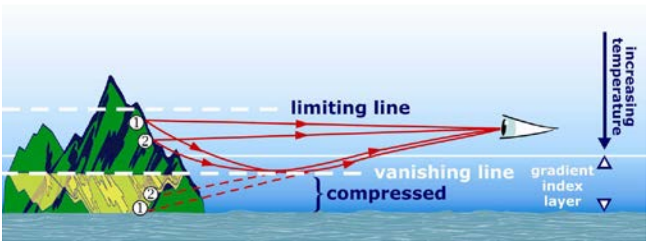


Figure 5. Ray paths for an inferior sea mirage

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. 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.

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

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

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.

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 [7,13,16]. A computer ray tracing for superior mirages can be seen also in [22].
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 [23]).
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.

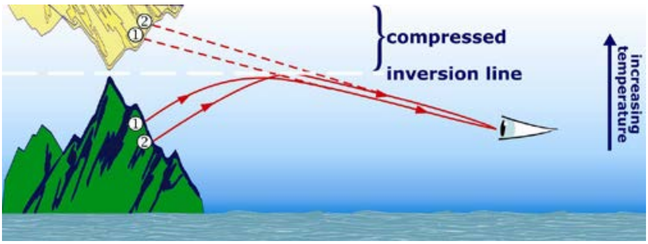


Figure 8. Rays paths for a superior mirage

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.
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.

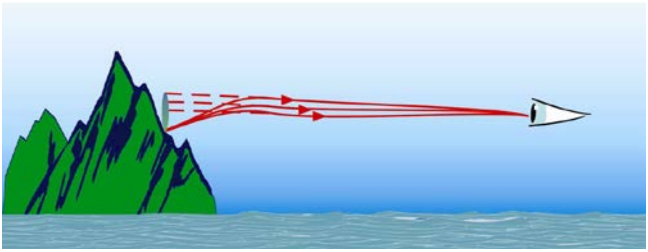


Figure 10. Vertical elongation of a point: formation of towers or walls. The same can occur in inferior mirages but with the rays curved on contrary sense

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

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

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.

(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

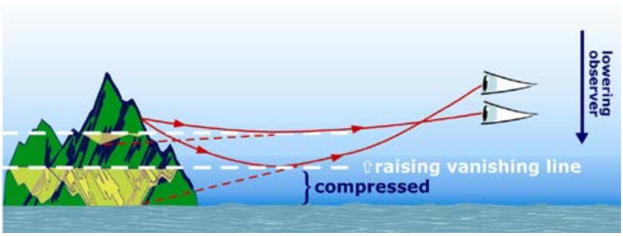


Figure 13. Ray tracing for the effect of changing the observer height when photographing an inferior mirage

Fig. 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 Fig. 13.

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.

References

[1] http://www.ametsoc.org/amsedu/wes/glossary.html#M
[2] http://mintaka.sdsu.edu/GF/mirages/mirintro.html
[3] http://mintaka.sdsu.edu/GF/bibliog/bibliog.html
[4] Berger M and Trout TT, Ray tracing mirages, IEEE Computer Graphics and Applications, 36-41, 1990.
[5] Minnaert MGJ, Light and Color in the Outdoors, Berlin, Germany: Springer-Verlag, 1993.
[6] Lynch DK and Livingston W, Color and Light in Nature, Cambridge, UK: Cambridge University Press, 2001.
[7] Vollmer M, Mirrors in the air: Mirages in nature and in the laboratory, Physics Education, 44: 2, 165-174, 2009.
[8] Blanco-García J and Ribas-Pérez FA, Mirages above the sea waters, Journal of Physics: Conference Series, 274 012001, 2011.
[9] http://www.walter-fendt.de/ph14e/refraction.htm
[10] http://lectureonline.cl.msu.edu/~mmp/kap25/Snell/app.htm
[11] http://phet.colorado.edu/en/simulation/bending-light
[12] Resnick LB, Learning in school and out, Educational Researcher, 16: 9, 13-20, 1987.
[13] Baker PR, Crofts PRM and Gal M, A superior “superior” mirage, American Journal of Physics, 57: 10, 953-954, 1989.
[14] Richey L, Stewart B and Peatross J, Creating and analyzing a mirage, The Physics Teacher, 44, 460-464, 2006.
[15] Strouse WM, Bouncing Light Beam, American Journal of Physics, 40, 913-914, 1972.
[16] Vollmer M and Tammer R, Laboratory experiments in atmospheric optics, Applied Optics, 37: 9, 1557-1568, 1998.
[17] Vollmer M and Greenler R, Halo and mirage demonstrations in atmospheric optics, Applied Optics, 42, 394-398, 2003.
[18] Gluck P, Material and Optical Densities, The Physics Teacher, 45, 140-141, 2007.
[19] Lombardi S, Monroy G, Testa I and Sassi E, Measuring variable refractive indices using digital photos, Physics Education, 45: 1, 83-92, 2010.
[20] Branca M, Simulation of the inferior mirage, The Physics Teacher 48, 372-373, 2010.
[21] Mak S, Showing the light path of a mirage, The Physics Teacher, 31, 476-477, 1993.
[22] Fabri E, Fiorio G, Lazzeri F and Violino P, Mirage in the laboratory, American Journal of Physics, 50: 6, 517-520, 1982.
[23] López-Arias T, Calzà G, Gratton LM and Oss S, Mirages in a bottle, Physics Education, 44: 6, 582-588, 2009.

[24] Tape CH, Aquarium, computer and Alaska Range Mirages, The Physics Teacher, 36, 308-311, 2000.
[25] Varela RA and Rosón Porto G, Métodos en Oceanografía Física, Barcelona, Spain: Anthias, 2008.

Paper presented at the 8th International Conference on “Hands on Science. Focus on Multimedia",
Ljbljana, Slovenia, September 15 to 17, 2011.

Hands-on Physics Experiments for Classroom

Dorrío BV, Blanco-García J and Costa MFM

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 [1-4]. 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 [5-8]. These difficulties are similar in various countries, yet the speed at which the necessary changes are applied varies [9]. 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 [10]. 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 [11]. 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 [12-13]. Many projects have shown the benefits of their use to attain quality learning [14-15]. 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 [16-17]. 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 [18].
In this work we present several ways of using HPEs based on our experience, taking into account the way in which people learn (Fig. 1): considering their previous knowledge, using interaction among 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.

