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Editorial

Teaching and learning out-of-school

Science has shaped our current way of life. People and Society aim to strengthen scientific capability in the hope of improving their personal, material and social life. Efforts to improve scientific capability have usually been made by schools based on improving the scientific curriculum and adapting it to Science-Technology-Society relationships. However, we usually underestimate the science learning potential within non school environments where people spend most of their time.

Beyond school, there are frequent opportunities to learn about sciences. Every year, thousands of citizens visit science centres and museums. Hundreds of institutions organise science fairs, publish reports on science and aim to improve citizens' scientific learning in nonschool environments. These institutions have different social features like libraries, civic centres, universities, governmental foundations and private institutions. The "non-formal science" environment includes a wide-ranging number of situations such as TV science programmes, articles in newspapers and magazines, visits to science museums and routes through gardens or exhibitions, as well as recreational or sports activities.

Research into teaching sciences has been taking in the importance of non-formal science education as an area of study with its own challenges and benefits. Monograph studies have been published in the most important science education publications, such as the Journal of Research in Science Teaching (Feher & Rennie 2003) or Science Education (Dierking & Martin 1997). This latter journal includes a permanent section on learning in non-school environments. The International Journal of Science Education also started publishing a second journal in 2011 as a "part B", dedicated exclusively to science communication and public engagement (Stocklmayer and Gilbert 2011). In addition, the different science teaching research handbooks and prestigious scientific institutions make significant room for teaching and learning out-of-school (NRC 2009).

Previous research shows that not all good forecasts on learning science in non-formal contexts come true. As more research is done in this area, the need for new research methodologies is becoming clear. Non-formal contexts are complicated and it is a challenge to develop significant research in them. However, to understand learning as a whole, it is highly important that we take up the challenge and use our ingenuity to investigate what happens when learning is a free option, outside school. In short, this is a matter of finding out how people learn sciences by means of analysing the impact and the relationships between situations experienced by people in school, at home or in society.

Within research into non-formal contexts, the most traditional line of research is teaching and learning in museums or science centres, mainly concentrated on evaluating how visitors use modules or informative elements put on display. This research has recently extended to analyse school visits and the role of students and teachers (Guisasola and Morentin 2007). In addition, there is an increasing number of studies on research methodology in relation to the contents and dynamics of conversations between visitors and interactions with the environment. These studies also propose different theoretical research frameworks although it is too early to talk about a dominant paradigm in the area, such as the human constructivist view of learning for the school context.

Studies are emerging in other contexts beyond Museums, science centres or fairs. These contexts refer to family conversations in relation to events or TV programmes, or the effect of scientific news on social groups. This line of research is just beginning and needs more evidence and research.

The set of contributions in non-formal contexts finds that science is communicated by means of modules, teachers, family members or TV programmes and multimedia. The research highlights the influence of the mediator's role on learning targets in each situation. We need to continue researching both the products and the processes: not only what people learn but how they learn. We need to redefine methodologies already in use and introduce new ones imaginatively. Finally, we would like to be capable of long term monitoring (not only visits or programmes lasting a few hours) and find how the different media and environments collectively affect people's level of knowledge.

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The influence of the history of science in designing learning indicators: electromotive force in dc circuits

La influencia de la historia de la ciencia en el diseño de indicadores de aprendizaje: fuerza electromotriz en circuitos cc

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Abstract

In this paper we shall consider the history of science, within the concept of the teaching of the sciences, as a useful instrument for identifying where the problems lie in the construction of concepts and theories; indicating epistemological barriers that had to be overcome and the ideas that permitted advancement. From this point of view, we have developed a conceptual framework for the topic of the electromotive force. We have subsequently formulated 'learning indicators' that indicate the different stages that must be worked through in a learning sequence, and that establish the major concepts and ways of reasoning that students should learn. We shall show that in the case of electromotive force knowledge of the historical difficulties and of the ideas that contributed to overcoming these difficulties furnished us with useful information for designing solidly based teaching sequences and learning objectives

Key words: *history of electricity, electromotive force in continuous current circuits, designing teaching sequences and learning indicators*

Resumen

En este trabajo se considera la historia de la ciencia en el contexto de la enseñanza de la física como un instrumento para identificar problemas en la construcción de los conceptos y teorías. Así mismo, la historia puede indicar posibles barreras epistemológicas que debieron superarse y las ideas que permitieron avanzar. Desde este punto de vista, hemos definido el marco teórico para el concepto de fuerza electromotriz en el contexto de circuitos eléctricos. A continuación hemos definido los indicadores de aprendizaje que pueden guiar los diferentes pasos que deben trabajarse en una secuencia de aprendizaje y establecer los conceptos y formas de razonamiento más importantes. Se mostrará las evidencias epistemológicas que apoyan la secuencia de enseñanza del concepto de fuerza electromotriz.

Palabras clave: *historia de la electricidad, fuerza electromotriz en circuitos de corriente continua, diseño de secuencias de enseñanza e indicadores de aprendizaje*

INTRODUCTION

The current consensus is that the comprehension of concepts and theories requires knowledge not only of the current state of understanding of a particular topic, but also of the way that knowledge was developed and refined, over time (Duschl 2000; Matthews 1994; McComas et al 2000; Rudge & Home 2004; Wandersee 1992). The structure of science, the nature of the scientific method and the validation of scientists' judgements, are some of the areas in which the h*istory and philosophy of science* can enrich the teaching of science. Scientific concepts and theories do not emerge miraculously, but rather are the result of an arduous problem-solving process and of the rigorous contrasting with initial hypotheses (Nerssesian 1995). Consequently, knowledge of the development of explicative ideas, which eventually resulted in the current scientific model, can bring important information when it comes to designing teaching sequences (Duschl 1994).

There are many arguments defending the inclusion of the history of science in the curriculum and especially its integration in learning strategies (Clough & Olson 2004; Izquierdo & Aduriz-Bravo 2003; Seroglou et al 1998; Solomon 2002), but very few studies have been published that explore this perspective in relation to the selection of knowledge that could aid the development of teaching sequences. In this paper, within the concept of the teaching of the sciences, we shall consider the History of Science as a useful instrument for identifying where problems lie in the construction of concepts and theories; indicating the epistemological barriers that had to be overcome and the ideas that permitted advancement. Building on this information, learning indicators can be elaborated that help in designing teaching sequences that will significantly improve the teaching and learning of concepts and theories. Nevertheless, in order for this information to be useful in the design of the didactic sequence it requires a historical and epistemological study carried out with 'didactic intentionality' and knowledge of the difficulties students have when trying to learn.

We have chosen the concept of electromotive force as the field of study for our presentation. A number of inter-related reasons have resulted in the choice of this idea. Firstly, this notion is included in both secondary school programmes (age 16-18) and first year university courses in engineering and sciences. Secondly, it is a basic prerequisite for explaining the functioning of a direct current circuit. From a scientific viewpoint, and in the context of simple electrical circuits, electromotive force is a property that quantifies the energy delivered to the charge unit by the electrical generator or battery. Examples of emf sources are battery, which converts chemical energy into electrical energy. A source of emf does work on the charge passing through it, raising the potential energy of the charge. A series of 'non-electrostatic electrical actions' take place in the battery, through which energy is delivered to the charge unit and this energy is quantified by means of the property 'electromotive force'. Thus, in physics, the concept of electromotive force is defined in a very specific manner in relation to the concepts of charge, potential, electric field and current intensity; and is used to explain the behaviour of electrical generators in circuits.

From the viewpoint of the epistemology of science, we cannot underestimate an analysis of the controversy that resulted from an electrodynamic interpretation of electrical circuits, that began with Volta's explanation and that lasted through the first half of the 19th century with contributions from Ohm and Kirchhoff. The concept of the electromotive force is relevant since it coincided with the historical period that produced the transition from electrostatics to electrokinetics, and the major repercussions this produced at the technological and research level during the first quarter of the 19th century (Sutton 1981; Willians 1962; Wise 1990). One example of this technological innovation is the battery; the subject being so spectacular that one can now scarcely conceive a society without them; a few examples are: pacemakers, hearing aids, mobile telephony, a great number of home appliances.

The paper we present here aims to answer the following research questions:

a) Elaboration of a conceptual framework, based on the history and epistemology of science, that will permit us to answer questions such as: Which problem in the origin of the concept of electromotive force do we wish to teach our students?; What obstacles had to be overcome and which ideas contributed to overcoming these obstacles?; What difficulties do students have in learning the essential ideas that constitute the concept of electromotive force?

b) Formulation of learning indicators for the concept of electromotive force, based on the preceding conceptual framework and that can be useful in designing a teaching sequence for this concept. What knowledge do students need to be able to understand the function of a battery in a simple direct current circuit? What problems would be suitable as a basis for the teaching?

The principal difficulties generated during the history the development of the concept of electromotive force will be outlined first. Then we shall establish learning indicators for the concept of electromotive force that can be useful in designing a teaching sequence.

THE TRANSITION FROM ELECTROSTATICS TO ELECTROKINETICS DURING THE FIRST HALF OF THE 19TH CENTURY

Between the end of the 18th and the beginnings of the 19th centuries, the work of scientists such as Coulomb, Lagrange and Poisson, among others, permitted the fixing of the mathematical fundaments of electrostatics, in a definitive manner, by defining properties utilising analytical calculus tools (Brown 1969; Buchwald 1977; Fox 1990; Frankel 1977; Guerlac 1976; Sutton 1981).

In this sense Coulomb quantified the theory of 'action at a distance' for electrical effects, defining the charge in an operative manner, based on its dynamic effects. This advance in the conceptual construction becomes evident, taking into account that Franklin had already introduced the concept of "quantity of electrical substance", but neither he, nor his successors, were capable of measuring it. Coulomb used his electric torsion balance scale to deduce and put forward his famous law; later extended to electrical attraction, utilising an electric pendulum (Guerlac 1976).

The work of Volta and the concept of electromotive force

In the years following Galvani's experiments (1789), Volta attempted to establish the fact that "galvanic fluid", of animal origin, was the same as ordinary electricity, that is, static (Hurd & Kipling 1958). In the midst of the controversy regarding the nature of electricity, Volta discovered that when two uncharged bodies of different metals were brought into contact, either directly or by means of an electrolyte, the two metals in a closed circuit acquired a charge and remained charged despite the presence of an excellent conducting path through which the charges could flow and thus neutralise themselves (Brown 1969; Fox 1990; Sutton 1981). This is a clear break with electrostatics, since according to electrostatics, opposite charges cannot be separated, or if separated will recombine.

Volta stated that a new type of "force", or capacity, was acting upon the charges; separating them and maintaining them separated, and he named this action the electromotive force, the name that is still applied (Pancaldi 1990; Willians 1962). These explanations, describing the functioning of the battery, did not fit within the theoretical framework of the physics of the day. In the coulombian paradigm that dominated the first third of the 19th century, the electromotive force defined by Volta was merely the capacity of certain bodies to generate electricity in other bodies (Brown 1969).

THE DEVELOPMENT OF ELECTRODYNAMICS AND THE CURRENT CONCEPT OF ELECTROMOTIVE FORCE

Ohm made a transcendental contribution to the explanation of electrical circuits with a series of experimental results, permitting the construction of the first coherent theory of electrical conduction. In his book "Die galvanische Kette: mathematisch bearbeitet (the galvanic circuit investigated mathematically)" (Varney & Fisher 1980) Ohm defined his idea of the "electroscopic force", the immediate predecessor of electrical potential in the case of electric circuits. He later defined the property 'voltage' (in his German works he utilised the word 'spannung') in a part of the circuit, as the difference between the "electroscopic forces" at its terminals.

In the same way that Fourier distinguished between heat and temperature, surmising that the flow of heat between two adjacent parts of a system is proportional to their temperatures, Ohm's theory makes *the quantity of electricity* the critical variable, allowing the *superficial charge density (electroscopic force)* the same role mathematically that temperature played in Fourier's theory. The electroscopic force was measured with an 'electrostatic instrument' in the same way that a thermometer measures temperature. Ohm's model was situated in the electrostatic paradigm.

When Kirchhoff began his study of Ohm's laws around 1847; electromagnetism having been further elaborated and the distance between electricity and galvanism reduced; there were sufficient similarities and the electrostatic paradigm was no longer prevalent, even less so in Germany. This German physicist, after analysing Ohm's work on conduction and Kohlrausch's on the measurement of voltages in capacitors, identified Ohm's electroscopic force with the difference in potential. This identification was possible only because of the change made by the introduction of the concept of energy: this new perspective permitting a global macroscopic interpretation of electrical circuits. The very same Helmholtz utilised Kirchhoff's work in his last developments on the principal of conservation of energy, published in 1847.

Explicatory models of electrical current received a new impulse with the theory of fields initiated by Faraday and developed later by Maxwell in 1865. This conceptual framework permitted development of the concept of energy associated with a field, being either conservative force (potential energy) or non-conservative force (electromotive force in the case of the battery in direct current circuits and in electromagnetic phenomena). It is in this energy and field paradigm that we currently define the concepts of electrical potential and electromotive force (Chabay & Sherwood 2002). The two concepts are epistemologically related, but quite distinct; as also happens with other concepts, for example, force and acceleration in dynamics.

The current definition of electromotive force for direct current circuits

We shall limit our definitions to the case of stationary direct current circuits, that is, comprising a battery, conducting cables and resistors. For these configurations, the electromotive force (emf) determines the energy that the battery supplies to a load unit that bridges any particular section of the circuit. This type of process in the battery usually consists of a series of chemical reactions that in general we can call "non-conservative actions" (Whittaker 1951). In the case of the battery the electromotive force is the cause of a separation of charges of different polarity between its electrodes, and thus the cause of a constant potential difference between its electrodes. Suppose chemical reactions do work $W_{chemical}$ (non-conservative actions within de battery) to move charge q from negative to positive terminal. In an ideal battery in which there are no internal no internal energy losses, the quantity $W_{chemical}/q$ which is the work done per unit of charge by the chemical reactions, is called the emf of battery (Knight et al 2007).

To summarise the historical developments, Table 1 presents the principle ideas of the different models implicit in the given description.

The word 'model' is polysemous and can thus be utilised to express different meanings (Matthews 2007). We use it here as an abstract scheme of

Table 1. Different explanatory models of a battery in a simple direct current circuit

Experimental facts in relation to the functioning of a battery in a circuit	Volta's model	Coulumbian model	Ohm's model	Kirchhoff's model
- Volta's battery On placing two different metals in contact by means of a "humid conductor" he finds that each acquires a net charge of opposite polarity.	The 'electromotive force' of the battery is its capacity to separate charges and to maintain them separated.	The electromotive force of a battery is no more than the capability some bodies have to generate electricity in others.	The notion of 'electroscopic force', related to the superficial charge density.	The electromotive force that separates charges in the battery measures the energy delivered to the load unit in the circuit. The battery generates an 'electroscopic force' differential that is identified as the potential difference as defined by Poisson.
- Electricity and charged bodies	Qualitative property. Electric fluid	Quantitative property. Electric fluid	Quantitative property. Electric fluid	Quantitative property. The electric fluid notion starts to become doubtful.
- Electrical current in a circuit	Cannot yet be measured	Cannot yet be measured	The current is caused by the difference in 'electroscopic force' value between two points	Quantitative property can be measured with the galvanometer.
- Rudimentary direct current electric circuits.	The notion of the closed circuit.	Charged bodies with electricity of different polarity attract each other by means of a conductor that connects them.	Analogy to Fourier's theory of heat. Electric current circulates through the circuit because of the difference in value of the 'electroscopic force' (superficial charge density) between two points of the circuit.	Electric current circulates because of the potential difference between two points of the circuit. Regards the movement of current as an equilibrium between the energy generated in the battery and that consumed in the circuit

the reality, considering that this reality can belong to the world of phenomena or of concepts, the model's role is relational or intermediary and plays an important role in the comprehension of the fact to be analysed, and in this case we have used it to better comprehend the process of conceptual capture (Halloun 2007; Justi & Gilbert 2000).

LEARNING INDICATORS FOR THE CONCEPT OF ELECTROMOTIVE FORCE IN SIMPLE DIRECT CURRENT CIRCUITS

In many scientific fields we find a gradation of theories and models capable of explaining and predicting an ever-increasing number of phenomena (Justi & Gilbert 2000). The greater the variety and precision of phenomena, the more complex will be the explanatory theory capable of explaining them. In this particular case, we believe that *Kirchhoff's model (extended by the current concepts of charge, work and energy)* rationally explains why the battery separates charges of different polarity, what happens when the battery is connected to a conductor with resistors, and why the current circulates throughout the circuit. This model does not contradict the currently accepted model; on the contrary the current model complements it and explains with greater precision and, predictive power, the phenomena that take place in the circuit. The model appears to us to be adequate for teaching simple direct current circuits to Secondary School students (age 16) who are beginning their study of electricity. That is, Kirchhoff's model (with the current concepts of charge, work and energy) appears to us as an intermediary model, but that is sufficiently coherent and predictive that students can construct a satisfactory explanation of the functioning of a battery in a direct current circuit from a scientific viewpoint. In fact, this model encompasses all the knowledge related to electricity that is contained in the Spanish science curriculum for secondary school (ages 16-18) and that is currently in use, although with scarce success (as demonstrated by research into the teaching of the sciences). In the Spanish secondary school curriculum, students are introduced to the study of electric circuits following a very elementary analysis of fields and electric potential in electrostatics. Frequently, this initial teaching input does not relate the study of electric circuits to the concepts of electrostatics.

As a result of what has just been set out, we consider that the question around which to organise the teaching sequence in order to achieve a basic understanding is *"how and why is electric current generated continuously in a simple circuit?"* The goal of this teaching sequence would be for students to be able to explain: what the property of the battery is that generates electrical current in a circuit and how that property is measured, constructing a concept of electromotive force within a functional model (the Kirchhoff model).

Choosing a problem that will guide us in the selection of knowledge that we want our students to learn is not sufficient. It is necessary to delve further into the sequence of potentially relevant ideas, in order to arrive at a comprehension of the concept of electromotive force within the model, and to overcome any possible obstacles to comprehension. This concretion involves the definition of "learning indicators". The concept of "learning indicators" allows us to sequence the principle stages that teachers must work through when designing teaching programmes. We have utilised this concept in order to specify the most significant concepts and the forms of reasoning that should make up students' learning objectives. The learning objectives decided upon for an adequate comprehension of the concept of electromotive force in Kirchhoff's model (extended by the current concepts of charge, work and energy) are set out below:

1. It is well known that charges are displaced along a conductor when a potential difference exists between its extremes. Thus, when constructing an explanatory model of the movement of charges in a simple direct current circuit such as the one in Figure 1, it is necessary to know that *a potential difference must exist between points a and b of a conducting wire, in order for the charges to be displaced along the wire.*

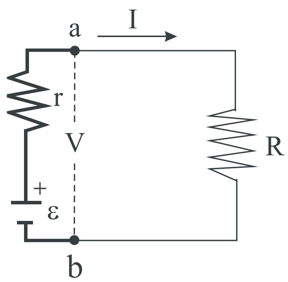
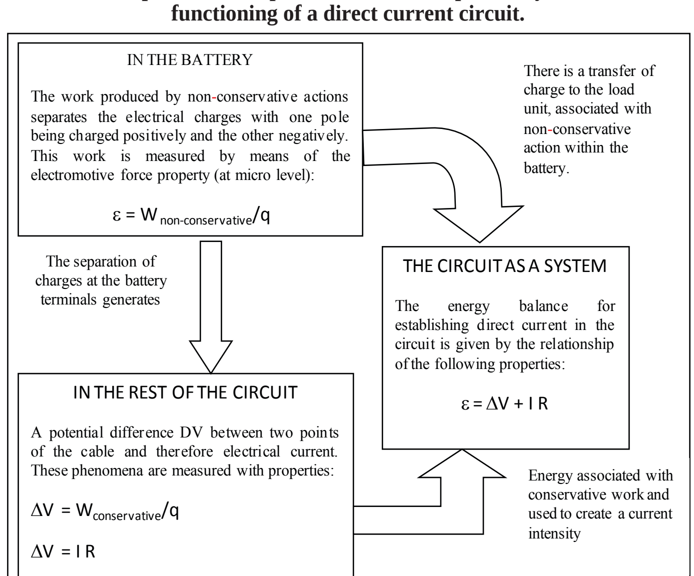


Figure 1. The darker lines represent that part of the circuit comprised of the battery. The lighter lines represent the rest of the circuit.

2. One way to generate a potential difference is to separate charges of different polarity within a spatial area, and in the case of a direct current circuit this function is realised by the battery. Therefore, it is necessary to know that *the need to define the concept of electromotive force results from the fact that the battery separates charges and creates a potential difference.* Within the battery, forces of different natures act upon the charges: non-electrostatic forces (non-conservative actions) and electrostatic forces of repulsion (conservative actions).
3. The quantitative measure of the energy used in the battery to separate the charges (and to maintain them separated) is given in an operative manner by the work per unit of charge performed by the non-conservative forces $fem_{ab} = \frac{W_{chemical}}{q} \int_a^b \frac{\vec{F}_{no-conservative}}{q} d\vec{l}$ (interpretative level) and by the potential difference and the current intensity $\varepsilon = \Delta V + Ir$ (empirical level). Thus, it is necessary to know that *the electromotive force is the property that measures the work per unit of charge done by the non-conservative forces to separate the charges and to displace them to the electrodes.*
4. The potential difference that we measure between points 'a' and 'b' belongs to the external part of the circuit (the lighter lines in Figure 1) and corresponds to the work performed in moving the charge units within a conservative electric field. In this sense, an operative definition of the potential difference is given, at the interpretative level, as $V_{ab} = \frac{W_{electrical}}{q} - \int_a^b \frac{\vec{F}_{coulombiana}}{q} d\vec{l}$ and at the empirical level as $V_{ab} = I R$. *The difference between electromotive force and potential difference results from measuring different types of action produced by radically different causes.* The first caused by non-conservative forces and the second by conservative forces. This implies understanding that *the electromotive force is a physical property that quantifies a transfer of energy (from the battery to the circuits loads) associated with a non-conservative action.*
5. From the above we deduce that the 'electromotive force' (emf) is a property of the electric energy generators and is not a property of either the circuit, or of the charges.
6. The use of scientific strategies of investigation For example: analyse problems qualitatively, conceive working hypotheses, design and perform experiments, devise models with adequate limitations, interpret numerical data physically, critical analyses of propositions, etc in the context of a direct current circuit composed of batteries and resistors.
7. Know how to analyse the Science, Technological and Sociological (STS) applications that will permit the contextualisation of the learned theory and that will permit them in the future, as the citizens they are, to adopt responsible attitudes towards technological developments and their social implications.

These learning indicators bring together a number of concepts that confirm the explanatory model of how and why continuous electric current is generated in a simple circuit, and give it significance. Table 2 presents these relationships:

Table 2. Map of the concepts utilised in the explanatory model of the functioning of a direct current circuit.



The historical and epistemological analysis not only allows us to make decisions as to the contents of the learning sequence, they also allow us to identify the obstacles that had to be overcome in arriving at the explanation given by Kirchhoff, permitting a solution that is compatible with current scientific theory. Different works in science education show the benefit of taking into account these historical obstacles when it comes to designing teaching strategies (Benseghir & Closset 1996; Leach & Scott 2002; Seroglou et al 1998); other research has repeatedly indicated the difficulties students have with each of the indicators, (Duit & Jung 1985; Furió et al 2004; Guisasola et al 2007; Guruswamy et al 1997; Maloney et al 2001; Metioui et al 1996; Thacker et al 1999) see Table 3.

Table 3. Relationship of Indicators and difficulties experienced in achieving them

Learning indicators	Difficulties
Potential difference provokes movement of charges along the conductor	Students have difficulty distinguishing between the empirical level (electric current) and the interpretative level (potential difference). They tend to identify potential difference as a property of the charge and not of the circuit.
One way to generate potential difference is by means of separation of charges. In the case of a battery this separation is work performed by non-conservative forces.	The majority of the students do not conceive electromotive force as a non-electrostatic and non-conservative action resulting in the separation of different polarity charges in the battery. They consequently do not distinguish between electromotive force and potential difference.
The property that measures the work performed by non-conservative forces is called electromotive force. Consequently, electromotive force is a property of the battery in the circuit.	How the property of electromotive force is measured is not clear to the students, and they associate it with a property of the electric charges.
Students will utilise arguments accompanied by rational justifications based on the theoretical corpus of the science and on their own scientific working strategies.	In analysing the battery in an electric circuit, the majority of students do not distinguish between the empirical level and the interpretative level, expounding instead their own common-sense reasoning.
Knowing how to analyse Science-Technological-Societal applications that allow the contextualisation of the learned theory.	The conceptual confusion and limited learning of the explanatory model hinder the students in being able to evaluate the importance of the study of technological applications in every-day life.

The relationship between learning indicators and students' difficulties leads to the concept of *learning demands* developed by Leach and Scott (2002). The learning demand from a particular area of contents arises due to differences between students' everyday ideas and the concepts and models of school science. As we have shown these differences may be ontological, conceptual, or due to epistemological assumptions. Having defined the learning demands, it will be necessary to delve further into the teaching sequence that will be used with the students, and that will result in classroom activities which give repeated opportunities for the application of a '*scientific approach*' in order to resolve problems. These activities will also directly confront the possible obstacles that students may have in working through the explanatory model. This will be the subject of further papers.

FINAL STATEMENTS

From the didactic point of view, the notions of electromotive force and potential difference, as well as their differences, were not a problem to 19th century physicists; as both concepts were investigated during the course of research that attempted to explain electrical phenomena coherently, those that are electrostatic as well as those that are not, and also their uses and applications. Therefore, and as a consequence of the priorities of the scientists of the era, the landmarks in the establishment of the concept that occupies us cannot be fixed with precision, but rather in relation to the results of other work, in the midst of which the concepts of electromotive force and electrostatic potential difference were being clarified. The History of Science shows that it is only through the explanation of direct current circuits in terms of energy; that is, in terms of potential difference (the work per unit of charge of conservative forces) and of electromotive force (the work per unit of charge of nonconservative forces); that a scientific understanding of these is possible. We note that, although it is ingenuous to establish a reciprocity between the historical difficulties that had to be overcome and the difficulties of students, amongst other things because the cultural contexts are very different, there can be no doubt that the History of Science gives us, through the resolution of problems over time, a good opportunity for not underestimating our students' difficulties and to select the knowledge, problems and activities that attempt to overcome them.

It may be the case that teaching of electricity should include more clearly the fundamental interrelations existing potential difference and electromotive force, as suggested here in the context of dc electrical circuits. Students should also work more with the concept of potential difference in a circuit as a property that explains the movement of charges between two points on a conductor, which should improve their eventual understanding of potential difference and electromotive force and their differences. One implication of the study for is the necessity of introducing the concepts of electromotive force and of potential difference in the context of the problem of finding an explanation for the way that a battery functions in a direct current circuit consisting of wires and resistors.

The ideas and the findings reported here have provided us ideas to define a research-based didactic sequence on teaching the concept of electromotive force concept in the context of dc circuits at High School and University (see table 3). Mulhall et al 2001 "Simplifications are necessary in physics teaching…The essential issue being illustrated by the above quote is that these simplifications (in the area of electricity) are idiosyncratic (to the textbook, and also then to the teacher), confused and therefore confusing to students"(p. 582). So, we believe this contribution may be relevant as one of the problems pointed out by research into the teaching of science in the area of electricity is the lack of consensus in the choice of teaching objectives for teaching sequences.

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Some personalities of the history of science and mathematics through postage stamps

Algunas personalidades de la historia de la ciencia y las matemáticas a través de los sellos de correos

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Abstract

The philately may be a powerful way of communicating science, to persuade society about the relevance of the scientific research. This work proposes that it is possible to communicate and to teach the mathematics through commemorative postage stamps images. By a survey carried through in the postal stamps emitted by some countries of 1843 the 2010, it was looked to analyze and to divulge the contents historical of some scientists who had contributed with the evolution of the mathematical thought. The initiative and results of this work reveal some possibilities to study the contents of the postage stamps, especially related to classic sciences themes.

Keywords*: science and math teaching; history of science; biography of mathematicians; philately.*

Resumen

La filatelia puede ser una poderosa forma de comunicación de la ciencia para persuadir a la sociedad sobre la relevancia de la investigación científica. Este trabajo propone que es posible difundir y enseñar matemáticas por intermedio de las imágenes presentes en sellos postales conmemorativos. Por una encuesta realizada a través de los sellos emitidos por algunos países de 1843 al 2010, buscó analizar y divulgar el contenido histórico de algunos científicos que han contribuido con la evolución del pensamiento matemático. La iniciativa y los resultados obtenidos en este trabajo revelan algunas de las posibilidades para estudiar el contenido de estos sellos postales, especialmente los relacionados con los temas clásicos de la ciencia.

Palabras clave: *enseñanza de las ciencias y las matemáticas, historia de la ciencia, bibliografía de los matemáticos, filatelia.*

INTRODUCTION

The word philately - a term etymologically formed by the Greek words *phylos* (friend) and *telia* (rate) - is defined as the study and the habit of collecting postage stamps. This habit has begun in 1840, practically with the invention of the postage stamp when, in England, the general manager of the post, Sir Rowland Hill, understood that postal services should be paid previously. Sir Hill envisioned a small rectangle of paper stamped with a predetermined value, which should be pasted on the message or letter, indicating that it has been duly franchised. Thus was created the world's first stamp, the "Penny Black" (with face value of "one penny"), which featured a portrait of the Queen Victoria's profile on a black background. From the late nineteenth century, the practice of collecting and studying the postage stamps became widespread throughout most of the world. Currently, it is estimated that there are 50 million adherents spread over almost all the countries (Carazo, 2001).

Considering that the stamps were originally designed as elements of the franchise, it should not be a surprise that the first issues to worry about were little details and to portray the fee to be paid. So many pioneer stamps did not even bring identification the country or even the currency to which they valued. With the passage of time and with a greater amount of stamps in circulation, gradually, the philatelic materials began to exhibit designs and motifs that characterized the country of origin. Currently, it is understood that the postage stamps are more than a mere proof of postal rates. It is recognized that, in the small physical space they have, they provide an important source of information about socio-cultural, historical, scientific, economic aspects, and the natural resources of the emitters countries.

Due to these factors, as well as the intense use and worldwide circulation, postage stamps were seen as an efficient way of mass communication, assisting on the dissemination of knowledge in various areas of knowledge. Philately is presented as an auxiliary science to other branches of cognizance. This respect, philately can be docked as an informal education, because it has no intention, nor is institutionalized, as it is practiced in unorganized and spontaneous moments of the day-to-days.

In particular, the History of Mathematics is an important part of knowledge, since it allows us to understand the origin of the ideas that have shaped our culture. It allows the observation of the human aspects of development and also to see the people who not only created these ideas, but also studied the circumstances in which they developed. This story is a valuable tool for teaching and learning from mathematics itself. It is possible to understand why each concept was introduced on this Science and the timing of this event.

The History of Mathematics also allows connections to the General History, Philosophy, Physics, Geography and many other manifestations of the culture of a country (Merzbach, Boyer, 1991; Eves, 2004). Knowing the History of Mathematics is perceived as the theories, now classified as "finished" and "elegantly designed", always resulted of challenges faced by mathematicians. They were developed with great efforts and, very often, in an order quite different from that presented after the whole process of discovery.

It is in this direction that this work fits, that is, through a broad survey of stamps issued by various countries around the world, it aims an analysis of the History of Mathematics and to see how philately treated one of its fundamental objectives, to disseminate and encourage the Science conceived by man. The paper also proposes to develop concepts and models that serve the thematic representation of philatelic documents as, in its small footprint; a stamp may have relevant information to the contents of the philatelic History of Mathematics. These contents can serve the teachers who want to use postage stamp as a teaching tool in class, to stimulate his students to appreciate, understand and analyze images that, in this case, portrait characters who contributed to the History of Science and, at the same time, explore mathematical concepts. It is expected from the teacher, interested on applying this material in the classroom, that he/she seek to encourage people to the practice of collecting, as a stimulus to civism and informal science education.

METHODOLOGY APPLIED ON THE INVESTIGATION

A survey of the postage stamps, issued by many countries during the years 1843 to 2010, was realized based on a private collection owned by one of the authors. It involves several thematic philatelic collections, from the Astronomy, Physics, Mathematics, Music, Biodiversity, the Engineering, Flora and Fauna. Also an analysis of several postage stamps issued worldwide was made through the Internet, exploring different web page addresses and using the address called "Google". In addition to these procedures, for the case of Brazilian labels, it was made use of the "*Catálogo de Selos do Brasil – 2010*" (Meyer, 2010), a publication that released all the national stamps launched from 1843 until end of 2010.

Through all these visits there were counted 557 different prints cards, divided into the categories: regular stamp, commemorative and promotional blocks. For not being significant on the analysis that the proposed work has made, the survey carried out did not consider the special envelopes and stamps from the first day of circulation for honors effects.

To organize and to appoint the consistently honored scientist, it has been decided to adopt the name that appears at Howard Eves' book, "*An Introduction to the History of Mathematics*" (Eves, 2004).

RESULTS AND DISCUSSION: A PART OF THE HISTORY OF MATHEMATICS TOLD THROUGH STAMPS

Several countries have used postage stamps to honor representative figures in different thematic areas of philately. In the literature, among the few books dedicated to the Mathematics on postage stamps, it was possible to find the work written by Robin J. Wilson, entitled "*Stamping through Mathematics*", (Wilson, 2001). This book contains almost four hundred stamps related to mathematics, ranging from the earliest forms of counting to the modern computer age. Featured, there are many of the mathematicians who contributed to this story, influential figures and some areas whose study aided this development, such as astronomy, art, navigation, physics and engineering. Hans Wussing's book offers a journey through the History of Science by means of postage stamps (Wussing, 1989). The development of mathematics is the subject that appears in chapter 9. A review of excellent quality, containing illustrations of many mathematicians, is called "*Spectrum of Sciences (09/02 Special)*", and was published by the German Heinz Klaus Strick (Strick, 2009). The chapters contain subjects appropriated to the History of Mathematics, and the stamps have a mathematically oriented introduction.

The thematic collections have emerged as a natural evolution of philately and consolidated markedly from the past half of the century. In principle, the collections involved the grouping of isolated stamps from various countries, depicting a specific topic or aspect. This type of material philatelic collecting has revealed a new facet to the postage stamp: its cultural and educational value, as well as being an important vehicle for communicating the values of a given society (Castro, Diniz, Barros, 2007).

It is difficult to say when, how and where mathematics began. However, with the invention of agriculture came the need to plan and divide the work, as well as think how to share the land and its fruits, and understand better the cycles of the seasons and count time using calendars. This led the man to observe the stars and to improve their understanding of what we call "number". Although man, for thousands of years before the invention of agriculture, already had the notion of quantity, it was the agricultural revolution that occurred around the 9th century BC that intensified trade, the cities were erected, governments and taxes been established and thus, temples, monuments and buildings began to be built.

Through a comprehensive survey of the literature it was found that, to the present date, no work involving the theme "History of Mathematics" was published using the philatelic world available material. Certainly, this work is important not only for the audience interested on philately, but also for those teachers who work in different areas of mathematics. Then, it is also through the stamps that become possible to offer the students a more depth, intimate, seductive, provocative, informative and scientific visual space about a social, political and cultural order of a particular country.

EARLY MATHEMATICS UNTIL THE BEGINNING OF THE MIDDLE AGE

Nicaragua, in 1971, portrayed the idea of counting using a stamp depicted in Figure 1A, which can be interpreted as an Egyptian, that when sees two birds flying, count on his fingers and records this value in his memory, represented in the background of the image by a human brain.