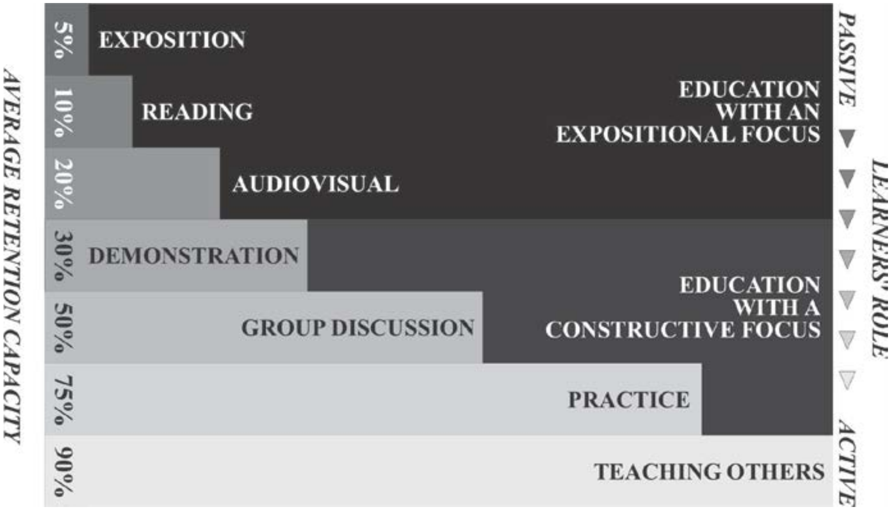


Figure 1. Learning methodologies [19]

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 (Tab. 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 [20]. 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 [21-22].

BOOKS ⇨	[23-25]
SPECIALISED JOURNALS ⇨	[26-28]
EVENTS ⇨	[29-31]
PROJECTS ⇨	[19,32-33]
ASSOCIATIONS ⇨	[34-36]
WORLD WIDE WEB ⇨	[37-39]
AUDIOVISUAL MATERIALS ⇨	[40-42]
SUPPLIER OF EDUCATIVE EQUIPMENT ⇨	[43-45]
INTERACTIVE MUSEUMS ⇨	[46-48]

Table 1. Available resources

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 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 (Fig. 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 [49-53]. 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.

Figure 2. Some examples of HPEs

b) Interactive demonstrations. The above demonstrations may be more effective in master classes if their interactivity is increased. In an interactive HPE [8,54-56] 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 [57-59].

c) Problem-based learning (PBL) mini-projects [60]. Challenge HPEs, in which learners working in small groups are simply given a project title (usually from a list taken from a book [23] or webpage [46]) 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 [61-63]. 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 [64-65]. 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 obtaining, without reflection, expected results that have quantitative verification in the way of a response that completes a pre-designed and directed experiment [66]. 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 [67-71]. 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 [72-75].

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 [76-78]. 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.

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.

Acknowledgements

We are grateful for funding received from the University of Vigo for carrying out the Educational Innovation Project “On-line Hands-on Experiments for learning Physics in Engineering degrees.”

References

[1] Gunstone R, Student understanding in mechanics: A large population survey, American Journal of Physics, 55, 691-696, 1987.

[2] Vineot L, Analyzing student´s reasoning: Tendencies in interpretation, American Journal of Physics, 53, 432-436, 1985.

[3] Hake RR, Interactive-engagement vs. traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses, American Journal of Physics, 66, 64-74, 1997.

[4] Kim E and Pak SJ, Students do not overcome conceptual difficulties often solving 1000 traditional problems, American Journal of Physics, 70, 759-765, 2002.

[5] Roth W, McRobbie C, Lucas K and Boutonne S, Why May Students Fail to Learn from Demonstrations? A Social Practice Perspective on Learning in Physics, Journal of Research in Science Teaching, 34: 5, 509–533, 1997.

[6] Powell K, Science education: spare me the lecture, Nature, 425, 234-236, 2003.

[7] Powell K, Spare me the lecture, Nature, 425, 234-236, 2003.

[8] Crouch CH, Fagen AP, Callan JP and Mazur E, Classroom demonstrations: Learning tools or entertainment?, American Journal of Physics, 72: 6, 835-838, 2004.

[9] Thacker BA, Recent advances in classroom physics, Report on Progress in Physics, 66, 1833-1864, 2003.

[10] Biggs J, Calidad del aprendizaje universitario, Madrid, Spain: Narcea, 2005.

[11] Brown G and Atkins M, Effective teaching in higher education, London, UK: Methuen, 1988.

[12] Flick LB, The meanings of hands-on science, Journal of Science Teacher Education, 4, 1-8, 1993.

[13] Dorrío BV, Rúa A, Soto R and Arias J, Hands-on Physics Bibliography, Proceedings of the 1st Conference on Hands-on Science. Teaching and Learning in the XXI Century, Divjak S (Ed.), 119-124, Ljubljana, Slovenia, 2004.

[14] NRC: National Research Council, National science education standards, Washington, USA: National Academy Press, 1996.

[15] AAAS: American Association for the Advance of Science, Project 2061, Washington, USA: Science for all the Americans, 1989.

[16] Dorrío BV, García-Parada E and González-Fernández PM, Introducción de demostraciones prácticas para la enseñanza de la Física en las aulas universitarias, Enseñanza de las Ciencias, 12, 63-65, 1994.

[17] Dorrío BV and Rúa-Vieites A, Actividades manipulativas para el aprendizaje de la Física, Revista Iberoamericana de Educación, 42: 7, 1-15, 2007.

[18] De Jong O, Korthagen F and Wubbles T, Research on science teacher education in Europe: teacher thinking and conceptual change, in International Handbook of Science Education, Fraser B and Tobin K G (Eds.), Dordrecht, Netherlands: Kluwer Academic Publishers, 745-758, 1998.

[19] http://www.ntl.org/

[20] Oppenheimer F, The Exploratorium: a playful museum combines perception and art in science education, American Journal of Physics, 40, 978-984, 1972.
[21] Morris C, Importing “hands-on” science into schools: the Light Works van programme, Physics Education, 25, 263-267, 1990.
[22] Johansson KE and Nilsson Ch, Stockholm Science Laboratory for schools: a complement to the traditional education system, Physics Education, 34, 345-350, 1999.
[23] Ehrlich R, Turning the World Inside Out and 174 Other Simple Physics Demonstrations, New Jersey, USA: Princenton University Press, 1990.
[24] Cunningham J and Herr N, Hands-on Physics activities with real life applications, New York, USA: Wiley, 1994.
[25] Rathjen D and Doherty P, Square wheels and other easy-to-build hands-on science activities, San Francisco, USA: Exploratorium, 2002.
[26] http://scitation.aip.org/tpt/
[27] http://www.iop.org/EJ/journal/PhysEd
[28] http://ijhsci.aect.pt/
[29] http://www.esa.int/SPECIALS/Science_on_Stage/
[30] http://www.girep.org/
[31] http://spie.org/x30117.xml
[32] http://www.hsci.info/
[33] http://physicslearning.colorado.edu/PiraHome/
[34] http://www.aapt.org/
[35] http://www.nsta.org/
[36] http://www.colos.org/
[37] http://demoroom.physics.ncsu.edu/
[38] http://web.physics.ucla.edu/demoweb/
[39] http://demo.physics.uiuc.edu/LectDemo/
[40] http://www.stevespanglerscience.com/
[41] http://www.grand-illusions.com/
[42] http://www.youtube.com/watch?v=ZYgFuUl9_Vs&NR=1
[43] http://www.sargentwelch.com/
[44] http://www.delta-education.com
[45] http://www.scientificsonline.com
[46] http://www.exploratorium.edu/
[47] http://www.sciencemuseum.org.uk/
[48] http://www.amnh.org/
[49] Carpenter DR and Minnix RB, The lecture demonstration: try it, they´ll like it, The Physics Teacher, 19, 391-392, 1981.
[50] Freier G, The use of demonstrations in Physics teaching, The Physics Teacher, 19, 384-386, 1981.
[51] Hilton WA, Demonstrations as an aid in the teaching of Physics, The Physics Teacher, 19, 389-390, 1981.
[52] Williams MJ, Understanding is both possible and amusing, Physics Education, 25, 253-257, 1990.

[53] Di Stefano R, Preliminary IVPP results: student reaction to in-class demonstrations and to the presentations of coherent terms, American Journal of Physics, 64: 1, 58-62, 1996.
[54] Sokoloff DR and Thornton RK, Using iterative lecture demonstrations to create an active learning environment, The Physics Teacher, 35, 340-347, 1997.
[55] Meltzer DE and Manivannan K, Transforming the lecture-hall environment: the fully interactive physics lecture, American Journal of Physics, 70, 639-654, 2002.
[56] Sharma MD, Johnson ID and Johnson H, Use of interactive lecture demonstration: A ten year study, Phys. Rev. ST Physics Ed. Research 6, 020119-1/020119-9, 2010.
[57] http://www.mhhe.com/cps/
[58] http://www.replysystems.com/
[59] http://www.sunvote.com.cn/
[60] Edelson DC, Gordin DN and Pea RD, Addressing the challenges of inquiry based learning through technology and curriculum design, Journal of Learning Sciences, 8, 391-450, 1999.
[61] http://phet.colorado.edu/
[62] http://www.animations.physics.unsw.edu.au/
[63] http://www.phy.ntnu.edu.tw/ntnujava/
[64] http://modellus.fct.unl.pt/
[65] http://www.opensourcephysics.org/
[66] Domin DS, A review of laboratory instruction styles, Journal of Chemical Education, 76, 543-547, 1999.
[67] Campbell J, Canterbury´s physics display facility, The Physics Teacher, 27, 526-529, 1989.
[68] Bone WJ and Roth MK, Organizing school science shows, The Physics Teacher, 30, 348-350, 1992.
[69] Esteves Z, Cabral A and Costa MFM, Informal Learning in Basic Schools. Science Fairs. International Journal of Hands-on Science, 1: 2, 23-27, 2008.
[70] Jones B, The little shop of Physics. A just-in-time science museum, The Physics Teacher, 34, 514-518, 1996.
[71] Williams J, Build your own interactive science centre, Physics Education 43, 580-587, 2008.
[72] Dorrío BV and Villar R, Indoor interactive science museums in school, Proceedings of the 3rd International Conference on Hands-on Science. Science Education and Sustainable Development, Costa M F and Dorrío B V (Eds.), 623-628, Braga, Portugal, 2006.
[73] Dorrío BV, Rodríguez S, Lago A and Diz J, Chladni plates: A hands-on energy activity, Proceedings of the 3rd International Conference on Hands-on Science. Science Education and Sustainable Development, Costa M F and Dorrío B V (Eds.), 241-246, Braga, Portugal, 2006.
[74] Rodríguez S, Fernández J, Asín JA, Lago A and Dorrío BV, An informal interactive science and technology centre, Proceedings of the. 2nd International Conference on Hands-on Science. Science in a changing education,

Michaelides PG and Margetousaki A (Eds.), 190-195, University of Crete, Rethymno, Crete, 2005.
[75] Villar R and Dorrío BV, Science interpretation in high school, Proceedings of the 2nd International Conference on Hands-on Science. Science in a changing education, Michaelides PG and Margetousaki A (Eds.), 184-189, University of Crete, Rethymno, Crete, 2005.
[76] Pinkerton KD, Interactive hallway physics for elementary schools, The Physics Teacher, 29, 166-168, 1991.
[77] Sampere SM, The Neon Sign, The Physics Teacher, 37, 140-141, 1999.
[78] Pizzo J, Echo Tube, The Physics Teacher, 24, 428-429, 1986.

Paper presented at the 8th International Conference on "Hands on Science. Focus on Multimedia",
Ljbljana, Slovenia, September 15 to 17, 2011.

High-Technology Materials for Hands-on Activities in Classroom

Pérez-Pérez C, Collazo-Fernández A and Dorrío BV

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 [1-2]. 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 [3]. 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 [4-5]. Its origin is found in science museums or museums interactive [6] and it was used successfully in numerous subjects, since some time ago [7-8].

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.

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 [9-11].

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 [12] 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 [13]. 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.

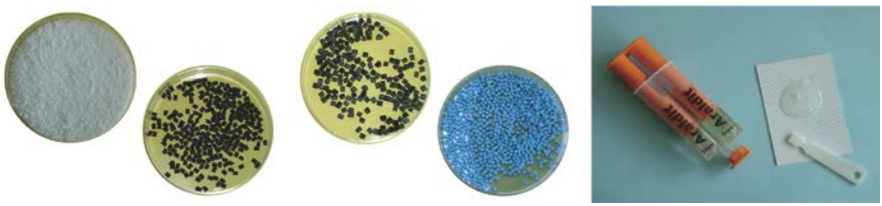


Figure 1. Examples of different types of termoplastics under pellets shape (left) and a commercial themosetting (Araldit®) made by two precursors (right)

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) [14]. 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 (left). 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 (right)

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 (left). Opacity generated in PP when it is stretched (centre). HDPE transparent obtained when it is heated above 140ºC (right)

Activity IV: Glass transition temperature (stiffness and brittleness)

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 [15]. After the introduction of this elastomer into liquid nitrogen, this is “frozen” adopting a rigid and brittle consistency, as it can be 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.