Starting from around 600 BC, mathematics and astronomy flourished for over a thousand years throughout the Greek-speaking world of eastern Mediterranean Sea. During this time, the Greeks developed the concept of deductive logical reasoning that became the hallmark of their work, especially in the area of geometry. In addition to the advances made in Mesopotamia and Egypt, in ancient China there were also several developments to facilitate human life, many of these have used observation and induction. Pythagoras (~586 - ~500 BC) was strongly influenced by the ideas of Thales of Miletus (~640 - ~564 BC), considered the "Father of Deductive Mathematics". He predicted a solar eclipse in 585 BC and showed how rubbing with a stone can produce electricity in feathers.

It is known that Pythagoras was a little over 20 years when Thales died and is believed that the Pythagoreans were the first to produce reasonably accurate statements. Perhaps they were the first to see mathematics as something abstract, while they saw the presence of mathematics in the physical world, leading them to believe that the world was made of numbers. In addition to these contributions, the Pythagoreans spread throughout the Greek world an epidemic of interest in the study of mathematics. Greece honored Pythagoras with the stamp in Figure 1B, that suggests the demonstration of the Pythagoras´ theorem can be stated, in this case, as in any right triangle, the area of the square on the hypotenuse of a right-angled triangle is the sum of the areas of the squares on the other two sides. (Eves, 2004, p. 183).

Aristotle (384-322 BC), systematizing deductive logic, appears honored on the postage stamp issued by Gibraltar (Figure 1C). The expert on calculating, mathematician, physicist, astronomer and engineer, Archimedes (287-212 BC), who performed the first time to accurately measure a circle, when came to the conclusion that the number pi (π) is between 223/71 and 22/7 (or, between 3.140845 and 3.142857, respectively), was remembered in stamp issued by Guinea Bissau (Figure 1D).

Perhaps the most important mathematicians of antiquity, Euclid of Alexandria (360-295 BC), who left his immortal work, "*Elements*", containing the famous postulates of Euclid, was remembered by the Maldives in the pattern in Figure 1E. After the contributions of Aristarchus of Samos (310-230 BC), the geocentric system, and Eratosthenes, with the measure from the Earth, the Greek mathematician and astronomer, Hipparchus (190-126 BC), was remembered by Greece in the stamp illustrated in Figure 1F. In this postage stamp, Hipparchus appears next to two images: an "armillary sphere" (ancient instrument of astronomy, applied in guidance and navigation) and a line indicating N (north) and S (south).

Entering the "Common Era", around the year 150, Claudius Ptolemy (90-168), who worked with trigonometry, board chords, planetary theory, geodesy, producing the work "*Almagest*", which ended up influencing many generations of scientists until the late Middle Age, was honored by the label of Figure 1G.

Tsu Ch'ung Chih was a Chinese mathematician and astronomer who lived from 430 to 501 (Figure 1H). His way to obtain an approximation of the number π was through the ratio of 355/113, which gave him a correct value for six decimal places of precision, that is, the value of 3.141592. It was through this value, that applying it to astronomy, he came to calculate the exact time of occurrence of the solstices[1], only measuring the shadow casted by the sun at midday the day before or after a solstice (Eves, 2004, p. 732).

The Soviet Union postage stamp in Figure 1I, from 1983, displays the Persian mathematician Mohammed ibn Musa al-Khowarizmi (780-850), who lived in the ninth century and who wrote an influential treatise of algebra called "*Hisab al-jabr w'al-muqabalah*" (hence the origin the word "algebra"). Besides this work, he wrote a book about the Indo-Arabic numerals, dealing with the positional counting, including the use of the number zero. It was from this work that the word algorithm was originated.

Ab Muhammad bin Ahmad al Rayhan Biruni (973-1048), or simply al-Biruni, was an extraordinary Iranian mathematician, astronomer, physicist, physician, geographer, geologist and historian. He is also considered an impartial writer on custom and creeds of various nations and was the most prominent figure in the Islamic science (Figure 1J). His great contributions in various fields gave him the title "al-Ustadh", or "Master or Teacher of Excellence." In the field of mathematics, he conducted numerous studies about angles and trigonometry.

At the end of the twelfth century, in Italy, emerged the figure of Leonardo Fibonacci (1170-1250), also known as Leonardo of Pisa, perhaps the most talented mathematician of the Middle Age. He worked with arithmetic, algebra and geometry, but the most remarkable work of his career was the one that gave rise to important *Fibonacci sequence* (0, 1, 1, 2, 3, 5, 8, 13, 21, 34, ..., x, y, x + y, ...). The stamp issued by China, reproduced in Figure 1K, illustrates this problem through draws of rabbits reproducing.

Figure 1 - Some postage stamps from the survey conducted in this work that show mathematical reasons and remember the accomplishments of personalities who contributed to the evolution of mathematics from Antiquity to the Middle Age (fourteenth century).

To end this period of development of mathematics, we must mention the fifteenth-century Persian astronomer, mathematician and sultan Mirza Muhammad Tariq bin Shahrukh, known as Ulugh Beg (1394-1449), who was remembered for a stamp of the Soviet Union (Figure 1L). Ulugh Beg was notable for his work on trigonometry and spherical geometry. He has produced remarkable trigonometric tables, containing sines and tangents in increments of one minute of arc (1'), right up to the eighth decimal place.

1 Solstice = Latin: sun + sistere, that does not move, it is the moment when the Sun, during its apparent movement on the celestial sphere reaches the largest decline in latitude, measured from the equator.

RENAISSANCE AND THE AGE OF EXPLORATION

The fifteenth and sixteenth centuries witnessed the beginning of the European Renaissance in art and knowledge. This Renaissance period, from the standpoint of mathematics, can be defined as work on arithmetic, algebra and trigonometry, mainly due to the needs of business activities, under the influence of commerce, navigation, surveying and astronomy. Names such as Nicholas Cusa (1401-1464), who worked with attempts to square the circle (constructing a square with the same area as a circle) and the angle trissecion, the German, Johann Müller, known as Regiomontanus (1436 to 1476) with his works on flat and spherical geometry applied to astronomy; Girolamo Cardano (1501-1576), with his works in algebra, Nicolo Tartaglia (1499-1557), with studies on cubic equations; François Viète (1540-1603), with contributions to algebra, geometry, trigonometry, notation, numerical solution equations, theory of equations and of the infinite product converges to 2/ ; Christopher Clavius (1537-1612), with the publication of works on arithmetic and algebra, and the work in trigonometry and astronomy, among others that should not be forgotten. Unfortunately, none postage stamp of these mathematicians was found in the survey.

This work begins the Renaissance period with the Polish astronomer who propelled the Mathematics and crystallized the heliocentric system to explain planetary motions, Nicolas Copernicus (1473-1543). In 1973, Copernicus was honored by the 500th anniversary of his birth, through postage stamps issued by many countries. Figure 2A illustrates one of these honors through the Brazilian stamp.

Two important astronomers contributed to mathematics again in the early seventeenth century: the Italian Galileo Galilei (1564-1642) and the German Johann Kepler (1571-1630). Several countries have launched stamps honoring these two exponents of the History of Science, mainly due to the legacy of both for the good of humanity. From this extensive philatelic material it is worth mentioning in the Italian label of Figure 2B, which depicts Galileo and his greatest invention, the astronomical telescope. On the stamp of the Republic of Benin, was known as "Republic of Dahomey" (Figure 2C), it appears the bust of Kepler with his greatest discovery, the laws of planetary motion.

The French stamp of Figure 2D illustrates Blaise Pascal (1623-1662), who contributed to the understanding of conic sections, cycloid and probability. The physicist and philosopher René Descartes (1596-1650), who also worked with the oval curves, the rules of signs, in addition to analytical geometry, appears the Albania stamp in Figure 2E. Pierre de Fermat (1601-1665), who worked with high and low probability and the known "Fermat's Last Theorem", is remembered by a stamp issued by the French Republic (Figure 2F), in which the equation appears in reference to this famous theorem.

Two great scientists appear on the Germany stamps of Figures 2G and 2H. Respectively, Isaac Newton (1642-1727), who described the relationship of mutual attraction between planets and celestial bodies of the universe (Figure 2G) and Gottfried Wilhelm Leibniz (1646-1716), who developed a calculation system independently of Newton´s, and was unfairly accused of plagiarism by Newton's followers (Figure 2H). A series of British stamps reproduced in Figure 2I is a tribute to the accomplishments made by Newton in the fields of mathematics and physics.

Jakob Bernoulli (1654-1705), who worked with Leibniz in the formalisms of differential and integral calculus and played an important role in the development of the probability theory, is remembered for philately in a Swiss stamp depicted in Figure 2J. Figure 2K shows a stamp in honor of the mathematician, physicist and German astronomer Carl Friedrich Gauss (1777-1855). Gauss is known as the "Prince of Mathematics", due to the important work performed within the mathematical analysis.

The movement aiming to strictly print the fundamentals of analysis began in the nineteenth century, with Lagrange and Gauss, but the participation of the French mathematician Augustin-Louis Cauchy (1789-1857) broadened and deepened considerably this work. The bi-centenary of Cauchy´s birth was remembered with a French stamp (Figure 2L) in which his face appears along with charts and formulas that remember his contributions to the approaches of the calculation contained in the current college texts, functions of complex variable, infinite series, in differential equations of Cauchy-Riemann.

The Norwegian Niels Henrik Abel (1802-1829), which appears in Figure 2M, greatly contributed with articles in several areas such as the convergence of infinite series, Abelian integrals and elliptic functions. A French stamp, referring to the importance of Galois´ work, a precursor of group theory, is reproduced in Figure 2N.

Nikolai Ivanovich Lobachevsky (1793-1856) was a Russian mathematician (Figure 2O) who worked extensively and published the first version of the non-Euclidean geometry, that is, one that does not make use of Euclid's fifth postulate, but treats it as a special case of it.

Figure 2 - Some postage stamps from the survey conducted in this work that show personalities who contributed to the evolution of mathematics from Renaissance to the nineteenth century.

William Rowan Hamilton (1805-1865), the greatest mathematician of the Irish, stood out for his works of non-commutative algebra in four dimensions, also called as quaternions. Besides these, he wrote papers on optics, dynamics, and numerical solutions of differential equations. Georg Friedrich Bernhard Riemann (1826-1866), in the work under analysis, non-Euclidean geometry and Riemannian geometry, Georg Ferdinand Ludwig Philip Cantor (1845-1918), with set theory, irrational numbers, transcendental numbers and the transfinite numbers and Karl Theodor Wilhelm Weierstrass (1815-1897), arithmetization in the analysis and definition postulacional determinant, among others, were mathematicians who have left their mark in the world of science. Unfortunately, in this survey, there are no postage stamps in honor to them.

The Russian mathematician who became interested in partial differential equations and the reduction of Abelian integrals of the third kind was Sonja Kovalevsky (1850-1891). In this survey, the stamp of Figure 2P, dedicated to Kovalevsky, is the only one found in honor to a woman who developed mathematic papers.

TWENTIETH CENTURY UNTIL TODAY

The examination of the grounds and the logical structure of mathematics is the largely work of this science in the late nineteenth century and throughout the twentieth century. This led to the creation of axiomatic, the study of systems of postulates and their properties. Only after the foundations of geometry and an intensive and detailed study, that logically satisfactory sets of assumptions to support Euclidean geometry, plane and space. Among the mathematicians who contributed most in this sense, stands out David Hilbert (1862-1943). Shown on the stamp of the Democratic Republic of Congo (Figure 3A), Hilbert, one of the greatest mathematicians of all time, has developed work in axiomatic calculus of variations, integral equations in set of postulates for Euclidean geometry, among other fields.

The most famous scientist of the last century, the mathematician and physicist Albert Einstein (1879-1955), known as the “Father of the Theory of Relativity” was honored in several philatelic series in many countries. Figure 3B reproduces two commemorative stamps of the Republic of Serbia and Montenegro. On the stamps on the left, Einstein appears next to a figure illustrating the curvature of space-time, while on the right stamp he appears next to the famous equation of mass-energy equivalence, $E = mc^2$.

The scientist who contributed with important work in set theory, game theory, numerical analysis, statistics and economics, John Von Neumann (1903-1957), was honored by the centenary of his birthday with the Hungarian stamp is reproduced in Figure 3C. In this stamp, Neumann appears next to the image of an old computer and a logical layout of an electrical circuit. Neumann´s work also gave a great impetus to the development of technology information.

Figure 3 - Some postage stamps from the survey showing important contemporary mathematicians.

The most famous scientist of our time, Stephen William Hawking (1942-), mathematician and theoretical physicist from London, has been conducting research on the nature of space-time and on the singularities created by a black hole. Hawking, remembered for the final stamp of this series, issued by the Republic of Palau (Figure 3D), appears next to an illustrative representation of how the space would be around a very massive body (a black hole).

Many other great mathematicians or physicists–mathematicians of the twentieth century and the beginning of this century – some linked to revealing the secrets of the structure of matter, others involved in the manufacture of nuclear weapons, others devoted to pure mathematics, as well as the Nuclear Physics and Cosmology, the Quantum Mechanics, the Theory of Relativity and Astrophysics – deserved to be remembered in this work. However space limitations and the lack of postage stamps in tribute to them did not make it possible.

FINAL REMARKS AND CONCLUSIONS

This work was an effort to contribute to an unexplored field of scientific literature: the History of Mathematics through postage stamps. With 37 stamps issued by several countries over eight decades, we attempted to rescue an important area of mathematics and the contributions some scientists have made in order to evolve the concepts of this science.

Mathematics through philately is characterized by the emission of postage stamps that represent elements of the evolutionary history of mathematics, the countries and the personalities who contributed to this evolution, in addition to the countries that recognized and honored mathematicians.

The periods discussed here were represented by postage stamps that, normally, not only show the human figures who contributed to the development of mathematical thinking, but also make use of equations, graphs and geometric figures like triangles, squares, cylinders, cubes and spheres.

It is worth nothing that among the different media available, postage stamps still represent a powerful vehicle of communication. This vehicle is still little used by teachers in the classroom to make a historical approach to content, featuring the students the evolution of mathematics over time. In this context, postage stamps help this method when focusing on the ways in which this evolution occurred, not only in historical, but also in social and economic context and geographic location where it occurred.

In fact, results of research in the area, with teachers in continuing education, indicate the important function of informal education making use of other educational devices, as a focus for dissemination and education in the sciences, developing highly motivating activities with teachers and students from the primary, secondary and tertiary education. In this context, the stamps can serve as another option for teaching and learning, because this material is an attractive feature that can be used with auxiliary devices, such as projectors, datashow, photos, Internet, etc. Certainly, the educational approach is still a challenge for many educators, indicating that there is still a long way to go.

The results of this study reveal a great deal of scopes for existing studies on the contents of postage stamps, especially those related to themes of the histories of other sciences and their interfaces with mathematics. It would be interesting that other works explore this enormous cultural wealth. In this sense, the authors intend to investigate the possible intersections between mathematics and other sciences through philately.

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Illustrating the invisible: engaging undergraduate engineers in explaining nanotechnology to the public through flash poetry

Ilustrando lo invisible: comprometiendo a estudiantes de ingeniería a explicar nanotecnología al público

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Abstract

A preliminary investigation of the merits of engaging undergraduate students in communicating the significance of nanotechnology to a lay audience was conducted. The remit is to create displays that could be directly handled by the general public and which demonstrate the main challenges faced by working at such small scales. The students were asked to compose poems which would be rendered on the micron scale on glass microscope slides by conventional photolithography and which would be indecipherable to the naked eye. The intention was to create a "magical" transition whereby the subsequent application of a magnifying glass by the handler would reveal the text and nature of the composition. Production of the microslide displays can be achieved through conventional photolithographic techniques, requiring modest outlay in terms of time and materials and thus being readily accessible to most engineering/physical science faculties. The practicalities of slide production and their utilisation as an out-reach tool to emphasize the micro-nano challenge is presented. In addition, the curricular issues and student response relating to the integration of the hybrid literary-engineering component as a complement to "Professional Skills" modules within a first year cohort is critically discussed.

Keywords: p*oetry, transferable skills, professional skills, nanotechnology, visualization*

Resumen

Se llevó a cabo una investigación preliminar sobre los méritos de involucrar a los estudiantes universitarios en la divulgación de la importancia de la nanotecnología a un público no especializado. El mandato es crear pantallas que puedan ser manejadas directamente por el público en general y que demuestren los principales desafíos a los que se enfrenta el trabajar a escalas tan pequeñas. Los estudiantes fueron invitados a componer poemas que se presentarían en una escala de micras en un portaobjetos de vidrio mediante fotolitografía convencional y que serían indescifrables a simple vista. La intención era crear una "mágica" transición por la cual la posterior aplicación de una lente de aumento por el controlador podría revelar el texto y la naturaleza de la composición. La producción de las pantallas portaobjetos se puede lograr mediante técnicas fotolitográficas convencionales, que requieren un gasto modesto en términos de tiempo y materiales y por lo tanto, son fácilmente accesible para la mayoría de las ingenierías / facultades de ciencias físicas. Los aspectos prácticos de la producción de diapositivas y su utilización como una herramienta de divulgación para hacer hincapié en el desafío de la micro-nano se presentan. Además se discute críticamente si, los temas curriculares y la respuesta de los estudiantes acerca de la integración del híbrido literario-componentes de ingeniería, como complemento a las "habilidades profesionales" modula dentro de una cohorte de primer año.

Palabras clave: p*oesía, habilidades transferibles, habilidades profesionales, nanotecnología, visualización*

INTRODUCTION

Nanotechnology has become an increasingly fashionable term in the media and is frequently portrayed within advertising promotions as representing a new panacea for improved performance – irrespective of the nature of the actual product or the "nano" modification (Ho et al, 2011; Dudo et al, 2011; Ackland et al, 2010). The significance of the term risks being trivialised but, more worryingly, the general ignorance of what "nano" really means can plant the seeds for future technophobia as witnessed by current concerns over the use of "nanosilver" (Cacciatore et al, 2011; Bostrum and Lofstedt, 2010; Siegrist, 2010; Satterfield at el, 2009). While it is unrealistic to expect the lay person to absorb the fundamental principles of the science, it is nevertheless important that they have an opportunity to embrace the core concepts in order to be able to discriminate the hazards from the benefits (Powell et al, 2011; Vandermoere et al, 2010). It is also equally important that the next generation of scientists and engineers are able to communicate, in lay terms, the nature of the work in which they are engaged (Gardner et al, 2010). The aim of the present communication was to investigate the potential for a combined literary-engineering approach that could address the latter whilst also serving to create interactive displays that could be used for out-reach activities and could capture the imagination of a lay audience.

The transferable skills of students have been a long standing concern within the engineering and physical sciences, countered to some extent with the near ubiquitous introduction of "Professional Skills" modules – almost invariably within the first year undergraduate course (Hunter et al, 2010). The remit is primarily to complement the academic course components and to improve the future employability and integration of the students within the workplace. While these are effective at addressing the technological aspects of communication, presentation, information retrieval and data analysis, they often fail to address issues in relation to the underlying literacy of the students (Mustaro, 2010; Anthony et al, 2010). Moreover, they will often do little to enhance their ability to communicate to a lay audience. In most cases the literacy component is assessed through the submission of an essay on a given topic relevant to the engineering sub-discipline being taught. There is a danger however that, barring the allocation of a few marks for grammar and presentation, the assessment process becomes unduly biased towards the use of information sources and the retrieval of the key concepts/facts. The use of the essay format to constructively counter the deficiencies in language and communication skills of the students too often can be sacrificed – thus reflecting that it is the engineering teaching staff, who are responsible for the delivery of such programmes. In such cases, they may lack the pedagogical skills to support the development of greater literacy and the confidence to engage the students in a way that seamlessly integrates the literacy/art aspects directly with engineering (Nathan et al, 2010).

One obvious solution to the problem is to develop inter-departmental associations in which the appropriate expertise is brought in to supplement the teaching, with a number of programmes already adopting such a strategy (Moran, 2008; Christy and Lima, 2007). In most cases, these have tended to focus on the art/illustrative components where there is a clear link with the drafting/perception skills of the engineers (Gabe and Abel, 2011; Trifonova et al, 2007; Ruttkay and Mouthaan, 2008; Gridley, 2007). Few however find mainstream application and most are the result of pedagogical research collaborations. While the outcomes of such studies have been largely supportive, have clear merits and would be universally welcomed within the engineering departments, financial constraints can inhibit individual departments. Surrendering portions of a precious budget to an external department is clearly an unattractive option - especially where the module may be considered as not being core to the overall degree outcome. A "make do and mend" approach is invariably the route taken and the one which this investigation seeks to explore.

METHODOLOGY

One of the main issues relating to nanotechnology is the scale and the difficulty in perceiving the "smallness". There is an extensive catalogue of nanoart which exploits the beauty inherent to many nanoscale features but these are presented to the audience in a conventional poster format and the sense of scale is inevitably lost. A nanoparticle can easily resemble that of an asteroid and while the two are at different ends of the scale – their pictures come across much the same to a general audience. Their true significance is often only apparent to those who can appreciate the difficulty in working at such scales. The present investigation sought to create examples that directly highlighted the challenges faced by constructing objects (in this case, lines of text) and characterising them at the micro-nanoscale.

The intention in the present investigation was to introduce within the Professional Skills modules an additional, lay communication, component that would complement the existing tutorials designed to teach "Scientific and Technical" writing skills. A one hour tutorial slot was arranged whereby the engineering students (N = 20, first year undergraduates) were introduced to the concept of flash fiction. The latter is a more regimented form of flash fiction - the aim of flash fiction being to produce a concise, self contained piece of literature – usually with a word limit (typically consisting of a complete story told in 55 words or less). In this instance, however, the aim is to convey facts rather than a plot line. The length of the composition was left to the discretion and imagination of the student, but a time limit of 30 minutes was levied to ensure the work would be completed within the actual tutorial.

The traditional lesson format for "technical writing" would normally involve a lecture supplemented by examples of best practice after which the students would be given an exercise to be completedin their own time and submitted the following week. No formal introduction to poetry was given nor any instruction on the nuances of style or construction and contrasts the more structured approach by Christy and Lima (2007). The intention here was to utilise the medium simply as a means of distilling, from the wealth of information that surrounds the subject of nanotechnology, a small selection of critical facts that could be used to convey the significance of engineering at the nanoscale to a general audience. The emphasis was more on the judicious selection of key facts and their presentation in a light, accessible and engaging form rather than the preparation of elegant prose.

A competitive component was introduced into the tutorial to avoid the potential trivialisation of the activity whereby those compositions deemed to be of sufficient quality would then be used in the preparation of microscale displays – microscope slides onto which the poem would be photolithographically rendered on the micron scale. These would then be mounted and used for outreach purposes (typically school or community-based talks) to illustrate and contrast the different scales that engineering encompasses – from the titanic to the tiniest of scales. These could be handed out to the audience and would provide a much more tangible example than that of the conventional academic poster or PowerPoint slide. The sense of scale becomes apparent from the fact that the student's poem patterned onto the slide would be largely indecipherable to the naked eye but would become visible and legible upon the application of a suitably powerful magnifying lens.

MATERIALS AND METHODS

Microfabrication of the poem layout was carried out using a photolithographic manipulation of a microposit S-1818 G2 SP16 positive photoresist (Rohm Haas Electronic Materials Europe Ltd). Coating of borosilicate glass microscope slides (Sigma) with positive photoresist was carried out using a spin-coating technique (SCS G3P-8 Spin Coat, Specialty Coating SystemsTM). The desired patterns were created with a maskless-lithography system (SF-100 Intelligent Micro Patterning, LCC), projecting the pattern with UV light to imprint the poem onto the positive photoresist layer. Submersion in 1:5 dilution of a Microposit 351 developer (Shipley Company) for approximately 1 minute allowed etching of the imprinted pattern into the positive photoresist layer. The basic process for the rendering of the poem on a conventional microscope slide is highlighted in Figure 1.

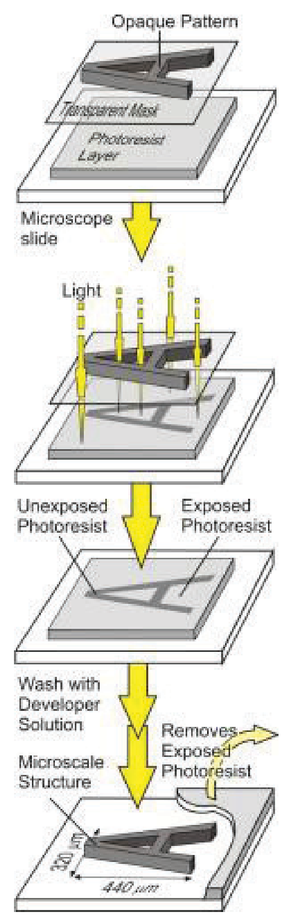

Figure 1. Schematic outlining the preparation of the microslide displays using a positive photoresist layer

RESULTS AND DISCUSSION

The "brief" given to the students was to illustrate, through a simple verse (rhyme was optional but almost universally adopted by the students), an example of where nanotechnology is either currently being used or could be used in the future. The main criteria is that it should be devoid of any technical terms and should be capable of being readily understood by their friends or family. It also had to be completed within 30 minutes. A typical example of the nano composition is highlighted in **Figure 2** along with the final representation patterned onto the microslide display. The sizes of microslide displays were generally in the order of 10 mm square (the size of the individual letters within would vary depending on the length of the composition as the entire stanza is scaled to fit within the boundaries. In most cases, the average length of a poem was 6 lines. The typical dimensions of the text were of the order of 400 microns (0.4mm) for a capital letter. It must be acknowledged that this scale does not represent the cutting edge of microfabrication and the text could easily be made much smaller. In this context however, the dimensions were chosen as a compromise – at this scale the text is just beyond resolution by the naked eye but could be easily viewed with a moderately powerful magnifying glass. Shrinking the dimensions further would certainly highlight the capability of modern photolithography but would have required the use of more elaborate microscopes – this would be impractical when considering using the slides for general outreach displays – limiting accessibility. Although micron dimensions are used rather than nano - the fact that the latter is 1000 times smaller should serve to reinforce the concept and provide a more memorable insight than a picture of a discrete nanoparticle or nanolandscape.

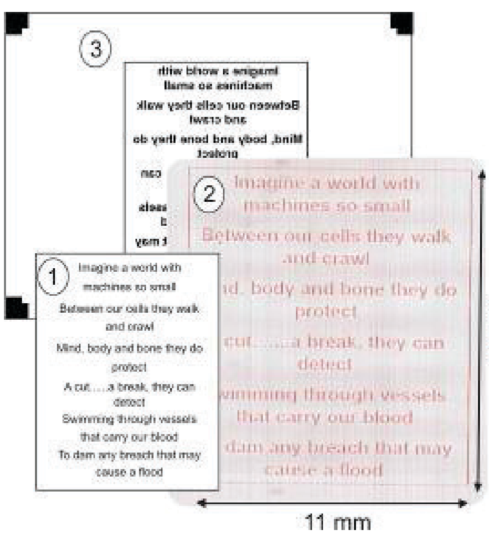

Figure 2. (1) Typical poem. (2) The final photolithographic representation patterned onto a microscope slide (magnified). (3) The mirror image mask used to create the photopattern.

In terms of the practical aspects of the microslide production – it was found that handling quickly eroded the photolithographic pattern – despite instructions to handle the slide by the edges only. There is an overriding compunction to attempt to "feel" the text. One remedy is simply to place a second, clear slide, on top of the patterned one. A more elegant solution however was to reverse the mask so that the mirror image (Figure 2(3)) is patterned onto the slide and a simple backing (i.e. an adhesive laser label) placed directly over the top of the pattern. Upon turning the slide over, the pattern is still visible. This is highlighted in Figure 3 where the text is sandwiched between glass and label and, through inversion of the slide – becomes fully readable - but protected from finger abrasion by the underside of the same slide.

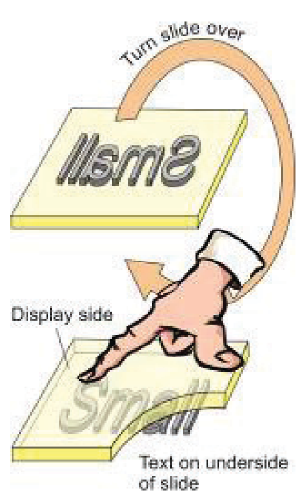

Figure 3. Schematic of the demonstration "Out-Reach" microslides

PRELIMINARY EVALUATION

The use of poetry could be considered a brave step as it can be, in its purest form, one of the more intimidating literary forms for the novice to attempt. While there have been a number of previous attempts to introduce poetry into the engineering curricula, these have largely been supported by a complementary instruction on the nuances of the art (Christy and Lima, 2007). The strategy taken here was more modest and has numerous advantages:

- Engineers are increasingly faced with large volumes of information. It is vital that they are able to discriminate, collate and prioritise the core facts from the milieu and distil them in a concise report. This embodies the very spirit of poetry where although brevity is key – the frugality of words cannot be allowed to betray the meaning being conveyed. The essay format can lead to the submission of work that is verbose and bloated with web content where the student attempts to cover all the bases by including everything – no matter how tenuous. Critical discrimination is lost. In contrast, the stanza format serves to focus the mind of the student into thinking exactly what points are critical and which are superfluous and can be sacrificed.
- There are a myriad of poetic forms and constructs each possessing their own peculiarities – often with a comprehensive set of rules that rival those of any conventional engineering discipline. Ironically, poetry is also one of the most accessible forms of literary expression as few students will have failed to come across it in some form during their childhood – irrespective of background – be it in the form of a nursery rhyme or as part of their secondary school English studies. Here the intention is not to produce a work robust to literary criticism, but rather allows freedom of expression that can be both humorous and informative. The overriding aim is to foster a degree of enjoyment through being free to be creative, which should overcome the otherwise intimidating artistic expectations associated with poetry.

The "flash" element of the tutorial is particularly significant as it plays into the professional life of the engineer where there can be a need for the rapid analysis of a situation with the production of a swift, but accurate response. Limiting the compilation of the poem to the 30 minutes and retaining it within the seminar room ensured that the work was free of internet "cut and paste" plagiarism which increasingly forms the basis of many essay submissions. The *in-situ* composition of the work also meant that the work had to be individual – participation was therefore mandatory and obviated the vagaries of group effort where one individual can end up being the sole creative force.

The time limit and structure limitation of the stanza also enables much speedier assessment of the work when compared to marking a host of 1000 word essays – which for a normal undergraduate year - could number anywhere between 200-300 submissions.

Composing the poem in lay language is the critical element and the main challenge to the student who, despite being only in their first year, will already be immersed in the jargon of the subject.

The response of the students to the flash fiction tutorial was assessed qualitatively through informal feedback after the completion of the session and supplemented by the return of an anonymous questionnaire. Despite some initial scepticism regarding the relevance of the activity in relation to engineering, there was a grudging acceptance by most (>90%) that it had been worthwhile, enjoyable and challenging by the end of the session. The introduction of poetry presented an immediate obstacle in terms of perception of its actual relevance to the students and required a greater degree of introductory explanation and justification of the learning outcomes associated with the session. There is little doubt however that the prospect of their work being used in the microslide displays was pivotal to ensuring a serious commitment to the process, as it was made clear that their name would be associated with the completed display which would then be on view to their peers as well as the general public. While only the best examples would be used in outreach events, it was nevertheless important to make the students feel that their contribution would be valued. It also ensured that greater effort would be expended in the quality of the work and, with the implied public exhibition of the final work, minimised the possibility of childish compositions.

One concession was necessary to ease participation and allow a greater degree of freedom of expression – it was made clear at the outset that the poems would not be read out to the class. The merit in not doing so was supported in the subsequent feedback (*c.f.* Christy and Lima, 2007). While the response to their work being incorporated in the microslides was overwhelmingly positive, there was marked reluctance over the immediate public airing of their work to the class. Peer evaluation of their work just prior to submitting was found to be a positive option, but this would only be between one or two of their friends – exposure to the whole class was felt to be a potential source of embarrassment and could have led to an erosion of the student's confidence.

Various approaches have been taken toInform the general public, via the medium of posters, leaflets, and the internet, of the issues of nanotechnology and its contribution to wider society (Ho et al, 2011; Dudo et al, 2011; Cacciatore et al, 2011). The majority of these approaches tend to be essentially passive. The microslide approach offers a versatile means through a simple magnification demonstration to provide a more tangible impression of the sense of scale involved. As such, it represents an opportunity to stimulate discussion and debate as to the wider implications of nanoscience (Powell et al, 2011; Bostrum and Lofstedt, 2010). The low cost of preparation and the minimal requirements for viewing the slides also opens up the possibility of distributing the microslides to schools within the community for demonstration purposes by science teachers. This could be an invaluable aid in supporting a more positive perception of modern engineering (Karatas et al 2011; Aschbacher et al, 2010).

CONCLUSIONS

Improving literacy and communication within the engineering and physical sciences has been a long running saga, but there is a concern that too much attention may be devoted to technical writing. The approach taken here allows the introduction of a component that seeks to enhance the lay communication skills of the student whilst requiring little additional overhead in terms of teaching time. The adoption of the flash approach, in which the work must be complete within the tutorial session, actually eases the burden and contrasts the heavy workload associated with the setting of a conventional essay. The combination of the literary (poem composition) and microslide display (photolithography) provides an ideal contextual framework in which to highlight the changing nature of engineering from the perception / perspective? of large scale industrial constructions to the more intricate micro and nano scale architectures. The exploitation of the slides as an engaging final outcome provides an innovative hook that seeks to give pertinence to the activity and inject a competitive spirit to enhance participation, thereby yielding a versatile end product suitable for out-reach activities within the community or for publicity purposes.

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Course 'ICT tools in science education' –what and how to teach
Curso "Herramientas TIC en la educación científica" – qué y cómo enseña

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Abstract

Using modern Information and Communication Technologies (ICT) is one of the key areas in pre-service and in-service teachers training, and in many countries it is a obligatory subject. Unfortunately, so far curriculum of this subject was not standardized. The aim of a study was to prepare the syllabus of ICT course for chemistry and science education students. The syllabus was designed, implemented and evaluated in 2009/2010. The body of the course was divided into six thematic units related to the most common multimedia didactic tools and techniques of its usage. Each unit was evaluated in terms of students' interests, form of realization and its usefulness in school practice. The results were analysed in the aspect of correlation between the studied factors and overall evaluation of the course units. The course was also verified for its potential use in the learning method.

Keywords: *blended learning, information and communication technology course, teachers' education.*

Resumen

Uso de la tecnología de información y comunicación (TIC) es una de las áreas clave en formación de profesores, y en muchos países es una asignatura obligatoria. Por desgracia, el currículo de este tema hasta ahora no se ha normalizado. El objetivo del estudio consistió en preparar el plan de estudios de curso de TIC para estudiantes de educación química y la ciencia. El plan de estudios fue diseñado, implementado y evaluado en 2009/2010 en la Universidad Jagiellonian (JU) en Polonia. Todo el curso se divide en seis unidades temáticas relacionadas con las herramientas multimedia más comunes, didácticas y técnicas de su uso. Cada unidad se evaluó en términos de intereses de los estudiantes, la forma de realización y su utilidad en la práctica escolar. Los resultados fueron analizados en el aspecto de la correlación entre los factores estudiados y la evaluación general de las unidades del curso. El curso fue verificado también por su potencial uso en el aprendizaje de los estudiantes.

Palabras clave*: aprendizaje, tecnología de información y comunicación, la formación del profesorado.*

INTRODUCTION

The continuous development of Information and Communication Technologies (ICT) has created new opportunities for teachers. During classes, a modern science teacher should be able to integrate ICT with various teaching methods (Orlik, 2006). Using ICT by teachers can be divided into three major areas (Shihkuan, 2010; Valanides & Angeli, 2008; Cox & Abbott, 2004; IBO, 2009; Donnelly, McGarr, & O'Reilly, 2011):

1. The general use of computers, operating system, office applications and Internet.
2. Use of the measuring equipment and its integration with a computer, applications for data collecting and processing.
3. Visualization of the lessons' content with the use of modern didactic tools, modelling, use of videos and animations, interactive presentations and assessment, virtual laboratories.

We should keep in mind that the use of ICT tools is not an easy task for many teachers, what was indicated by the recent studies (Karasavvidis, 2009). The extremely fast development of IT in the recent years can be seen as an additional difficulty. Therefore, it is a great challenge for the educators to create ICT courses that prepare pre-service teachers for complex, reasonable and effective usage of modern didactic tools in their courses. That approach is compliant with European Union's development strategy (EU, 2000).

Following the current trends and the expectations of the students, in 2009/2010, a new syllabus of the 'ICT tools in the science education' course was introduced and evaluated. The course is obligatory for students of chemistry and related studies that choose the block of subjects called Chemistry methodology. After graduating, students are certified to teach chemistry at all levels of education (teaching license for the Elements of Science in primary school can be obtained after completing extra hours). The course can be taken during the third year of bachelor studies. Students who attend the course have already completed the general computer usage course that includes the use of MS Office, OpenOffice and chemical structures modelling software: Isis Draw and ChemSketch. Additionally, they attended 465 laboratory hours, during which they were familiarized with various techniques of taking measurements and data processing, as well as the usage of data loggers and data plotting software. Some of the courses were supported by e-learning materials, so the students are familiar with the e-learning platform (Moodle), but only from a user's point of view. Thus, as the main focus of the discussed ICT course was placed on visualization and the use of interactive didactic tools in the course.

The role of visualization in science education cannot be underestimated, especially in chemistry education (Lamanauskas, 2005; José & Williamson, 2005). One of the most difficult problems in teaching introductory chemistry is conveying the three dimensional structure and dynamic interactions of molecules (Jones, 1996) to students. That can be easily achieved with the use of animations, simple modelling applications and didactic movies. The only equipment necessary for such visualization is a PC and a multimedia projector. Such a setup can be connected to a digital camera or to a web camera, which gives the possibility of presenting experiments in both mini- and micro-scale. The other improvement for the PC and the multimedia projector, which settled in classrooms, is the so-called Interactive Learning Environment. A standard equipment of such a classroom is usually an Interactive Whiteboard, Tablets and Electronic Assessment Systems (also called Personal Response Systems or PRS). The use of such a package allows the teacher to fully control the computer and all of the software, without looking away from the students (Murcia & Sheffield, 2010). What is more, the students can easily engage in lessons and control the computer and the presentation. The use of PRS not only allows the teacher to control the progress of the students (Bernard, 2011), but it also helps them to teach classes with the use of problem based methods (MacArthur & Jones, 2008). In the near future we can expect further development of ICT technologies and new solutions introduced to classrooms, i.e. 3D visualization systems combined with elements of a virtual reality (Lamanauskas, 2007). Finally, one cannot forget about more traditional tools, i.e. an overhead projector, as they are still present in classrooms. Another problem is the use of web resources during classes taught in a traditional "face to face" setting, as well as those that contain elements of distance education (Bonk & Graham, 2006). Of course, during a course, it is necessary not only to familiarize the students with the capabilities and technical aspects of didactic tools, but also with teaching strategies based on those tools (Castro Sánchez & Alemán, 2011; Damavandi, Bagherzadeh, & Shahmir, 2011). The 'ICT tools in the science education' course, mentioned above, is divided into six thematic units (Table 1). Each unit begins with a short lecture, followed by the students' self-practice.

Students choose courses of didactics as an additional element of the study, so all of the courses in this block are not included for the obligatory number of credits. The complete didactic block consists of 270 course hours plus 150 hours of vocational training. This amount of hours is determined by the Polish law (Act of The Polish Parliament, 2009), and is a heavy burden on the students. Because of this, it was decided to prepare the ICT course in a blended form which mixes traditional and e-learning classes (Bonk & Graham, 2006).

A questionnaire survey was conducted to evaluate whether and in what way are the prepared course units interesting and useful for the students. The additional issue was to choose, which parts of the course should be executed via an e-learning platform. Another interesting aspect was to find out how the students' choice of e-learning units is compared to its assessment.

Table 1. Curriculum of the 'Utilization of didactic ICT tools in the science education' course

Title of the unit	No. of hours	Objectives	Students' activity
I. Basics of presentation	3	To acquaint students with the rules of the transfer of information and face-to-face teaching, aided by multimedia tools. In this unit, students learn how to: choose the form of a presentation; use various techniques of visualization; design an arrangement of contents (colours, spacing, graphics etc.); reach the desired effect during the presentation (effects include bonding with the audience, standing in the spotlight, relaxing, behaving in a professional way, controlling the debate etc.).	
II. The use of the overhead projector	5	Familiarize students with the techniques of visualization based on the overhead projector. Using a single layer and complex transparencies. Conducting experiment demonstrations on the overhead projector's plate. Students also learn about the technical support of the overhead projector and graphics software used for designing transparencies, the use of raster and vector graphics.	Preparation of transparencies to support a chosen chemical demonstration. (Software used: Isis Draw, ChemSketch)
III. The use of the multimedia projector	6	Students learn how to: create attractive and eye-catching multimedia presentations, operate graphics, sound and video files, use the digital camera and multimedia projector setup for the presentation of experiments at the micro level. avoid distracting and fatiguing the listeners, adjust the slides' content to different groups of listeners.	Preparation of a fragment of a multimedia presentation tailored to a given group of listeners. (Software: MS PowerPoint, OO Impress)
IV. Interactive learning environment	5	Familiarize the students with the techniques of teaching with the use of the interactive whiteboard, electronic assessment systems and tablets. Specification, composition and advantages of various Learning Environments. Using PRS systems for assessment, survey conducting and brainstorming in the synchronous and asynchronous mode.	Preparation of a multimedia presentation on interactive board. Composition of quizzes and tests to be used with a PRS system in a given mode.
V. Mind and Concept maps	5	Application of the Mind Mapping and Conceptual Mapping techniques supported by chosen software. Teaching classes with the use of activation techniques.	Creation of the Mind or Concept Map on a chosen topic and with a given technique (software: Freemind, Cmap Tools)
VI. Elements of e-learning	6	Students learn about the possibilities of enriching school courses with e-learning materials and various ways of realization of distance learning (mobile learning, blended learning, different ways of blending etc.). Students have an opportunity to watch several popular e-learning platforms and their advantages.	Preparation of e-learning classes with the use of files prepared in previous units. (Software: MOODLE e-learning platform)

METHODS

The presented syllabus was implemented in 2009/2010. Its assessment began in the same year. The survey questionnaire was conducted on a group of 98 students participating in the course. The evaluation covered the usefulness of units, their form of execution, the degree of the students' interests and an overall rating. The assessment was based on the adapted five-point Likert scale (Likert, 1932): 5 - very good, 4 - good, 3 - acceptable, 2 - poor, 1 - very poor. The students were also asked for a brief justification of the assessment.

Another issue was to evaluate the units in terms of realizing them in the blended form. The students were asked to consider, whether the content of each unit is appropriate for being executed through an e-learning platform and decide which units they would like to be executed in such a way.

The results were analysed in the aspect of a correlation between the studied factors and an overall evaluation of the course units and the students' wish to implement these units at an e-learning mode. For this purpose, correlation strength was estimated on the basis of Pearson's correlation coefficients (Rodgers & Nicewander, 1988; Cohen, Cohen, West, & Aiken, 2002). The results were analysed statistically on the basis of the STATISTICA 9 software.

RESULTS AND ANALYSIS

The mean grades for the units were calculated and compared with the average grade for each factor (Table 2). The wish to execute units online was introduced as a percentage choice of each unit.

Table 2. Assessment of the course units (scale: 5 - very good, 4 - good, 3 - acceptable, 3 - poor, 1 - very poor). Estimation of the wish to execute units online (percent of choices).

	Units						
	I	II	III	IV	V	VI	Average
Total grade	4,53	4,33	4,54	4,48	4,35	4,43	4,44
Degree of interest	4,40	4,12	4,35	4,49	4,44	4,21	4,34
Usefulness	4,51	4,45	4,60	4,32	4,01	4,37	4,38
Form of execution	4,56	4,40	4,52	4,49	4,59	4,40	4,49
Would you like to execute this unit online?	46,67%	15,56%	13,33%	24,44%	86,67%	46,67%	38,89%

Presented results can be considered as adequate reliable. Questionnaire survey is moderately internally consistent, calculated Cronbach's alpha equals: 0.68 (Cronbach, 1951). Calculation based on split-half method (Raju & Guttman, 1965) with correlation between first and second half: 0.48.

The overall assessment of the course units is in the range 4.3 - 4.6, which can be considered very high.

Analysing the 'Degree of interest', we can state that the least popular were units: II – 'Use of the overhead projector" and VI – 'Elements of e-learning'. In their justifications, the students pointed the use of transparencies as outdated and boring. Additionally, it was said that these techniques are commonly known and that their usage does not increase the attractiveness of the classes.

On the other hand it should be noted, that the students have described unit no. II as useful (above average). The above resulted from the prevailing reality of schools in Poland. The overhead projector is still the most widely used tool for visualization.

Using the multimedia projector was considered to be the most useful. The students appreciated the wide range of opportunities for the usage of this tool in school practice. Demonstrations of experiments in the micro scale (drop analysis and micro distillation) were often described as the most innovative.

Unit V - 'Mapping techniques' was evaluated as the least useful. The majority of the comments stated that typically, chemistry classrooms are not equipped with students' PCs, and that group mapping techniques would be hard to execute in the Polish school environment (there are on average 25 students in the class). However this topic was recognized as one of the most interesting. The students justify that fact with the potential use of mapping techniques for taking notes during lectures and for studying.

The evaluation form of the execution of units was associated with the need to verify the ratio of time, designed as lectures and students' practice. What is more, the form of practice was considered. In most cases, the form of the classes was assessed as very positive; however, the students pointed the need for longer individual work with the Interactive Learning Environment.

For the blocks that should be executed at a distance, the students picked: I – 'Basics of presentation', V – 'Mind and Concept Maps', VI – 'Elements of e-learning'. It can be seen that a great majority of students would like to learn about 'Mind and Concept Maps' via e-learning system. Units I and VI were assessed as appropriate for distance learning by about half of the students. It can be seen that units V and VI were also found to be the least interesting and useful.

Influence of the 'Degree of interest', 'Usefulness' and 'Form of realization' of units on 'Total grade' and 'Willingness to execute units online' was analysed. The strength of correlation was based on calculated Pearson's correlation coefficients (Table 3).

Table 3. Correlation coefficients for relation of 'Total grade' and 'Willingness to execute units online' to studied factors

	Total grade	Would you like to execute this unit online?
Total grade		-0,33
Degree of interest	0,46	0,37
Usefulness	0,60	-0,82
The form of execution	0,33	0,53
Would you like to execute this section online?	-0,33	

Considering the value of correlation coefficient for the 'Total grade', it is mostly determined by the 'Usefulness of the unit'. The 'Degree of interests of students' has a smaller impact and 'The form of execution' appears to have no or very small correlation to the 'Total assessment'.

Correlation coefficients for 'Assessment of possible realization of the unit in distance learning form' once again shows that the 'Usefulness of the unit' plays the major part. In this case, a very strong inverted correlation can be seen. Correlation coefficient for 'The form of realization' can be considered as medium-strong. The 'Degree of interest' and 'Total grade' have small impact, but opposite influence on the 'Willingness to execute units online'.

DISCUSSION

The analysis of the results indicates that from this course the students expect practical knowledge that can be directly used in the school. Because of that, 'Mapping techniques' were poorly rated by the students. The students' comments indicate that they don't know these techniques very well. They see the benefits of mapping techniques, but have no sense and willingness to use them at school. This may be due to the fact that they had not been taught in that way and had not had a chance to get used to these methods. This should draw educationists' attention to developing the use of activation methods (including mapping techniques) during the courses of subject didactics.

Students clearly pointed out these units that they would like to attend via a distance mode. However, it should be noted that they have chosen units that in their opinion are not very useful or interesting. Therefore, their choice might be dictated by the inclination to avoid these classes, and an attempt to complete them with minimal effort and time. This indicates a need to modernize the curriculum in such way as to make those units more attractive and show more practical ways of applying presented techniques, which should convince the students about the quality and the usefulness of presented solutions.

The medium-strong correlation of 'The form of realization' and 'Willingness to execute units online' can be seen as quite surprising. It shows that the students would like to turn the classes which had been assessed positively into the e-learning form. The question is: 'Why change something that works properly?' Probably, in this case, the quality and the attractiveness of the presented materials and students' activities played the most important part. It can be assumed that the students are sure that the quality of e-learning materials will be adequate.

CONCLUSIONS AND RECOMMENDATIONS

The current level of use of ICTs at schools is not satisfactory. The great challenge for educators is to prepare pre-service teachers for casual, conscious and free use of the latest technology in their classes. The need to prepare science teachers for general computer and Internet usage is obvious, especially in the aspect of lifelong learning (EU, 2000). Due to the experimental nature of science, it is also necessary to prepare chemists for the use of data logging devices and data plotting software, tools that are more and more frequently used in classrooms (Vannatta, Richards-Babb, & Solomon, 2010). Distinguishing between the most important areas and teaching aims in the aspect of visualization in the classroom can be problematic. In this aspect, it can be said that introduced syllabus of the 'ICT tools in the science education' course into the Chemistry Didactic curriculum at JU was assessed positively by the students. The detailed analysis of the units indicated their weaknesses and helped to identify the areas that need to be improved. The conducted studies also allowed students to choose units that can be transformed into an e-learning form.

In the future, some of the units will need to be modernized, especially in the context of changing the form of its execution to web-based. What is more, the approach to the e-learning classes has to be decided upon. Unfortunately, the conducted research does not answer the question, whether the units should be divided into the ones taught completely in a classical way and the ones executed in a pure e-learning form, or whether all of the units should be blended together.

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The progressive development of skills for advanced level chemistry students

El desarrollo progresivo de los conocimientos para los estudiantes de química del nivel avanzado

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Abstract

The authors report on the results of an international pilot project that developed a database of problem-based chemical laboratory activities. The database consists of 32 activities and background information, available free on the internet and which provide an opportunity for the progressive development of skills relevant to advanced level chemistry students. The activities can be used in schools, colleges and first year undergraduate chemistry courses. The structure of the database allows very flexible use, allowing teachers to select and sequence activities to suit their courses. During the pilot, users were encouraged to adapt activities according to particular curriculum and specification requirements. Importantly, the database was created to enable professional and transferable skills to be developed in a progressive systematic way.

Keywords: *Problem-based learning, competence-based education, team work, group work, practical chemistry skills*

Resumen

Los autores reportan los resultados de un proyecto internacional que desarrolló una base de datos de actividades problémicos en laboratorio químico. La base de datos consiste en 32 actividades, accesibles en la internet gratuitamente y que proporciona una oportunidad del desarrollo progresivo de capacidades y conocimientos importantes a estudiantes en nivel avanzado de química. Las actividades pueden ser utilizadas en escuelas, en colegios, y en el primer año de cursos de química para las universidades . La estructura de la base de datos permite un uso flexible, que a los profesores utilizar una serie de actividades para sus cursos. Durante el proyecto, usuarios fueron animados a modificar actividades según su currículo y los requisitos especiales . La base de datos fue creada para permitir desarrollar conocimientos profesionales y capacidades transferibles en una manera progresiva y sistemática.

Palabras clave: *educación basada en problemas, competencias, trabajo en equipo, conocimientos químicos prácticos.*

SCIENTISTS IN THE WORKPLACE

Scientists work on routine and non-routine tasks of varying degrees of complexity. They work within constraints, often needing to find optimal solutions to problems within, for example, fixed budgets and timescales. This requires applying scientific skills and knowledge, together with well developed organizational skills, communication skills and the ability to work collaboratively. Increasingly, the latter may mean working with colleagues from other institutions, sometimes based in other countries.

Scientists need a number of professional skills (Belt et al., 2005). Surveys (Gadd, 2004) indicate that scientists need to be able to:

- use knowledge and understanding to tackle scientific problems
- observe, measure, analyse and evaluate
- communicate to a range of audiences both verbally and in writing, and using ICT
- manage time and workloads
- manage physical resources such as materials and equipment
- work with others and manage relationships with people.

Acquisition of these essential skills should not be left to chance. Planned programmes for incremental development are needed. This idea was at the heart of the ProBase project 'Problem-based learning in vocational science' funded through the European Union (EU) Leonardo da Vinci programme (ProBase, 2009). It was finished by the end of February 2009. Activities developed in the project could be downloaded free from the following website: http://www.compacitypro.nl/ProBaseMenu/tabid/377/Default.aspx

Science in schools and colleges

Undergraduate chemistry courses tend to emphasise the development of subject knowledge and understanding, and of the use of scientific techniques and practical skills (Meester and Maskill, 1995; Bennett and O'Neale, 1998; McGarvey, 2004; Kelly and Finlayson, 2007). School and college science courses are similar in this respect, with students usually tackling closed problems. Alternative approaches to undergraduate laboratory work in chemistry have been reported, both in the US and Europe (Kelly and Finlayson, 2007; American Chemical Society, 2009; Clevenger and Richards, 2009). At all levels, many courses include, for example, enquiry-based (or inquiry-based) learning, problem-based learning, investigations and projects. However, the extent to which students are made ready to tackle such projects effectively is uncertain. The ProBase sought to address this issue.

Skills and competence

Competence-based education has gained much attention in the EU in the higher as well as vocational-technical education. Competence (contrary to 'competency') nowadays is interpreted holistically rather than in an atomistic or behaviouristic way. This requires integration of knowledge, skills and attitudes (Mulder et al., 2008). Mulder said: "The European Council has decided to create one education space, which holds for higher education (the so-called Bologna process), but also for the upper part of vocational-technical education (the so-called Copenhagen process). These initiatives should support the achievement of the Lisbon goals, to create a reference knowledge economy, based on the European social model and which should be sustainable." This idea is behind EU support for investigations into vocational education and training (VET). An example is the Leonardo da Vinci programme, from which funding was obtained for the ProBase project. A key objective of the Leonardo programme is 'improve the skills and competences of people'.

The ProBase project

The aim of the ProBase project was to develop a series of activities that enable professional skills to be developed incrementally alongside subject knowledge and understanding. Thirty-two activities were written, piloted and revised. They covered five skill areas:

Skill area 1: Using scientific knowledge and understanding to solve problems
Skill area 2: Working in teams to solve problems
Skill area 3: Communication
Skill area 4: Resource/budget management
Skill area 5: Time and work load management

Skill areas 1 and 2 were components of all activities. The other skills were allocated to activities as shown in Table 1.

Table 1: Specific description of the 32 activities in terms of skills-focus

	ADDITIONAL SKILL AREAS			ESTIMATED TIME (HOURS)	
Activities[1]	3	4	5	Inside classroom	Outside classroom
Type A				3	1½
Type B	ü			3	1½
Type C			ü	3	1½
Type D		ü		3	1½
Type E	ü		ü	6	3
Type F		ü	ü	6	3
Type G	ü	ü		6	3
Type H	ü	ü	ü	12	6

The incremental approach to the development of a complete skill set is:

Stage 1: Type A activities included only skill areas 1 and 2

Stage 2: Type B, C and D activities included skill areas 1, 2 and one from 3, 4 and 5

Stage 3: Type E, F and G activities included skill areas 1, 2 and two from 3, 4 and 5

Stage 4: Type H activities included all five skill areas.

Work with a similar approach was reported by other authors while the ProBase project was going on (Kelly and Finlayson, 2007).

The ProBase team

The team consisting of teachers and science educators from four countries – Hungary, Netherlands, Slovenia and UK:

- 4science, Salisbury, UK
- Drenthe College Unit Techniek, Emmen, the Netherlands
- Eötvös Loránd Univertsity, Budapest, Hungary
- Institute Jozef Stefan, Ljubljana, Slovenia
- Petrik Lajos Bilingual Vocational School for Chemistry, Environmental Sciences and Information Technology, Budapest, Hungary
- University of Technology and Economy, Budapest, Hungary
- VaPro, Leidshendam, the Netherlands.

ACTIVITY DESIGN

Educational systems in member states of the European Union are independent and have their own structures. Consequently, course content and assessment requirements of vocational science qualifications in the four participating countries are different from one another. A unified teaching programme for all countries was not feasible. Therefore, ProBase set out to provide activities that could be incorporated into a range of learning programmes.

Problem-based learning and its associated approaches have been widely used to develop competence (Engel in Boud and Feletti (Eds.), 1991; Chappell and Hager, 1992; Breslin and Sanudo-Wilhelmy, 2001; Belt et al., 2005; Cessna et al., 2009). In these educational programmes real-life cases serve as stimulus (Belt et al., 2005). According to earlier reports, students are more motivated and can get more relevant knowledge by using industrial chemistry case studies (Kesner et al., 1997). Therefore the ProBase activities were based on methods and techniques applied by professional scientists and used contexts where students could see the relevance of scientific study. Ideas for the ProBase problem-based activities came from consultation with practicing scientists. This ensured the authenticity of scenarios upon which activities were based.

Groupwork increases the resemblance of a real-life situation, where people usually work in teams. The starting point was to promote active learning. Students benefit from the examples how professionals deal with real-life cases and by the experience of working with others (Belt et al., 2005). Employers of the graduated students also welcome this approach (Van Engelen, 2007). That is why each ProBase activity requires a well designed and organised teamwork on the students' part.

According to the goals of the project, the activities should help the users to develop their communication skills, using ICT for their everyday work. It also involves learning more about English as the common language of science. In Eastern Europe, the English language skills of the advanced level chemistry students have recently been improving. However, often it is still not sufficient to be used as a working language on vocational chemistry courses. Therefore each activity that was piloted in Hungary was translated into Hungarian and the ones tried in Slovenia into Slovenian. These translations could also be downloaded free from the following website: http://www.compacitypro.nl/ProBaseMenu/tabid/377/Default.aspx . Comparing the English versions with the Hungarian or Slovenian ones can also help to develop English language skills.

As well as many advantages, problem-based learning has disadvantages. But the same can be said of 'recipe labs' (McGarvey, 2004). Insufficient instructions have negative consequences on the outcome of the problem-based projects. Students on these courses have to practice a variety of laboratory techniques and instrumental methods, as well as using them to solve problems. Therefore ProBase activities require students to apply established procedures to tackle problems. This builds upon an earlier Leonardo da Vinci pilot project developed by the same team members who participated in ProBase. This project was called StandardBase (StandardBase, 2005) and contained seventy-two tried and tested standard analytical procedures used, for example, in industrial, environmental and public laboratories. Where necessary, procedures were adapted for use in school laboratories. All procedures, covering a wide range of analytical techniques, are available online at the project website (StandardBase, 2005): http://www.standardbase.com/tech.htm . Building the ProBase database on work developed in the StandardBase project has resulted in flexible student activities, supported by tried-and-tested procedures and links to laboratories in the partner countries. A similar combination of the 'recipe-like' and problem-based activities has been applied successfully by other authors too (Kelly and Finlayson, 2007).

Because of the differences in the assessment requirements in the European countries, the project team decided to leave the summative assessment to the teachers using the activities. However, formative assessment was considered to be important. Qualitative assessment (Cheng, 1995) and web-based interactive tests (Holman and Pilling, 2004) are suggested by the literature. Both of these methods were applied in the project. It is suggested that students complete an interactive test ("Testing prior knowledge") found in the ProBase database before starting the work to test prior knowledge. They are also asked to make qualitative self-assessment in the end of each activity.

DEVELOPING THE ACTIVITIES

Setting up the activities properly and writing teaching materials requires a thorough theoretical knowledge, much time and care (Rudd et al., 2001). However, teachers have rarely got enough time to read relevant literature. Therefore the results of theoretical educational research are built in only very slowly in the everyday teaching practice (Childs, 2009). Nevertheless, it is valuable to involve teachers in the educational developing process (Stolk, 2009). Since the situation is very similar in many countries (Mulder et al., 2008), it seems sensible if teachers, scientists and course designers working in different countries exchange professional knowledge and experience while writing, piloting and publishing activities to be used at advanced level chemistry courses. Sharing the work in a carefully planned way maximizes the effective use of time and resources at international level. It can also enhance the trust among people working in different countries, as they can recognize and acknowledge one another's professional skills.

Finally, teachers working in other institutions and countries can also make use of the results of the teaching material developed by this combined effort. Therefore, following project team discussions, ideas for further development were selected. Draft activities were written by experienced science educators from each of the participating countries. These were reviewed by university teachers in terms of scientific accuracy and descriptions of instructional methods.

Each activity was piloted in two European countries by the minimum number of students expected to undertake the activity (in some instanced with more students). Teachers wrote reports, to which students contributed, about each trial. Students also gave presentations about their experiences at the times of the project team meetings. Activities were corrected by authors in the light of piloting. Finally the use of English, SI units and layout (previously agreed by the project partners) were also checked before the final versions of the activities were uploaded into a web-based database (Probase, 2009)

The ProBase database contains Teacher files, Student's documents (simply called 'Student Activities' in the database) and the 'Tests' in each languages on that they are available. The website of the project contains other background information and has additional functions, e.g. Frequently Asked Questions and Photo Gallery (ProBase, 2009).
Each activity consists of:

Student's document

- Introductory text
- Your brief: The aim is to stimulate curiosity amongst students. These set the scene, present the problem on which the activity based and show what the activity involves.
- Your investigation: Students' instructions and advice about planning and organizing their work. Their attention is always called to carry out a risk assessment before starting the work. (This is helped by the Chemical Abstract (CAS) numbers of each material that is given in the 'Technical notes'.)
- Your findings: Students are also asked to present their findings in a particular way.
- Student self assessment: Students are given aspects of self-assessment, which is considered to be useful when they are expected to follow their own personal development.

Teacher file

- Image: Image relates to the problem and may be used to stimulate student interest.
- Summary and metadata: As well as a brief description of the activitiy, the name, workplace and e-mail address of the author, languages on that the activity is available, activity type with the skills to be developed, techniques used, field, time in minutes needed for practical lessons, theory lessons and out of class time (according to the piloting) and resources (including StandardBase procedures and techniques) are also provided.
- Student's document: (as described above).
- Student sheet(s) and Data sheet(s): These describe the tasks, the procedures and provide some necessary data. In more complicated activities, students have to pick the one(s) their group needs.
- Teacher's document: This provides an overview of the activity as a whole and describes the specific skills to be developed. It also provides information about the minimum group size and number of group, as well as an exemplar session plan to be applied.
- Technical notes: This helps the preparation by providing necessary information about the methods, procedures and measurements to be used; includes the lists of equipment and materials; describes how to prepare the sample, the stock and the standard solutions, as well as other reagents.
- Testing prior knowledge: This shows test questions related to the activity and found in the ProBase database. In its first version the correct answers are shown in red, whereas in the second version the correct answers are not marked. This way (apart from filling in the online version as part of the formative assessment) it can also be printed and photocopied by the teacher to be used in the laboratory.

Classroom management

The role of a teacher at the time of the problem-based laboratory activities is different from that in traditional ways of teaching (Cheng, 1995; McGarvey, 2004; Kelly and Finlayson, 2007; Mulder et al., 2008). It needs much care and experience on the teacher's part to provide the appropriate level of guidance and support to students and to give it at the appropriate time. This is vital to ensure that students complete the task successfully and on time, learning about both the scientific knowledge and skills and taking away positive memories of the experience.

Therefore the project team decided to develop four activities in each type that cover various fields and techniques (mostly related to analytical chemistry, but a few others too), so that VET teachers and course designers could choose the ones that are the most suitable and appropriate for the particular course. When applying a set of these activities in the case of a group of students (starting with one of the simplest type A activities and working through the other types, finishing with one of the most complicated type H activities) the necessary skills are developed step by step with their increasing complexity.

Using the ProBase website and database

The piloting of each ProBase activity in two countries showed that the database contained a sufficient number and range of activities which could be readily implemented in their vocational chemistry courses. Teachers can make direct use of the activities found in the ProBase database. However, applying the standard activity structure developed by the international project team, they can also create their own activities by using the components of the ProBase and StandardBase databases. This way the vocational schools, colleges and other training institutions can provide broader, more flexible education and training. Apart from VET courses, the database can also be used for undergraduate chemistry courses in the higher education.

EXAMPLES OF ACTIVITIES

Here is an example of building a series of activities based on organic syntheses and analytical chemistry.

Stage 1: Type A activity (skill areas 1 and 2)

ProBase activity: ASPIRIN STRENGTH - Determining the aspirin content of tablets.

In this students need to identify the most appropriate analytical method for tackling an analytical problem. They have to choose between two analytical methods available in their laboratory to measure the active ingredient of aspirin (acetylsalicylic acid) - acid-base titration and ultraviolet and visible absorption spectroscopy. They need to consider precision and accuracy of measurements. They use their scientific knowledge and understanding of the two analytical methods to determine aspirin while working in teams to solve this problem. To help their work they can find one of the standard procedures in the StandardBase database. The other method is amongst other resources provided and available in the ProBase database.

Stage 2: Type D activity (skill areas 1, 2 and 4)

ProBase activity: SYNTHESISING PHARMACEUTICALS - Comparing manual and robotic parallel synthesis of aspirin like compounds.

In addition to the skills developed in the previous activity, students have to consider the resource/budget management aspects of synthesizing pharmaceuticals. They are asked to imagine that they have been given the task of setting up a new synthetic laboratory for a pharmaceutical company. The budget is fixed and they have to decide how to make best use of it. Compounds can be made by people or robots. They have to find out how they could decide the balance needed in the laboratory. To do so, first they have to carry out a microscale preparation of aspirin, which is a simple standard procedure often used in undergraduate chemistry laboratories. After that they plan a small array parallel synthesis to make a series of compounds that have structural similarities to aspirin and, therefore, may have potential as analgetics. Finally they compare the costs of manual one-off syntheses, manual parallel syntheses and robotic parallel syntheses (for the latter, they are provided with a datasheet Economics of manual and robotic syntheses).

Stage 3: Type F activity (skill areas 1, 2, 4 and 5)

ProBase activity: PAIN RELIEF - Parallel synthesis of paracetamol analogues.

This activity adds the further dimension of time and workload management. Students need to realize that pharmaceutical companies synthesize and test tens of thousands of compounds in the search for one that shows significant therapeutic biological activity. Carrying out these syntheses efficiently and effectively is crucial. Combinatorial chemistry is used - in particular, a form of combinatorial chemistry called parallel synthesis. This is often done using robotic systems, but a few manual parallel syntheses are also carried out. Paracetamol, i.e. N-(4-hydroxyphenyl)ethanamide is one of a number of well known over-the-counter (OTC) pain relievers. It is relatively easy to synthesize paracetamol and its chemical analogues in the lab even for undergraduate students. In this activity they work again in small groups. For a start, each group member prepares a sample of paracetamol, following again a simple standard procedure often used in the organic chemistry labs. Then the members of the group investigate the microscale preparation of paracetamol and the formation of a range of organic compounds structurally related to paracetamol. They examine the reaction mixtures using thin layer chromatography. From their results, the team needs to provide advice to the research and development (R&D) management team of an imagined pharmaceutical company about which reactions appear to give products and, therefore, might be worked up to provide samples that can be tested for biological activity. This advice must also come with a costing exercise, saying how much it would cost to make these compounds. From the report written about the piloting of this activity we got know that the students enjoyed very much to use the OSIRIS Property Explorer programme (OSIRIS Property Explorer, 2001) to estimate a 'Drug-Likeness Prediction' and 'Overall Drug-Likeness Score' about the drug potential of the product.

Stage 4: Type H activity (includes all five skill areas)

ProBase activity: BEAUTIFUL PEOPLE - Analyzing cosmetic ingredients

Type H activities require students to demonstrate a grasp of the complete skill set. Using a range of analytical techniques (volumetric analyses, gravimetry, potentiometry, thin layer chromatography, gas liquid chromatography) they must measure various ingredients (chloride, ethanol, hydrogen peroxide, sulfites, zinc etc.) in certain cosmetics. Since there are many measurements to do by each group, students are asked to prepare a time schedule and estimated budget of all the analysis that the team has to accomplish to determine each ingredient. In the end of the activity they decide whether the estimated budget was sufficient and the time schedule correct. They are also asked to write a general report to explain to consumers what is in the cosmetics they use every day, and whether the contents meet the legal requirements of their country.

FEEDBACK FROM TEACHERS AND STUDENTS AND CONCLUSIONS

Thirty-three teachers participated in the piloting process in the four countries. Most of those approached were keen to be involved. However, some replied saying they did not feel they could try a particular activity with their students because of the limited time available to meet the demands of a tightly defined teaching programme. A few were simply reluctant to start doing something that they had never tried before.

However, all participating teachers reported that activities they piloted proved to be an effective and useful tool. It helped them to plan and structure the laboratory-based learning activity. Teachers felt free to criticize the activities if they found the description improper or insufficient in some cases. All comments were taken into account while preparing the final versions of the activities before uploading them into the database.

Feedback (573 pieces) from students (summarized and provided in the piloting reports) were mostly very positive. They found the tasks interesting and challenging. However, the ones who had not been used to teamwork realized that time and workload management is difficult in a group. Occasionally they reported failures caused by insufficient planning or lost notes or records. Sharing responsibility among team members sometimes caused conflicts, especially when summative assessment also followed the students' self-assessment (this was always decided by their teacher who organized the piloting). These remarks support the statement that assessment is very difficult in problem-based learning (Kelly and Finlayson, 2007). However, the students admitted that they learned not just from their successes, but also from their failures.

At the time of the dissemination process we tried to encourage colleagues outside the project to use the activities. We have received feedbacks from Hungarian teachers not participating in the piloting and from other countries (e.g. France, Israel, Scotland and Turkey). They welcomed the databases developed in the ProBase and StandardBase projects as new resources that help their students to meet demands awaiting them in the workplace.

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'ProBase' is the acronym for a Leonardo da Vinci pilot project titled: 'Problem-based learning in vocational science – designing activities that develop the skills used by scientists in the workplace for integration into vocational science courses. The database developed in this project is available online from February 2009 at http://www.pro-base.eu/ via the link 'Show activities' or directly at http://www.compacitypro.nl/ProBaseMenu/tabid/377/Default.aspx (accessed 31 Oct 2010)

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Analysis of the astronomical concepts presented by teachers of some Brazilian state schools

Análisis de los conceptos astronómicos presentado por maestros de algunas escuelas estatales de Brasil

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Abstract

The reason for the development of this work is based on the fact that many teachers of the basic education level (EL) don't deal with concepts related to astronomy, but when they do so they just follow didactic books, which contain many conceptual errors. Astronomy is one of the subjects being taught in the EL and it is part of the proposals (proposal to do what?) of the Education Ministry and the Education Department of the State of São Paulo; but it is a fact that several researchers point out many mistakes in teaching Astronomy. Their purpose is to minimize some deficiencies, and this aim was worked out in an Academical Extension Course for Teachers from the Directorate of Regional (DR) Teaching (Mauá, Ribeirão Pires and Rio Grande da Serra) with the following objectives: to raise alternative conceptions; to provide supplemental instruction of teachers by means of lectures, discussions and workshops, and to check the learning success after the course. Therefore, sixteen questions were applied before and after the course, so that quite satisfactory results could be established afterwards: 100.0% of the teachers knew the names of the phases of the moon, 97.0% understood that the Solar System is composed by eight planets, 78.1% were able to explain how a "Lunar Eclipse" occurs , a "Solar Eclipse" and a "Solstice", 72.7% knew how to explain the occurrence of the seasons of the year; 64.5% explained the occurrence of the equinox correctly, 89.7% were able to define properly the term "comet"; 63.6% defined "Asteroid", 54.5% "meteor"; 58.1% "galaxy", and 42.4% "planet".