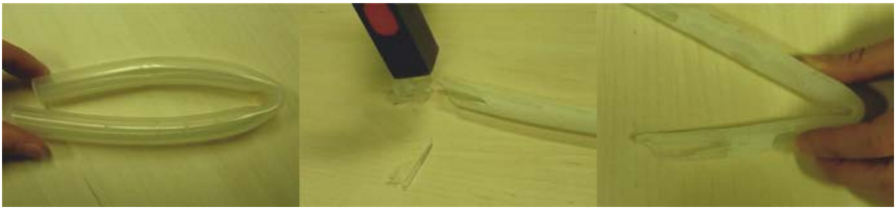


Figure 4. Rubber hose bent at room temperature (left). Brittle behaviour when it is being hit by a hemmer, after the introduction into liquid nitrogen (centre). Recovery of the flexible behaviour after a few minutes at room temperature (right)

Activity V: Viscoelasticity

The important concepts related to the viscoelasticity of polymers can be illustrated using Silly Putty® [16-17], 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.

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

Activity VI: Memory shape

Figure 6. Shrink PE before and after submitting to heat source (left). 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 (right)

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) [18-20]. 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.

Activity VII: Chemical properties of polymers

The absorption properties of nonpolar substances, such as oils or petroleum products, can illustrate by using a commercial hydrophobic styrenic polymer: IMBIBER® [21], 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 [22]. 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.

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

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.

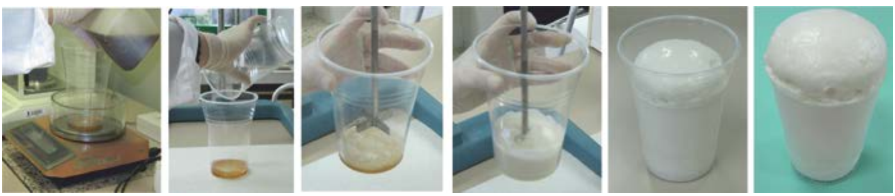


Figure 8. Different stages of the manufacturing process of a foam

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.

References

[1] Benito A and Cruz A, Nuevas claves para la docencia universitaria en el EEES, Madrid, Spain: Narcea, 2005.
[2] Anderon RD, Reforming science teaching: what research says about inquiry, Journal of Science Teaching Education, 13, 1-12, 2002.
[3] Thorne K, Motivación y creación en clase, Barcelona, Spain: Graó, 2008.
[4] Vázquez Dorrío JB, García Parada E and González Fernández PM, Introducción de demostraciones prácticas para la enseñanza de la Física en las aulas universitarias, Enseñanza de las Ciencias, 12, 63-65, 1994.
[5] Costa MF and Dorrío BV, Actividades manipulativas como herramienta didáctica en la educación científico-tecnológica, Revista Eureka sobre Ciencias y Divulgación de las Ciencias, 7, 462-472, 2010.
[6] http://www.exploratorium.edu/snacks/bone_stress/index.html
[7] Dorrío BV and Rúa Vieites A, Actividades manipulativas para el aprendizaje de la Física, Revista Iberoamericana de Educación, 42: 7, 1-15, 2007.
[8] Dorrío BV, Rua A, Soto R and Arias JP, Hands-on Physics Bibliography, in Selected Papers on Hands-on Science, Costa MF, Dorrío BV, Michaelides P, Divjak S (Eds.), 80-88, Braga, Portugal: Copissaurio Repro, 2008.
[9] Sokoloff DR and Thornton RK, Using interactive lecture demonstrations to create an active learning environment, The Physics Teacher, 35, 340-347, 1997.
[10] Mazur E, Fagen AP, Crouch CH and Callan JP, Classroom demonstrations: Learning tools or entertainment?, American Journal of Physics, 72: 6, 835-838, 2004.
[11] Loverude ME, A research-based interactive lecture demonstration on sinking and floating, American Journal of Physics, 77: 10, 897-901, 2009.
[12] http://www.teachersource.com/
[13] Liff MI, Polymer Physics in an Introductory General Physics Course, The Physics Teacher, 42, 536-540, 2004.
[14] Mills N, Plastics. Microstructure and Engineering Applications, Amsterdam, The Netherlands: Elsevier, 2005.
[15] http://www.strangematterexhibit.com/demoworks_final.pdf
[16] Astin C, Talbot D and Goodhew P, Weird materials, Physics Education, 37, 516-520, 2002.
[17] http://www.youtube.com/watch?v=Wx7FGhV_wdI&feature=related
[18] Chanda M and Roy SK, Plastics Technology Handbook, New York, USA: Marcel Dekker, 1987.

[19] Papalexopoulos PF and Patapis S, Nuevo material de estudio en cursos de ciencia en escuelas a partir de materiales inteligentes, Journal of Materials Education, 24, 229-242, 2002.
[20] http://www.youtube.com/watch?v=Fzt6hAhmJyQ
[21] http://www.marinebuzz.com/2007/11/05/how-super-absorbent-imbiber-beads-contain-oil-and-chemical-spills-at-sea/
[22] http://www.blackcatbags.co.uk/

Paper presented at the 8th International Conference on “Hands on Science. Focus on Multimedia",
Ljbljana, Slovenia, September 15 to 17, 2011.

Design and Construction of Solar Ovens. A Practical Approach to the Greenhouse Effect and Climate Change

Diz-Bugarín J and Rodríguez-Paz M

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)

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 [1]. 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)

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.

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.

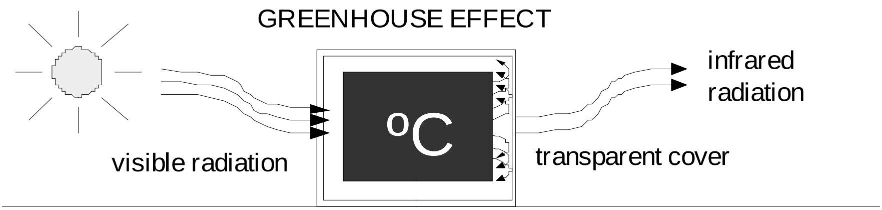


Figure 3. Solar radiation and greenhouse effect

Conduction and Convection

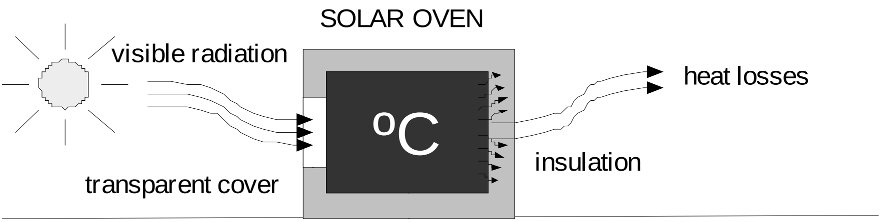


Figure 4. Heat losses in a solar oven

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).