Key words: *teaching, astronomy, alternative conceptions, teacher education*

Resumen

La motivación para el desarrollo de este trabajo se basa en el hecho de que muchos profesores del nivel básico de la educación (EL) no trabajan con conceptos relacionados con la astronomía, pero cuando lo hacen, sólo siguen libros didácticos, que contienen muchos errores conceptuales. Como se sabe, la astronomía es uno de los contenidos que se enseñan en EL y es parte de las propuestas del Ministerio de Educación y el Departamento de Educación del Estado de São Paulo, pero es un hecho que varios investigadores señalan muchos errores en la enseñanza de la Astronomía. Su propósito es reducir al mínimo algunas deficiencias y este objetivo se trabajó en un Curso de Extensión Universitaria de Profesores de la Dirección Regional (DR) de Enseñanza (Mauá, Ribeirão Pires y Rio Grande da Serra) con los siguientes objetivos: aumentar las concepciones alternativas para apoyar a los maestros por medio de conferencias, debates y talleres y comprobar el éxito del aprendizaje después del curso. Para constatación, se aplicaron dieciséis preguntas antes y después del curso, que en forma satisfactoria permitieron establecer que: 100,0% de los profesores sabían los nombres de las fases de la luna, 97,0% entienden que el Sistema Solar está compuesto por ocho planetas, 78,1% fueron capaces de explicar cómo se produce un "Eclipse Lunar", un "Eclipse Solar" y un "Solsticio", el 72,7% sabía cómo explicar la aparición de las estaciones del año, 64,5% explicó la aparición del equinoccio correctamente, 89,7 % fueron capaces de definir correctamente el término "cometa", 63,6% definieron "Asteroide", el 54,5% "meteoro", 58,1% "galaxia" y el 42,4% supo definir el término "planeta".

Palabras clave: *enseñanza, astronomía, concepciones alternativas, formación docente.*

INTRODUCTION

The idea of developing this work came in response to researches showing that only a few students do understand basic concepts related to astronomy (Gonzaga, 2009; Albrecht & Voelzke, 2008; Gonzaga & Voelzke, 2008, 2009; Oliveira *et al*., 2007) and that teachers do not have certainty and rely on textbooks containing conceptual errors (Boczko, 1998; Langhi & Nardi, 2004; Scarinci & Pacca, 2008; Faria & Voelzke, 2008; Iachel *et al*., 2008), which makes one think "What kind of level of astronomical knowledge do teachers of state-run schools have?" The project also seeks to comply with the official documents connected with the school curriculum (São Paulo, 2008; Brasil, 2005; Brasil 1999, 2002).

The work of Danaia & McKinnon (2008) also deals with the identification of alternative conceptions of students(?)in junior secondary science classes of four Australian educational jurisdictions. Our work also focuses on the increase of alternative concepts and provides an understanding of conceptual aspects, in order to minimise the gaps in knowledge related to astronomy. For this, we need to organise a University Extension Course for Teachers of EL.

METHODOLOGY

The study was conducted at the College Objetivo with support from the DR in Mauá and the Cruzeiro do Sul University, São Paulo. The disclosure was part of the DE and the course was offered to teachers free of charge and with certification from the University Cruzeiro do Sul. It was held on March 28 and April 4, 2009, three hours in the morning and another three hours in the afternoon of each day.

In order to raise teachers' alternative conceptions, a questionnaire with sixteen open questions was applied before starting up the activities, and the teachers were explained the aim of it. After completing all activities, the sixteen questions were applied again - until then teachers were unaware that it was the same questionnaire. We have here an outline of work, showing only six questions - designed to investigate the assimilation of astronomical concepts discussed during the course. The questionnaires dealt with the following subject areas: the solar system, planets, eclipses, lunar phases, seasons, solstice, equinox, comets, asteroids, meteors, and galaxies. The utilised questionnaires are in agreement with Leite and Hosoume (2007), mentioning the importance of using questionnaires to survey concepts, and Ausubel et al. (1980), by treating the Theory of Meaningful Learning.

RESULTS

To organise the results Mourão (1995, 2006), Ridpath (2007) and Voelzke (2006) were consulted. The questionnaire had six open questions, and the first one was: "Of how many planets is the solar system currently composed? As you can see in Figure 1, even with the reclassification of Pluto by the General Assembly of the International Astronomical Union (2006) in Prague, Czech Republic, many teachers answered the question incorrectly. This allows us to reflect on the downgrading of teachers in relation to old information from the scientific point of view.

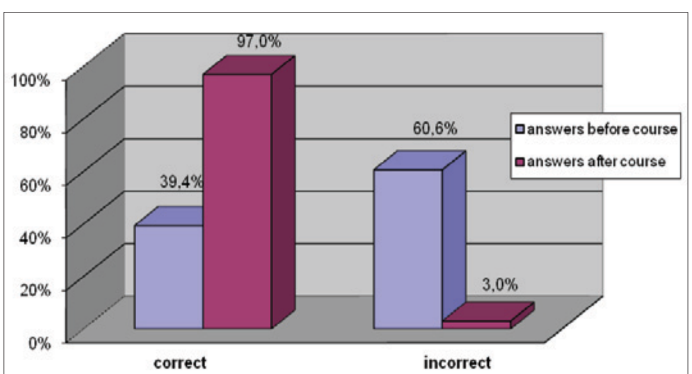

Figure 1 – Percentage of right and wrong answers for the question: How many planets does the solar system have? Before and after the course.

When asked: "How would you define the term "planet"?", it's to observe in Figure 2 that the majority answered incorrectly, which means that teachers of EL students either transmit incorrect information while explaining contexts or do not clear up the students' doubts. However, in the post-course survey many teachers got the planet definition, according to Mourão (2006).

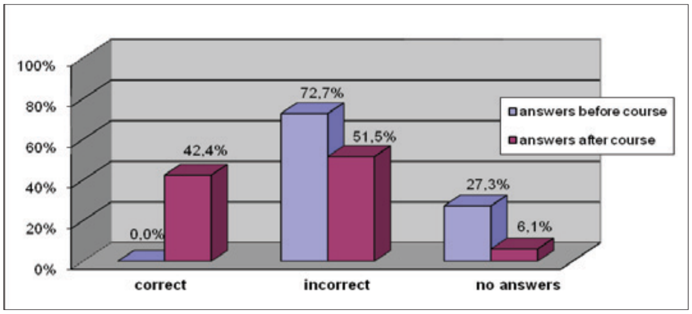

Figure 2 - Percentage of right and wrong answers for the question: How would you define the term planet? Before and after the course.

When asked: "How would you explain a Lunar Eclipse?" many students could not explain the occurrence of such a phenomenon, as observed in Figure 3 (pre-course responses), but the post-course answers show that most of them did understand this phenomenon afterwards.

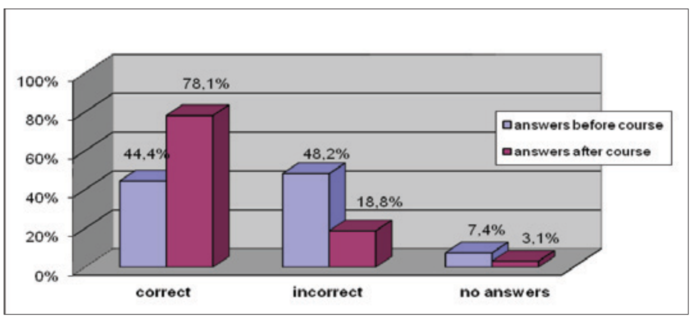

Figure 3 - Percentage of right and wrong answers for the question: How would you explain a lunar eclipse? Before and after the course.

When asked: "How would you explain a Solar Eclipse?" it can be seen again in Figure 4 that many teachers were not able to explain to their students the occurrence of such a phenomenon, but here it must be considered that the explication of the phenomenon "Solar Eclipse" is not habitual because of the rare observations of the population. But despite of it, it's remarkable that the analysed data in Figures 3 and 4 were collected in relation to teachers who had declared to know what an eclipse is (in numbers: 27 (81.8%) teachers in the pre-course- and 32 (97.0%) in the post-course question).

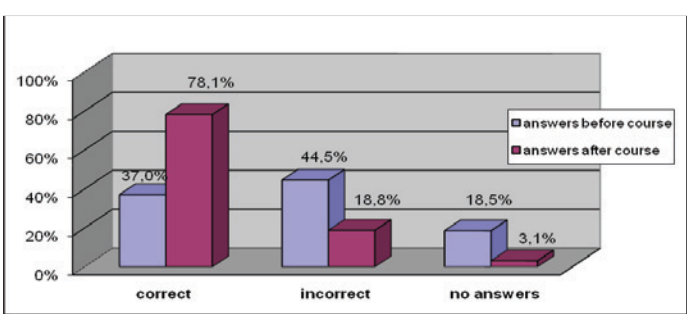

Figure 4 - Percentage of right and wrong answers for the question: How would you explain a solar eclipse? Before and after the course.

When asked in Question 5: "How would you explain to students the existence of the seasons?" Before the course (Figure 5) many teachers were unable to clarify the operation of the seasons, only 27.3% of them answered correctly. As examples of these teachers' correct answers we can cite: "Due to the translational motion of the Earth and its inclination to the Sun" and "Due to the translational motion of the Earth and the tilt of its axis". Among the incorrect answers before the course, about 42.4% wrote something of the kind: "Because of the movement of rotation", "The presentation using the globe shows that the motion of the Earth is elliptical, so the Earth is sometimes far away from the sun and sometimes close , Nature´s essential need to organise itself in cycles called seasons" and "The seasons occur because the planet approaches and distances itself from the sun". Before the course 30.3% of the teachers did not respond this question.

Among the correct answers after the course, about 72.7% gave responses like: "Because the Earth's tilt and the movement of translation, there are different incidences of rays (two teachers cited the Earth's tilt of about 23)" and "Due to the tilt of Earth's axis and its motion relative to the Sun". Among the incorrect answers after the course, about 12.1% wrote something like: "With Earth's movement and the incidence of sunlight on it", "There are several factors that explain the seasons" and "Because of the characteristics and conditions of our planet, the motion carried by it includes various positions which in turn gives us the specific characteristics of the environment". After the course 15.2% of the teachers did not answer, we believe that the lack of time and approach of the subject with slides may have influenced the non-response.

However, there is the strong growth of correct answers of the other teachers, resulting in 72.7%, one can notice a clear improvement.

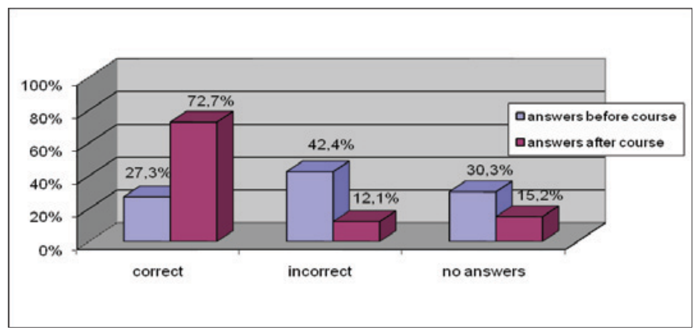

Figure 5 - Percentage of right and wrong answers for the question: How would you explain to students the existence of the seasons? Before and after the course.

In Question 6 it was asked: "What is the definition of a comet?" It can be seen in Figure 6 that most of the teachers did not dare to answer, while others responded incorrectly. However, the responses show that the post-course discussion and lecture with an expert astronomer of this area were of a great importance, as the displayed result is satisfactory.

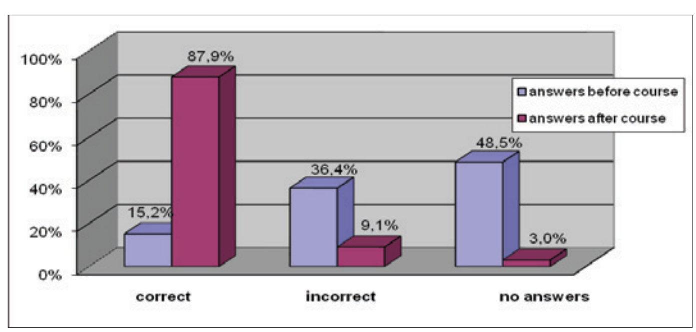

Figure 6 - Percentage of right and wrong answers for the question: What is the definition of a comet? Before and after the course.

CONCLUSIONS

The results show a clear improvement of the teachers´ astronomical knowledge: 97.0% of teachers know that the solar system is composed of eight planets, 42.4% know the correct definition of planet, 78.1% explain correctly how a Lunar Eclipse and a Solar Eclipse occurs; 72.7% are able to explain the occurrence of the seasons and 89.7% can correctly define the term “Comet”. Based on this conducted study it is to hope that there will be more people interested in the scientific literacy, using the theme astronomy for this aim, since it is known that it is a very rich subject and will certainly play an extremely important role for the current society and for the education of the citizen.

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Use of computer generated hyper-realistic images on optics teaching: the case study of an optical system formed by two opposed parabolic mirrors

Uso de imágenes generadas por ordenador en la enseñanza de la óptica: el caso de estudio de un sistema óptico formado por dos espejos parabólicos enfrentados

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Abstract

While the educational value of computer simulations is broadly accepted, it is also true that the student using them often encounters learning difficulties in not being able to fully identify what is seen to happen in the simulated model with what can be observed in reality. This is mainly caused by the highly schematic graphical interface of the simulation. A new method is proposed here which endows simulations with greater realism, making the identification of the model with reality far easier. On our case study, we generated and tested with our students several hyper-realistic images and animations of an optical system consisting of two parabolic mirrors. In light of the results and given the burgeoning growth of non-presential (Does "non-presential" mean that the teacher is not present? I am familiar with the term "distance learning" for this situation, which may be a more appropriate term to use here – at least for US readers. Perhaps the term 'computer-aided learning' is appropriate.) teaching, we believe that this new type of computer generated images are destined to play a major role in the virtual laboratories of optics practicals, complementing traditional simulations.

Keywords: *simulations, teaching/learning strategies, virtual reality, interactive learning environments.*

Resumen

Aunque el valor educativo de simulaciones informáticas es ampliamente aceptado, también es cierto que el alumno que las utiliza encuentra con frecuencia dificultades de aprendizaje al no ser capaz de identificar plenamente lo que ve ocurrir en el modelo de simulación con lo que se puede observar en la realidad. Esto es causado principalmente por una interfaz gráfica muy esquemática en la simulación. En este trabajo proponemos un nuevo método que dota a las simulaciones de mayor realismo, por lo que la identificación del modelo con la realidad es mucho más fácil. En nuestro caso de estudio, hemos generado y probado con nuestros alumnos varias imágenes y animaciones hiperrealistas de un sistema óptico formado por dos espejos parabólicos. A la luz de los resultados y dado el auge de la enseñanza no presencial, creemos que este nuevo tipo de imágenes generadas por ordenador están destinadas a desempeñar un importante papel en los laboratorios virtuales de prácticas de óptica, como complemento de las simulaciones tradicionales.

Palabras clave: *simulaciones, estrategias de enseñanza/aprendizaje, realidad virtual, entornos interactivos de aprendizaje.*

INTRODUCTION

Practical laboratory experience is considered essential to ensuring that science students receive adequate training (Hofstein, Lunetta, 1982). The interaction that takes place in the laboratory enables students to develop multiple skills, and facilitates the teacher's task of introducing problems of great educational interest. Nevertheless, one often faces many obstacles in terms of space, time, or economics against implementing laboratory practicals. These difficulties can be alleviated with the use of computer simulations of the phenomena under study (Chang, Chena, Lina, Sung, 2008; Finkelstein, Adams, Keller, Kohl, Perkins, Podolefsky, et al., 2005; Steinberg, 2000; Tolentino, Birchfield, Megowan-Romanowicz, Johnson-Glenberg, Kelliher, Martinez, 2009).

In most computer models of optical systems, the perception that the student has of the physical phenomenon is usually limited by the lack of realism. Consider as an example the case of an optical system consisting of two parabolic mirrors facing each other. The usual ray tracing computer simulations, based on the geometrical optics approach, fall short in showing the full extent of the optical phenomenon they are intended to simulate. However, thanks to the constant and rapid development of multimedia software and graphics programming, one can today create an invaluable teaching tool that endows computer simulations with an extraordinary realism that brings the model far closer to reality perceptually. The constructivist educational environment thus created, based on new technologies, enables students to achieve meaningful learning (Jonassen, 1999; Reigeluth, 1999).

The aim of this work is to validate the use of hyper-realistic computer generated images on Physics teaching, which could complement traditional simulations. For this purpose, we use hyper-realistic computer generated images (Martínez, Naranjo, Pérez, Suero, Pardo, 2011), in the sense that the images seem to come from a camera, and thus make it easier to identify the model with reality. On our case study, we shall generate hyper-realistic images and animations of two opposed parabolic mirrors

MATERIALS AND METHODS

Techniques chosen: Ray Tracing and Photon Mapping

For our hyper-realistic simulations of optical systems, we needed a technique capable of faithfully and credibly representing them as well as being consistent with the underlying theoretical models. The technique that we believed best suited to our needs was the geometrical optics technique called Ray Tracing. This provides great realism in the synthesis of images since it models the path that light takes by following the rays as they interact with optical surfaces. The calculations are performed using a specific Monte Carlo algorithm for the synthesis of three-dimensional images which provides accurate simulations of such phenomena as reflection and refraction.

The basis of the functioning of the technique is to trace a path from the eye of an imaginary observer through each pixel of a virtual screen, accumulating the contribution of each of the scene's light sources at that pixel. However, since the vast majority of rays from a light source usually do not reach the observer, only a small minority of the rays from a source will be required to form our image. Therefor., it is unnecessary to waste time calculating and following those rays which will not contribute to the image. One very simple solution to the question of how to select the set of rays that will actually participate in the generation of a given scene is to see the problem in reverse. Instead of following the rays from a light source, one travels backwards starting from the observer's position. With this technique, known as Backward Ray Tracing (Arvos,1986), when there occurs an intersection between a ray and an object, one only needs to project new rays directly to each light source. The result is that the image rendering time in our simulations is reduced by several orders of magnitude. The original idea for the algorithm comes from an earlier technique called Ray Casting (Appel, 1968). This technique was subsequently enhanced by the inclusion of a new illumination model (Whitted, 1980), which added realism to the rendered image.

The main advantage of using this technique rather than others (such as systems of triangle meshes) lies in the realism of the images that are generated. For example, effects such as reflections or shadows which are difficult to simulate using other algorithms (those based on random sampling, for example) emerge naturally with the Ray Tracing algorithm.

For some of the simulations performed in this work, however, indirect lighting was needed. This is a phenomenon that the Ray Tracing algorithm was unable to simulate. For example, it cannot generate reflection or refraction caustics (one of the visible effects of indirect light). This is a serious limitation for cases such as the optical system to be presented in this work. To solve this problem, we had to implement a global illumination algorithm on top of the Ray Tracing procedure. The method we chose was Photon Mapping (Jensen, Christensen, 1998). This is capable of endowing the scene with a model of indirect lighting, thus allowing us to simulate more accurately the interaction of light with transparent media, allowing the emergence of realistic effects such as scattering and caustics.

POV-Ray

Having decided on the techniques that could realistically simulate optical systems, the next step was to select appropriate software with which to perform our hyper-realistic simulations. The program we chose was POV-Ray, Persistence Of Vision Raytracer (POV-Ray, 2008). This allows one to generate high quality three-dimensional images by Ray Tracing with the implementation of additional algorithms such as photon mapping. Furthermore, it is open source, zero cost, and available for almost all computer platforms.

POV-Ray allows representing objects internally by mathematical functions using a scene description language. This is a major advantage, since the user then only has to be concerned with the geometric description of the optical system. All the underlying optics (Snell's law, the Fresnel equations…) is already included as part of the program's source code (Dolling, Wegener, Linden, Hormann, 2006; Halimeh, Ergin, Mueller, Stenger, Wegener, 2009).

Another reason that led us to the choice of POV-Ray was that it is written in C++, so it can be exported to any system that has a compatible C++ compiler. This universality puts it ahead of other similar programs that are exclusive to proprietary systems. It is currently distributed pre-compiled for Macintosh, Windows, and Linux operating systems.

Check of the validity of POV-Ray for the simulation of optical systems

First we needed to check the validity of the program we had selected. To this end, we used POV-Ray to simulate simple optical systems – opaque polished surfaces capable of reflecting light, i.e., simple first surface mirrors. The results faithfully reproduced the behaviour of a light ray reflected in a section of both concave and convex spherical mirrors. Fig. 1 shows, by way of example, some of the images generated versus photographs of the real phenomenon.

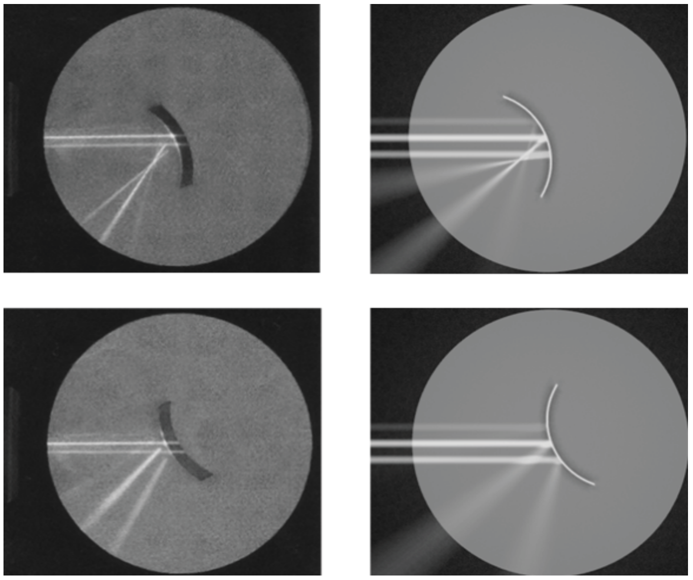

Fig. 1. Photographs (left) compared to hyper-realistic computer-generated images (right) of various beams of light reflected from a section of a spherical concave mirror (top) and from a section of a spherical convex mirror (bottom).

Hyper-realistic recreation of an optical system formed by two opposed parabolic mirrors

After having verified that the program POV-Ray was valid for our recreations of simple optical systems, and that the results of these trial systems were consistent with theory and gave a realistic appearance, we next carried out hyper-realistic generation of images of optical elements not usually found in basic optics laboratories.

In particular, the system we represented consisted of two parabolic mirrors, one face up and the other (with a hole in the centre) placed face down on the first in the form of a lid. The centre of the bottom of the first mirror coincided with the focus of the second. A small object was placed at this centre point, hidden from view of an outside observer. With this configuration, a real image of the object below is formed in the aperture of the upper mirror. On Fig. 2 we show screenshots of this system.

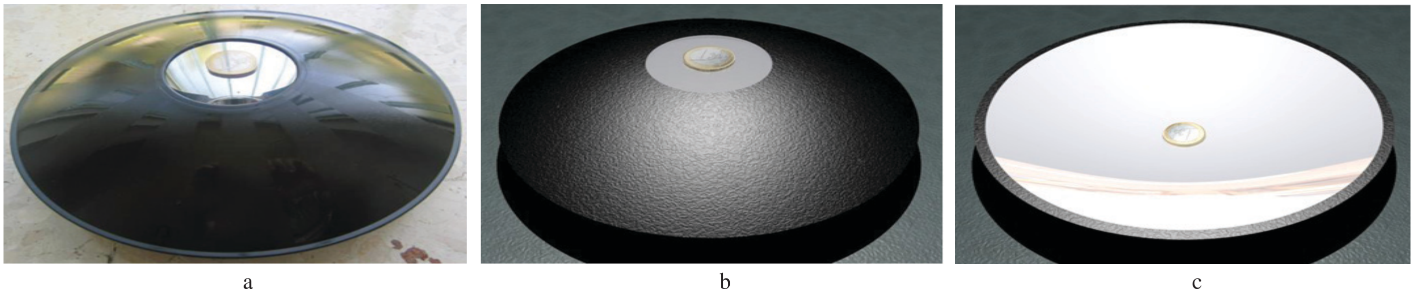

Fig. 2. Double parabolic mirror. (a) Real photograph. (b) Screenshot of the hyper-realistic computer generated image. (c) Screenshot of the hyper-realistic computer generated image, without the top mirror. Notice the real coin at the center of the bottom mirror.

Why is the image seen in that position? One commonly finds (both in textbooks and on the Internet) diagrams such as that depicted below on Fig. 3, which attempt to explain the formation of this image by tracing rays inside the optical system. In practice, however, these are insufficient to explain the formation of the image at the place where it appears (Pérez, Suero, Pardo, Gil, 2003).

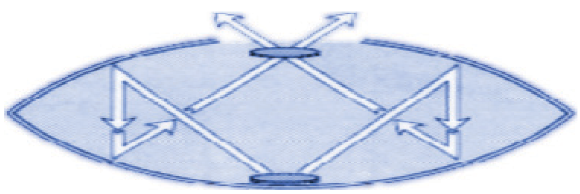

Fig. 3. Figure copied from the Internet (similar to many others) that attempts to explain the formation of this image.

The explanation that usually accompanies these diagrams is as follows: "Two rays are drawn from the object which are reflected in the mirrors. The reflected rays intersect at a point, and that is where the image of the object will be." Given this figure, a student might ask the following innocent question: "Why is the image formed where a ray from a point on the right of the object intersects another ray from a point on the left of the object? What does the intersection of these two rays at a point have to do with the fact that the observer gets the impression that the object is at that point?"

The explanatory diagram that we use for the paths of the rays in the real or simulated system is shown below in Fig. 4.

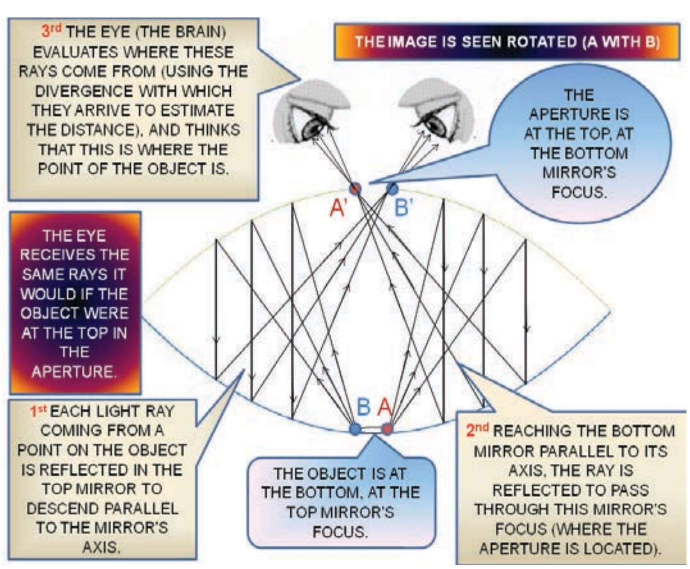

Fig. 4. Explanation of the diagram of the paths of the rays between two parabolic mirrors.

As is shown in the explanatory diagram, every ray of light leaving a point of the real object is reflected in the top mirror to descend vertically, parallel to the system's optical axis. (Since they are parabolic mirrors, every ray through the focus is reflected parallel to the optical axis, and vice versa). When the ray reaches the bottom mirror parallel to its optical axis, it is reflected to go through that mirror's focus, which is located at the aperture in the top mirror. All the rays from any given point on the object meet in a single image point.

The human eye, the brain, evaluates the rays reaching it. In particular, it evaluates the direction in which to look, and the distance as a function of the divergence with which the rays reach it. It then thinks that that is where the point on the object is (and from experience we will think that we can touch it if we put out our hand). Thus the object is "seen" in the aperture because, as is shown in the explanatory figure, the eye is receiving exactly the same rays that it would if the object really was there. We have created an animation of this explanation in flash-video format, which we make available for our students on our Web site http://grupoorion.unex.es/optoelectronicaweb/index.html. (I copied this link and went to it. To help the reader find the animation, it would be good to specify to click first on 'simulaciónes' and then scroll down to 'doble espejo parabólico).

Evaluation Instruments

To demonstrate the validity of these hyper-realistic simulations, we first compared the generated optical systems with their theoretical behavior, with the realism of their appearance, and with photographs of the real system. The experience was carried out during the 2009/2010 academic year with 25 Physics undergraduates of the Science Faculty in the University of Extremadura (Spain) who were taking an Optics course.

3. Analysis and discussion of results

The students who used these hyper-realistic images had no difficulty in identifying them with their real counterparts, and on several occasions some of the students said they were practically indistinguishable.

Given this concordance of the two opposed parabolic mirror simulation with reality, we believe that this new type of computer generated images could improve traditional computer simulation. This new simulations, which we term hyper-realistic, may have an important role to play when the real device is not available in the laboratory. It would thus be an invaluable teaching tool for today's virtual (non-presential) learning platforms (. Crippen, Earl, 2007; Jara, Candelas, Torres, Dormido, Esquembre, Reinoso, 2009; Martín-Blas, Serrano-Fernández, 2009; Rey-López, Díaz-Redondo, et al. 2008).

For the end-users to evaluate the proposal, two assessment instruments were used, designed respectively for teachers and for students:

END-USER EVALUATION: TEACHERS' EVALUATION

For the teachers of the subject of optics, we prepared a questionnaire based on a 5-degree Likert scale (Likert, 1932). It consisted of evaluating four aspects related to the educational functionality of the simulation. In addition, there were four open items to allow feedback from the teachers in the form of comments and suggestions for improvement.

The goal of this first questionnaire was to ascertain whether the proposal:

- Manages to motivate the student
- Is effective for learning
- Is applicable to other physical phenomena
- Is an effective teaching resource

The chart on Fig. 5 shows the percentage responses of the teachers' evaluation of these four aspects.

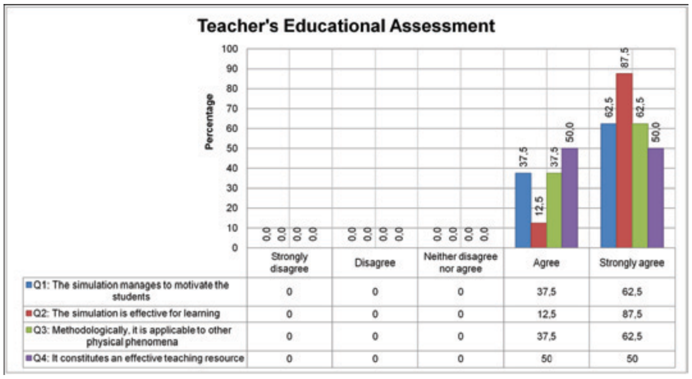

Fig. 5. Percentage responses of the teachers' evaluation.

As one observes, the teachers gave an overall positive evaluation of the hyper-realistic simulation, since 100% of their responses to the four items were either "agree" or "strongly agree". Particularly noteworthy is that the highest scoring aspect was the effectiveness of the hyper-realistic computer generated images for learning: 87.5% "strongly agreed" and 12.5% "agreed".

End-User Evaluation: Students' Evaluation

In parallel with the teachers' questionnaire, we prepared a twenty-five item questionnaire directed at students. Of these items, twenty were closed, based on a 5-degree Likert scale. The remaining five were open, to give the student the possibility of including comments which we subsequently used to analyze the advantages and possible facets that needed improvement.

The objective pursued in this second questionnaire was the evaluation of three attributes of the computer-generated images:

- Technical aspects
- Educational aspects
- Degree of coherence between the real system and the hyper-realistic system

In working towards this objective, we first designed twenty-five closed items to score on the Likert scale. After an initial test with a pilot group, we discarded five of these items following the criteria of the specific LXRTest computer program applied to these preliminary results.

Of the twenty closed items finally included, four corresponded to technical aspects of the simulation, ten to educational aspects, and six to the degree of coherence of the simulation. The items of these groups were distributed randomly through the test.

The data obtained from the questionnaire were subjected to statistical analysis using SPSS survey analysis software. The results are presented in the following chart (Fig. 6), which represents as percentages the distribution of the students' responses to each item, and the percentage distribution of their responses grouped into each of the three aspects – technical, educational, and coherence of the simulation with the real system. (In figures 5 and 6, replace the commas with decimal points. On the percentage scale in figure 6, just list the percents to whole numbers: 10, 20, 30....without any decimal value.)

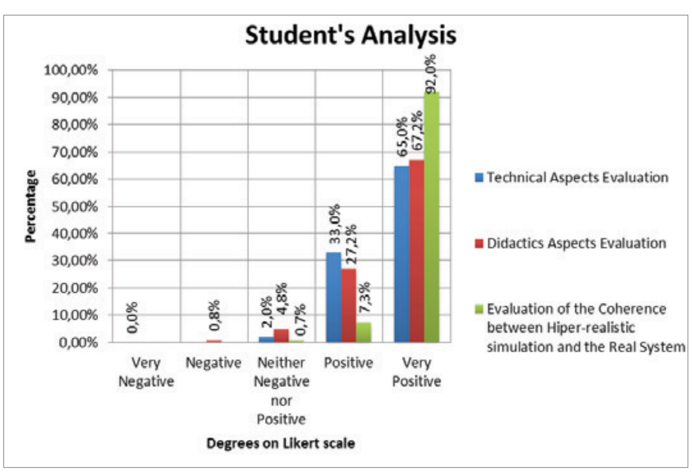

Fig. 6. Grouped distributions of the students' responses.

As was the case with the teachers, the students' general assessment of the hyper-realistic simulation was positive. They valued the technical and educational aspects of the simulation, and particularly strongly (92%) considered there to be a high degree of coherence between the hyper-realistic simulation and the real system.

CONCLUSIONS

The results of this work confirmed our initial assumption: that the use of hyper-realistic computer generated images provides students with a better view of the physical phenomenon they are studying, and markedly reduces their difficulty in associating what they perceive in the simulations with the real phenomenon that can be observed in a laboratory.

The hyper-realistic images that we developed allowed the students to appropriately visualize the simulated optical system without the need for it to actually be available in the laboratory. Our proposal therefore constitutes on the one hand a supplementary educational tool to better understand the functioning of unavailable optical devices, and on the other a complement to real systems. Since they coherently reproduce reality, satisfying the theoretical model being represented to a far higher level of reality than that of traditional computer simulations, they are more likely to make assimilation of the physical concepts involved successful. This hyper-realistic quality is what gives our images a somewhat innovative quality, because they take into account not only the mathematical model describing the physics of the system, but also the realism of its appearance.

Given the present burgeoning interest in non-presential teaching, this new type of computer simulation is destined to become indispensable in the virtual optics laboratories of teaching at a distance.

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The perception of chemistry of first-year undergraduate students at the University of Buenos Aires

La percepción de la química de estudiantes ingresantes a la Universidad de Buenos Aires

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Abstract

At the University of Buenos Aires, Argentina, the first undergraduate Chemistry course is taught within the Ciclo Básico Común (CBC), aimed at students of Technology, Health and Basic Sciences. Its massive attendance (30000 students per year) gives – along with the development of fundamental topics of the discipline– the chance to discuss the importance of Chemistry for the Society as a whole to a broad spectrum of teenagers, coming from many different backgrounds. Moreover, it shows the relevance of these topics in relation to the different careers chosen by the students. In this work, we analyzed how a group of young students perceive the Chemical Sciences by means of instruments such as questionnaires, interviews and workshops. We gathered around 600 opinions. Our results suggest that Chemistry is perceived by these students neither as a "polluting" nor a "dangerous" discipline, but rather as a body of knowledge with both vague and diffuse interests.