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. CEIP Barrantes. Explanation and first construction step (left). Covering with aluminium foil (center). Solar ovens ready to cook and the delicious result (right)

Complementary activities

Figure 6. CEIP Barrantes. Exhibition of solar devices (left). Sunflowers painting workshop (center). Boiling water with the parabolic cooker (right)

Figure 7. CEIP Chano Piñeiro. Solar pasteurization workshop (left). Solar activities and games (center). Solar oven workshop at IES Valadares-Vigo (right)

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.

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.

References

[1] Solar Cookers International. Solar Cookers: How to make, use and enjoy (10th Edition), 2004.

Paper presented at the 8th International Conference on “Hands on Science.
Focus on Multimedia",
Ljbljana, Slovenia, September 15 to 17, 2011.

Learning the Importance of the Sun as an Important Energy Source by Building "Solar Cars"

Pereira A and Costa MFM

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 [1]. 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 [1], 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 [2-3].
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 [4]. 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 [1].
It is important that young people get in touch with this technology, understanding the basic physics concepts involved, rather important in physics and science 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).

Implementation

In the next paragraphs we will show an example of how a class of nineteen 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 develop their skills in abstract thinking and group dynamics.

Figure1. Materials used by a group of students to build a solar car

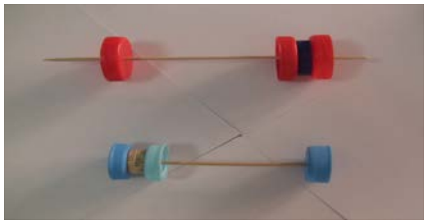


Figure 2. Two different solar car transmission axis

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 (Fig. 1), and all its construction steps.

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 (Fig. 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 3. Solar car chassis with drilled holesforaxis support

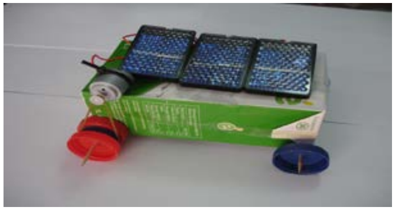


Figure 4. Assembled solar car

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 (Fig. 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 W) 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 panells 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 (Fig. 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.
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.

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.

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 improved 66%, in comparison with the previous year. This was achieved by letting the students put their "hands-on science"!

References

[1] Partain LD and Fraas LM, Solar Cells and Their Applications, Wiley Series in Microwave and Optical Engineering, New Jersey: John Wiley and Sons, 2010.
[2] Sariciftci NS, Smilowitz L, Heeger AJ and Wudl F, Science, 258,1474, 1992.
[3] Spangaard H and Krebs F, Sol. Energy Mater. Sol. Cells, 83, 125, 2004.
[4] Miles RW, Zoppi G and Forbes I, Inorganic Photovoltaic Cells, Materials Today, 10: 11, 2007.

Paper presented at the 8th International Conference on "Hands on Science. Focus on Multimedia",
Ljbljana, Slovenia, September 15 to 17, 2011.

RoboWiki: Resources for Educational Robotics

Ribeiro CR, Coutinho C and Costa MFM

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 [1].

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 [2].

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 [3].

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 [4].
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 [5]. 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 [6]. 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 [7].
- 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 [8].
- 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 [9].
- 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 [8].
- 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 [10].
- 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 ([11], quoted by [9]). 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 [2].
- 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.

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 [12]. 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 [13]. Santamaria [14] and Schwartz [15] 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.

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 Mindstormsplatform 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.).

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 presen-tation 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 Fig. 1).

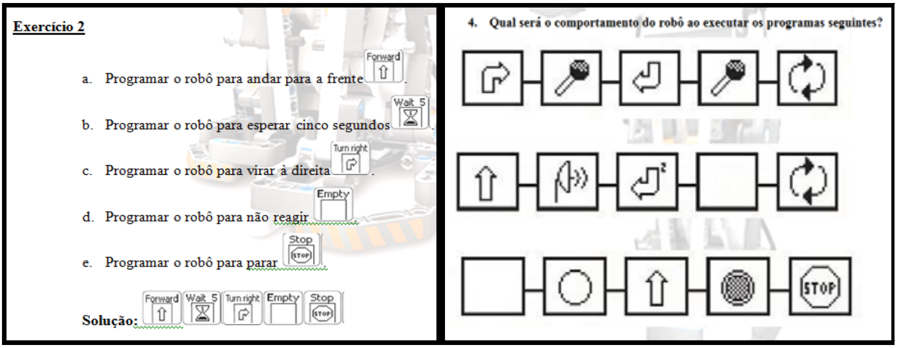


Figure 1. Exercises in the programming of robots

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 Fig. 2 and 3).
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 Fig. 4).

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).

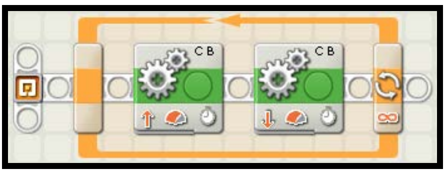
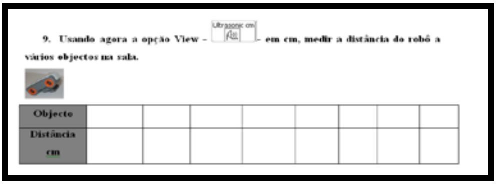


Figure 3. Exercises in the blocks of programming the robot



9. Usando agora a opção View – Ultrasonic cm – em cm, medir a distância do robô a vários objectos na sala.

Objecto								
Distância cm								

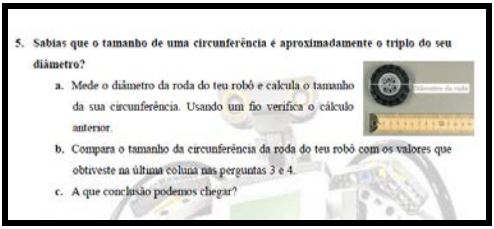
Figure 4. Exercise - with the ultrasound sensor to measure the distance of objects

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 (Fig. 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 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.