Keywords*: chemistry, perception, introductory course, undergraduate students, inquiry.*

Resumen

En la Universidad de Buenos Aires, Argentina, el primer curso de grado de química se dicta en su Ciclo Básico Común (CBC), para estudiantes de las áreas de ciencias de la salud, ciencias básicas y tecnologías. Conjuntamente con el propósito de desarrollar contenidos curriculares fundamentales de la disciplina, su matrícula de 30.000 alumnos/año brinda una oportunidad para discutir, con un alcance social relevante, la importancia de la química en la sociedad actual, al tiempo de mostrar a los alumnos la importancia que esta ciencia central tiene para el desarrollo y avance de las diferentes profesiones cuyos estudios de grado acaban de iniciar. Se relevó la percepción de la disciplina de un grupo de jóvenes estudiantes a través de instrumentos diversos (encuestas de indagación, entrevistas en profundidad y talleres participativos), consignando así unas 600 opiniones. Los resultados obtenidos sugieren que para estos estudiantes, la química no los impresiona como una disciplina, por ejemplo, "contaminante" ni "peligrosa", si bien la imagen que subyace en su ideario (con respecto a sus incumbencias y su rol en la mejora de la calidad de vida de los seres vivos y su entorno) es vaga y difusa.

Palabras clave*: química, percepción, ingresante, curso introductorio, indagación.*

INTRODUCTION

The Chemistry course at the Ciclo Básico Común (CBC) of the University of Buenos Aires (UBA) is the first one for careers related to Health, Natural and Technological Sciences. It has an enrollment of approximately 30,000 students per year and could be considered as an "Introductory Chemistry" in Schools of Science; besides, for approximately 70 % of the students (Health Sciences undergraduates) it is the only one covering General Chemistry topics. The course is taught in eight UBA sites located in the City of Buenos Aires and its surroundings, with a 3 hours long - twice a week lectures' schedule. These are of theoretical-practical nature and are carried out by two teaching assistants. An optional Experimental Workshop is offered also on those UBA sites with laboratory facilities. Lectures are available for students from 7 am to 11 pm, Mondays to Saturdays, in up to 7 lecture theatres simultaneously, summing up 180 to 140 student groups, depending on the semester. Massiveness, therefore, is a key characteristic of this Chemistry course.

Insofar our research project is aimed at developing an approach to teach this introductory and massive course in a way that promotes or at least sustains a positive appreciation of the acquisition of "scientific culture", Chemistry in particular, we found it necessary to investigate the students' representation of the discipline and its instructional implications. It is about "…a kind of common sense or spontaneous knowledge, socially shared and elaborated, which takes part in the social building of our reality" with a significant impact over the instructional act to the extent that "...it tries to essentially take control of our surroundings, understand and explain the ideas and facts of life, act upon and with other people, answer questions about the world" (Lifsyc and Iacobellis, 2007). This is particularly relevant to Chemistry, since its teaching is considered difficult because "...is, at the same time, a very concrete science (it concerns a great diversity of substances) and a very abstract one (it is based on some 'atoms' to which one does not have direct access), and because the relation between the observed changes and their explanation is not obvious since it talks about the chemical changes with a symbolic language that is very different from the one familiar to and used by the students when they transform materials in everyday life. Even the whole purpose of Chemistry (understand and manage materials' transformations), is far from people's interest, who are more used to accept the most striking phenomena without the need to understand them" (Izquierdo Aymerich, 2003).

Understanding that "...the inquiry process is inherent to teaching and instruction learning, and investigation is nothing but that process conducted in a systematic way and publicly contrasted" (Gimeno Sacristán, 1984), this work is aimed at the inquiry of the perceptions of Chemistry by first-year undergraduate students, to help develop teaching strategies able to improve our students' consideration on the social relevance of the discipline (Di Risio y col., 2009a).

METHODOLOGY

As a first step of the inquiry process, a survey was designed to categorize some of the students' ideas about the role of Chemistry within the scope of Science and its relevance for everyday life. This instrument was presented to 493 students (84 % of them are enrolled in Health Sciences careers, 90 % of them being under 22 years old), and 27 more students, acting as a control group, enrolled to careers that do not include Chemistry in their syllabus (mostly from Economic Sciences).

The survey first asked students to draw what "Chemistry" meant to them. This item gave relevant information by not being mediated by language and not being oriented by the following questions.

Next, students were asked to write three examples of: a) scientific disciplines they considered relevant for social development; b) professions for which Chemistry knowledge is necessary; c) everyday products and activities available due to the discipline´s ongoing state of knowledge improvement. The survey ended with two open questions, in which they could explain their ideas about the importance of studying Chemistry for their future careers and the importance of the advance in Chemistry knowledge for the development of todays' society.

Further oral interviews contributed both to the validation of our instrument and the identification of the analysis categories most relevant to our work.

The same ideas were also inquired through a workshop: the students, divided into small groups, were asked to produce a poster, either promoting the CBC Chemistry course (half the groups) or opposing the inclusion of Chemistry in their syllabus (the other half). This experience corroborated some of the preliminary conclusions obtained from the analysis of the survey responses, making evident that many students have concerns related to their comprehension of the Chemistry course contents.

RESULTS

One interesting aspect to describe in the first place relates to the drawings produced to represent "Chemistry". Five groups of answers soon became apparent: a) those identifying Chemistry with chemical symbols or formulas, i.e. using the discipline's symbolic language; b) those associating the discipline with laboratory work, which relates to a macroscopic view of Chemistry; c) those referring to the submicroscopic level, approaching to the graphic language symbolizations frequently used by experts (atoms, molecules and their structures); d) those "metaphorical" in nature: drawings of landscapes, the planet, the origin of life; e) those representing the students themselves, considering their role with respect to the course. Quantitative results are shown in Figure 1, where it can be seen that the first three groups of answers comprised more than 90 % of the students. Figure 2 shows examples of each category. These productions seem to evoke the students' experience during high school education; we shall come back to this aspect later. The fourth group of answers relates to the environment and life itself, a more encompassed representation of the discipline.

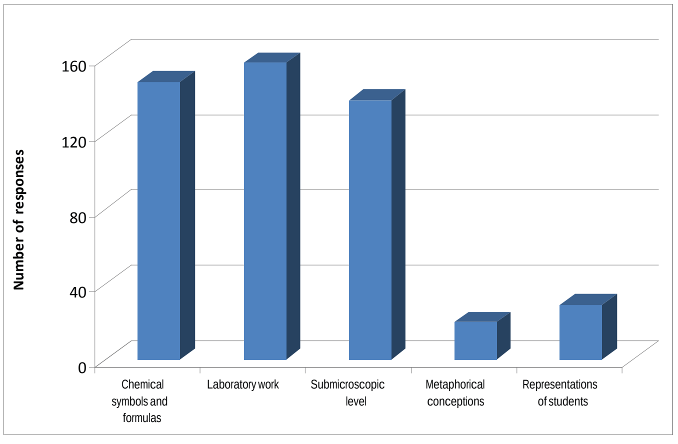


Figure 1: Pictorial representations of "Chemistry"

A second group of questions concerns the provision of three examples of scientific disciplines, activities, professions and everyday products related to Chemistry. From their answers, it is clear that students, in most cases, cannot tell the difference between discipline, profession and activity (e.g., some of them think about mathematics as an activity, or nutrition as a profession). A preliminary analysis allowed us to find regularities which gave relevant information:

About activities related to Chemistry, the 1500 answers were classified in 42 categories. From these, the four most frequent ones were: *cooking, eating/drinking, use of medicines and research and laboratory activities*. Although most opinions related Chemistry to food and medicines, a less common image also appeared: that related to the activities of chemists as researchers, portrayed by a stereotyped image of the scientist.

About professions for which Chemistry knowledge is necessary, 35 categories were identified, the more important being: *medicine* (sic), *biochemistry and pharmacy* (sic), and others related to Health Sciences and Engineering. There is a strong correspondence between professions chosen as answers to this item and careers students are appointed to.

Up to this point, it can be argued that because most students taking CBC Chemistry do so as part of the syllabus of non-chemical career, their views about Chemistry are strongly influenced by the latter.

About products of everyday use related to Chemistry and its development, 20 categories were identified with a vast majority of answers related to: *pharmaceutical products, cleaning products and food*. Unlike the already described queries, more coincidences came up among the answers, as we can see from the lesser number of categories identified. But even more significant that the answers that were effectively consigned, is the almost total absence of other expected answers. For example, almost no one mentioned water (which its lack of availability for human consumption is a major problem at present, one in which Chemistry is decisively involved) or fuels, or environment polluting products, etc. It is also striking that virtually none of these products appears among the drawings asked for in the first item of the survey.

The answers to open questions suggest a very general, quite diffused view of Chemistry, but they contributed a lot in representing our students' thoughts about the discipline.

In regard of the importance of Chemistry in the future professional life of the students, most of them answered affirmatively, but in a very vague way. We transcribe some of the most frequent formulations as examples:

YES:

- "Because to be able to study the human body I need to know its chemical reactions."
- "Because it's essential to understand the reactions that occur."
- "Because you have to know certain important compounds."
- "Because Chemistry explains many things."
- "Because sometimes a physiotherapist prescribes medicines."

NO:

- "Kind of, you can be happy without knowing much chemistry."
- "I don´t know; I think Physics is more important, but they´re teaching me this stuff for some reason."
- "I guess it´s related because they´re similar subjects, but it won´t be once I become a nutritionist."
- "No, an obstetrician does not prescribe medicines."

An idea which became apparent deals with the imaginary relationship between Chemistry and "medicine prescribers" as perceived, in the above example, by the future physiotherapist and the future obstetrician (despite their disagreement about drugs prescription, their answers are otherwise coherent).

As with the answers analyzed above, those related with the role of Chemistry in Society's progress were mostly affirmative (including the control group of Economic Sciences students), but very general and strictly related to Medical Sciences. Some examples that portray the most frequent formulations are quoted below:

YES:

- "Because specialists who prescribe save peoples' lives."
- "We need people capable of dealing with the development of medicines."
- "Pollution is due to some chemical compounds and it's important to identify them."
- "Because as population increases new diseases appear, and with chemistry, I guess, (this problem) could be solved."
- "More responses for diseases could be created and improve peoples' lives quality."

NO:

- "I don´t think Chemistry it's important for present Society's progress because Chemistry it´s overrated."
- "I think that Society has more important things to solve, I do find Chemistry important for the planet survival, but not for human societies."
- "Because there isn't a straight relationship with Society."
- "I think an education devoted to the human being it´s more important."

From these negative answers, it can be observed that Social and Natural Sciences are dissociated, rather than related or complementary.

When trying to get more insight on the student opinions about the social relevance of Chemistry their responses are again very general and diffuse, stating that Chemistry is very important but not being able to tell the reasons why they think so. Developing more and better medicines to cure more diseases is the only opinion clearly stated.

General and vague responses to the open questions can be related to a diffuse –but not negative- attitude towards the discipline.

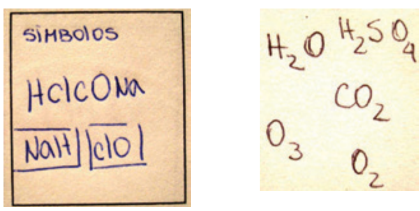
The analysis shows as well that first-year undergraduates have a disciplinary conception in which the ideas of inter- or trans-disciplinarity are absent.

DISCUSSION AND CONCLUSIONS

The study of these perceptions allows us to reflect and make instructional decisions (Di Risio et al., 2009b) in order to provide a positive influence on teachers doing and learning within the frame of a massive introductory course.

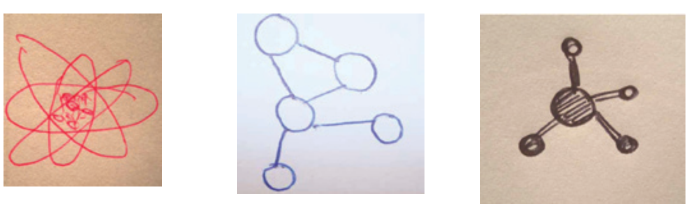
Particularly, the idea of a negative image of Chemistry, allegedly "polluting / prejudicial / dangerous", was already identified as an object of inquiry after frequent statements made in research articles (Stocklmayer and Gilbert, 2002). However, along various bodies of our work, we find that few students do actually have such conceptions.

Chemistry's positive or negative image, according to what we recollected at interviews and workshops, seems to be more related to student academic situations than to their view of Chemistry as a discipline (Figure 2e, although these representations were not majority). This is in agreement with reports on the perception of the discipline of primary and high school students and teachers in the United Kingdom (House of Lords, 2000).



a., Chemical symbols and formulas

b. Associations with laboratory work



c. References to the submicroscopic level

d. Metaphorical conceptions

Figure 2: Categories for pictorial representations of "Chemistry"

a. Stress on the condition of students of undergraduate Chemistry

A global analysis of the responses suggests that the information known by our students is vague and diffuse; the relationship between Chemistry and food and medicines is most frequently quoted. Nevertheless and despite the difficulties for the study of Chemistry as an academic subject often remarked by students, their attitude towards the discipline is mostly positive. They consider Chemistry as an important discipline for their university careers and generally appreciate its applications and influence in everyday life, although probably with a very limited knowledge of what it really is and the benefits this "central Science" (Shaik, 2003) provides to Society as a whole.

During the inquiry process here analyzed, it was expected that students graphical and verbal representations were influenced by what they learnt about the discipline during their high school education (the survey was presented at the beginning of the CBC course and Chemistry is taught during high school final stage). Even though the nature of the responses seems to support this hypothesis, repeating the inquiry with 399 high school students during their final three years at this educational level (and therefore with different curricular backgrounds of the discipline) showed similar answers to those of the new undergraduates. Therefore it is true to say that their ideas about the discipline come straight and exclusively from that period of schooling. In fact, some authors have speculated that the general public considers Chemistry as a body of knowledge reserved to scholars (Wallace and Louden, 2000) and others (House of Lords, 2000) found that the discipline is perceived, at the primary and high school levels, as "boring" (opinion also shared by quite a few teachers). Considered altogether, this information suggests that it is not expected that those levels of schooling can provide at present any substantial input to a significant learning process of the discipline.

Several authors have written about the perception of Chemistry by students considering their learning experiences and the discipline as an instructional object (Millar, 1996; Pilling et al., 2001; Gutwill-Wise, 2001). On the other hand, there is no such information available when it comes to the perception of Chemistry as a discipline of social relevance without considering student experiences inside the educational system. We consider it valuable to have specific information about this scenario, which will foster the improvement of our instructional tools considering not their allegedly negative image about Chemistry, but rather their general and vague (but positive nevertheless) one.

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Ensenãnza de la deriva continental: contribuciones epistemológicas e históricas

Teaching continental drift: epistemological and historical contributions

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Resumen

Contradicciones entre epistemólogos e historiadores, y debates entre corrientes científicas controversiales, marcaron desde muy temprano la Historia de la Ciencia. Sin embargo, es habitual que la Enseñanza de la Geología se refiera a una ciencia sin historia, y que excluya reflexiones epistemológicas que ayudarían al alumno a comprender la construcción del conocimiento científico. Los autores, partiendo de formas diferentes de analizar la ciencia según Popper, Khun, Lakatos y Laudan, revelan reflexiones epistemológicas sobre la controversia fijismo / movilismo, destacándose el camino recorrido por la geociencia desde la deriva continental hasta la tectónica de placas. Este artículo realza la aplicabilidad de las tesis de los epistemólogos ya referidos, en momentos claves de confrontación de ideas, que conllevaron a avances y retrocesos, a éxitos y fracasos en la comunidad científica geológica. Los autores presentan una aplicación educativa que puede ayudar a enseñar la deriva continental obligando a reflexionar sobre las contribuciones históricas y epistemológicas.

Palabras clave*: fijismo, deriva continental, tectónica de placas, historia de la ciencia, aplicaciones educativas*

Abstract

In the history of science there have been numerous contradictions between epistemologists and historians, as well as debates among controversial scientific theories. However, in geology teaching, it is common to refer to geology as a science without history, as well as to exclude epistemological thought that could help students to understand the process of construction of scientific knowledge. In this article, the authors look into different ways of analysing science, according to Popper, Kuhn, Lakatos and Laudan, and present epistemological thoughts on the controversy on fixism/mobilism, thereby describing the long path undertaken in geosciences from continental drift to the plate tectonics. The article looks into the applicability of the thesis from different epistemologists, at key moments of the confrontation of ideas, that have led to developments and setbacks, achievements and failures within the scientific geological community. The authors present an educational material to teach continental drift obliging students to reflect upon epistemological and historical issues.

Keywords: *fixism, continental drift, plate tectonics, history of science, educational materials.*

INTRODUCCIÓN

El análisis epistemológico de la ciencia ha sido defendido por varios autores como un valor añadido al proceso de enseñanza y aprendizaje de las ciencias (Marques, 1996; Praia, 1996; Bolacha, 2008). Sin embargo, frecuentemente se verifica que tanto los manuales escolares como los propios profesores de ciencias naturales no valoran este tipo de análisis en sus clases. La situación más frecuente es la de ciencia sin historia, en la cual el conocimiento científico se enseña sin que se haga cualquier referencia al contexto que lo engendró. Otras veces, el modo como muchas concepciones y teorías ultrapasadas son introducidas y exploradas, inducen con frecuencia a la idea de que nuestros antecesores sufrían de una cierta ingenuidad colectiva. Esas teorías aparecen muchas veces como una clara señal de insensatez, ya que sus concepciones, carentes de un contexto histórico adecuado, son contrapuestas a las ideas actuales, tomadas como realmente verdaderas y definitivas. Cuando, aún así, se recurre a una contextualización histórica, ésta se limita frecuentemente a valorar las partes del trabajo que pueden considerase fácilmente como atributos del enunciado actual, lo que acaba acentuando la idea de que las teorías que hoy se aceptan fueron objeto de una construcción lenta pero determinada hacia el camino de la verdad, finalmente alcanzada. Siguiendo estas formas de mirar a la ciencia, es igualmente frecuente que se considere a los científicos como individuos excéntricos que, en momentos de genialidad, descubren leyes y teorías. Sin embargo, si estas ideas parecen deberse, en parte, a imágenes estereotipadas difundidas por los medios de comunicación social, ellas pueden también interiorizarse a través de la lectura de obras sobre la propia historia de la ciencia. Tomemos como ejemplo el trabajo de Bryson (2003) que muestra un número interminable de científicos excéntricos ya sea en términos de sus actitudes comportamentales en sus vidas cotidianas o incluso a nivel de sus opciones metodológicas. Exageraciones de quien pretende efectuar una divulgación divertida de la ciencia o relatos verídicos de personalidades que, de hecho, sobresalían por comportamientos no comunes, conducen a la confianza sobre la necesidad de buscar encuadrar y contextualizar muchas de las narrativas de la historia de la ciencia, para evitar desviaciones acerca de las características del emprendimiento científico. Este artículo analiza las principales ideas de los epistemólogos Popper, Kuhn, Lakatos y Laudan relacionadas con la construcción de la ciencia y aplicabilidad en el abordaje de la Deriva Continental.

DERIVA CONTINENTAL: FORMAS DIFERENTES DE ANALIZAR LA CIENCIA

La Deriva Continental, propuesta por Alfred Wegener en 1912, trató de explicar de una forma consistente la idea de que en el pasado (hace cerca de 250 Millones de años) los continentes actuales habrían estado unidos en un súper continente, el Pangea. Su fragmentación habría dado origen a diferentes bloques continentales que a lo largo de la historia de la Tierra se habrán desplazado y ocupado diferentes posiciones geográficas. Recordando aspectos de la Historia de la Geología, se sabe que antes de Wegener presentar la teoría de la Deriva Continental a inicios del siglo XX, la Geología, ya desde los siglos XVIII y XIX era blanco de varias controversias envolviendo escuelas con concepciones muy diferentes sobre el mundo natural. Una de estas controversias oponía el Neptunismo al Plutonismo. El Neptunismo, defendido por Abraham Werner (1749-1817), explicaba la constitución de la corteza terrestre teniendo como base la precipitación y la deposición secuencial de materiales que estarían en suspensión o en solución en medio de un océano primitivo. De acuerdo con este modelo evolutivo de la tierra, la evaporación del agua, que inicialmente habría cubierto todo el globo terráqueo, provocaría el descenso de su nivel haciendo emerger elevaciones y valles submarinos, que habrían dado origen a las montañas. A su vez, en el Plutonismo, modelo teórico expuesto por Hutton (1726-1797), los residuos resultantes de la erosión de áreas continentales eran transportados y depositados en los océanos, en capas horizontales. El calor interno y la presión resultante de su acumulación provocarían la licuefacción de esos sedimentos, quedándose éstos con tendencia a subir a la superficie dando origen, en esa fase, a erupciones volcánicas y a la formación de montañas (Amador y Contenças 2001). Esta teoría establecía así el origen ígnea intrusivo del granito, en oposición al neptunismo, que le atribuía un origen sedimentar (Gohau 1987). Las relaciones de campo observadas por Hutton, en que las formaciones sedimentares son instruidas por el granito, fueron determinantes para abalar el neptunismo y de la misma manera, la formación de las rocas volcánicas constituía un obstáculo que Wegener testarudamente desvalorizaba. De acuerdo con las ideas de Popper, el falsificacionismo parece haber tenido aquí un papel decisivo en la refutación del neptunismo. Para que tal refutación haya ocurrido, mucho habrá contribuido el cúmulo de evidencias de campo que lo contrariaban de forma inequívoca. Otra controversia que se vivía en esa época ocurría entre el uniformitarismo y el catastrofismo. El uniformitarismo (para los autores de lengua inglesa) o actualismo (para alemanes y franceses) argumentaba que los fenómenos geológicos sufrían un cambio gradual durante largos períodos de tiempo, mientras que el catastrofismo defendía que la tierra era un planeta joven (con cerca de 75 000 años), marcado por una sucesión de fenómenos catastróficos, ejemplificados en los cambios del registro fosilífero que indicaban extinciones cortas y violentas (Bolacha 2008). Al proponer el uniformitarismo (contra las ideas catastrofistas que se vivían en la época), Hutton afirmó que "El presente es la Llave del Pasado", lo que quiere decir que gran parte de lo que comprendemos acerca del pasado geológico se basa en la observación actual del funcionamiento del planeta. Por esa razón, los procesos geológicos que hoy vemos modificar la corteza continental deben haber actuado de la misma manera a lo largo del tiempo geológico. Así, el pasado es explicable desde el presente, o sea, los acontecimientos del pasado pueden ser explicados con base en las causas actuales (Amador y Contenças 2001). El principio orientador del uniformitarismo tuvo gran importancia para el desarrollo de la geología a finales del siglo XVIII, considerándose, aún hoy, como la base más importante de la investigación en geociencias. Si en el siglo XIX la controversia entre catastrofismo y uniformitarismo llegó a un nivel alto, habiéndose impuesto el uniformitarismo durante los siglos XIX y XX, actualmente son ambos aplicables y no se excluyen mutuamente. Este episodio de la historia de la geología parece concordar con las ideas de Lakatos, ya que nada impidió que un programa degenerativo (en un determinado momento) se hiciese progresivo más tarde (Dieguéz, 2005). Además, muestra también que, como refieren Popper, Lakatos y Laudan, es posible que varias teorías (o PIC) rivales puedan coexistir. Kuhn (1992) tiene un entendimiento diferente cuando defiende el surgimiento del primer paradigma en la geología con la publicación de *Principles of Geology* de Charles Lyell. Laudan (1977), por ejemplo, refuta firmemente esta idea que él afirma ser contrariada por la evidencia histórica. Según él, la supuesta revolución interpretativa de Lyell, con base en el uniformitarismo, obtuvo un impacto reducido en los geólogos de Europa continental, e incluso en Inglaterra y en los Estados Unidos sus ideas fueron objeto de severas críticas. Y por eso afirma: "No existía ningún paradigma geológico que fuese aceptado universalmente o acríticamente. Una multiplicidad de redes alternativas era la regla y no la excepción", (Laudan 1977, 136). Así, especialmente durante el siglo XIX, existía aún una competición saludable entre escuelas con concepciones diferentes sobre las interpretaciones del mundo natural, y Marques (1996) afirma incluso ser difícil concluir que la comunidad geológica de 1850 a 1950 estuviese ya unida en torno de un paradigma. A pesar de todo, valorar esta posibilidad obliga a admitir, siguiendo las ideas de Kuhn, el prolongamiento de la fase pre-paradigmática de la geología hasta después de la segunda mitad del siglo XX lo que, dado el extraordinario progreso que las ciencias geológicas alcanzaron desde el siglo XIX, parece ser inadecuado. Sin embargo, hasta finales del siglo XIX, el origen de las montañas (orogénesis) constituía el problema central de la geología (Borges, 1992). De hecho, una de las concepciones más populares, a finales del siglo XIX y principios del siglo XX, afirmaba que la tierra se encontraba en un proceso continuo de enfriamiento y contracción (Bolacha, 2008). Como resultado, y como consecuencia de la acomodación gradual de los materiales, se explicaba no sólo la formación de las montañas (y, consecuentemente, estructuras como pliegues y fallas) sino también la formación de enormes depresiones que constituían las cuencas o cubetas oceánicas. A la par de la teoría de la contracción del globo terrestre, se impone el principio fixista que seguía el pensamiento de J. D. Dana: "continentes permanecen como continentes; océanos permanecen como océanos" (Borges 1992, 60). Para los fixistas la corteza continental y las cuencas oceánicas tuvieron su origen en el inicio de la formación de la Tierra, no habiendo sido modificadas posteriormente. Es contra estas ideas (contraccionismo/fijismo) que se debatiría la teoría movilista de Wegener, dando paso así a la controversia entre fixistas y movilistas. Estos puntos (contraccionismo y fijismo) constituirían de alguna forma el núcleo duro de la tesis de Lakatos del modelo explicativo fixista o de la tradición de investigación de Laudan, que era necesario mantener a todo costo (Marques, 1996). Ya siguiendo el modelo de Kuhn, el fijismo sería, muy probablemente, el paradigma de la geología en aquella época. Algunas explicaciones que contemplaban la existencia de movimientos laterales de los continentes fueron avanzadas, pero tenían en cuenta el modelo fixista. Eduard Suess (1831-1914), y con él la comunidad geológica, creía que la tierra se encontraba en contracción, por lo que aquellos movimientos serían apenas marginales, pues los núcleos de los continentes permanecían fijos (Borges, 1992). Para Suess los continentes actuales eran fragmentos de un paleocontinente, del cual algunas porciones habían sufrido subsidencia después de fracturadas (Amador y Contenças, 2001). Fue Frank Taylor (1860-1938), un glacialogista estadounidense que, a pesar del cuadro teórico de su época ser, en general, antagónico con la aceptación de la deriva continental, se anticipa, de cierta forma, al trabajo de Wegener, y defiende en 1908 la existencia de un deslizamiento de la corteza, responsable por la formación de algunas cadenas montañosas (Amador y Contenças, 2001). Se trataba de una teoría no globalista, que tenía que ir a buscar al exterior de la tierra las fuerzas dinamizadoras para el movimiento de los continentes (Borges, 1992). Esta primera propuesta de movilidad horizontal de los continentes, en una comunidad geológica fuertemente fixista, fue ignorada. Sólo en 1912, tal como ya fue referido, Wegener propuso la teoría de la Deriva Continental, en la cual las montañas resultaban de "colisiones" entre masas continentales distintas. No siendo pionero, Wegener (1966 [1929]) se destacó por la diversidad de argumentos que movilizó: geodésicos, geofísicos, geológicos, paleontológicos y biológicos y paleoclimáticos. Con todo, a pesar de la rica argumentación dada por Wegener, la comunidad científica de la época no se mostró dispuesta a aceptarla, principalmente porque Wegener no había conseguido mostrar una fuerza creíble capaz de explicar el movimiento lateral de los continentes. Para Laudan, este sería un problema conceptual interno, ya que era la propia teoría la que demostraba inconsistencia. Uno de los críticos más duros lo fue el geofísico H. Jeffreys que, con cálculos simples, demostró que las fuerzas de Eotvos y de las mareas, propuestas por Wegener, tenían una magnitud de prácticamente un millón de veces menor que la fuerza necesaria para mover los continentes. Estas críticas fueron incorporadas por la llamada Escuela Geofísica de la Tierra Ultrasólida, establecida en Gran Bretaña y los Estados Unidos, y que defendía que el planeta poseía una rigidez demasiado grande, incompatible con la posibilidad de deriva continental (Hallam, 1985). No obstante, Wegener (1966 [1929]) tenía la noción que la completa justificación de las fuerzas que provocaban el movimiento de los continentes podría demorar algún tiempo a encontrarse. Y por eso afirmó que "El Newton de la teoría de la deriva aún no había aparecido", p. 167. Aún así, creía que la comunidad científica podría adherir a sus ideas, independientemente de que el fenómeno se encontrara o no totalmente explicado físicamente. Hecho que para Laudan sería fácilmente aceptable puesto que, ya bien fuera esta nueva tradición de investigación (Deriva Continental) verdadera o no, ésta era la que respondía con mayor eficiencia al problema empírico del movimiento de los continentes. Sin embargo, la adhesión no se materializó y fueron muy pocos los geólogos que inmediatamente lo apoyaron; Argand habrá sido su mayor defensor y Du Toit, su mayor impulsor (Borges, 1992). Para justificar la poca adhesión es importante recordar que el fijismo y el contraccionismo dominaban en aquella época, pero la propia espectacularidad de la idea de la deriva asociada al movimiento horizontal de las masas continentales, pesando millones de toneladas, no debe desvalorarse como causa. Además, a principios del siglo XX, la geología se encontraba desarticulada, obstruida por el impasse de las polémicas entrecruzadas de movilistas contra fixistas. La evolución tuvo lugar en medio de las contradicciones propias de un clima social convulso (Borges 1992), lo que concuerda con la visión externalista de la Ciencia defendida por Kuhn, Lakatos y por el propio Laudan. Los argumentos que Wegener presentó serían, en una perspectiva popperiana, refutadores del fijismo. Basta recordar su intento de demostrar la imposibilidad de la existencia de puentes intercontinentales considerados responsables por la distribución geográfica de varias especies de seres vivos, extintos desde hace mucho tiempo. Al abrigo de las tesis de Lakatos y Kuhn, sus argumentos se presentan, respectivamente, como anomalías al PIC o paradigma fixista de la época. Sin embargo, un nuevo PIC empieza a afirmarse con Wegener, siendo sus argumentos parte de las "hipótesis explicativas" del programa, en que la idea del desplazamiento de los continentes constituiría su núcleo duro o central. De la heurística negativa formarían parte ideas que podrían refutar el núcleo duro como, por ejemplo, la de considerarse al contraccionismo responsable por las características externas del globo, o la de la corteza de los fondos oceánicos originarse en la subsidencia de las porciones continentales (Praia, 1996). La presencia simultánea de más de un programa de investigación en competición (fixistas y movilistas) también concuerda con el modelo de Lakatos. En el modelo de Kuhn, los argumentos presentados por Wegener representaban anomalías al paradigma vigente (contribuyendo para el inicio de una posible crisis), mientras que la idea central de su teoría (el desplazamiento lateral de los continentes) abría el camino al surgimiento de un nuevo paradigma. Como refiere Kuhn (1992), el futuro paradigma puede emerger antes que la crisis esté bien avanzada o incluso reconocida y, por lo tanto, incluso antes de la adhesión de la comunidad científica a las nuevas ideas. Ya para Laudan, si respondiera con mayor capacidad al problema empírico, entonces estaríamos ante una situación de progreso científico, no necesariamente cumulativo. La propuesta de Wegener continuó siendo ignorada durante los años 30, pudiendo decirse incluso que fue recibida por la comunidad científica con cierta hostilidad (Marques, 1996). Muchos se preocupaban en atacar las carencias del nuevo PIC, aunque ignoraban las carencias de sus propios programas o paradigmas fixistas. Tales ataques pueden verse también como tentativas para hacer sobresalir los problemas conceptuales internos de la teoría, ampliamente valorados en las tradiciones de investigación de Laudan. Un ejemplo de esta situación es que el descubrimiento de la radioactividad en 1909, que vino a probar que el calor producido por el decaimiento radioactivo era incompatible con la idea de una tierra en enfriamiento, no fue suficiente para abandonar la explicación de la orogénesis a partir de la contracción del planeta. Igualmente, el catastrófico sismo de San Francisco, el 18 de Abril de 1906, demostró que la corteza puede sufrir movimientos horizontales (carreteras y cercas fueron notoriamente desplazadas). Ese desplazamiento fue horizontal y ocurrió a lo largo de una falla vertical, la de San Andrés. Tal movimiento refutaba la teoría vigente que atribuía los sismos a explosiones subterráneas, derivadas de la contracción de la tierra (Borges, 1992). La tesis de Popper parece aquí poco aplicable, ya que datos que contrariaban la idea contraccionista de la tierra no fueron suficientes para refutar el fijismo. En esta situación, los modelos de Kuhn y Lakatos parecen más aplicables, ya que defienden que un paradigma o PIC sólo puede ser refutado cuando existe otro en condiciones de substituirlo (cuando ocurren los acontecimientos referidos, Wegener aún no había propuesto su teoría). No obstante, cuando Wegener propuso una alternativa fundamentada, ésta no fue aceptada inmediatamente. Esta situación corrobora también las tesis de Lakatos, Laudan y Kuhn, pues, si los dos primeros ven al cambio como progresivo y lento a lo largo del tiempo (Dieguéz, 1995), Kuhn (1992) considera que antes de una revolución ocurre la "crisis" del viejo paradigma, por lo que los argumentos presentados serían vistos "apenas" como anomalías al paradigma de la época (el fijismo). Sin embargo, la constatación que no sería posible explicar ni la génesis de las cadenas montañosas, ni algunas de las estructuras geológicas observadas en ellas, apelándose únicamente a fuerzas verticales, se tornaba cada vez más evidente (Amador y Contenças, 2001). Las anomalías se acumulan, el PIC (basado en el modelo fixista) se vuelve cada vez más degenerativo y la "crisis" del viejo paradigma cada vez más acentuada. La nueva tradición de investigación parecía capaz de resolver mejor los problemas. Pero como realza Kuhn (1992), con tantas dudas parece natural que la balanza se incline para la tradición, lo que en cierta medida muestra que las teorías no ceden al primer ataque, pues si tal aconteciese, era la propia Ciencia que estaría en riesgo debido a la falta de coherencia interna. Por otro lado, la capacidad de abertura de espíritu, disponibilidad para la innovación y capacidad para reconocer el error, por parte de los científicos, no es tan frecuente como muchas veces se defiende. Como destaca Kuhn (1992), la fuente de resistencia es la confianza (o la esperanza) de que el paradigma antiguo acabará resolviendo todos los problemas. Para Lakatos la no aceptación inmediata del nuevo programa de investigación es igualmente comprensible pues, tratándose de un PIC nuevo, es natural que necesite de tiempo para que se torne más progresivo y pueda superar a su rival más tarde. Fueron algunos resultados de investigaciones, llevadas a cabo con otros objetivos, que posibilitaron la recuperación de las ideas de Wegener en los años cincuenta. Sería aquello que Laudan referiría como un problema anómalo, o sea, aquel que es resuelto no por la teoría para la cual constituye una anomalía, sino por una teoría rival. Así, después de la II Guerra Mundial, investigaciones en el campo de la geofísica y del estudio de la topografía submarina, desarrolladas para fines militares, evidenciaron diferencias de espesura, densidad y composición entre las cortezas oceánica y continental y la inexistencia de continentes sumergidos. En este contexto, algunas de las explicaciones para defender el fijismo son falseadas, lo que para Popper corresponde al camino para refutarlo. Sin embargo, recordemos que la teoría de la deriva había sido igualmente refutada, debido principalmente a la alusión de fuerzas no creíbles para la justificación de la movilidad horizontal de los continentes. Así, siguiendo el pensamiento de Popper, se podría concluir que se trataba igualmente de una teoría inconsistente, pues fue refutada con relativa facilidad, pero como no es el caso, el falsificacionismo de Popper no parece ser la mejor interpretación para este episodio de la historia de la Ciencia. No obstante, la tesis de Laudan, de que lo importante es la capacidad de la teoría para resolver el problema y no tanto si es verdadera o falsa, parece ser de fácil aplicación en esta situación. La teoría de Wegener gana así significado nuevamente, lo que, considerando al modelo de Lakatos que se revela aparentemente adecuado, hace al nuevo programa de investigación cada vez más progresivo (y al antiguo degenerativo), aumentando su número de apoyantes. Según la tesis de Kuhn, el paradigma vigente presenta anomalías cada vez más contundentes y se vuelve más debilitado, abriendo un espacio decisivo para el surgimiento de un nuevo paradigma. A partir de 1955, estudios sobre el paleomagnetismo comprobaron definitivamente la importancia de los movimientos horizontales de la corteza terrestre. En 1963, con el desgaste del paradigma vigente, la teoría de la Deriva Continental es efectivamente recuperada, pero esta vez con nuevas evidencias y una nueva perspectiva. Se establecía definitivamente la importancia de los movimientos tectónicos horizontales y se ampliaba, a dimensión planetaria, la escala de observación geológica (Borges, 1992). En 1965, el geofísico Wilson propone, por primera vez, la idea de Tectónica de Placas. El nuevo PIC supera definitivamente el PIC basado en el modelo fixista y ocurre, en una perspectiva kuhniana, la revolución, o sea, el viejo paradigma es substituido por otro, el de la teoría de la Tectónica de Placas.