5. Sabias que o tamanho de uma circunferência é aproximadamente o triplo do seu diâmetro?
   a. Mede o diâmetro da roda do teu robô e calcula o tamanho da sua circunferência. Usando um fio verifica o cálculo anterior.
   b. Compara o tamanho da circunferência da roda do teu robô com os valores que obtiveste na última coluna nas perguntas 3 e 4.
   c. A que conclusão podemos chegar?

Figure 5. Exercise – solving with the robot´s wheels

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)- (Fig. 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"

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.

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.

References

[1] Oliveira JAC, Robótica e educação: aproximações piagetianas numa tese de doutorado, XI Seminário Internacional de Educação Tecnológica, Novo Hamburgo-RS, 2004.

[2] Ribeiro C, RobôCarochinha: Um Estudo Qualitativo sobre a Robótica Educativa no 1º ciclo do Ensino Básico, Dissertação de Mestrado, Braga: Instituto de Educação e Psicologia da Universidade do Minho, 2006.

[3] Bacaroglo M, Robótica Educacional, Monografia (especialização)- Univ. Estadual de Londrina, Centro de Ciências Exatas, Londrina, 2005.

[4] Quevedo RI, Bouchan MGA and Martínez PM, Un Ambiente de Aprendizaje con la robotica pedagógica para embalaje, CFIE – IPN, 2008.

[5] Badilla-Saxe E, Proyecto de Trabajo Final de Graducación: Interacción, preescolares, átomos y bits, Facultad de Educación, Universidad de Costa Rica, 2006.

[6] Resnick M, Computer as Paintbrush: Tecnology, Play and the Creative Society, in Singer, Golikoff and Hirsh-Pasek (Eds.), Play = Learning: How play motivates and enhances children´s cognitive and social-emotional growth, Oxford: Oxford University Press, 2006.

[7] Rogers C and Portsmore M, Bringing Engineering to Elementary School, Journal of STEM Education, 5: 4/5, 2004.

[8] Gura M and King KP, Classroom Robotics. Case stories of 21st Century Instruction for Millennial students, Charlotte, NC: Information Age, 2007.

[9] Teixeira J, Aplicações da Robótica no Ensino Secundário: o Sistema Lego Mindstorms e a Física, Dissertação de Mestrado, Coimbra: Faculdade de Ciências e Tecnologia da Universidade de Coimbra, 2006.

[10] Torre A, Web Educativa 2.0, Edutec, Revista Electrónica de Tecnologia Educativa, 2006.

[11] Lau KW, Heng KT, Ervin BT and Petrovic P, Creative Learning in school with Lego® Programmable Robotics products, Frontiers in education, Conference, FIE'99, 29th Annual, 2, 12d4/26-12d4/31, 1999.

[12] Ferreira AA, Silva BD and Siman LMC, Web 2.0 o ensino de história: trabalhando com Wiki), Encontro nacional perspectivas do ensino de História, 7, Uberlândia, Minas Gerais, Brasil, Anais do VII Encontro Nacional Perspectivas do Ensino de História, Uberlândia: Universidade Federal de Uberlândia, 2009.

[13] Carvalho AAA, Manual de Ferramentas da Web 2.0 para professores, Lisboa: Direcção-Geral de Inovação e de Desenvolvimento Curricular do Ministério da Educação, 2008.
[14] Santamaria FG and Abraira CF, Wikis: posibilidades para el aprendizaje colaborativo em Educacion Superior, Proceedings of the 8th International Symposium on Computers in Education, Panizo L *et al* (Eds.), 2, 371-378, 2006.
[15] Schwartz L, Clark S, Cossarin M and Rudolph J, Educational Wikis: features and selection criteria, The International Journal of Research in Open and Distance Learning, 5: 1, 2004.

Paper presented at the 8th International Conference on “Hands on Science.
Focus on Multimedia",
Ljbljana, Slovenia, September 15 to 17, 2011.

1st Hands-on Science Science Fair

Esteves Z and Costa MFM

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 [1] within or outside of their school context, in different themes [2-3], and that allows the involvement of all the community [3].
These activities allow scientific research in any science subject [3] to be developed and interdisciplinary should be most welcomed [2]. It facilitates the establishment of relations between science and daily life phenomena [4], helping students to understand the nature of the problem to be solved, gaining problem solving capabilities [2], make decisions, create hypothesis, and develop their creativity and imagination [2-3,5-6]. They also develop others skills such as resilience and self confidence as well and social interaction [7] or communication ones [5].
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.

The organization of the Science Fair

During the 2010/2011 school year, a national science fair was organized by the Hands-on Science Network [8], with the support of the University of Minho, and the Portuguese Association for Science and Technology Education [9]. 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 [10] 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 [11] 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.
Contributions 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 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.

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 Tab. 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, mathematics 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, 1^{st}, 2^{nd}, 3^{rd} prizes and one or two honor mentions were selected, as is possible to see on Tab. 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

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.

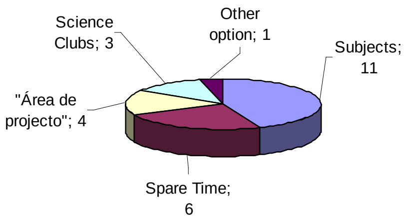


Figure 1. Places where teachers work with their students

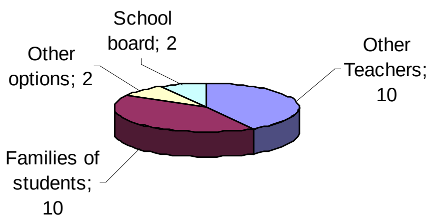


Figure 2. Other collaborators on science fair projects

As it is possible to see on Fig. 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 Fig. 2.

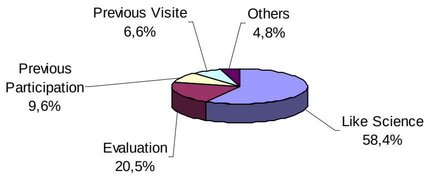


Figure 3. Reasons presented by the students to participate at the science fair

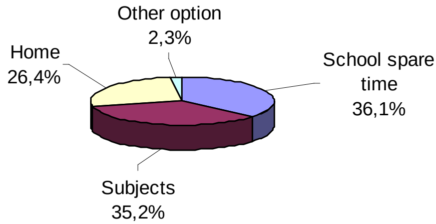


Figure 4. Places where students developed the science fair projects

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 Fig. 3. 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.

From Fig. 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 Fig. 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.

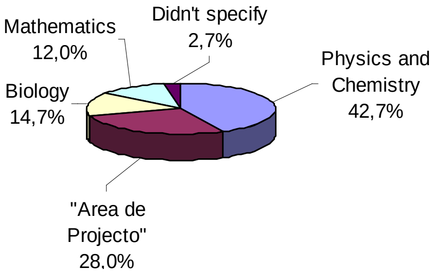


Figure 5. Subjects involved on the development of the science fair projects

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.

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.

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 seem 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.

Future work

The 2nd Hands-on Science Science Fair will organize during the school year of 2011-2012 aiming also to select student 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.

References

[1] Grote M, Teacher Opinions Concerning Science Projects and Science Fairs, Ohio Journal of Science, Ohio Academy of Science, January, 1995.
[2] Bencze JL and Bowen GM, A National Science Fair: Exhibiting support for the knowledge economy, International Journal of Science Education, 31: 18, 2459-2483, 2009.
[3] Ministério da Educação, Programa Nacional de Apoio às Feiras de Ciências da Educação Básica, Brasil, 2006.
[4] Scheneider RM and Lumpe AT, The Nature of Student Science Projects in Comparison to Educational Goals, Science, 81-88, 1996.
[5] Esteves Z, Cabral A and Costa MFM, Informal Learning at School, Science Fairs in Basic Schools, International Journal on Hands-on Science, 1, 23-27, 2008.
[6] Montes A, Didactical History of a Science Fair, Proceedings of the 3rd International Conference on Hands-on Science: Science Education and Sustainable Development, Costa MFM, Dorrío BV (Eds.), 345-352, Braga, Portugal, 2006.
[7] Sumrall W, Non tradicional characteristics of a successful science fair Project, Science Scope, 20-25, 2004.
[8] https://www.hsci.info
[9] https://www.uminho.pt
[10] https://www.aect.pt
[11] https://sites.google.com/site/feiradeciencias2011/home

Paper presented at the 8th International Conference on “Hands on Science.
Focus on Multimedia",
Ljbljana, Slovenia, September 15 to 17, 2011.

Hands-on Experimental Activities in Inquiry-Based Science Education

Trnova E and Trna J

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. 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.

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.

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 [1]. 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 [2-3]. 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 [4].
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 [5-7]. H. Banchi and R. Bell [8] 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.

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.

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.

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.

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 [9]. 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.

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 [10]. 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.

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 [11].

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, 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.

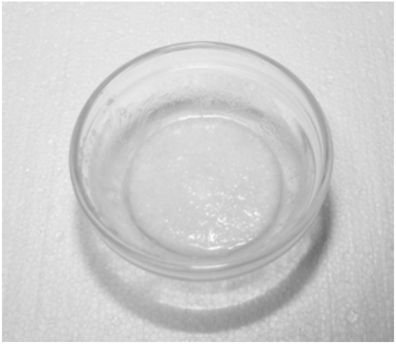


Figure 1. Home-made toothpaste

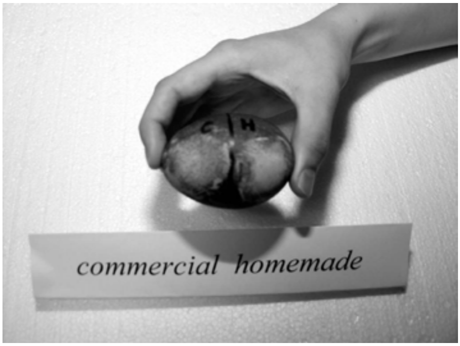


Figure 2. Comparison of abrasiveness

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.
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).
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.

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.

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.

Acknowledgements

The study initiated within the project PROFILES: Professional Reflection-Oriented Focus on Inquiry-based Learning and Education though Science (FP7-SCIENCE-IN-SOCIETY-2010-1, 266589).

References

[1] Narode R, Teaching Thinking Skills: Science, Washington, DC: National Education Association, 1987.

[2] Kyle WC, What research says: Science through discovery: Students love it, Science and Children, 23: 2, 39–41, 1985.

[3] Rakow SJ, Teaching Science as Inquiry, Fastback 246, Bloomington: Phi Delta Kappa Educ. Found., 1986.

[4] Duschl RA, Schweingruber HA and Shouse AW, Taking Science to School: Learning and Teaching Science in Grades K–8, Washington, DC: The National Academies Press, 2007.

[5] Bell R, Smetana L and Binns I, Simplifying inquiry instruction. The Science Teacher, 72: 7, 30-34, 2005.

[6] Herron MD, The nature of scientific inquiry, School Review, 79: 2, 171–212, 1971.

[7] Schwab JJ, The teaching of science as inquiry, The teaching of science, Schwab JJ and Brandwein PF (Eds.), 3-103. Cambridge, MA: Harvard University Press, 1962.

[8] Banchi H and Bell R, The Many Levels of Inquiry, Science and Children, 46: 2, 26-29, 2008.

[9] Kirschner PA, Sweller J and Clark RE, Why minimal guidance during instruction does not work: an analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching, Educational Psychologist, 41: 2, 75–86, 2006.

[10] Hofstein A, Navon O, Kipnis M and Mamlok-Naaman R, Developing Students Ability to Ask More and Better Questions Resulting from Inquiry-Type Chem. Laboratories, J. of Res. in Sc. Teach., 42, 791-806, 2005.

[11] Trantow A, Classroom Activity, Brushing up on chemistry, J. Chem. Educ., 79: 10, 1168A, 47, 2002.

Paper presented at the 8th International Conference on “Hands on Science. Focus on Multimedia",
Ljbljana, Slovenia, September 15 to 17, 2011.

AUTHOR CONTRIBUTORS

Allemandi W	[167]	Universidade de São Paulo	
Anagnostakis S	[342]	University of Crete	sanagn@edc.uoc.gr
Ayres de Campos J	[209]	Universidade do Minho	julia@fisica.uminho.pt
Bannwarth H	[125]	University of Cologne	Horst.Bannwarth@uni-koeln.de
Berchenko N	[44]	Rzeszow University	nberchen@univ.rzeszow.pl
Bérczi S	[371]	Eövös Loránd University	
Berezovska I	[44,294]	Ternopil State Technical University	iberezov@hotmail.com
Bhattacharyya RK	[203]	Calcutta University	rabindrakb@yahoo.com
Blanco-García J	[401,411]	Universidade de Vigo	jblanco@uvigo.es
Bonanno A	[395]	University of Calabria	assunta.bonanno@fis.unical.it
Buchinger K	[294]	Upstate Medical University	
Cabral A	[136]	Universidade do Minho	andreiacabral@hotmail.com
Camarca M	[395]	University of Calabria	michele.camarca@fis.unical.it
Carreira-Leal S	[198]	Universidade de Lisboa	sergioleal20@gmail.com
Čepič M	[383]	Jozef Stefan Institute	mojca.cepic@pef.uni-lj.si
Chirosa-Horie CA	[167]	Universidade de São Paulo	
Collazo-Fernández A	[421]	Universidade de Vigo	acollazo@uvigo.es
Correia R	[80]	Francisco de Holanda Secondary School	s_rakel_correia@hotmail.com
Costa MFM	[136,176,209,217,226,284,288, 367,411,433,437,447]	Universidade do Minho	mfcosta@fisica.uminho.pt
Coutinho C	[437]	Universidade do Minho	ccoutinho@ie.uminho.pt