EN SÍNTESIS

De una forma global, considerando lo que pasó desde el surgimiento de la Teoría de la Deriva Continental, propuesta por Wegener hasta la formulación de la Teoría Tectónica de Placas, las teorías de Lakatos y de Kuhn se presentan como las más adecuadas a todo el proceso. De hecho, la sustitución del modelo explicativo no ocurre por una simple confrontación con factos contradictorios isolados, mas apenas cuando surgió una alternativa creíble, resultante del desenvolvimiento de una teoría que agrupó de forma articulada y coherente los datos provenientes de orígenes diversos. En tanto, se tuvo que optar por uno de los dos modelos, la tendencia fue hacia la tesis de Lakatos, una vez que el nuevo programa da respuesta a situaciones ya resueltas por el modelo fixista, y no habiendo, un corte abrupto con conocimiento anterior (por ejemplo, el principio de uniformitarismo ahora aplicable); presenta soluciones creíbles para los dos problemas no solucionados y hace predicciones para nuevas situaciones que antiguamente no era capaz de hacer. En este sentido, podríamos igualmente referir el modelo de Laudan, o aceptar que en una misma tradición de investigación coexistan teorías rivales desde que respeten los compromisos ontológicos y normas metodológicas. Nótese que fue también posible constatar que, en varios momentos de la Historia de la Geología contemplados en este artículo, se verifica la existencia de un cierto pluralismo teórico en competición, bastando pensar que tanto el paradigma mobilista como el fixista coexistirán durante casi medio siglo.

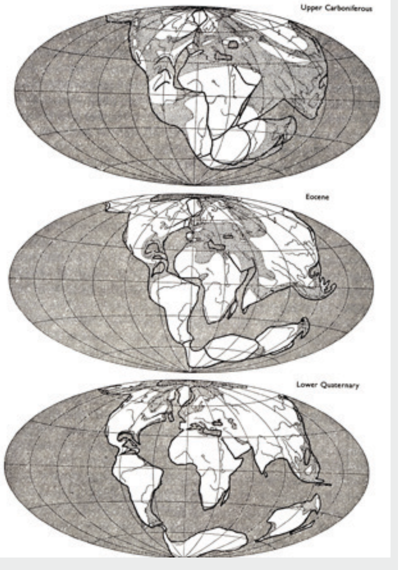
Mas, independientemente de éste que mejor se adapta al episódio descrito, es esencial realzar la importancia de estos abordajes en el sentido de permitir contrariar, como destaca Hodson (1998), la visión tendencialmente inductivista de la construcción de la ciencia encontrada entre los profesores. La enseñanza de las ciencias, en este caso de la geología, no puede ignorar la necesidad de un abordaje contextualizado de información histórica, y tiene que llamar la atención para los aspectos socio-económicos, políticos, religiosos y éticos que influencian la práctica científica. Tal abordaje pasa, así, por la necesaria inclusión de la historia de la ciencia y la dimensión epistemológica de la ciencia en los programas escolares de ciencias y para la valorización de estos aspectos en la práctica pedagógica de los profesores. La historia de la geología aquí abordada podrá ayudar a los alumnos a ultrapasar la idea de imagen heróica de los cientistas, no sólo a través de la contextualización del pre-escenario continental, sino también, a través de la contribución dada por varios cientistas, necesario para llegar a la Teoría de la Tectónica de Placas, la cual no se engloba necesariamente en Alfred Wegener. La Teoría de Tectónica de Placas resultó de un largo recurso, repleto de avances hasta su aceptación generalizada. Ahora, solo la inclusión en contexto formal de episodios como lo descrito, permitirá a los alumnos la visión de ciencia con historia, donde los procesos de construcción del conocimiento científico pueden ser blanco de una atención más cuidadosa.

APLICACIÓN EDUCATIVA

Seguidamente se presenta una posible aplicación educativa que permite explorar algunos aspectos epistemológicos e históricos de mobilidad de la superfície de la tierra.

Parte I

Wegener publica en 1915 el libro "El origen de los continentes y los océanos" en el que menciona la Deriva Continental como la responsable por el movilismo de la litósfera. En la década del sesenta del siglo XX, Tuzo Wilson y otros investigadores presentaron la Teoría de la Tectónica de Placas como la responsable por la dinámica interior del planeta.



(La posición de los continentes en tres ocasiones distintas. En, Wegener, 1966 [1929], p. 18)

1) ¿Cuál es el problema con el que se debatió la comunidad científica que puso en causa el fijismo? ¿Cómo explicaría Laudan el surgimiento de una teoría que lo resolviera?
2) ¿Por qué razón algunos autores mencionan la Deriva Continental como hipótesis y otros como teoría?
3) Con base en la información facilitada, explica la razón por la cual unas teorías (y sus modelos) van siendo sustituidas por otras a la luz de la teoría de Kuhn, Popper y Lakatos.
4) En su momento Wegener fue criticado, no únicamente por la falta de un mecanismo convincente causador de la movilidad de los continentes, sino también por la metodología utilizada en la construcción de su teoría. Veamos el comentario del paleontólogo E. W. Berry:

El método de Wegener según mi opinión no es científico, sino que sigue la trayectoria normal de una idea inicial, una búsqueda selectiva a través de la literatura para corroborar sus pruebas, ignorando los hechos opuestos a esta idea, y finalizando en un estado de autointoxicación en el cual la idea subjetiva acaba siendo considerada como un hecho objetivo.

Y Wegener se desahoga en una carta que le envía a su suegro en la que comenta sobre sus críticos:

¡Esta gente que insiste en basarse solamente en los hechos y no quieren saber nada de las hipótesis, están utilizando ellos mismos una falsa hipótesis sin darse cuenta…!

(Citas sacadas de Hallam, A., Great Geologic Controversies, Oxford University Press, New York, 1989).

4.1. ¿Cuál es el proceso de construcción de la ciencia aparentemente seguido por Wegener?

4.2. ¿Qué autores de los citados defienden un proceso de construcción de la ciencia como el seguido por Wegener?

5. El geofísico Dr. Jeffreys prefirió expresar sus críticas a las fuerzas presentadas por Wegener generadoras de la deriva, tras haber probado matemáticamente que éstas no podrían causar la movilidad de los continentes. Él ha proferido la siguiente afirmación:

En la teoría de Wegener, por ejemplo… el supuesto de que la Tierra puede deformarse indefinidamente debido a pequeñas fuerzas, siempre que actúen en un tiempo suficientemente largo es, por consiguiente, muy peligroso y puede inducir a serios errores.(Recogido de Hallam, A., Great Geologic Controversies, Oxford University Press, New York, 1989).

5.1. Explique por qué parece que el Dr. Jeffreys se aproxima claramente del modelo de Popper para la construcción de la Ciencia.

5.2. Incluso con la demostración matemática de la imposibilidad de la deriva, cuando motivada por las fuerzas presentadas por Wegener, algunos científicos, como Du Toit, permanecen sus fieles seguidores. ¿Cómo se explica que algunos científicos sigan nuevas ideas, pese a las fragilidades detectadas?

6. El avance tecnológico, en las décadas de los cuarenta y cincuenta, fue indispensable para el resurgimiento de la idea de movilidad de los continentes en la década de los sesenta bajo la forma de la teoría de la tectónica de placas.

6.1. ¿Qué ejemplos se podrían presentar para respaldar esta idea?

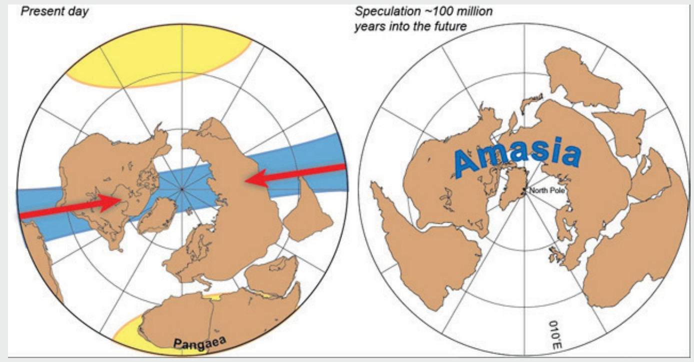
6.2. ¿Qué autores, de los citados, mejor recogen los avances de la tecnología en el progreso de la Ciencia? ¿Lo sabes? ¿ Se puede recoger del texto?

6.3. El concepto de placa traduce un modelo para explicar la movilidad horizontal de los continentes. ¿Cuál es el papel de los modelos en la construcción del conocimiento científico?

7. ¿Qué importancia tiene que el trabajo científico en la actualidad se haga en equipo, designadamente en equipos interdisciplinarios?

Parte II

En febrero de 2012, la revista *Nature* publica un artículo de Mitchell Ross y colaboradores, mencionando el modelo de la ortoversión. Este modelo alternativo a los otros dos presentados anteriormente a la comunidad científica, prevé la localización del futuro supercontinente (Amásia), dentro de 50 a 200 millones de años, en el Polo Norte.



(En, http://aeiou.visao.pt/amasia-o-novo-supercontinente=f645862, consultado en abril de 2012)

1. ¿Esta previsión se basa en la inmutabilidad o en la refutación de la teoría de la tectónica de placas en los años futuros?

1.1. ¿Cómo explicas esta aparente inmutabilidad de paradigma, a la luz de las ideas discutidas?

1.2. Esta previsión, denominada de especulación, ¿de qué forma puede tener importancia en la ciencia? Verifica si tu respuesta se incluye en las ideas de alguno de los autores discutidos.

2. Discute a la luz de las ideas de los autores presentados en el texto sobre la posibilidad de la existencia de teorías inmutables en Ciencia.

3. ¿Qué fragilidades ha revelado la teoría de la tectónica de placas y cómo ha procurado sobrepasar esas mismas fragilidades?

4. Una nueva teoría sugiere que por lo menos mitad de los puntos calientes primarios de la Tierra pueden haber resultado de la colisión de grandes asteroides en zonas de océano en el punto exacto del globo, a 180 grados de distancia. Como evidencia de esta teoría, algunos científicos mencionan el Yellowstone y las islas Kerguellen. Recordando las dificultades de aceptación de la Deriva Continental y de la Teoría de la Tectónica de Placas, ¿cómo esperas que pueda reaccionar la comunidad científica a esta reciente teoría?

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La utilización doméstica de plaguicidas en ambientes rurales y urbanos - situación e intervención educativa

Domestic use of pesticides in urban and rural communities. Status and educational intervention

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Resumen

Es importante un diagnóstico de la situación y la implementación de estrategias educativas concordantes con los resultados obtenidos en materia del uso doméstico de plaguicidas. La educación y la información son las herramientas más importantes para el cambio de conductas. El diagnóstico de situación respecto del uso, manejo y efectos de plaguicidas de uso doméstico proporciona el espacio conveniente para el desarrollo de actividades que permiten al estudiante mejorar la imagen empobrecida de la ciencia y a su vez que participe de una formación ciudadana acorde con las necesidades del mundo actual. Sobre esta base se plantean los siguientes objetivos: Obtener información sobre uso, manejo y efecto de los plaguicidas de uso doméstico en una población urbana y una rural y compararla e implementar una estrategia pedagógica y didáctica que interese a los estudiantes de la enseñanza secundaria y posibilite la reconstrucción de conocimientos científicos relacionados con la toxicología y el cuidado de la salud. Los resultados obtenidos tanto del diagnóstico como de la actividad en las escuelas, muestran la necesidad concreta de la realización de acciones preventivas referidas al uso de los plaguicidas domiciliarios tanto en el ámbito rural como en el urbano.

Palabras clave: *plaguicidas, ambientes rurales y urbanos, educación, prevención*

Abstract

Information and education are important resources to strengthen people's conservation behavior. Information about domestic use of pesticides and its effects is a convenient tool within a Science, Technology, Society and Education (STSE) focus, to perform student activities in a scientific way, and to involve them in the needs of the current world. The objectives of the present study were to obtain information about the domestic use of pesticides and its effects in urban and rural communities, to compare both situations and to apply pedagogic and didactic strategies from STSE focus, with interesting activities to the secondary school students in relation to the toxicological scientific knowledge and the health care. The results obtained from the diagnostic poll and the strategies applied, show the real necessity to perform conservative actions in the daily use of pesticides. Educative strategies are relevant resources to improve public responsibility in particular problems such as negative pesticide effects, which have not been identified as a local public health problem.

Keywords: *pesticides, rural and urban environments, education, conservation.*

INTRODUCCIÓN

La necesidad de controlar las plagas domiciliarias es incuestionable. Sin embargo es indispensable plantear la discusión sobre la mejor manera de hacerlo sin que su uso signifique algún riesgo en la salud de los otros organismos y el ambiente.

Los plaguicidas constituyen un grupo heterogéneo de compuestos químicos diseñados para el control de insectos, roedores, hongos, enfermedades de plantas y control de malezas. Su aplicación es el modo más efectivo y aceptado para proteger las plantas de las plagas, y han contribuido en forma significativa a aumentar la productividad agrícola y el rendimiento de las cosechas (Bolognesi, 2003). En nuestro país cerca de 300 principios activos se usan a través de 1.550 formulaciones comerciales (Otamendi *et al*., 2001).

De acuerdo con las etiquetas de los productos, son compuestos de baja toxicidad y poseen un riesgo mínimo para las personas y el ambiente.

En la teoría los plaguicidas actúan selectivamente contra ciertos organismos sin efectos adversos para otros. Sin embargo, es difícil que sean absolutamente selectivos y la mayoría de los plaguicidas tienen riesgo de toxicidad para las personas. Por otro lado, son un método importante usado para el auto-envenenamiento. En el mundo ocurren tres millones de casos/ año de envenenamiento con plaguicidas, de los cuales 220.000 tienen desenlaces fatales (Eddleston *et al.,* 2002).

En Argentina existen 21 Centros de Información, Asesoramiento y Asistencia Toxicológica (CIAATs). En el Informe estadístico del 2001 de Consultas por Exposiciones/ Intoxicaciones enviados por 9 Centros Hospitalarios de Argentina, se computan un total de 32679 episodios individuales de intoxicación, que corresponderían al 30% del total de Consultas registradas (PRECOTOX, 2001). El 91,75% de las intoxicaciones por plaguicidas son por plaguicidas de uso doméstico, el 7,40% son plaguicidas de uso agrícola y el 0,85% por agroquímicos no plaguicidas. Dentro de los plaguicidas de uso doméstico los insecticidas con piretroides son responsables del 30,65% de las intoxicaciones, los insecticidas con fosforados del 20,25% y en tercer lugar los rodenticidas anticoagulantes con el 17,35%. Del total de las consultas aproximadamente el 50% corresponden a niños de 0 a 9 años (CASAFE, 2003).

Los efectos sobre la salud de diversos contaminantes ambientales entre ellos los plaguicidas, se producen por exposición aguda. A las exposiciones crónicas, a niveles menores de diversos contaminantes, que no producen efectos precoces visibles, se les asigna menor importancia. Sin embargo el efecto crónico suele ser acumulativo y reflejarse en daño a diversos órganos y sistemas, causando enfermedades en el mediano o largo plazo, en períodos más tardíos de la vida o en la descendencia de los sujetos expuestos. Los agentes que mejor se conocen son los teratogénicos, mutagénicos y carcinógenos (Tchernitchin, 2005)

La población en su conjunto está expuesta a los residuos de plaguicidas incluyendo los productos de degradación biológica en aire, agua y alimentos (Bolognesi, 2003), por lo tanto, la capacitación sobre los riesgos de exposición a plaguicidas de uso domiciliario, debe ser la orientación principal para plantear estrategias educativas vinculadas a la protección de la salud humana y ambiental. La educación y la información son las herramientas más importantes para el cambio de conductas.

Esta mirada del problema implica llegar a los sujetos desde la realidad por medio de la acción/reflexión y concretar una eficiente tarea de socialización con respecto al desconocimiento de los riesgos de la utilización de plaguicidas en el hogar.

El propósito de este trabajo es recoger información acerca de los usos y efectos de los plaguicidas domiciliarios desde las vivencias de los hogares de los estudiantes (diagnóstico de situación) y utilizarla como base en la implementación de estrategias educativas que contribuyan a mejorar el conocimiento del riesgo para la salud asociado al uso de estas sustancias, considerando a los estudiantes como multiplicadores en la difusión de acciones de prevención.

METODOLOGÍA

Área de estudio para el diagnóstico de situación

La población seleccionada corresponde a los hogares de estudiantes de dos organizaciones educativas de enseñanza secundaria de una localidad rural y otra urbana de la Provincia de Córdoba.

Las organizaciones educativas comprenden 250 hogares (110 hogares de la localidad rural de Las Vertientes y 140 hogares de la ciudad de Río Cuarto). La localidad de Las Vertientes está situada en el departamento Río Cuarto (33°16′58″S 64°34′41″O). Su población está compuesta por 762 habitantes (INDEC, 2001) y se encuentra situada en el sur del departamento aproximadamente a 24 km de la ciudad de Río Cuarto, y a 250 km aproximadamente de la Ciudad de Córdoba. La principal actividad económica es la agricultura y la ganadería.

La localidad de Río Cuarto se encuentra en el departamento Río Cuarto (33 08′23″S 64 20′44″O) al sur de la Provincia de Córdoba. Cuenta con 144.021 habitantes (INDEC, 2001). Su importancia radica en su estratégica ubicación entre varios corredores comerciales del centro del país, en especial los que conectan al Océano Atlántico con el Océano Pacífico, además de hallarse en una muy fértil región.

Diagnóstico de situación

El diagnóstico de situación se llevó a cabo a través de un cuestionario estructurado. Para la elaboración del cuestionario se tuvieron en cuenta dos criterios: la eficacia para la investigación de cada pregunta (si la posible respuesta aporta datos de interés para el estudio que se está realizando), y el número adecuado de preguntas para no cansar al encuestado y obtener suficientes datos.

Se combinaron preguntas de tipo abiertas y cerradas por considerar necesario que el encuestado tuviera total libertad para responder, mientras que en otras se pretendía valorar su respuesta sobre la base de una serie de criterios previamente fijados y respondiendo a las características enunciadas por Badía y Carné (1998). El cuestionario fue entregado a cada estudiante y se solicitó que lo completaran en los hogares con el aporte de todos los miembros de la familia.

El punto central de la justificación de la información que contiene el cuestionario se relaciona directamente con el objetivo planteado y para ello las preguntas se dirigieron hacia el tipo de plagas, la sustancia química, los efectos sobre la toxicidad para la salud y el ambiente, las medidas de protección utilizadas, los accidentes ocurridos en el hogar, la información sobre los centros de atención.

Estrategias educativas

Se entiende como de vital importancia habilitar un espacio de diálogo con la comunidad a través de los jóvenes, estableciendo canales de comunicación que permitan poner el problema en palabras, priorizando las vivencias cotidianas, es por eso que se elige trabajar con la modalidad taller (Perkins, 1997) en los espacios curriculares correspondientes a Biología de las organizaciones educativas donde se implementa el diagnóstico de situación.

El taller se estructuró según la siguiente secuencia: presentación y explicación de la propuesta y metodología de trabajo (1 clase), el trabajo en el aula (1 clase), una plenaria (1 clase) y un trabajo grupal de elaboración de material de divulgación (1 clase).

Análisis de los datos

Para analizar los resultados se siguieron las siguientes acciones:

revisión de la información recopilada con el propósito de obtener categorías para analizar la información; análisis de la información generada considerando la distribución porcentual para cada categoría analizada; socialización de resultados con los informantes a partir de sus propias creencias, significados y experiencias; identificación de hallazgos significativos, mediante la confrontación de la discusión de resultados.

RESULTADOS Y DISCUSIÓN

Diagnóstico de situación

A partir de la revisión de la información generada por los cuestionarios que se respondieron en cada hogar de los estudiantes (entre 12 y 17 años) de las dos organizaciones educativas, se construyeron las siguientes categorías de análisis:

plagas más combatidas, principios activos de los plaguicidas utilizados, percepción sobre la toxicidad para la salud y el ambiente, utilización de medidas de protección, accidentes ocurridos en el hogar, información sobre los centros de atención.

Del análisis de los cuestionarios surge: en el 99,6% del total de los hogares estudiados en ambas localidades, se utilizan plaguicidas.

El uso de plaguicidas en el interior de las viviendas, tanto en la población rural como en la urbana está muy difundido, es generalizado y elevado.

Las plagas más combatidas en el grupo de los artrópodos son los insectos (las moscas, los mosquitos y las hormigas) seguidos de las garrapatas, las arañas y en el grupo de los mamíferos son los roedores, en ambas poblaciones. En el ámbito rural se destacan además los hongos y en la ciudad los caracoles terrestres. En ambas poblaciones también se combaten las malezas (Figura 1 y Figura 2).

Se observa en ambas poblaciones un desconocimiento de los principios activos que contienen los plaguicidas. En la población rural el 80% reporta desconocimiento y en la ciudad el 63% de la población. De los reportes sobre el conocimiento de los principios activos, los indicados fueron: Piretroides:

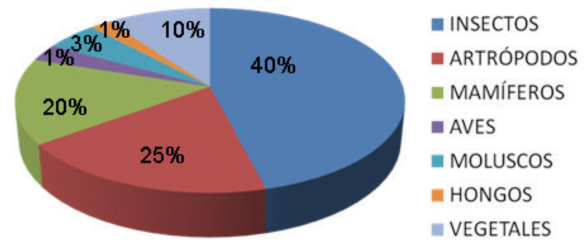

Figura 1. Principales plagas combatidas en la población rural

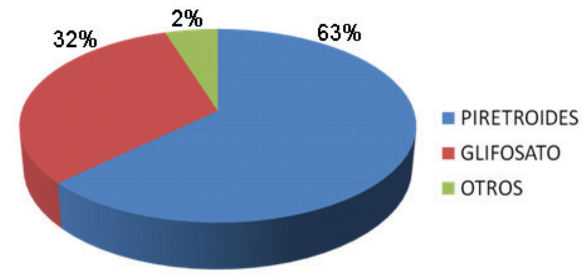

Figura 2. Principales plagas combatidas en la población urbana

Tetrametrina – Cipermetrina (63% en la población rural) y Piretroides: Tetrametrina – Cipermetrina – Permetrina – Ciflutrina – Transflutrina-Sulfuramida – K-Othrina (66% en la ciudad), Aminofosfonato: glifosato (32% en la población rural), y otros Organofosforados y Organoclorados: 18% en la población de la ciudad, Alcaloides: estricnina (1% en la población urbana) (Figura 3 y Figura 4).

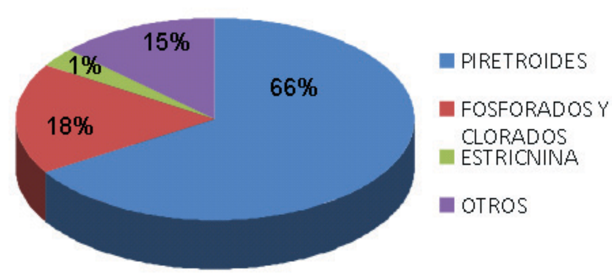

Figura 3. Plaguicidas empleados en la población rural -Figura 4. Plaguicidas empleados en la población urbana

En las dos poblaciones, el 73% de los hogares, conocen que los principios activos de los plaguicidas son peligrosos para la salud. Del análisis de las respuestas surgen varias agrupaciones: agrupan a los plaguicidas según su acción específica (insecticidas, herbicidas, raticidas, hormiguicidas, garrapaticidas), según su principio activo, según su presentación (aerosoles).

La población rural considera como peligroso para la salud a los insecticidas (25%), seguidos por los herbicidas (24%). La población de la ciudad considera también a los insecticidas (28%) seguidos de los hormiguicidas (14%), de las presentaciones en aerosoles (9%) y de los pediculicidas (2%). Las dos poblaciones, 67% de los hogares, tienen conocimiento de la peligrosidad para el ambiente. Destacan como más peligrosos para el ambiente a los insecticidas (37%) y los herbicidas (12%) en la población rural. En la población de la ciudad son considerados peligrosos para el ambiente las presentaciones en aerosoles (34%), los insecticidas (13%) y los herbicidas (6%). Ambas poblaciones consideran que los riesgos que presentan los plaguicidas son más nocivos para la salud del hombre en un (80%) que para el ambiente y el resto de los seres vivos.

El 58% de la población rural usa elementos de protección personal y toma medidas de precaución al manipular plaguicidas mientras que en la ciudad el 84% hace uso de esos elementos y de las medidas (Figura 5 y Figura 6). Los elementos de protección personal (EPP) más utilizados son guantes y barbijos en la población rural y guantes en la población de la ciudad. Se destaca el uso de otros elementos referidos a indumentaria (mameluco, anteojos) en menor proporción. Las precauciones que tienen en cuenta al momento de la aplicación son: no fumar durante la aplicación, aplicar lejos del fuego, lavarse las manos, no rociar sobre los alimentos, ventilar el ambiente, evitar inhalar, evitar la presencia de niños y animales al momento de la aplicación y almacenar el producto en lugar seguro.

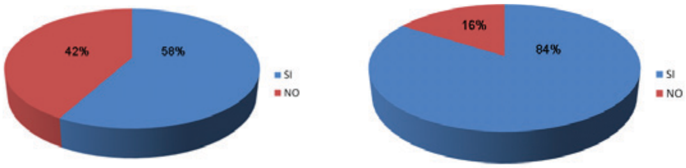

Figura 5. Uso de protección en la población rural- Figura 6. Uso de protección en la población urbana

El criterio de elección más relevante fue la eficacia en ambas poblaciones. El 17% de la población rural y el 10% de la población de la ciudad no saben el motivo de la elección.

En relación con los síntomas de intoxicación en las personas que aplican plaguicidas existen mayor registro en la población rural (27%) que en la población de la ciudad (10%). En ambas poblaciones se informan los siguientes síntomas que tuvieron las personas que aplicaron el producto: vómitos y mareos, dolor de cabeza y malestar estomacal, mareo, nauseas y dolor de cabeza, sólo dolor de cabeza, sólo vómitos, alergias inespecíficas, desmayos. En las personas que permanecen en el lugar cuando se aplican plaguicidas un 22% estuvo afectado de la población rural y un 12% de la población de la ciudad. El mayor porcentaje (40%) de síntomas se refieren a boca seca, vómitos, mareos y convulsiones en la población rural y dolor de cabeza, mareos, vómitos y desmayo (27%) en la población de la ciudad. Otros relatados son: tos, picazón de ojos y pérdida de conocimiento.

Ambas poblaciones (63% de la población rural y 77% de la población de la ciudad) conocen dónde recurrir en caso de accidentes con plaguicidas de uso doméstico. Reportan como lugares de consulta a los centros de atención médica (emergencias, dispensarios, hospitales y médicos) y los lugares que figuran en la etiqueta de los envases (12%) en menor proporción. En la población rural destacan al dispensario como lugar más próximo de atención seguido del Nuevo Hospital de Río Cuarto. Se destaca que también consultarían a las áreas especializadas en toxicología de hospitales de Córdoba y Buenos Aires. Si necesitan teléfonos de emergencias lo harían al número que figura en el envase. Ambas poblaciones dicen desconocer acerca de estudios médicos específicos que se realizan para detección de daños producidos por la exposición domiciliaria a plaguicidas.

Estrategias educativas

El trabajo en el aula se desarrolló a partir del diagnóstico de situación, cada docente expuso los resultados obtenidos de los cuestionarios que se implementaron en cada hogar, el aporte que ese contenido, las vivencias de los estudiantes y la actividad a implementar, puede contribuir a la formación de los estudiantes y a los procesos de aprendizaje.

Seguidamente y con el propósito de la conceptualización se implementó la lectura y reflexión de material bibliográfico seleccionado sobre la base del diagnóstico de situación y acorde al currículo de Biología correspondiente a cada curso.

Se organizaron grupos de 3-4 estudiantes para trabajar con la misma consigna pero con material bibliográfico diferente.

En la plenaria, un representante por grupo presentó de forma oral los emergentes del trabajo grupal y se continuó con varias preguntas abiertas, que los grupos fueron respondiendo dando lugar a comentarios y narraciones.

Durante el transcurso de la plenaria se percibió, en general, un cambio cualitativo de actitud, manifestado en la necesidad de hablar de la problemática y contar cada experiencia propia.

Las respuestas más significativas de los participantes son: se identifica el plaguicida como un químico, veneno y tóxico "tiene químicos que envenenan e intoxican", "los plaguicidas producen daños", "matan bichos".

Se pudo observar que los jóvenes que expresan conciencia de los riesgos que se corren con el uso de plaguicidas son muy pocos y simultáneamente existe la negación de los mismos. "Solo, los que ponen el plaguicida deben utilizar medidas de protección y los que están en el lugar no lo necesitan", "no es necesario protegerse en la casa", "actúa solamente con los bichos", "hay que rociar y cerrar todo para que mate los bichos", "a nosotros no nos pasa nada".

Los jóvenes perciben que las medidas de protección y seguridad sólo deben ser adoptadas por los adultos (que aplican el producto), posiblemente los estudiantes no relacionan el riesgo con su participación pasiva.

La percepción de riesgo es reconocida ante el uso de plaguicidas "nos puede hacer daño si lo respiramos", "si hay un niño se puede morir", "son beneficiosos porque matan los insectos pero pueden hacernos daños".

Respecto a los efectos en la salud discutidos se observó que se consideran los efectos directos de la exposición a los plaguicidas, especialmente aquellos relacionados con síntomas agudos de intoxicación "si lo aspirás directamente te hace mal, te sentís mal", "te intoxicás si te lo tiran en la cara", "si lo tomás podés tener que ir al médico", "te duele la cabeza o vomitás si te entra por los ojos o la boca".

Se expresó el deseo de comenzar a pensar sobre tomar medidas colectivas para cuidarse a sí mismos y cuidar a los otros.

A partir de la exposición y discusión de los contenidos se consideraron como interrogantes más representativos de cada curso los siguientes:

Antes de usar un plaguicida, ¿qué debemos tener en cuenta? (en todos los cursos); ¿Qué hacer en caso de intoxicación por plaguicidas? (primer año); ¿Por qué es importante eliminar moscas, mosquitos, hormigas y otras plagas domiciliarias? (segundo año); ¿Qué riesgos tiene para la salud la utilización de un plaguicida? (tercer año); ¿Qué riesgos tiene para el ambiente la utilización de un plaguicida? (cuarto año); ¿Qué daños al material genético pueden producir los plaguicidas? ¿Cuáles pueden ser las consecuencias del daño? (quinto año).

Estos interrogantes sirvieron de base para el desarrollo de la actividad práctica que se implementó. Se planteó la elaboración de un folleto que contiene texto con las preguntas y respuestas e ilustraciones (Figura 7 y Figura 8) elaboradas y seleccionadas por los estudiantes con la guía de los docentes.

Para la evaluación se tuvieron en cuenta todas las actividades realizadas en el transcurso de las clases y la producción final (folleto).

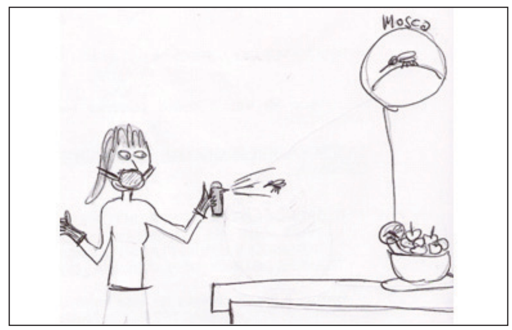

Figura 7. Ilustración realizada por los estudiantes (Francisco Conti)

Figura 8. Ilustraciones realizadas por los estudiantes (Constanza Barbero, Merlina Medina y Nabila Safadi Rojo).

En líneas generales el diagnóstico de situación demuestra por un lado que el concepto que tienen estas dos poblaciones estudiadas respecto a los plaguicidas, no está claramente definido y por otro lado que la percepción ante su uso los define como veneno, químico y tóxico que extermina las plagas nocivas y más peligroso para el hombre que para el ambiente u otros organismos, resultados concordantes con el trabajo de Oviedo-Zuñiga y col. (2007).

La población urbana tiene mayor conocimiento sobre la importancia del uso de las medidas de protección a la hora de la aplicación y esto concuerda con los casos de intoxicación que fueron reportados. En ambas poblaciones conocen los lugares de emergencias ante la intoxicación con estos productos.

Existe un desconocimiento generalizado de los principios activos de mayor consumo, relacionados con piretroides y en menor medida con inhibidores de colinesterasa, pero advierten que son peligrosos para la salud y el ambiente asociando esta variable en mayor proporción con la plaga que se combate (insecticidas) o la forma de presentación y no con los principios activos. Entonces como se observa, las instrucciones normativas y de rutina no son suficientes para proteger la salud humana y ambiental. Esto refuerza el fundamento para incorporar los estudios de percepción de riesgo en las campañas educacionales y en el currículo de las asignaturas.

Otros trabajos como Lorenzatti y col. (2008) realizado en Santa Fe y Amable y col. (2005) para Buenos Aires, dan cuenta también de la necesidad de realizar intervenciones que permitan evidenciar el riesgo al que las poblaciones están expuestas por el uso inadecuado o sin medidas de protección de los plaguicidas domésticos.

En relación a la estrategia educativa que se implementó (talleres) ésta permitió dejar en evidencia el origen de la adopción de ciertas actitudes que no favorecen el cuidado de la salud, por ejemplo las medidas de protección inadecuadas que provienen de la costumbre que transmite el adulto al joven para protegerse, concordante con los resultados del trabajo de Oviedo-Zuñiga y col. (2007).

Para los jóvenes existe riesgo sólo donde se hace evidente. Entonces, cuando no hay un efecto visible de la exposición, se tiene la impresión de que el riesgo no existe. Esta apreciación se encuentra en Vaughan (1993) donde explica que los factores de estilo de vida que aumentan el riesgo de enfermedad crónica presentan circunstancias que difieren fundamentalmente de riesgos agudos de salud. La demora de posibles consecuencias negativas, el inicio gradual de una enfermedad, la influencia de opiniones acerca del daño pasado en las percepciones de riesgo futuro, y la incertidumbre inherente en estimadas probabilísticas de riesgo han sido consideradas por los investigadores en el dominio de riesgo ambiental como factores importantes cuando se explican las percepciones de riesgo y la conducta de auto-protección relacionada con exposiciones de largo plazo.

Por lo tanto, queda evidente que la percepción de riesgo y la conducta de auto-protección no se asocia con la exposición crónica a los pesticidas.

En conjunto esta estrategia educativa tomó en cuenta desde la evidencia científica y desde la misma población, los aspectos cognitivos y prácticos y los aplicó para el diseño de un taller educativo en salud, pedagógico y creativo, que podría ser aplicado en otras poblaciones que cuenten con características socio-culturales similares.

En conclusión los resultados obtenidos del diagnóstico de situación permitieron responder a preguntas referidas al uso y efecto de los plaguicidas en dos poblaciones (rural y urbana). Las respuestas a estas preguntas plantean el empleo responsable de los plaguicidas para la protección de la salud y del medio ambiente. Abordar el problema de los efectos biológicos de los plaguicidas domiciliarios lleva implícito un deber en la concienciación sobre las medidas de prevención, protección y cuidado personal en el ámbito del hogar y, de ser necesario, con la participación de las respectivas instancias gubernamentales y con mecanismos que permitan ampliar dicho abordaje.

Teniendo en cuenta que estos productos se encuentran al alcance de todos ya que pueden ser adquiridos en supermercados, minimercados sin asesoramiento adecuado y los resultados obtenidos en el diagnóstico se corrobora la presunción previa acerca de la necesidad de la educación preventiva de la población en relación con esta problemática.

La teoría y la práctica de prevenir, evaluar y corregir los factores que interfieren con el medio ambiente, son importantes de ser difundidos porque pueden afectar no sólo a la salud de las generaciones presentes sino la de las generaciones futuras.

Por otra parte es importante señalar que existen numerosas prácticas y medidas factibles que pueden ser tomadas por el común de las personas, para reducir de manera significativa el nivel de contaminación del ambiente domiciliario en que viven: como por ejemplo, el manejo integrado de plagas, los biopesticidas, y los plaguicidas localizados.

En cuanto a las acciones educativas implementadas se considera que son relevantes en cuanto a que contribuyen al protagonismo de los ciudadanos en problemáticas particulares que no han sido identificadas aún como una problemática de la Salud Pública local como el impacto negativo del uso de plaguicidas.

La metodología de trabajo presentada permitió promover el trabajo colectivo y colaborativo, la vivencia, la reflexión, el intercambio de opiniones, la toma de decisiones y la elaboración de propuestas en grupos de trabajo dejando en evidencia a través de los productos de los talleres (folletos) lo valioso de ésta para la confrontación y articulación de la teoría con la práctica.

El taller ha permitido relacionar el potencial intelectual individual y colectivo con la propuesta para la búsqueda de soluciones a problemas reales. De este modo, los participantes pudieron enriquecerse dentro del proceso de las actividades, tanto como de sus resultados prácticos.

Es también importante señalar que actividades presentadas en el salón de clases a los jóvenes permite llegar de manera efectiva a todos los hogares y desarrollar contenidos del currículo abordando problemáticas de la vida cotidiana.

Por último, cabe destacar que los hallazgos de este estudio se dirigen a los especialistas de la salud y docentes involucrados con asignaturas afines especialmente aquellos responsables por las campañas educacionales y de comunicación de riesgo.

En consecuencia, los educadores necesitan ir más allá de la instrucción de repetición mecánica y rutinaria, abriendo un espacio interlocutorio substancial que permita a los jóvenes expresar sus sentimientos, temores, percepciones e ideas. A través de sus discursos, es posible comprender aspectos importantes de sus vidas y las representaciones que hacen.

La educación en salud humana y ambiental permite implementar cambios relativamente simples en los hábitos diarios. Sin embargo algunas veces esta educación no se planea suficientemente y se extrapolan estrategias aplicadas con éxito en otras poblaciones sin tener en cuenta nuestras propias consideraciones culturales, políticas, económicas y sociales.

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Noise and perceived discomfort in Greek school children

Ruido y molestias percibidas entre niños griegos en la escuela

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Abstract

The survey herein aims to record the types of noise that school children frequently encounter at school (both indoors and outdoors), to investigate the degree of distress and to record the views of school children as to whether background noises distract them. In total, 594 randomly chosen children who attended fifth and sixth grade in three different regions of Greece with various population densities (Larissa, Volos and Naxos) participated in the survey. The tool used was a questionnaire properly designed for the purpose of the study.

The results revealed that children of the largest city (Larissa) were more exposed to internal and external noises and also reported higher levels of perceived annoyance. Moreover, according to the study, the most common perceivable external noises were those produced by vehicles and from the voices of children in the schoolyard. Regarding indoor school noises, children appeared to be chiefly disturbed by the noises in the corridors and the neighbouring classes. Finally, children did not report any particularly negative attitude towards indoor school noise since they did not consider it fully responsible for distracting them during the lessons.

Key words: *noise, children, distress, school*

Resumen

El sondeo realizado tiene como objetivo identificar los tipos de ruido frecuentemente encontrado por estudiantes en las escuelas (tanto en espacios interiores como exteriores), para investigar el grado de ansiedad y distracción que causa en los estudiantes. En total 594 niños, elegidos al azar, estudiantes de quinto y sexto grado de tres regiones con diferente densidad de población de Grecia (Larissa, Volos y Naxos) fueron sondeados. Como herramienta se utilizó un cuestionario específicamente diseñado para este estudio. Los resultados obtenidos revelaron que los niños que estudian en la ciudad mas grande (Larissa) están mas expuestos a ruidos en interiores y exteriores y registran niveles mas altos de irritación. Al mismo tiempo, según el estudio, el ruido exterior mayormente percibido fue el producido por el tráfico y por otros estudiantes en el patio. En cuanto a ruidos interiores, los estudiantes no mostraron ninguna actitud negativa hacia ellos al no percibirlos como una clara distracción durante las clases.

Palabras clave: *ruido, niños, angustia, escuela*

INTRODUCTION

Noise has become one of the major factors of environmental pollution affecting quality of life. Noise is defined as the sound that is unwanted, disturbing or unpleasant for humans (WHO, 1999). The main features of noise are its frequency and intensity. It is generally accepted that continuous exposure to noise exceeding 85 dBA, can lead to gradual loss of hearing (Clark & Stansfeld, 2007). Similar damage can be caused if the intensity of the source is high enough even if there is no frequent exposure to the noise.

Noise sources can be many and uncontrollable, especially in large urban centers. Several studies show that many noise problems can be related to human activity (WHO, 1999). Road traffic, air traffic, industrial plants, tracks of trains, public works construction, are among the main sources of intense and frequent noise (Schomer, 2001).

According to WHO, noise is a major health problem, which has diverse effects on human beings, starting from a simple annoyance or discomfort and leading to permanent damage to the body. For instance, it was reported that noise adversely affects the hearing, mental and psychosomatic health, increases the arterial pressure, causes headaches, discomfort, anxiety, sleeping difficulties and reduces the productivity and cognitive performance in humans. WHO defines health as: “The state of an integrated physical, mental and social wellbeing and not merely the absence of illness or disability”. This shows that the effects of noise such as discomfort, interference with communication, and decrease in work performance are health issues (WHO, 1999).

It is documented that noise causes serious discomfort (Kempen et al. 2009, WHO, 1999). This discomfort is a psychological phenomenon, which is determined by acoustic factors such as noise source, the exposure level, and the time of day of exposure. These factors however only partially determine the size of discomfort of a person (Clark & Stansfeld, 2007). This is because noise is a multi-faceted psychological concept, including assessment and behavioural components (Guski, Schuemer & Feischer-Shur, 1999).

The effects of noise in school are of particular importance since they affect the educational process. It is accepted that noise has an effect on cognitive development and performance of the student, particularly when s/he is in the first grades of school (Shield & Dockrell, 2008). Other studies have shown that noise affects the cognitive performance of the student, particularly reading skills, attention and understanding and that reduces the incentive for learning and memory of the pupil (Maxwell & Evans 2000, Haines et al. 2002, Clark et al. 2006, Shield & Dockrell, 2008). Noise also impacts the mental health of the pupil, causing stress, fear, anxiety, irritation and discomfort. Children may be particularly vulnerable to the effects of noise because they are less able to expect, to understand and to face problems such as stress, caused by noise (Kempen et al, 2009).

In general, noise in a classroom is either created in the external environment and transmitted through the building or it is produced in the interior of the class. It is therefore anticipated that children at school can be exposed to a wide variety of noise sources (Shield & Dockrell, 2008). External noise, especially in urban centres, may be caused by sources such as means of transport of all types, constructions, aircrafts etc outside the schoolyard and as well as the voices of people outside school. The internal noise, which could interfere with proper communication and understanding, is likely to be caused by the voices of children or the teacher in the classroom or next class and the ventilation and heating system (Maxwell & Evans 2000) of the classroom.

The objectives of the present research are to identify the most common types of noise which children are exposed to in their school, to investigate the degree of distress, as well as to find out whether children believe that environmental noise distracts them during lessons.

METHODOLOGY

Sample

The study included 594 children (51% boys and 49% girls) of the fifth (51%) and sixth (49%) grade coming from three regions of Greece. There was a large city with high population density, (Larissa, 39.1% of the sample), one average size city of Greece (Volos, 33% of the sample) and a small Greek island (Naxos, 27.9% of the sample). The sample was chosen randomly. (How?)

Data collection

As this was a school-based survey, a questionnaire was prepared and administered to the pupils by the researchers. A consent form was sent out to the parents of all children, so that they were informed of their children’s participation in this project. The whole procedure was completed within three weeks. The researchers read each question to the pupils in the class and gave them sufficient time to respond (ten minutes).

The children recorded the most common types of noise, during the lesson and the degree of distress noises caused to them. They also reported their school grades. Data were analysed using the statistical package SPSS (version 15.0). For the presentation of the results, frequencies and percentages were calculated. Chi-square and ANOVA tests were used to evaluate differences in percentages and in mean scores. A p-value less than 0.05 was considered statistically significant.

RESULTS

Students’ answers are divided into two categories: a) answers concerning the frequency of different types of noises (internal and external in schools) and b) answers revealing the degree of students’ perceived annoyance.

Figure 1 shows the most common types of external noises which children hear. These are noises from cars (89.9%), motorcycles (84.56%), voices from the playground (83.8%), trucks (67.5%), sirens (57.6%), the tweet of birds, construction work, adult's voices from the street, buses, airplanes and finally the noise of the train.

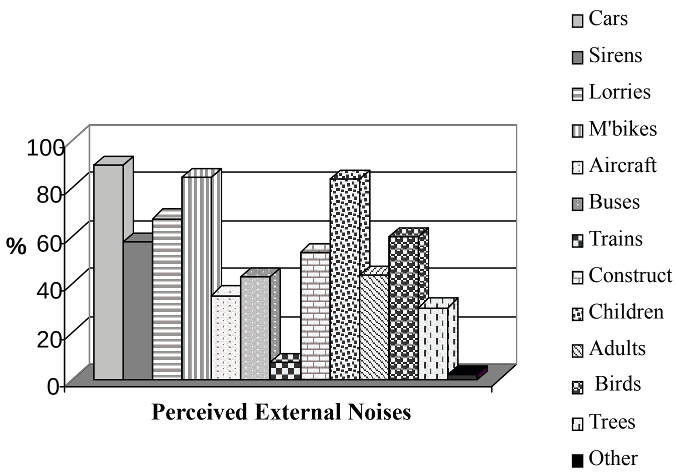

Figure 1. Percentages of perceived external noises

Children in the island of Naxos reported the lower incidence noises caused by sirens (27.4%) (x2=111.62 df=2 p<0,005), caused by cars (83.5%) (x2=17.83 df=2 p<0,005), and caused by motorcycles (78.9%) (x2=8.19 df=2 p<0,05).

To measure the level of perceived annoyance by external noises, a five-point scale (0=not at all – 4=very much) was used indicating the degree of discomfort among the different types of noises during the lessons. Table I shows the most discomforting noises according to children answers. The most annoying noises come from motorcycles, voices of children playing in the playground, from cars, construction works, trucks and finally from sirens.

Table I. Reported levels of annoyance by external noises in three cities

Rank 0=not at all 4=very much	p	Larissa (N=232)		Volos (N=196)		Naxos (N=166)	
		Mean	Std deviation	Mean	Std deviation	Mean	Std deviation
cars	<.005	2.19	1.16	1.90	1.29	1.79	1.15
sirens	<.0005	1.87	1.22	1.58	1.26	0.89	1.14
lorries	<.05	1.46	1.18	1.67	1.26	1.74	1.22
m'bikes		2.10	1.37	2.30	1.40	2.10	1.31
aircraft	<.0005	1.56	1.49	0.55	0.93	0.42	0.82
buses		0.77	0.96	0.65	0.91	0.87	0.99
trains	<.0005	0.36	0.87	0.34	0.87	not available	not available
construct	<.005	1.66	1.51	2.14	1.46	1.89	1.57
children	<.0005	2.39	1.33	1.74	1.26	1.86	1.32
adults		1.09	1.30	1.12	1.12	0.86	1.15
birds		0.66	1	0.52	0.96	0.74	1.13
trees		0.25	0.71	0.28	0.63	0.32	0.72

The second column of the table shows the statistically significant mean differences found among children of the three different regions according to ANOVA tests. Post hoc test (Scheffe method) showed that the sources of these differences were as following: Children from the biggest city (Larissa) reported the highest levels of discomfort caused by cars (F=6.17, df=2, p<0.005), sirens (F=32.54, df=2, p<0.0005), aircrafts (F=60.78, df=2, p<0.0005) and children playing in the playground (F=15,15, df=2, p<0.005). The noise of construction works was more of a problem for children from Volos (a medium sized city) (F=5,33, df=2, p<0.005). No differences were found due to gender or age.

Figure 2 presents the reported incidence of internal noises during lessons. As it can be seen the most common reported noises are sounds from the school corridors (82%), from the neighboring classrooms (76.4%), from the telephone (35.4%) and from the noise caused by the central heating system (8.4%). No differences were found due to place of residence or to gender and age.

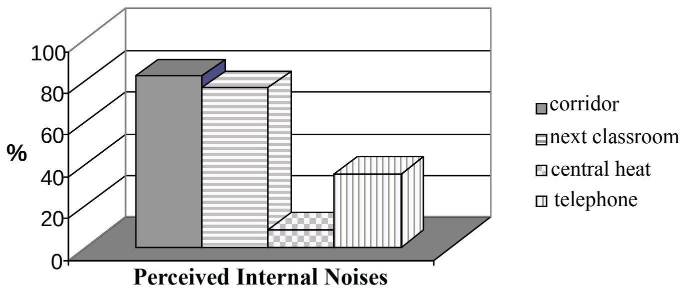

Figure 2. Percentages of perceived internal noises

The results on perceived level of annoyance due to internal noises during the lesson are presented in Table II.

Table I: Reported levels of annoyance by internal noises in three cities

Rank 0=not at all 4=very much	p	Larissa (N=232)		Volos (N=196)		Naxos (N=166)	
		Mean	Std deviation	Mean	Std deviation	Mean	Std deviation
Corridor	<.05	1.84	1.25	1.77	1.91	1.49	1.20
Neighbouring classroom	<.01	1.86	1.36	1.49	1.30	1.85	1.36
Heat system / ventilation		0.34	0.76	0.30	0.79	0.19	0.64
Phone rings		0.65	1.06	0.74	1.04	0.62	0.93

Significant differences according to ANOVA test were found for the mean scores of perceived annoyance among the three cities. Multiple comparisons Scheffe tests showed that children from the biggest city (Larisa) were more disturbed by noises from the corridor (F=4.33, df=2, p<0.05), whereas children from the medium sized city (Volos) were less disturbed by noises from neighboring classrooms (F=4.93, df=2, p<0.01). No age or gender differences were found.

On the question whether the children believed that noise has a potential negative effect on their academic performance using a scale from 0=not at all to 4=very much, children's answers mean score was found to be 1.91 (standard deviation 1.22). A medium degree effect was found. Only gender differences were significant (F=3.86, df=1.590, p<0,05), with girls reporting higher scores than boys (girls' mean score =2.0, s.d.=1.18, boys' mean score =1.81, s.d.=1.26), a difference that remain steady even when in the statistical analysis we entered as covariates the effects of age and town .

DISCUSSION

The aim of the present study was to identify the most common internal and external types of noise in schools from three different Greek regions and to investigate the degree of children's perceived annoyance due to noise. Results showed that the most frequently perceived outside noise is road traffic (i.e. cars, motorcycles, trucks, sirens) and voices in the schoolyard. This is in agreement with the survey by Shield & Dockrell which revealed as the dominant source of noise outside schools in London is cars (86%) followed by airplanes, trucks, buses and trains (Shield & Dockrell, 2004). Our research also showed that there are statistically significant differences in the responses of pupils of Naxos (a small town on an Aegean island) in terms of traffic and vehicles with regard to external noise sources. Shield & Dockrell, 2003, Schomer, 2001 and WHO, 1999 have shown that traffic and street noise, aircraft noise, train noise and construction work noise are classified as the most annoying noise sources for humans.

Our study revealed that city children appear to be most disturbed by noise generated by cars, sirens, planes, buses and the voices of children. This confirms the results found by Kempen et al (2009), who reported that children attending schools in a city are more exposed to road traffic noise. It is obvious that children in urban areas are exposed to more environmental noise (WHO, 1999).

It was found that the most frequent inside noise, faced by schoolchildren, is noise coming from the corridors and the neighbouring classrooms and to a lesser extent, noise coming from the phone and from the ventilation or heating system. Statistically significant differences were found in the degree of inside-school noise annoyance reported among school children from different regions, with urban pupils reporting the highest. This apparently is due to large school units existing in urban areas.

It was also found that a small percentage of children indicated that noise plays an important role in distracting them during lesson. Girls are more affected by noisy environments as they stated that noise can distract them from their work. The finding is in accordance with Enmarker & Boman, who also reported differences between genters, indicating that the girls appear to be more distracted by environmental noise (Enmarker & Boman, 2005).

In conclusion our results revealed that children of the largest city that participated in the study were more exposed to internal and external noises and also reported higher levels of perceived annoyance. Moreover, the most common perceivable external noises were those produced by vehicles and from the voices of children in the schoolyard. Regarding indoor school noises, children appeared to be chiefly disturbed by the noises in the corridors and the neighbouring classes. Finally, children did not report any particularly negative attitude towards indoor school noise since they did not consider it fully responsible for distracting them during the lessons.

The present research is a pilot study, part of a research project currently under way aiming at gathering information on the types of noises schoolchildren face during the lessons and the degree of disturbance noise cause to them. Many factors such as diversity of schools, age, gender of students and socio-economic status of the family are being taken in account. This information will help us to implement effective measures for the minimization of noise in schools.

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Ideas of students and faculty about reading and writing in science and technology careers

Las ideas de los estudiantes y profesores sobre la lectura y la escritura en carreras científicas y tecnológicas

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Abstract

The objective of this work is to characterize the ideas that students have about reading and writing as they start their studies at university level in science and technology careers, and the ideas that faculty members have regarding students' writing and comprehensive reading. The study was conducted at the entry level in the Faculty of Exact, Physical and Natural Sciences of the National University. Data was collected by means of semi-structured questionnaires, in-depth interviews, and lesson observations. Results show that students find differences between reading and writing at secondary school and at university levels, that they value positively being taught graphical tools that are useful to organize and represent knowledge and that they are not fully informed about how efficient writing can be when used as a tool for thinking. The main associated obstacle found by faculty is the comprehension of texts and assignments given to students as part of their studies. Faculty members consider that reading and writing skills should have been developed already at secondary school level.

Key words: *reading, science, technology, university, writing.*

Resumen

El objetivo de este trabajo es caracterizar las ideas que tienen los estudiantes acerca de la lectura y la escritura al comenzar sus estudios universitarios en carreras científicas y tecnológicas. También se describieron las ideas que tienen los profesores con respecto a la comprensión lectora y la escritura de los estudiantes. El estudio fue realizado en el ingreso universitario de la Facultad de Ciencias Exactas, Físicas y Naturales de la Universidad Nacional de Córdoba en Argentina. Los datos fueron recolectados a través de cuestionarios semiestructurados, entrevistas en profundidad y observaciones de clases. Los resultados muestran que los estudiantes encuentran diferencias entre la lectura y la escritura realizadas en la escuela secundaria y la universidad, que valoran positivamente la enseñanza a través de herramientas gráficas que permiten organizar y representar el conocimiento y que no están completamente informados sobre la eficiencia de la escritura como herramienta del pensamiento. Los profesores señalan que la principal dificultad de sus alumnos es la falta de comprensión de los textos y de las consignas dadas durante el cursado. Los profesores consideran que las habilidades de lectura y escritura deberían haber sido desarrolladas completamente en la escuela secundaria.

Palabras clave: *lectura, ciencia, tecnología, universidad, escritura.*

INTRODUCTION

From the 1970s onwards, several American, British and Australian universities carried out research centered on the development of writing skills in university students. All these works are focused on the fact that learning writing skills is a process which is not completed when students finish secondary school, and that knowing how to write is essential to learn any course (Bazerman & Russell, 1994; Russell, 1990). Afterwards, several pieces of research on different levels of the educational system proved the value that both reading and writing have for the comprehension of scientific concepts (Armstrong, Wallace, & Chang, 2008; Gunel, Hand, & Prain, 2007;

Hand, Hohenshell, & Prain, 2007; Lakrim, 2007; Rivard, & Straw, 2000; Wallace, 2004). Besides, contributions show that reading and writing are key elements to develop competences in the argumentative practices of disciplines, and that they play a central role in the creation of learning communities (Carlsen, 2007; Kelly, & Bazerman, 2003). However, science teachers often highlight that students start their university studies with deficiencies in reading comprehension, writing, handling context specific terms, and note taking, so that those become central problems of science teaching in higher education (Milwaukee Area Technical College, 2006).

In Argentina, the setting is different from the one described above: research about reading and writing at university level started later and, in most of the cases, it was carried out in social-related disciplines. Results yielded in this context show that few teachers are aware of the cognitive challenge that the reading and writing proposals they make to students imply. Moreover, they do not provide students with strategies that could help them understand the texts read in university courses (Carlino, 2002; Estienne & Carlino, 2004). On the other hand, in science and technology university careers, there are teachers´ proposals that integrate methodologies applied for the development of reading and writing skills (Iglesia & De Micheli, 2008; Richter & Carr, 2008). However, very few institutional curricula include teaching reading and writing along a complete university career (Moyano, 2009).

When taking into account both the abovementioned antecedents and lack of information about reading and writing practices in scientific-technological careers in our country, it is important to carry out more comprehensive research in this field. In order to achieve this, the research reported in this paper was done to characterize the ideas that a group of teachers and students of science and technology university careers have about the role that reading and writing plays at university level.

The study was conducted at an entry level course taught for the 15 university careers at the Faculty of Exact, Physical and Natural Sciences of the National University (Biological Sciences, Geological Sciences and nine Engineering careers, among others). This course lasts for one month, and it was chosen as a research area because it is the place where students produce their first writings at university level.

METHODOLOGY OF RESEARCH

Data was collected by means of two semi-structured questionnaires, one for students and the other one for faculty members.

The questionnaire for students consisted of one closed question designed to know about the strategies that they used to apply at secondary school to study and five open questions, out of which three were designed for them to describe the characteristics of reading and writing at secondary school. The other two questions were asked to inquire about the difficulties in reading and writing that they think they will encounter during their university studies. Furthermore, 25 closed questions were designed using a three-point Likert scale (1= fully agree, 2= partially agree, and 3= disagree). These 25 questions were asked based on four dimensions of analysis: the characteristics attributed to reading and writing at secondary school, at the entry level, at university and the relationship that is established between having knowledge and expressing knowledge.

The questionnaire for faculty members consisted of three open questions designed for them to describe the difficulties that students may encounter during the entry level, the skills that they should have developed before starting this level and the differences that faculty make between reading and writing practices at secondary school and at the entry level. Besides, 16 closed questions were added using the same Likert scale described above, and based on three dimensions of analysis: the characteristics attributed to the activities included in the study material, the characteristics of the classes during the entry level and the relationship that is established between having knowledge and expressing knowledge. All of the questions were designed in accordance with the categories of ideas about reading and writing at university level presented by Ellis (2004). Moreover, previous studies about these topics made in universities in Argentina were considered (Brunetti, Stancato & Subtil, 2002; Fernández & Carlino, 2008).

A conglomerate probabilistic sample was chosen so that students from all the careers of the Faculty are represented proportionally. The questions were asked to 291 students and to 12 faculty members. In order to deal with the answers found in the questionnaires, and to corroborate them, in depth interviews were conducted to 10 students (eight from Engineering, one from Geological Sciences and one from Biological Sciences). Finally, observations and audio records were made in all the lessons given by two faculty members. The criterion applied for choosing these people was their experience as university teachers: one of them had been teaching at the entry level for more than 15 years and the other one was experiencing teaching at this level for the first time.

Fos data analysis, the quantitative sections of the questionnaires were analyzed using the SPSS program, calculating agreement and disagreement frequencies with the assertions included in the questionnaire. The qualitative sections of the questionnaires, the interviews and the records of the lessons were analyzed using the QDA Miner program. This program allowed the allocation of codes to certain fragments of the transcriptions of questionnaires, interviews and lessons, as well as the analysis of coding frequency and the comparison of results.

RESULTS OF RESEARCH

Reading and writing at secondary school and at university: comparison and contrast established by students and faculties

According to their answers to the questionnaire, students highlighted summaries as the main tool they used to resort to at secondary school. Less frequently used were making comparative charts, overviews and conceptual overviews (see Figure 1). Even though these tools are included in the contents for the entry course, no teacher in the observed lessons stressed teaching them. In addition to this, in several occasions the most experienced teacher mentioned that these tools had already been studied at secondary school, so they would not be the subject of study during this course.

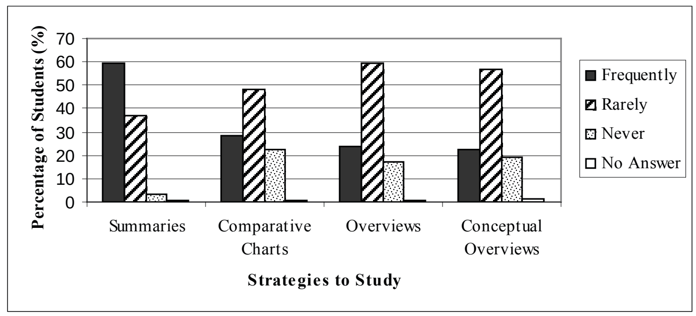

Figure 1. Strategies to study applied by students at secondary school (n= 291).

Furthermore, the interviews conducted showed that most of the students identified themselves as having had poor performance both in reading and writing during secondary school. In this sense, they expressed that their best skills in the field of Mathematics and their difficulties reading and writing were decisive elements when they had to choose their university career.

On the other hand, the questionnaire included inquiries about the amount of material given for study and the complexity of texts. Ninety one percen% of the students fully agreed that studying at university level demands more time devoted to reading than the one devoted at secondary school, and 87% agreed that they have to read more texts at university compared with secondary school. As far as the complexity of texts is concerned, 77% of the students asserted that the study material they have to work with at university is more complex than the one at secondary school. The results of the interviews fully agreed with these trends.

As regards the answers from faculty, five teachers stated that the main difference between secondary school and the entry level lies in the complexity of topics, and they mentioned - in a lesser degree- that secondary school fails to foster autonomy and initiative. None of them made reference to differences in the amount of study material.

Moreover, during the lessons, teachers highlighted some differences between these two levels of the educational system. In the case of the most experienced teacher, when referring to the problem of secondary school, he said: "*It is becoming more and more noticeable, little reading and little writing*". The inexperienced teacher did not refer to problems related to language; however, he criticized the autonomy expected from university students.

The characteristics of reading and writing at the entry level

Interviewed students mentioned their difficulties to read, especially because of the lexicon used and unknown authors, which implies an obstacle to differentiate what ideas are to be associated with each author. Most of the students indicated that they did not have difficulties understanding the assignments in textbooks.

In the interviews, students established a difference between activities important to be done in written and others for which writing is not necessary. They highlighted the fact that they need to write those activities that allow them to organize their thought, such as comparative charts and conceptual overviews, and they gave little value to those activities that lead to reproducing ideas or to establishing simple relations between concepts.

Regarding faculty´s opinions, eight of them mentioned that the main problem is assignment interpretation from students, and the rest stated that students have difficulties solving problems. On the other hand, whereas eight teachers considered that students should have learnt to interpret assignments at secondary school, nine teachers said that the entry level is a space to learn how to solve problems.

The role of reading and writing at university

As for the epistemic potential of writing, 84% of the students said that writing ideas while reading a text helps understanding the topic. Nevertheless, when they were asked specifically about the function assigned to writing at university, students stated it works as record or note taking in the first place (42%) and as answers to questions in exams and communication with teachers in a lesser degree (20% and 13% respectively). During the interviews, students stressed that writing helps memorizing and favors re-reading. They also focused on the functionality of writing for note taking.

The analysis of questionnaires made to faculty reveals that all the surveyed teachers agreed that writing is a tool that helps to think. However, 10 faculties said that university does not represent a space to continue learning how to read and write.

In regard to lesson observation, it is important to highlight that the most experienced faculty made reference to the importance of reading concerning the development of imagination, connecting it with the knowledge provided by an illustrate patrimony and presenting it as opposed to the use of technologies: *"Matters that men need start being left aside, such as reading to develop imagination and creativity. Let´s resume good habits as we are losing them, either because of the computer, computer games or other activities. [This leads us] to detach from these good habits that our great grandparents, grandparents and parents used to have"*. Additionally, he referred to the importance of writing for professional work, and focused on making reports. He stressed proper writing and orthography but did not mention structure or possible addressees. On the other hand, the less experienced faculty did not refer to the importance of reading and writing at all.

The relationship between having knowledge about a topic and expressing that knowledge

In the questionnaire, 56% of the students fully agreed with the idea that having knowledge about a topic equals being able to express that knowledge properly during a written exam. Nevertheless, during the interviews, most of the students stated that they have little capacity to synthesize, define and reformulate ideas during a written exam.

Most of the faculty members established the same correspondence as students: eight of them agreed with the idea that having knowledge about a topic is a synonym of being able to communicate it. During the lessons, the most experienced faculty insisted on the need to understand assignments for activities, stressing that students may know the topic but misinterpret a statement and, consequently, provide the wrong answer to a question. However, none of the observed lessons was centered on assignment interpretation.

DISCUSSION

The results presented in this article prove the wide usage of summary at secondary school compared with other strategies that require deeper text reading. These data coincide with studies such as the ones carried out by Mateos, Martín and Villalón (2006). These authors indicate that the most frequent tasks at the Spanish secondary school are note taking, reading and underlying, the identification of main ideas and summary and chart making after reading a text. Moreover, they signal that the least developed tasks are schemes, conceptual overviews, and essay and reflection writings.

The results about the difficulties that students have when they are faced with reading textbooks from the entry level coincide with the research carried out by Fernández and Carlino (2008) in Argentina. According to them, students stress that the complexity of texts, as well as the presence of new vocabulary and new authors are the main obstacles they come across when approaching texts at university. The difficulties related to discursive genres reported by Iglesia and De Micheli (2008) were not evident in the results yielded in this research.

As regards knowing about a topic and being able to express knowledge, both faculty and students find it difficult to view exams as activities that demand relating what someone knows about a topic and what the writing situation demands. This aspect, taken by Carlino (2005), addresses the importance for both students and faculty to start adopting the idea that exams can require the construction of several types of texts, with different purposes and different addressees, which demands new challenges that imply continuing learning to read and write at university level.

Finally, it is important to highlight that Meneses (2008) has described ideas about reading and writing similar to the ones described in this paper for lesson observations. The author describes that one of the ideas in the Chilean school frames reading as the approach of texts associated with illustrate patrimony and writing as the conservation of language: orthography, vocabulary and calligraphy.

CONCLUSIONS

As closure, the following conclusions are provided:

- Students value positively being taught graphical tools that are useful to organize and represent knowledge (comparative charts, overviews, conceptual overviews).
- Faculty members take a critical position of the formation that students receive at secondary school. However, they omit to teach those skills that are scarcely studied at secondary school and that students' value (for example, conceptual overviews).
- Both students and faculty members view the potential of writing as a tool for thinking. Nevertheless, action is needed that aims at broadening students´ perspective about the multiple functions that writing can have, as well as action that allows faculty to conceptualize writing as a tool feasible to be taught in every discipline at university.
- Both students and faculty have difficulties conceptualizing assignments as tools that mediate between previous and new knowledge, and argue that there is a reciprocal relationship between having knowledge about a topic and expressing that knowledge.

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Effective large scale integration of the iPad mobile learning device into first year programs

La integración a gran escala del dispositivo de aprendizaje móvil iPad en los programas universitarios de primer año

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Abstract

Higher education faculty members in the United Arab Emirates' (UAE) federal universities recently enhanced active learning in and outside of the classroom by integrating the iPad mobile learning device. There was an aggressive plan to provide each incoming student with a meaningful, relevant, emerging mobile teaching tool that acts as a catalyst for active and authentic learning, especially in the area of conceptually-based e-learning objects. Throughout the entire process, leaders maintained high quality and relevant pedagogical methods in an open environment that supported collaboration among the three federal universities' faculty. In order to ensure this project develops into something more than an isolated effort, we plan to integrate an appropriate social science experimental design, collect data on our progress to gather empirical understanding that will result in wisdom about practice, both for internal and external dissemination. This approach will create showcase mobile learning methods, which are scaleable to other higher education communities.

Key words: iPads, mobile learning, engagement, collaboration, first year programs

Resumen

Las universidades federales de los Emiratos Árabes Unidos recientemente aumentaron el aprendizaje activo dentro y afuera de las salas de clase con la integración del dispositivo iPad de aprendizaje móvil. Había un plan muy agresivo para proporcionar a cada nuevo estudiante una herramienta emergente de enseñanza móvil, significativo y pertinente para actuar como un catalizador para el aprendizaje activo y auténtico, especialmente en el área del aprendizaje electrónico. Durante todo el proceso, los líderes mantuvieron métodos pedagógicos de alta calidad y pertinencia en un ambiente abierto que soporta colaboración entre los miembros de las tres universidades federales. Para asegurar que este proyecto se convierta en algo más que un esfuerzo aislado, planeamos integrar un diseño experimental de las ciencias sociales apropiadas, recoger datos de nuestro progreso. Esta técnica creará un modelo de métodos de aprendizaje móvil, cuales son validos para otras comunidades de educación superior.

Palabras clave*: iPads, aprendizaje móvil, colaboración, programas de primer año*

INTRODUCTION

In April 2012, the Chancellor of Higher Education and Minister of Scientific Research, His Excellency Sheikh Nahyan Mabarak Al Nahyan inspired the academic community with his charge for implementing iPads in each federal institution for all First Year programs in September 2012. The Chancellor asserted that this project must maintain the same high international standards of quality as with all of our efforts in the UAE. The Chancellor also indicated that the technology should not lead this initiative, but rather, a strong presence of pedagogy should guide the implementation.

On 16 April, 2012, a unified team comprised of all three UAE federal universities met with Apple Senior Leaders in Cupertino, California. During this meeting, three areas of emphasis were outlined, which included content, pedagogy, and technology. This paper will focus on the dynamics and outcomes for the pedagogy team. Introduction of the iPad into all federal higher education Foundation programs was the natural next step to advance andragogical active learning methods which provide our students with the relevant, current skills and mindset required to become leaders in the country. The iPad allows teachers to capitalize on authentic active learning centered on interaction between students, faculty, and community experts; and to integrate inquiry-based project/problem-based learning approaches (in virtual, physical and blended environments). A unique opportunity to aggressively take higher education in a direction, which research has long validated, although academe has not achieved.