Coutinho Costa AT	[352]	Colégio Internato dos Carvalhos	
da Rocha Afonso LP	[152]	Museu de Ciências Naturais PUC Minas	lidiabio2011@yahoo.com.br
Dias Tavares A	[16]	Universidade do Estado do Rio de Janeiro	tavares@uerj.br
Diz-Bugarín J	[10,428]	I.E.S. Escolas Proval	javier.diz@edu.xunta.es
Dorrío BV	[1,24,176,284,401,411,421]	Universidade de Vigo	bvazquez@uvigo.es
Erdoğan M	[244,322]	Akdeniz University	merdogan@metu.edu.tr
Erentay N	[69,244,322]	Middle East Technical University	nerentay@odtugvo.k12.tr
Esteves JS	[80]	Universidade do Minho	sena@dei.uminho.pt
Esteves Z	[136,226,284,288,367,447]	Externato Maria Auxiliadora	zita.esteves@gmail.com
Fernandes Lapa MI	[352]	Colégio Internato dos Carvalhos	
Fernández Zaragoza J	[377]	Health Department, Government of Catalonia	
Fernández-Novell JM	[377]	University of Barcelona	jmfernandeznovell@ub.edu
Ferreira D	[360]	Universidade de Aveiro	dulce.ferreira@ua.pt
Forinash K	[104]	Indiana University Southeast	kforinas@ius.edu
Franco S	[209]	Universidade do Minho	sfranco@fisica.uminho.pt
Fujun R	[276]	China Research Institute for Science Popularization	hljrenfujun@126.com
Garg A	[232]	University of Delhi	amit_andc@yahoo.co.in
Gil-Pérez D	[1]	Universitat de València	daniel.gil@uv.es
Godinho-Netto MCM	[96]	Centro Federal de Educação Tec. São Paulo	martha.godinho@cefetsp.br
Gonçalves Pinto J	[352]	Colégio Internato dos Carvalhos	
Gousopoulos D	[315]	University of Athens	dimgouso@gmail.com
Holubova R	[390]	Palacky University	renata.holubova@upol.cz

Hudoba G	[371]	Obuda University	hudoba.gyorgy@arek.uni-obuda.hu
Kalkanis G	[315]	University of Athens	kalkanis@primedu.uoa.gr
Khan Z	[232]	University of Delhi	
Kumar A	[232]	University of Delhi	
Lahane RD	[252]	Homi Bhabha Centre for Science Education	
Leal JP	[198]	Universidade de Lisboa	jpleal@itn.pt
Leite-Dutra JA	[152]	Museu de Ciências Naturais PUC Minas	jesicaalves_15@yahoo.com.br
Lelingou D	[337]	Hellenic Physical Society	lelingou@eef.gr
Lira M	[209]	Universidade do Minho	mlira@fisica.uminho.pt
Matsyuk O	[294]	Ternopil State Technical University	kuba.molva@ukr.net
Mesquita Contarini J	[35]	Universidade Estadual do Norte Fluminense	julianacontarini@hotmail.com
Michaelides PG	[342,348]	University of Crete	michail@edc.uoc.gr
Moraes J	[96]	Universidade de São Paulo	josuem@usp.br
Morais de Sousa A	[58]	Universidade Estadual do Norte Fluminense	annemsousa@hotmail.com
Muramatsu M	[16]	Universidade de São Paulo	mmuramat@if.usp.br
Nandi KK	[238]	Brahmananda Keshab Chandra College	kknandi@yahoo.com
Nilza C	[360]	Universidade de Aveiro	nilzacosta@ua.pt
Nogueira MI	[167]	Universidade de São Paulo	minog@usp.br
Oikonomidis S	[315]	University of Athens	sarecon@gmail.com
Oliveira Guedes SR	[89]	Colégio Internato dos Carvalhos	sar@cic.pt
Pathare SR	[252]	Homi Bhabha Centre for Science Education	shirish@hbcse.tifr.res.in
Pavlin J	[383]	University of Ljubljana	jerneja.pavlin@pef.uni-lj.si

Pečar M	[383]	University of Ljubljana	maja.pecar@pef.uni-lj.si
Pereira A	[433]	Universidade do Minho	profisicaquimica@gmail.com
Pereira da Silva JM	[89,352]	Colégio Internato dos Carvalhos	zemanel@cic.pt
Pereira-Coutinho C	[217]	Universidade do Minho	ccoutinho@iep.uminho.pt
Perera S	[191]	The Australian National University	Sean.Perera@anu.edu.au
Pérez-Pérez C	[421]	Universidade de Vigo	cperez@uvigo.es
Qiao SUN	[259]	Dalian University	
Rangachar B	[161]	Clt India	bhagya@cltindia.org
Redondas J	[114]	CPEB de Cerredo	fredonda@serbal.pntic.mec.es
Ribas-Pérez FA	[401]	Universidade de Vigo	fribas@uvigo.es
Ribeiro AF	[141]	Universidade do Minho	fernando@dei.uminho.pt
Ribeiro CR	[217,437]	Universidade do Minho	celiarosaribeiro@gmail.com
Ribeiro Vaz AT	[352]	Colégio Internato dos Carvalhos	
Rodríguez-Paz M	[10,428]	IES Valadares	montserpaz@edu.xunta.es
Ruggeri Waldman W	[35,58]	Universidade Estadual do Norte Fluminense	walterw@uenf.br
Sanches-Diniz AC	[152]	Museu de Ciências Naturais PUC Minas	anacsdiniz@yahoo.com.br
Sapia P	[395]	University of Calabria	peppino.sapia@fis.unical.it
Sharma R	[232]	Dhingra V University of Delhi	
Sitamoto C	[167]	Universidade de São Paulo	
Sitamoto S	[167]	Universidade de São Paulo	
Soares Costa RF	[352]	Colégio Internato dos Carvalhos	
Sotiriou S	[263]	Ellinogermaniki Agogi	sotiriou@ea.gr