An aggressive plan for iPad training was implemented at every institution, which included topics such as drivers and factors that influenced the Post-Laptop Era; teaching and learning with the iPad; and demonstrations of recommended Apps and of iBook creations using iBooks Author. For appropriate and active pedagogy, faculty members were encouraged to adopt and adapt the technology as a teaching and learning tool in their course. These stages depended on an aggressive faculty development effort; and devices imaged with appropriate apps and evaluation rubrics. One example is an e-portfolio system, which is a powerful tool that our students can use to represent and share their learning in meaningful ways, while bridging to employment.

Ultimately, the iPad and student-centered tool-based teaching and learning can transform the higher education and experience. Such transformation is about the people. Transforming a national higher education culture requires intense focus in order to capitalize and build on the richness of ideas and people to reach our ultimate goal of optimizing meaningful, relevant learning for all students. With vision and planning, we created a community of experts to lead across the three federal universities to collaborate closely over the next several years.

This is a critical time for higher education to appropriately integrate a dynamic teaching tool, such as the iPad. However, one of the greatest risks is that we fail to use this opportunity as a significant leap forward in our pedagogical process. Simply repackaging existing materials into a revised format will not only represent a missed opportunity, but also be detrimental to our students. For example, if we scan documents into static files and open them on an iPad and assess learning with closed-ended exams, then we have actually regressed, because we are doing simple things in a complex and costly way.

Timeline (2012)

11 April - Charge for implementing the iPad for teaching and learning.

16 April - Team of three Federal Universities travel to California.

26 April – Team attends Apple Conference in Geneva, Switzerland

03 May - National iPad Pedagogy team created.

09 May - Website created to review, crowd sourced and select Apps (www.ipads.ae)
14 May – First National iPadagogy meeting.
15 May – First National Content meeting.
23 May - Apple training 30 iChampions, one from each campus

16 June - Apple large scale training of 1000 teachers.
18 June - iCelebrate, teachers showcasing progress (www.adwc.hct.ac.ae/icelebrate)

26 August - Full day iPad training program for 120 faculty second wave iChampions.
27 August – "Train the Trainers" full day program on iTunesU and iBook Author

09 September – Students return to classes
23 September - Official iPad Federal Launch
24 September - First Annual Mobile Learning Congress

03 October - Federal Steering Team meet to discuss finalize Assessment
15 October - iPadagogy team presents Data Triangulation Rubric for iPad success

The charge of the Higher Education iPadagogy Team was to identify, organize and communicate new and emerging, empirically-based teaching practices, which used the iPad to create active and authentic learning environments, in the context of Emirati students. The team connected an extensive, unified team across institutions, and created an easy to use, open-source platform that aggregated and disseminated the new and emerging practices. The urgency, importance and game-changing opportunity required frequent conversations associated with aggressive action plans.

The iPadagogy Team will provide:

1. an overview of the evidence and potential for iPads in education;
2. empowerment for serving all students;
3. a venue for promoting active learning in and beyond courses;
4. literature, speakers and resources for new and effective learning environments;
5. Professional Development needed for successful new learning environments; and
6. ideas for eLearning Objects (eLOs) needed for connecting faculty, students and resources.

Working closely with the National Content Group, the iPadagogy Team integrated their conversations with the ideology of Content. Each institution created both a Content and a Pedagogical strategic plan on how to address the

- Curricular area which will adopt iPads as the primary means of delivery;
- Numbers of faculty and students impacted;
- Summary information regarding: course management system, pre-loaded apps requirements;
- Sourcing of content materials;
- Authoring activities; and
- Professional Development plans.

In addition, we addressed the future of course management; standardized apps; strategic partnerships; and protocols for collaboration among institutions (Shared information portal; authoring protocols; assessment; and curriculum development).

PROPOSED NEXT STEPS

1. Every faculty member beyond first year teachers receive and begin to learn and personal their iPad (Entry);
2. Multiple layers and opportunities of training on the iPad, basic and advanced; and especially in the area of connecting to integrating the iPad into new methods for active teaching and learning (Adoption);
3. Ask faculty to begin from a learning task they have recently delivered in the classroom and to re-plan it with the iPad. This would produce a 'before and after' scenario for everyone to view and analyze the differences (Adaptation);
4. Faculty should be connected in professional learning communities in order to share and learn more rapidly in ways that move beyond current practice to new practices (Infusion);
5. Students should have many opportunities to develop communities for sharing their work in their personal learning networks that include families and employers so the impacts move beyond the walls of the campuses (Transformation); and
6. Conceptual Learning Objects and evidence should be shared to inform the scholarly academic community and to guide the next cycle of implementation. (Extension).

FUTURE WORK

We plan to create an open source web-accessible presence, where ALL teachers can open share their dynamic, conceptually-based e-learning objects (eLO). The site would be a work-in-progress, simple organization of boxes, which are labeled with Foundational concepts, outcomes, skills, dispositions or knowledge and two buttons – Submit and Review. People can submit their work in raw or completed form, with their name or anonymous. Others can view, add to, rate and share widely. This approach applies what has been popular in the Technology Integration Matrix and it can be enhanced easily with social, folksonomy, and community features. It should be simple, quickly browsed or searched, and directly aimed at connecting everyone with resources they can use.

Even more ideally, the eLO's would integrate gaming principles, which would be transparent to the learning, adhering to best practice in gaming and learning theories. The major theoretical construct typically used in this context is the Information Processing Model, where the instructor/designer has intentionally build in coding activities to connect working memory to long term memory. When this is done properly, the learner can decode the information in meaningful ways. The second and in the context of an iPad perhaps as important of an aspect is the gaming theory. There is cognitive science research (www.mauronewmedia.com/blog/2011/02/why-angry-birds-is-so-successful-a-cognitive-teardown-of-the-user-experience/) that shares the reason why and how we can incorporate gaming into learning. The research points out the following key attributes for a successful learning game:

1. Simple, yet engaging interactive concept;
2. Cleverly Managed Response Time;
3. Short Term Memory Management;
4. Mystery (i.e., Inquiry);
5. How things look and sound (Sensory); and
6. Measuring that which some say cannot be measured.

Finally, our hopes are to continue along the progressive lines, and quickly take the next steps from substitution to transformation as we further integrate the mobile learning device. One of the major guiding documents is the 2012 Educause/NMC Horizon Report. In this report, the authors share educational technology which they predict are on the near, one year or less horizon, and up to five years in the future. The one year or fewer technologies include mobile apps and tablet computing, which we were fortunate to implement. The two to three years technologies include game-based learning and learning analytic, which we are well on our way at developing games, which is made easier on the iPad, and are having aggressive discussions on how we can formatively assess learning, and provide quick feedback via learning analytics. The four to five year predictions include gesture-based computing and the Internet of Things, both which we are excited to explore with the mobile learning device.

Authors Dr. Jace Hargis is currently a College Director at the Higher Colleges of Technology in the United Arab Emirates. Previously, he enjoyed assisting faculty as an Assistant Provost at the University of the Pacific, CA. He has authored a textbook, an anthology and has published over seventy academic articles as well as offered over two hundred national and international academic presentations. His undergraduate and graduate degrees are in the chemical sciences and he has earned a Ph.D. from the University of Florida in Science Education. His research agenda is in the addresses the theoretical aspects of how people learn with the use of emerging instructional technologies.

Melissa Soto is a PhD candidate at the University of California, Davis majoring in Mathematics Education. Previously, she assisted in grants which provided mathematical professional development to elementary school teachers in northern California and marital education classes to low income families throughout the greater Orlando area. Her undergraduate degree is in Elementary Education with an ESOL endorsement and her graduate degree is in Mathematics Education. Her research agenda is in investigating students' mathematical thinking, particularly English Language Learners, and making it accessible to teachers.

Jan Rajmund Paśko - 50 years of teaching and 45 years of scientific work

Jan Rajmund Paśko is a famous Polish specialist in the field of chemistry education: teacher of chemistry, photographer and educator of youth, Associate Professor of the Pedagogical University of Kraków and Małopolska Wyższa Szkoła Zawodowa. He has just celebrated the 45[th] anniversary of his scientific work and 50 years of teaching.

During his work Professor Paśko has been awarded:

– the prize of Minister of Science and Higher Education (1987);
– the Gold Cross of Merit (1987);
– the medal of the National Education Commission (1998);
– Jan Harabaszewski's medal by Polish Chemical Society (2012);
– the commemorative medal for cooperation with University of Trnava (2012);
– the congratulation letter from the Medical Faculty of Trakia University, Bulgaria (2012).

He was born on 1st January 1943 in Kraków, Poland, where he also carried outhis entire learning and teaching process. He studied chemistry at the Jagiellonian University and in 1966 obtained a master's degree in chemistry by defending a thesis in organic chemistry. His subsequent research focused on the synthesis of anilides of quinolinecarboxylic acids. which finally, in 1977 led to his successful defence of a doctoral dissertation entitled "The studies for new biologically active connections of anilides of 2-,3-, 4-quinolinecarboxylic acids" and a degree of Doctor of Chemical Sciences at the Jagiellonian University, Kraków, Poland.

The colloquium of Dr. Jan Rajmund Paśko was held in pedagogy at the Massaryk University in Brno, the Czech Republic in 2003 and in 2004 he has been appointed as a professor at the Pedagogical University of Kraków, Poland.

The Professor was fascinated by chemistry as a science in elementary school and developed his interest by attending activities organized at the Youth Cultural Centre in Krakow. During the chemical studies the development of his interest in teaching occurred.. Since then his career was related to education. After graduation, encouraged by the director of XIII High Scool in Kraków he joined the Department of Chemistry of Pedagogical University of Kraków. Initially his interest and research were connected with teaching process at university level, which resulted in the modernization of the process of teaching chemistry at Pedagogical University.

Working for many years as an examiner during the entrance examination for the candidates to study biology and while leading classes of general and analytical chemistry, Dr. Paśko noted that in many cases, unsatisfactory results of entrance examination and weak learning outcomes of first year biology students are caused probably due to errors in the process of chemical education at previous education levels. He stated the hypothesis that the cause of this situation is the result of underestimation of the impact of negative transfer during the entire cycle of teaching chemistry. Verification of this statement required research in primary school. For this reason, Dr. Jan Rajmund Paśko started in 1982, an additional part-time job as a chemistry teacher at primary school No. 33 in Kraków. The study showed that his hypothesis was correct. The unquestionable merit of the Professor's work is the application of modern pedagogical theories to the field of chemistry teaching. As a result of his research on the effects of psychological processes in chemical education the chemistry curriculum in primary schools has been modernized. The results of the experimental program have led to the development of its new version, which in 1993 was authorized for use in selected schools.

In 1999 he developed an innovative program to teach chemistry in high school, which has been approved for use in Poland by the Ministry of National Education, after the positive opinions of the reviewers.

The most important feature of this program is a holistic approach to teaching of chemistry. As a result of this approach is, among others:

– a joint introduction of organic and inorganic acids, as well as organic and inorganic salts;

– a joint discussion about substances that contain -OH groups (hydroxides, alcohols, acids) with distinguishing the differences among the properties of that compounds.

– use of quantum propaedeutic model of atom instead of model of atom by Rutherford/Bohr.

– use of Bronsted and Lowry theory of acids and bases instead of the Arrhenius one.

Professor Paśko in his concept of chemistry education tries to pass the newest and up-to-date knowledge, which is in agreement with current scientific knowledge. At this level of education he leaves the historical approach to the chemistry teaching in order to prevent negative transfer.

Based on this program Professor Paśko developed a handbook for learning chemistry, which was approved for use by Ministry of Education. The textbook was also equipped with other teaching and learning aids. This conception is continued in a second textbook which is prepared with Dr. M. Nodzyńska.

The professor is not only the author of a textbook for teaching of chemistry at high school, but since 1996 he has been authorized by the Minister of Education to be the reviewer of new textbooks to be published.

The professor is also a great supporter of the introduction of modern teaching methods into the teaching programme. He introduced ICT into the chemistry classes as soon as it had been possible.

Professor Paśko was also a leader of several national and international research projects which were focused on upgrading and improving the chemistry teaching process, especially at lower stages of education.

During his career he held many functions at the Pedagogical University, such us: Head of the Chemistry and Chemistry Education Research Group, students' tutor and supervisor of doctoral dissertations, graduate and undergraduate theses, a member of many committees, long-term member of the The Faculty Council at the Faculty of Mathematics, Physics and Technical Science, Faculty of Geography and Biology, and also Faculty of Pedagogy. Moreover, Professor Paśko was a former member of the section „education of chemistry" at the Central Institute of Methodology of Teachers Study. He is currently a member of the Senate of the Pedagogical University.

In many universities chemistry teachers training usually has been done as an additional course to the graduate studies in chemistry. For many years professor Paśko was fighting in order to change this situation. He has sought to create a special undergraduate studies for prospective teachers for which curriculum should be designed in such a way to be able to prepare students for the profession of chemistry teacher. The professor, with help of his research group, succeeded in 2009. At the Pedagogical University of Kraków such branch of studies have been launched.

The activities taken by Prof. Paśko aim to raise the rank of didactics of chemistry and didactics of other sciences. As an example of such activities can be given the launch of the international conference „Research in Teaching of The Sciences" which is held every two years, and organizing the conference "The Role and Tasks in the metodology".

For many years Professor Paśko has been cooperating with research centers in the Czech Republic and the Slovak Republic.

He has written nearly 300 articles and several scripts for the students. His credits include 20 books and school textbooks of chemistry. He is the editor of more than 10 monographs. He reviewed books, textbooks and actively participated in more than 80 domestic and foreign scientific conferences.

Currently, the scientific activity of Professor Paśko focuses on computer-aided research on perception of the microworld among pupils in primary and secondary schools. The second branch of his activities is the creation of interactive teaching software.

Full biography of the Professor was described in the book by M. Mamica and M Nodzyńska - Jan Rajmund Paśko - scientist, educator, passionate: in 50 years of teaching and 45 years of scientific work. The book is available in the Pedagogical Digital Library of Pedagogical University of Kraków.

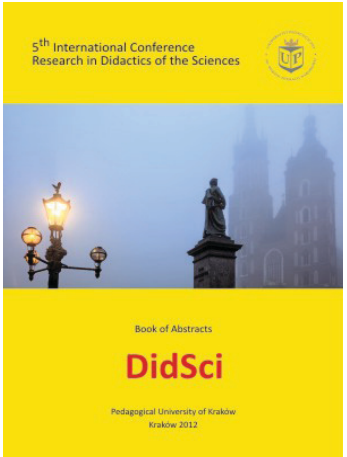
(http://dlibra.up.krakow.pl:8080/dlibra/dlibra/docmetadata?id=2840&from=&dirids=1&ver_id=274318&lp=1&QI=6BAFACB43341F4B98E8CCA0627C2E323-1)

We would like to mention a beloved hobby of the Professor, which is obviously related to the professional interests, however this short article would change into a book, so please visit the website:

http://dlibra.up.krakow.pl:8080/dlibra/Content/2810/index.html

Paweł Cieśla, Małgorzata Nodzyńska, Iwona Stawoska
Pedagogical University of Kraków, Poland

International Conference on Research in Didactics of the Sciences



In Poland there are currently over 400 universities, with approximately 40 in Krakow. With such a big market for education it is difficult to compete, for example, with the the largest university in Poland - Warsaw University and the oldest one - Jagiellonian University. However, the Pedagogical University of Kraków named after National Education Commission is rated very highly in its category and takes first place among the pegagogical universities.

The beginning of the Pedagogical University of Kraków is dated on the 11th of May 1946. At that time the High School of Pedagogy (WSP) was formed. Since then, the university promotes the development of new teaching strategies for use in Poland and abroad. This conception is also realized by the Department of Chemistry and Chemistry Education (http://chemia.up.krakow.pl/) and discussed during international seminars and conferences in the field of natural sciences.The last week of June 2012 the 5th International Scientific Conference ”Research in Didactic of the Sciences” (DidSci) took place. The conference was held under the auspices of Rector Magnificus of Pedagogical University of Kraków Professor Michał liwa. The conference is organized by the Group of Chemistry and Education of Chemistry, Pedagogical University of Kraków, Poland (Chairman – Dr. Małgorzatat Nodzy ska, Secretary – Dr. Waldemar Tejchman, and Dr. (I don't know what "hab." means) Prof. UP.Jan Rajmund Pa ko, Dr. Paweł Cie la, Dr.Iwona Stawoska, Dr. Ewa esławska and Alice ylewska M.Sc.)

The Scientific Committee is made up of well-known professors, experts in education from various universities from different countries. The Scientific Committee is responsible for the review of abstracts of conference presentations.

The conference takes place regularly every second year (the next one will be held on June 2014) and it is a continuation of a long-term cooperation among scientists and teachers from all over the world, sharing a scientific interest in natural sciences education. A major objective of the meetings is to develop a platform for mutual scientific contacts between researchers, teachers and students from European and other countries, and to foster future collaborations between them. It is also an excellent opportunity to exchange experiences obtained in the field of quantitative and qualitative researches in natural sciences (biology, chemistry, physics and geography), conducted by standard methods, as well as with using of multimedia and other modern techniques.

The conference participants are mainly specialists in didactics of the sciences (chemistry, biology, geography, physics, nature), who conduct courses in science with students of different branches of studies. We can observe that a growing group of participants of the DidSci meetings are Ph.D. as well as M.Sc. students. For them reduced fees are provided. Moreover, many teachers who regularly work at schools (both primary and secondary) participate in the conference. Also for them a nominal fee or even no conference fee is proposed .

At the conference, there are also psychologists and specialists in pedagogy who discuss the latest research in this area in reference to the teaching of sciences. Moreover, the scientists engaged in research in biology, chemistry, physics or geography outlines the latest results of their research so that the achievements can be transferred to the process of environmental education.

Frequent participants of the conference are also people involved in new technologies in the teaching process. Their participation helps to familiarize educators with the latest teaching aids and their application in school practice. During the conference participants can find the offer of educational publishing houses.

The first meeting was in 2004 and it was a continuation of Polish-Czech seminars in the field of teaching chemistry which since 1991 took place at the University of Opole. Because of this fact, during the first and the second conference there were mainly participants from Poland, Czech, Slovakia and Russia. However, since the third meeting in 2008 conference formula has spread among scientist from other countries like from: Australia, Brazil, Bulgaria, Chile, Croatia, Cyprus, Denmark, Estonia, Finland, France, Greece, Spain, Holland, India, Ireland, Israel, Japan, Canada, Colombia, Latvia, Macedonia, Morocco, Mexico, Germany, New Zealand, Portugal, South Africa, Serbia, Slovenia, Sweden, Thailand, Turkey, Ukraine, USA, Hungary, Great Britain and Italy.

Participants of the DidSci are offered various forms of presentation of their didactics work: keynote speeches, announcements, workshops and poster sessions. Moreover, it is a great opportunity to listen to the plenary lectures of outstanding scientists from all over the world.

The conference has always a social program (exhibitions, excursions, dinners at famous restaurants of Krakow). The charm of the old town - Krakow as well as interesting topics of the conference lectures that results in participants returning for future meetings

The DidSci conference is always accompanied by a book of abstracts, and after the meeting, the monograph containing the full texts of speeches is prepared. This year, for the first time, all the presentations shown during the lectures or communications will be send to the Digital Library of the Pedagogical University of Krakow.

This year, during the 5th International Conference ”Research in Didactic of the Science” (DidSci) organized by Group of Chemistry and Education of Chemistry, Pedagogical University of Kraków, Poland, 6 plenary lectures were presented:

- prof. Peter E. Childs from Department of Chemical & Environmental Sciences and National Centre for Excellence in Mathematics and Science Teaching and Learning, University of Limerick, Ireland: "From SER to STL: translating science education research into science teaching and learning"
- prof. Jan Rajmund Pa ko from Group of Chemistry and Chemistry Education, IB, Pedagogical University of Kraków: "Education of chemistry and chemistry teaching"
- prof. Andrzej Bara ski from Department of Chemistry, Jagiellonian University, Kraków, Polska: "On teaching and learning of stoichiometry"
- prof. Liberato Cardellini[1], prof. Jack Holbrook[2], form [1.]Dipartimento SIMAU, Facoltà di Ingegneria, Ancona, Italy, [2.]Centre for Science Education, University of Tartu, Estonia, "Motivational Secondary Science Education: A Requirement for Promoting Tertiary Education",
- prof. Mordechai Livnehz Bar-ilan University Ramat-Gan, Israel: "Science and Heritage - Chemistry in the Bible"
- prof. Zehava Livneh and prof. Mordechai Livneh z Yavneh High-School, Holon and Bar-Ilan University Ramat-Gan, Israel: "Science and Society
– Parents and Children Doing Science Together".

Moreover, during the last conference approximately 50 short oral communications as well as 60 posters were presented.

It is worth adding that the International Conference ”Research in Didactic of the Sciences” (DidSci) organized by the Group of Chemistry and Chemistry Education from Pedagogical University of Kraków, is the largest meeting of natural science in the Central Europe. The detailed information about previous conferences are available below.

2004
The conference web page: http://www.ap.krakow.pl/dydchem/dydchem04.html
2006
The conference web page: http://www.ap.krakow.pl/dydchem/dych06_summ.html
Abstracts: http://www.ap.krakow.pl/dydchem/dydchem6caly.pdf
2008
The conference web page: http://www.ap.krakow.pl/dydchem/nowa/index.php?option=com_content&task=blogcategory&id=32&Itemid=62&lang=pl_PL
Abstracts: http://www.ap.krakow.pl/dydchem/nowa/pliki/didsci_15.pdf
2010
The conference web page:: http://ecrice2010.ap.krakow.pl/
Abstracts:
http://dlibra.up.krakow.pl:8080/dlibra/dlibra/docmetadata?id=1488&from=pubstats
Library - ECRISE http://dlibra.up.krakow.pl:8080/dlibra/dlibra/docmetadata?id=1489&from=pubstats
2012
The conference web page: http://didsci2012.up.krakow.pl/index.php/pl/ - The book of Abstracts: http://didsci2012.up.krakow.pl/abstrakty/Didsci2012_abstracts.pdf

Małgorzata Nodzyńska, Iwona Stawoska, Paweł Cieśla
Pedagogical University of Kraków, Poland

Book review

Maite Morentin y Jenaro Guisasola.
Centros de Ciencia y Visitas Escolares (2012)
Editorial Académica Española, Academic Publishing GmbH&Co KG, Alemania
ISBN: 978-3-659-01699-8, 219 páginas, 69.00 €
Disponible on line en www.morebooks.es

En estos últimos años la ciencia y la tecnología han pasado a forma parte de la cultura general de la sociedad y tanto las estructuras formales (escuela, universidad…) como los ámbitos no formales (medios de comunicación, museos…) coinciden en su objetivo de formar el pensamiento científico de la ciudadanía. En este libro se ofrece una propuesta educativa desde la complementariedad entre los contextos formales y no formales. En concreto, se propone la utilización de los museos y centros de ciencia como recursos educativos y culturales enfocados al aprendizaje del alumnado y al desarrollo profesional del profesorado, sin olvidar su papel como impulsores de la cultura científica de cualquier visitante.

En el primer capítulo se hace una revisión de los nuevos retos que surgen en la educación científica al incorporar los contextos extraescolares (Museos y Centros de ciencias) para mejorar el aprendizaje de las ciencias. A partir de esta revisión, surge la necesidad de formar al profesorado en nuevas estrategias de enseñanza en contextos no formales para que sigan las recomendaciones que están surgiendo en esta nueva área educativa. El estudio se ha realizado con profesorado de Educación Primaria en formación inicial, utilizando las visitas escolares al Eureka Museo de la Ciencia de San Sebastián (España).

En el capítulo 2, desde las recomendaciones de la investigación, se diseña y desarrolla un estudio previo para conocer las ideas del profesorado que visita el museo Eureka situado en el País Vasco. Una de las conclusiones es que este profesorado organiza la visita con una finalidad principalmente lúdica, sin preparar actividades complementarias y sin utilizar los recursos que el museo pone a su alcance. A la vista de estos resultados, que coinciden con otros estudios a nivel internacional, en el capítulo 3, los autores presentan su marco teórico denominado "Visitas Centradas en el Aprendizaje" (VCA), y los correspondientes recursos específicos derivados de la investigación en el aprendizaje en contextos no formales. La propuesta de los autores puede servir para proporcionar a los futuros maestros y maestras las estrategias adecuadas para integrar en su programación cotidiana la enseñanza de las ciencias en un contexto no formal.

En la segunda parte del libro los autores ponen en práctica el modelo VCA, diseñando una unidad didáctica que incluye la visita al museo Eureka (capítulo 4) y elaborando diseños (capítulos 5 y 6) para evaluar el aprendizaje conceptual, procedimental y actitudinal logrado por los futuros profesores de Educación Primaria mediante dicha unidad. Así pues, en el capítulo 4 los autores eligen un tema del curriculum de primaria cuyo contenido tiene amplias conexiones con varios módulos del Museo Eureka de San Sebastián, de forma que se pueda diseñar una Unidad Didáctica que incluya una visita escolar al Museo, y se puedan trabajar las competencias seleccionadas. La Unidad Didáctica "Fuerzas en Acción" se apoya en una serie de actividades previas y posteriores a la visita al museo Eureka que constituyen la propuesta a trabajar con los estudiantes de Magisterio (futuros Profesores de Educación Primaria), con el objetivo de mejorar su formación inicial, tanto en la integración de este tipo de visitas en el currículum escolar como en los contenidos científicos elegidos.

En los capítulos 5 y 6, los autores muestran, en primer lugar, la validez y fiabilidad de los diseños realizados de acuerdo con la investigación educativa y la muestra elegida, y en segundo lugar constatan que se produce una mejora sustancial en las concepciones de gran parte del alumnado, apoyando la conclusión de que las visitas a los museos de ciencias "sirven para pasarlo bien y motivar a los estudiantes" pero también deben prepararse de forma adecuada por parte del profesorado si se pretende que sean eficaces desde el punto de vista del aprendizaje. Así mismo, estos estudiantes han conseguido una evolución importante en sus concepciones acerca de las fuerzas y sus efectos, aspecto conceptual necesario de cara a su futuro profesional.

En el último capítulo, se presentan, a modo de síntesis, las conclusiones fundamentales que se desprenden de este estudio así como sus limitaciones. El trabajo está limitado a una pequeña muestra y a una única unidad didáctica en un programa de enseñanza por lo que se apunta que será necesario experimentar el modelo VCA en diferentes contextos y programas educativos. Finalmente se plantean nuevos retos para la investigación educativa en contextos fuera de la escuela.

Index 2012. Special issue, vol.13, 2012

INSTRUCTIONS FOR AUTHORS

The Journal of Science Education (REC) publishes articles, short communications and other original materials relating to the results of investigations and new experiences in the field of teaching natural sciences (Biology, Physics, Chemistry, Environment sciences , Biotechnology and other natural sciences), in secondary (high) school and university . Also investigations in the teaching of Mathematics, applied to education of the sciences. Opinions and discussions on the improvement of the national and international educational policy at all levels will also be welcomed.

Articles and short communications sent to the REC should not have been previously published or submitted for publication to other national or international Journals.

The principal sections of REC are:

- Innovations and modern active methods in the teaching of the sciences
- Design of the modern curricula
- Educational evaluation
- Laboratories and experiments in teaching
- Educational technology
- Educational policy in the teaching of the sciences
- Book reviews

A special section of the REC is: " Physics, Chemistry, Biology and integrated Sciences in your secondary (high) school". In this section, short communications on the sciences in secondary school life will be published:

- Innovations from teachers
- News of exams and evaluations
- Text books in science and other resources for teaching
- Weeks, days of natural sciences
- Educational games
- Science Olympiads etc.

The authors should fulfil the following instructions:

The word processed manuscripts of the articles , double spaced and written in English or Spanish should be sent in triplicate , in white paper (21,6 x 27, 5 cm), keeping margins of 3 cm. An electronic copy must be included on diskette (PC format)

The preliminary text of the article can be sent as a .doc file in the attachment by e-mail:
e-mail: oen85@yahoo.com

The text must be elaborated in Word for Windows or compatible word processors, using 12 points Times New Roman letters .

The work must have a maximum of 15 pages, included figures, tables and bibliography.

The language must be clear and accurate. The work should be written in an impersonal style.

The authors have to present the results, propositions and conclusions in a form that can suit better for teachers from different countries .

We recommend the following structure for article:

Title: no longer that 15 words; a translation of the title in Spanish or English must also be included.

Authors: names and surnames of the authors, the institution to which they belong, their electronics address (e-mail).

Abstract: not to exceed 200 words written in single paragraph. Key words: no more than five words; Resumen : a translation of the abstract into Spanish . Palabras claves: the translation of key words into Spanish.

The body of the text of the article must generally have the following parts:

- Introduction
- Methodology applied in the investigation
- Results and discussion
- Conclusions
- Acknowledgements
- Bibliography

Introduction:

general planning of the topic, objective or hypothesis of the investigation, references to relevant previous works.

Investigation methodology :

in case of investigations on new methodologies and innovations in sciences teaching the details of the organization of the pedagogic experiment or other methods of the educational investigation must be presented.

Results and discussion:

Supporting evidence should be presented together with the stated results of the pedagogic experiments, including tables , figures and photographs (black and white). and relevant statistical data. The discussion must be short and be limited to the key aspects of the work.

Conclusions:

should be based on results and if possible the solutions to the problem outlined in the introduction should be mentioned.

References in the text:

the name of the author and the year of issue , indicated between bracket (for example, (Moore, 1997).

Bibliography: the list will be cited in alphabetical order .

Reference to books : authors, name of the cited book (in italic), editorial, city, country, year of the publication, cited pages.

Example:

Hanson, R., Molecular Origami. Precision Scale Models from Paper, University Science Books, Sausalito, AC, 1995, p. 3-4.

Reference to articles: authors, name of the article, name of the magazine (in italic), volume (in bold), number between square brackets, initial and final pages, year of publication.

Example:

Rugarcía, A., El ingeniero químico para el siglo XX1, Educaión Química 9 , [1], 46-52, 1998.

Short communications (3-6 pages) should generally contain the introduction with the problem planning, results, discussion, conclusions and bibliography. We especially recommend this form to teachers of the secondary (high) school.

The text of the article must be sent as a .doc file in the attachment by e-mail:
e-mail: oen85@yahoo.com
The mail address of the REC is :
Journal of Science Education
phone/2708348
e-mail: oen85@yahoo.com

INSTRUCCIONES PARA AUTORES

La Revista de Educación en Ciencias (REC) publica artículos, comunicaciones cortas y otros materiales originales como resultado de las investigaciones y experiencias nuevas en el campo de enseñanza de las ciencias naturales a nivel de escuela segundaria y superior (enseñanza de Biología, Física, Química y otras ciencias naturales, sobre educación en las ciencias del Medio ambiente, Biotecnología y otras ciencias integradas), y también investigaciones en la enseñanza de Matemáticas, aplicadas a la educación de las ciencias. También son bienvenidos materiales de opinión y discusión sobre el mejoramiento de la política educativa nacional e internacional de la enseñanza de las ciencias para los niveles de la escuela secundaria (bachillerato) y superior.

Los artículos y las comunicaciones cortas enviados a la redacción no deben ser publicados o enviados a otras revistas de nivel nacional o internacional.

Las secciones principales de la REC son:

Innovaciones y métodos activos modernos en la enseñanza de las ciencias
Diseño del curriculum moderno
Evaluación educativa
Laboratorios y experimento (físico, químico, biológico) en la enseñanza
Tecnología educativa, incluido el uso de Internet e informática educativa
Política educativa y organización en la enseñanza de las ciencias
Revisión de libros

Sección especial de la REC : "Práctica y vivencia de la Física, Química, Biología y Ciencias integradas en su colegio" En esta sección planeamos publicar comunicaciónes cortas sobre la vida escolar en las ciencias:

Hallazgos metodológicos de los profesores
Logros educativos
Libros de textos en ciencias y otros medios de enseñanza
Semanas, jornadas, días de ciencias
Juegos educativos
Olimpiadas de ciencias y otros.

Los autores deben cumplir las instrucciones siguientes:

Los manuscritos de los artículos o comunicaciones cortas , escritos en español o inglés, deben enviarse por triplicado , en papel blanco, tamaño carta (21,6 x 27, 5 cm), a espacio doble , con márgenes de 3 cm.

Debe incluirse la copia electrónica del trabajo en diskette.

El texto preliminario del artículo se puede enviar (el archivo .doc en attachment) via e-mail:
e-mail: oen85@yahoo.com

El texto debe ser elaborado en Word Windows para PC o aplicaciones compatibles , en letra Times New Roman de 12 puntos.

El trabajo debe tener una extensión máxima de 15 páginas, incluidas figuras, tablas y bibliografía.

El lenguaje debe ser claro y preciso. El trabajo debe ser escrito en un estilo impersonal.

Se aconseja a los autores, presentar las recomendaciónes y conclusiones no sólo de carácter local, para que los materiales sirvan mejor a los profesores e investigadores de diferentes países.

Recomendamos la siguiente estructura del artículo:

Título: no más de 15 palabras. Debe incluirse la traducción del título al inglés.

Autores: nombres y apellidos de los autores, la institución a la cual pertenecen, dirección electrónica.

Resumen: no más de 200 palabras escritas en un sólo párrafo.

Palabras claves: cinco palabras claves.

Summary: una traducción del resumen al inglés. Keywords: la traducción de palabras claves en inglés.

La estructura del texto del artículo debe tener generalmente las siguientes partes:

Introducción,
Metodología aplicada para investigación
Resultados y discusión
Conclusiones
Agradecimientos
Bibliografía

Introducción :

planeamiento general del tema, objetivos de la hipótesis de la investigación, referencias a los trabajos previos relevantes.

Metodología aplicada para investigación:

en el caso de que la investigación sea sobre nuevas metodologías e innovaciones en la enseñanza de ciencias, deben ser presentados los detalles de la organización del experimento pedagógico u otros métodos de la investigación en la educación.

Resultados y discusión:

los resultados de los experimentos pedagógicos , incluido las tablas , figuras y fotografías (en blanco y negro).. Se recomienda presentar los resultados con los cálculos estadísticos pertinentes. La discusión debe ser breve y limitarse a los aspectos claves del trabajo.

Conclusiones:

deben basarse en los resultados obtenidos; si es posible, mencionando las soluciones al problema planteado en la introducción.

Referencias (citas biblliográficas en el texto):

el nombre del autor y el año de edición , indicados entre paréntesis (por ejemplo, (Moore, 1997).

Bibliografía: la lista se citará en orden alfabético .

La referencia del libro : autores, nombre del libro citado (en itálicas), editorial, país, año de la publicación, páginas citadas.

Ejemplo:

Hanson, R., Molecular Origami. Precision Scale Models from Paper, University Science Books, Sausalito, CA, 1995, p. 3-4.

La referencia a un artículo: autores, nombre del artículo, nombre de la revista (en itálicas), volumen (en negrillas), número entre paréntesis cuadrados, páginas inicial y final, año de publicación.

Ejemplo:

Rugarcía, A., El ingeniero químico para el siglo XX1, Educación Química 9 , [1], 46-52, 1998.

Las comunicaciones cortas (3-6 páginas) generalmente deben contener la introducción con el planeamiento del problema, los resultados, la discusión, conclusiones, bibliografía. Recomendamos especialmente, esta forma para los profesores de los colegios.

Los textos de los artículos se envían como archivo .doc por correo electrónico oen85@yahoo.com
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